FINAL SAMPLING AND ANALYSIS PLAN
VOLUME 1 – FIELD SAMPLING PLAN
REMEDIAL INVESTIGATION DESIGN
FORMER JOSLYN MANUFACTURING AND SUPPLY COMPANY

FORT WAYNE, INDIANA

Prepared for:

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TABLE OF CONTENTS

1.0 INTRODUCTION 1

1.1 Site Location and Description 1
1.2 Historical Site Usage 2
1.3 Physical Setting 3
1.4 Previous Investigations 4

2.0 PROJECT SCOPE AND OBJECTIVES 7

2.1 Project Data Quality Objectives 7
2.2 Task Description 9
2.3 Investigative Areas 10
2.4 Constituents of Potential Concern 11
2.5 Applicable or Relevant and Appropriate Requirements 12
2.6 Schedule 12

3.0 PROJECT ORGANIZATION 13

3.1 Program Manager 13
3.2 Project Manager 13
3.3 Site Supervisor 13
3.4 RI Field Geologist 13
3.5 Quality Assurance/Quality Control Officer 14
3.6 Site Safety and Health (SSH) Manager 14
3.7 Site Safety and Health Officer 14
3.8 Site HP 14
3.9 Site Radiation Safety (SRS) Officer 15

4.0 FIELD SAMPLING PROGRAM STRATEGY 16

4.1 Records Review and Evaluation 16
4.2 Conceptual Site Model 16
4.3 Data Gap Analysis 16
4.4 Preliminary Sampling Considerations 16
4.4.1 Identify Contaminants 16
4.4.2 Establish Screening Levels 17
4.4.3 Classification of Site Areas and Facilities by Contamination Potential 19
4.5 Precursor Actions to Field Sampling Activities 21
4.5.1 Mobilization, Temporary Facilities, Utility Location, and Demobilization 22
4.5.2 Structural Survey of Buildings 24
4.5.3 Inventory of Building Interiors 25
4.5.4 Consent for Sampling 25
4.5.5 Establish Property Boundaries 25
4.5.6 Site Walk to Identify Physical Characteristics of Site 25
4.6 Characterization Survey Design 25
4.6.1 Data Control for Decision Making 25
4.6.2 Methodology for Selection of Statistical Based Sample Locations 26

4.6.3 Reference Coordinate System Grid 27
4.6.4 Building Grid System 27
4.6.5 Site Coordinate System 27
4.7 General Sampling Methodologies and Procedures 27
4.7.1 Instrumentation 27
4.7.2 Scanning and Direct Measurement Techniques for Radiological Surveys 28
4.7.3 Surface and Subsurface Soil (Volumetric) 34
4.7.4 Volumetric Facility Samples (Volumetric) 35
4.7.5 Groundwater 35
4.7.6 Surface Water/Wastewater 38
4.7.7 Sediments/Sludges 38
4.8 Background Reference Areas 39
5.0 FIELD ACTIVITIES 41
5.1 Sampling Assumption Basis and Strategy 41
5.2 IA-01 Facilities Interior and Exterior Surfaces 43
5.2.1 Interior Surfaces – Building 8 43
5.2.2 Interior Surfaces – Building 6, Building 7, and Building 9 43
5.2.3 Interior Surfaces – Building 1 44
5.2.4 Exterior Surfaces – Buildings 1, 6, 7, 8, and 9 45
5.3 IA-02 Building Exterior Areas 46
5.3.1 Soils Under Building 6/Quench Basin Area, Building 7, and Building 8/Pickling Tank Area, Old Burn Areas I, II, III, and IV, Acid Neutralization Basin Area, Pickling Tank Area, and Buffer Zones 46
5.4 IA-03 Site Soils 50
5.4.1 Classification of Site Soils 50
5.4.2 Survey and Sampling Basis 50
5.5 IA-04 Groundwater 51
5.5.1 Classification of Groundwater 51
5.5.2 Sampling Basis 51
5.6 IA-05 Surface Water and Sediments from Junk Ditch 52
5.6.1 Classification of Surface Water and Sediments 52
5.6.2 Sampling Basis 52
5.7 IA-06 Sediments in Building Catch Basins 53
5.7.1 Classification of Sediments 53
5.7.2 Sampling Basis 53
5.8 IA-07 Wastewater 53
5.8.1 Classification of Wastewaters 53
5.8.2 Sampling Basis 53
5.9 IA-08 Sludges 53
5.9.1 Classification of Sludges 53
5.9.2 Sampling Basis 53

5.10 Boring, Survey, and Sample Location Survey 53

6.0 FIELD OPERATIONS DATA MMENT AND DOCUMENTATION 55

6.1 Daily Quality Control Reports 55
6.2 Field Logbooks 55
6.3 Photographic Records 57
6.4 Sample Documentation 57
6.4.1 Sample Numbers 57
6.4.2 Sample Labels 58
6.4.3 Chain of Custody Records 59
6.4.4 Field Analytical Records 60
6.5 Records 61
6.5.1 Responsibilities 61
6.5.2 Controlled Records 61
6.5.3 Quality Control 61
6.6 Field Documentation Procedures/Data Management and Retention 61
6.7 Archival of Samples 62

7.0 SAMPLE PACKAGING AND SHIPPING REQUIREMENTS 63

7.1 Sample Handling and Tracking System 63
7.2 Sample Custody 63
7.3 COC Documentation 63
7.4 Sample Labels 63
7.5 Corrections to Documentation 63
7.6 Sample Delivery 64

8.0 INVESTIGATION-DERIVED WASTE 65

8.1 Investigation-Derived Waste Collection and Containerization 65
8.2 Waste Container Labeling 65
8.3 IDW Field Staging Area 66
8.4 IDW Characterization and Classification for Disposal 66
8.5 Disposal of IDW 67

9.0 DECONTAMINATION 68

10.0 REFERENCES 69

TABLES

TABLE 1. SUMMARY OF HISTORICAL DATA 72
TABLE 2. DATA QUALITY OBJECTIVES AND DATA NEEDS 75
TABLE 3. SAMPLING SUMMARY 78
TABLE 4. SAMPLING POINT LOCATIONS FOR INTERIORS OF BUILDINGS 6, 7, AND 9 83
TABLE 5. SAMPLING POINT LOCATIONS FOR INTERIOR OF BUILDING 1 88
TABLE 6. SAMPLING POINT LOCATIONS FOR EXTERIORS OF BUILDINGS 1, 6, 7, 8, AND 9 89
TABLE 7. SAMPLING POINT LOCATIONS FOR CLASS 1 SOILS AND CLASS 2 BUFFER ZONE 91
TABLE 8. RANDOM SOIL SAMPLING POINT LOCATIONS FOR REMAINING SITE FOOTPRINT 97
TABLE 9. JUNK DITCH SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS 99

FIGURES

FIGURE 1. SITE LOCATION
FIGURE 2. SITE PLAN
FIGURE 3. MED/AEC ERA INVESTIGATIVE AREAS
FIGURE 4. HISTORIC OPERATIONAL PROCESS FLOW DIAGRAM
FIGURE 5. GROUNDWATER MONITORING WELLS
FIGURE 5A. GEOLOGIC CROSS-SECTION E - E'
FIGURE 6. CONCEPTUAL SITE MODEL
FIGURE 7. PROJECT ORGANIZATION CHART
FIGURE 8. HISTORIC SURVEY RESULT FROM BUILDING INTERIORS
FIGURE 9. SAMPLING (SURVEY) LOCATIONS FOR BUILDING 6 INTERIOR
FIGURE 10. SAMPLING (SURVEY) LOCATIONS FOR BUILDING 7 INTERIOR
FIGURE 11. SAMPLING (SURVEY) LOCATIONS FOR BUILDING 9 INTERIOR
FIGURE 12. SAMPLING (SURVEY) LOCATIONS FOR BUILDING 1 INTERIOR
FIGURE 13. SAMPLING (SURVEY) LOCATIONS FOR BUILDING 1 EXTERIOR
FIGURE 14. SAMPLING (SURVEY) LOCATIONS FOR BUILDING 6 EXTERIOR
FIGURE 15. SAMPLING (SURVEY) LOCATIONS FOR BUILDING 7 EXTERIOR
FIGURE 16. SAMPLING (SURVEY) LOCATIONS FOR BUILDING 8 EXTERIOR
FIGURE 17. SAMPLING (SURVEY) LOCATIONS FOR BUILDING 9 EXTERIOR
FIGURE 18. SAMPLING LOCATIONS FOR OLD BURN AREA III
FIGURE 19. SAMPLING LOCATIONS FOR OLD BURN AREA I
FIGURE 20. SAMPLING LOCATIONS FOR OLD BURN AREA II
FIGURE 21. SAMPLING LOCATIONS FOR OLD BURN AREA IV (BETWEEN BUILDINGS 7 AND 8)
FIGURE 22. SAMPLING LOCATIONS FOR ACID NEUTRALIZATION BASIN AREA
FIGURE 23. METHODOLOGY FOR SELECTING VOLUMETRIC SOIL SAMPLES
FIGURE 24. RANDOM SOIL SAMPLING LOCATIONS FOR INTERIOR OF BUILDING 8
FIGURE 25. METHODOLOGY FOR SELECTING BUFFER ZONE BOUNDING SOIL SAMPLE LOCATIONS
FIGURE 26. RANDOM SOIL SAMPLING LOCATIONS FOR BUILDING 6
FIGURE 27. RANDOM SOIL SAMPLING LOCATIONS FOR INTERIOR OF BUILDING 7
FIGURE 28. RANDOM SOIL SAMPLING LOCATIONS FOR SITE FOOTPRINT
FIGURE 29. JUNK DITCH SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS

APPENDICES

APPENDIX A - UFGS SECTION 01 50 00
APPENDIX B - ASTM STANDARD PRACTICES
APPENDIX C - ADDITIONAL GUIDANCE MANUALS
APPENDIX D - FIELD ACTIVITY FORMS

LIST OF ACRONYMS

AEC	Atomic Energy Commission
AGC	US Army Geospatial Center
APP	Accident Prevention Plan
ASTM	ASTM International
bgs	Below Ground Surface
CDC	Center for Disease Control
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COC	Chain of custody
COPC	Constituent of Potential Concern
cpm	counts per minute
CSM	Conceptual Site Model
$DCGL_w$	Derived Concentration Guideline Level for Average Concentrations over a Wide Area
DO	dissolved oxygen
DOE	United States Department of Energy
dpm	disintegrations per minute
DQCR	Daily Quality Control Report
DQO	Data Quality Objective
EDR	Environmental Data Resources, Inc.
FS	Feasibility Study
FSA	Field Staging Area
FSP	Field Sampling Plan
ft	feet
FTP	File Transfer Protocol
FUSRAP	Formerly Utilized Sites Remedial Action Program
GE	General Electric
GIS	Geographic Information System
GPR	Ground Penetrating Radar
GPS	Global Positioning System
GWS	Gamma Walkover Survey
HHRA	Human Health Risk Assessment
HP	Health Physicist
ICP-MS	inductively coupled plasma mass spectrometry
ID	identification
IDEM	Indiana Department of Environmental Management
IDW	Investigation-derived waste
KO	Contracting Officer
m^2	square meters
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MCL	Maximum Contaminant Level
MED	Manhattan Engineering District
NIOSH	National Institutes for Occupational Safety and Health
NRC	Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
ORP	oxidation reduction potential

PARS	PARS Environmental, Inc.
PCB	Polychlorinated Biphenyl
PDF	Portable Document Format
PM	Project Manager
PP	Proposed Plan
PPE	Personal Protective Equipment
PWS	Performance Work Statement
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
QCP	Quality Control Plan
RA	Remedial Action
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RI	Remedial Investigation
ROD	Record of Decision
RSP	Radiological Safety Plan
RSSI	Radiation Safety Services Incorporated
SAP	Sampling and Analysis Plan
SEC	Special Exposure Cohort
SRS	Site Radiation Safety
SS	Site Supervisor
SSH	Site Safety and Health
SSHP	Site Safety and Health Plan
St.	Saint
STP	Sewage Treatment Plant
TCE	Trichloroethylene
TPP	Technical Project Planning
U-billet	Uranium Billet
UFP	Uniform Federal Policy
USACE	United States Army Corps of Engineers
USCS	unified soil classification system
USDOT	United States Department of Transportation
USEPA	United States Environmental Protection Agency
Valbruna	Valbruna Slater Stainless Steel, Inc.
VRP	Voluntary Remediation Program
VSP	Visual Sample Plan

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1.0 INTRODUCTION

PARS Environmental, Inc. (PARS), under contract with the United States Army Corps of Engineers (USACE), Buffalo District, has prepared a Sampling and Analysis Plan (SAP) for use in the project titled: *Remedial Investigation, Former Joslyn Manufacturing and Supply Company, Fort Wayne, Indiana.* The task was performed in accordance with the Performance Work Statement (PWS), prepared by USACE and dated July 2018, Contract No. W912QR-14-D-0006, Delivery Order No. W912P418F00047, and the Quality Control Plan (QCP) prepared by PARS (PARS, 2018a). This work is under USACE responsibilities under the Formerly Utilized Sites Remedial Action Program (FUSRAP) and is being performed at the Former Joslyn Manufacturing and Supply Company located in Fort Wayne, Allen County, Indiana, hereinafter the "Site."

The SAP consists of two volumes for the Remedial Investigation (RI) for the Site. This Volume I, Field Sampling Plan (FSP) is intended to be used in conjunction with Volume II, the Uniform Federal Policy (UFP) Quality Assurance Project Plan (QAPP).

The purpose of this SAP is to present the sampling necessary to complete a RI at the Site and to support Site closure to address environmental and health risks resulting from Manhattan Engineering District (MED) and Atomic Energy Commission (AEC) activities performed at the Site between 1943 and 1952. The SAP was developed based on the Draft *Site Closure Strategy* (PARS, 2019a) as amended by USACE Buffalo District comments, PARS responses and subsequent resolution; herein referred to as the *Site Closure Strategy*. The SAP also takes into consideration materials presented in the *Document Review Narrative* (PARS 2019b) and *Site Inspection Report* (PARS, 2018b), in addition to information gathered and discussed during a Technical Project Planning (TPP) meeting that the Project Planning Team attended in Fort Wayne, Indiana on December 4, 2018. The intent of the RI is to collect all data needed to support closure of FUSRAP-related concerns at the Site using the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) process. Based on findings of the RI and associated risk assessments, a Feasibility Study (FS) or Proposed Plan (PP) will be developed.

1.1 Site Location and Description

The Site is a 63-acre industrial property located at 2400 Taylor Street in Fort Wayne, Allen County, Indiana. The Site is bounded to the north by railroad tracks and West Jefferson Boulevard, to the east by railroad tracks and commercial/industrial properties, to the south by Taylor Street and commercial/industrial properties, and to the west by Junk Ditch. Swinney Park, a local community recreational area, is located approximately 700 feet northeast of the Site. Rockhill Park is located approximately 500 feet to the west of the Site and Saint (St.) Marys River is located approximately 2,100 feet to the east of the Site. Residential areas are located to the southeast of the Site. A Site location map and Site Plan are shown on Figures 1 and 2, respectively.

The Site is divided into two distinct areas owned by Valbruna Slater Stainless Steel, Inc. (Valbruna) and Fort Wayne Steel, respectively. Fort Wayne Steel is a subsidiary of Valbruna. Valbruna specializes in the production of stainless steel and hot and cold finished bars.

Valbruna owns the property west of and including Building 10, which is approximately 40 acres in size. Fort Wayne Steel owns the property east of and including Building 9, which is approximately 23 acres in size. Buildings involved in historic uranium billet (U-billet) shaping activities are located on the Fort Wayne Steel property and are designated by numbers 1 and 6 through 9 on Figure 3.

1.2 Historical Site Usage

Joslyn Manufacturing and Supply Company was selected by the MED for the task of U-billet shaping because it possessed the unique ability to perform centerless grinding. Uranium processing was conducted at the Site for the MED from August 1943 through June 1946, for the University of Chicago until 1949, for the New York Operations Office of the AEC through about January 1952, and for Great Britain and Canada beginning in August 1946 into the early 1950s. In addition to uranium processing, thorium rods were processed at the Site in two distinct campaigns: June 1946 and January 1947.

The operational flow of uranium processing activities is depicted on Figure 4. Uranium billets were received by rail directly into Building 9 (Processing and Final Operations). Materials were moved within buildings using overhead cranes and between buildings using rail-mounted push carts. The billets were moved from the off-loading location in Building 9 to Building 6 (Rolling Mill) for processing. In Building 6, the billets were staged before being heated in the furnace to make the material more malleable. The heated billets were then transferred over rollers to the 12-inch and 14-inch rolling mills. After rolling, the rods were transferred to a quench tank for cooling, and possibly a pickling tank for acid treatment. The rods were then moved to Building 7 (Wire Mill) for straightening and through Building 9, where the rod ends were cut. The straightened, cut rods were moved into Building 8 (Processing Department) where they were ground to final specification. Grinding was performed in self-contained structures within Building 8 to contain dust. Floors and the grinding areas were swept nightly to collect dust and grinding debris, which were placed in metal containers or buckets and placed outside of the doors on the north and south sides of Building 8 for disposition. The collected dust and debris were oxidized (i.e., burned) in Old Burn Area III and Old Burn Area IV (Figure 3), and possibly other potential burn areas. All burn residue was collected for accountability purposes and returned to the MED/AEC with the final rods. The rods were then moved to the old Machine Shop where the rods were threaded. The rods were then moved back to Building 9 for packaging and staging for shipment.

Historical operations have resulted in a release of trichloroethylene (TCE) from the Site. Valbruna entered into a Voluntary Remediation Agreement with the State of Indiana to address this issue. A system of groundwater monitoring wells has been installed and is sampled quarterly. The source of the plume, located below Building 8, has been remediated by Valbruna using thermal treatment. In addition, the Site has also entered into agreements addressing polychlorinated biphenyl (PCB) contamination on the Site. Currently, Valbruna and the State of Indiana have agreed to restrictions on future site use. Specifically, deed restrictions prohibit future Site use for residential purposes, prohibit the installation of new drinking water wells on the Site, and restrict the use of groundwater on the adjacent General Electric (GE) site. The use of groundwater on the GE site is prohibited within the first 75 feet below ground surface (bgs) for any industrial, commercial, or residential purpose other than to collect samples for analysis, or to conduct environmental response or remediation activity. The restriction does not limit the

use of groundwater under the GE property that is located at depths greater than 75 feet or the installation or use of wells completed into any area below 75 feet.

1.3 Physical Setting

The Site is a low-lying area surrounded by a four-foot-high levee constructed after major flooding in 1982. Levee construction started in 1984 and was completed in 1997. In addition to levee construction, approximately three to four feet of fill material consisting of slag and soil were added primarily to the western portion of the Site to raise elevations and provide additional flood protection. All surface runoff from the Site is collected in storm drains and transferred with sanitary waste to the City of Fort Wayne sewage treatment plant through a 30-inch outfall located on the east side of the Site. To provide further protection against flooding, the Site's access driveways from Taylor Street are blocked using large concrete barriers and sandbags when necessary.

The Site is located on the Bluffton Till Plain with the original surficial soil consisting of two to three feet of poorly drained silty clay loam (Lenawee soil), which is commonly overlain by fill throughout the Site. Unpaved areas, such as parking lots and driveways, are covered by gravel. The fill and soil are underlain by up to 70 feet of variably-textured Pleistocene-age lacustrine clay layers and glacio-fluvial sand and gravel deposits that together overlie the Trafalgar Till, which is an aquitard hydraulically separating the upper glacial deposits from lower groundwater producing limestones, dolomites, and thin shale beds of the Traverse Formation (Keramida, 2002).

As part of a Voluntary Remediation Program (VRP) agreement with the State of Indiana, 44 shallow and 43 deep monitoring wells were installed in the sand and gravel deposits under the Site (Figure 5). Boring logs from these wells indicate the coarse-grained water-bearing deposits have two hydrostratigraphic zones: 1) a shallow groundwater system varying between 10 and 20 feet bgs, and 2) a deeper groundwater system varying between 20 and 30 feet bgs (Figure 5A) (Keramida, 2002). On the western portion of the Site, the sand and gravel deposits are interrupted by one- to 15-foot-thick clay layers that pinch out to the east. The glacial deposits below the Site appear to coarsen from west to east, transitioning from silty or clayey sand (three to 10 feet thick) to silty sand, and then to layers of sand that grade to gravel (Figure 5A).

Potentiometric surface data indicates that groundwater flow on the Site is predominantly east towards the St. Marys River, which gains groundwater flowing under the Site (Keramida, 2002).

Valbruna operates a cooling-water production well that is located on the west side of the property and approximately 177 feet deep in the limestone bedrock. The monitoring well array on the Site does not show drawdown artifacts from this production well, which verifies that the Trafalgar Till aquitard isolates the upper water-bearing zone from the underlying bedrock aquifer below the Site. This is also reflected in the groundwater restrictions discussed in Section 1.2, which isolates shallow groundwater uses.

The City of Fort Wayne obtains its municipal water supply from surface water sources, with the nearest intake located at the confluence of the St. Marys and St. Joseph Rivers, approximately two miles northeast of the Site. A review of groundwater usage indicates that

only one industrial well (discussed above) currently operates on the Site. No other on-Site wells are used as water sources. The nearest off-site wells are located on the GE property to the east. The nearest drinking water well is located in a residential area approximately one mile south of the Site (Keramida, 2002). Deed restrictions prohibit: (1) residential use of the Site; (2) installation and use of any drinking water wells on-Site except the monitoring wells and existing industrial well; and (3) installation of wells or use of groundwater at depths less than 75 feet on the GE property, which equates to the glacial overburden deposits. The primary water-bearing zones monitored at the Site are the shallow and deep hydrostratigraphic zones of the coarse-grained glacial deposits.

1.4 Previous Investigations

The following previous investigations have confirmed the presence of radiological contamination and the release of contaminants into the environment or provided other important information:

- *Residual Contamination Survey at Joslyn Steel Company*, Memorandum to File, A. R. Piccot; Health and Safety Laboratory, Atomic Energy Commission, 22 August 1949;
- *Preliminary Survey of Joslyn Stainless Steel Company, Fort Wayne, Indiana*, Health and Safety Research Division, Oak Ridge National Laboratory (ORNL); Oak Ridge, Tennessee; March 1980;
- *Report of a Focused Radiological Survey at Slater Steels Corporation, Fort Wayne, Indiana*, Radiation Safety Services Incorporated (RSSI), March 2004;
- *Preliminary Assessment, Joslyn Manufacturing Site, Fort Wayne, Indiana*, USACE Buffalo District, August 2005;
- *Groundwater Sampling Results – In-house Groundwater Sampling Under Site Investigation, Joslyn Manufacturing Site, Fort Wayne, Indiana*, USACE Buffalo District, December 2006;
- *Site Inspection Report, Joslyn Manufacturing Site, Fort Wayne, Indiana*, USACE Buffalo District, May 2007)
- Environmental Data Resources, Inc. (EDR) report titled "The EDR-Radius Map" dated February 24, 2005.
- US Army Geospatial Center (AGC), Joslyn Manufacturing & Supply Co. Historical Photo Analysis, July 2012.

The RSSI investigation identified areas of fixed and transferrable radiological contamination in Building 8 and soil contamination at the Old Burn Area III (Old Burn Area locations are depicted on Figure 3). In 2006, USACE sampled 21 existing VRP monitoring wells. Results indicated levels similar to background and below the United States Environmental Protection Agency (USEPA) Maximum Contaminant Level (MCL) for mass-based uranium and did not indicate a release of radiologic constituents to the groundwater. In 2007, USACE conducted soil sampling as part of its Site Inspection (USACE, 2007). Twenty-four (24) sample locations (14 interior and 10 exterior to the buildings) and five (5) background samples were taken. Elevated isotopic uranium concentrations were reported in samples from the Old Burn Area III. Boreholes inside Building 8 did not replicate elevated readings identified in the RSSI investigation. Contamination was not confirmed in locations identified as Old Burn Areas I and II. The recently identified location of Old Burn Area IV was not sampled. A summary of

collected survey and radiological analytical data along with NUREG-1757 screening values are presented in Table 1.

To date no soil samples for radiological contamination from other areas of the Site, including areas where the original soil surface is now buried under fill, have been collected. No samples of sediments for radiological contamination in Junk Ditch or the sediment-surface water interface have been collected. Groundwater in the direction east-southeast and southeast of Building 8 has not been sampled.

In addition to the previous Site investigations noted, a web-based literature review identified the following additional sources of information:

- Center for Disease Control (CDC), National Institutes for Occupational Safety and Health (NIOSH) Radiation Dose Reconstruction Program; https://www.cdc.gov/niosh/ocas/default.html.

    1. Special Exposure Cohort (SEC) Petition Evaluation Report, Petition SEC-00200; Joslyn Manufacturing and Supply; December 3, 2012.
    2. Tomes, Thomas; *Cleanup After Uranium Operations at Baker Brothers, Toledo, Ohio*; April 2, 2013.
    3. Site Profile for Atomic Weapons Employers That Worked Uranium Metals; Revised June 17, 2011, Appendix J – Joslyn Manufacturing and Supply Company; approved October 7, 2014;

- Indiana Department of Environmental Management (IDEM), Virtual File Cabinet, VRP, Valbruna Slater Steel Corporation electronic file; https://vfc.idem.in.gov/DocumentSearch.aspx?xAIID=15727. The Virtual File Cabinet for the Valbruna Site contains 963 records regarding VRP actions. Several key information sources are listed below:

    1. Indiana Department of Environmental Management; *Letter to Slater Steel; Subject: Site Characterization Slater Steel*; May 26, 2000.
    2. Stantec Consulting Services; *Letter to Indiana Department of Environmental Management; Subject: Groundwater Monitoring Data Package, Valbruna Slater Steel Corporation*; October 19, 2017.
    3. Indiana Department of Environmental Management, Office of Solid and Hazardous Waste Management; *Resource Conservation and Recovery Act (RCRA) Facility Assessment Report, Slater Steel Corporation, Fort Wayne, Indiana, USEPA ID No. IND 005 447 537*; March 10, 1995.
    4. Keramida Environmental Inc.; *Letter to Indiana Department of Environmental Management; Subject: Slater Steels Voluntary Remediation Project*; July 10, 2000.
    5. Avant Group; *Phase I Investigation Work Plan Off-Site Groundwater Contamination Slater Steels Fort Wayne, Indiana*; October 20, 1998.
    6. Keramida Environmental Inc.; *Letter to Indiana Department of Environmental Management; Subject: Site Wide Sampling Report, Slater Steels, Fort Wayne, Indiana; IDEM VRP #6960201*; January 31, 2001.

7. Keramida Environmental Inc.; *Submittal to Indiana Department of Environmental Management; possible addendum to Site Wide Sampling Report, Slater Steels, Fort Wayne, Indiana; IDEM VRP #6960201*; received February 6, 2001.

- Additional References:

1. U.S. AEC; New York Operations Office; *Machining Techniques and Procedures for Uranium, Graphite, Titanium, Zirconium, Thorium, Tantalum, Beryllium, Bismuth, Lithium, and Stellite*; November 3, 1952.
2. Nuclear Regulatory Commission (NRC), 2000, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*; Report Number NUREG-1575, Rev. 1 USEPA 402-R-97-016, Rev. 1 DOE/EH-0624, Rev. 1; August 2000.
3. Johnson, R., L. Durham, C. Rieman, and R. Hoover; *Adapting MARSSIM for FUSRAP Site Closure;* Environmental Assessment Division, Argonne National Laboratory; Proceedings of Waste Management Symposium; February 27 – March 1, 2005; Tucson, Arizona.
4. Gilbertson, M. A.; letter from M. A. Gilbertson (United States Department of Energy [DOE]) to General C. Strock (USACE) dated August 26, 2004; DOE eligibility determination for the Joslyn Manufacturing and Supply Company.

2.0 PROJECT SCOPE AND OBJECTIVES

The project objectives, task description, investigative areas, potential constituents of concern, and project schedule are discussed in the sections below.

2.1 Project Data Quality Objectives

The objective of the project is to close out FUSRAP-related environmental and health concerns at the Site using the CERCLA process. Completion of the RI is projected for 2019-2020 with finalization of the Record of Decision (ROD) in 2023-2024. It is assumed that land use at the Site will remain industrial for the foreseeable future. Remedial activities may include cleanup, or no action if risks are determined to be within acceptable limits based on human health or ecological risk assessments. USACE will maintain oversight of the Site for two years after a Remedial Action (RA) is completed or, if no action is required, after the ROD is finalized. After this two-year period the DOE will take over all remaining Site-related activities, if any, as specified in the ROD.

The site-specific Data Quality Objective (DQO) statements and related data needs are presented below and in Table 2.

1. Conduct a structural survey and an inventory of building content/structures to support FS alternatives and evaluations.

    - Compile observations from building inventory to determine whether any MED/AEC-related equipment remains on-site and, if so, survey for both fixed and removable impacts.
    - Based on the structural survey, identify any safety concerns for future RI/FS activities.

2. Identify the underground utility system within the Site, including if possible, utilities in place at the time of MED/AEC activities and utilities installed afterward.

    - Obtain all available utility drawings from current property owner (Valbruna). Because available drawings are limited, additional approaches to identifying the locations of underground utilities such as ground penetrating radar surveys, Indiana one call, etc. will be required.

3. Acquire information to define the fate and transport of contaminants from the Site.

    - Determine if uranium has been discharged to off-site surface water bodies or through the utilities.
        - Sample the on-Site sewer/storm drainage system's main outfall and catch basins.
        - Investigate past and planned future dredging actions in Junk Ditch including disposition of dredged materials (i.e., placement on banks, off-site disposition, etc.).
        - Sample the sediment and surface water in Junk Ditch and assess potential ecological concerns.

- Determine if uranium in the subsurface soils has infiltrated to groundwater.
  - Determine if monitoring well layout is adequate to assess potential groundwater impacts (review existing monitoring well locations, potentiometric groundwater maps and subsurface conditions).
  - Collect groundwater samples. The need for additional monitoring wells closer to the source term will be evaluated based on sampling results and hydrologic flow conditions.
- Determine movement/placement of fill on-Site. Areas on Site that received fill originating from portions of the Site potentially impacted by MED/AEC activities will be sampled. Areas on Site that were potentially impacted by MED/AEC activities and received fill will be sampled.
- Collect background data for potentially impacted media in order to distinguish naturally occurring radioactivity from on-site releases.

4. Gather sufficient data to complete a Baseline Human Health Risk Assessment (HHRA).

5. Define the extent of isotopic uranium and thorium in surface soils, subsurface soils, and buildings to support risk assessment(s) using Nuclear Regulatory Commission screening levels for human health and development and evaluation of FS alternatives (volume determination).

   - Investigate soil and building impacts, survey potentially impacted areas and collect samples.
   - Assess potential habitats on-Site to determine if an ecological risk assessment is needed.

6. Determine the extent of MED/AEC-related constituents present at the Site (i.e., uranium and thorium and associated daughter products, and the media and locations in which they are present).

   - Perform investigations of areas suspected or known to be impacted by MED/AEC-related activities, which may include facilities, soil, groundwater, sediment, and surface water.
   - Survey building interiors for both fixed and removable impacts.
   - Collect volumetric samples of building materials for isotopic ratios (to help determine criteria for future clean up requirements).

7. Determine if isotopic uranium and/or thorium has contaminated underground utilities.

   - Sample Site's main sanitary/storm sewer outfall and catch basins located near former MED/AEC operations.

8. Determine whether surface water and sediments have been impacted by isotopic uranium or thorium above screening levels (screening levels for these media will need to be researched and developed during RI/FS tasks, although levels provided by DOE [2002] or NRC [2006] may be used for initial screening).

- See DQO 3 and 5. Junk Ditch sediments and surface water will be sampled in order to determine if they have been impacted by MED/AEC activities.

9. Determine whether groundwater has been impacted by isotopic uranium or thorium above screening levels and, if so, determine the extent of impacts to support risk assessments and development and evaluation of FS alternatives.

    - Sample groundwater wells. As noted previously, the need for additional monitoring wells closer to the source term will be evaluated based on sampling results.

10. Provide sufficient characterization data to allow completion of subsequent FS, Remedial Design (RD), and RA.

    - Delineate extent of any required removal action.

11. Determine the magnitude of any chemical contamination to support establishing transportation and disposal requirements (e.g., waste classification) and associated costs to be included in various FS alternatives.

    - Obtain waste classification requirements.
    - Obtain and review Valbruna's previous waste characterization sampling results.

12. Archive collected samples in the event subsequent laboratory radionuclide analyses is required to support site-specific DQOs.

Data needs to address the site-specific DQOs depend on the type of decision the data must support. Identified project data uses/users include risk assessment, compliance, remedy identification and evaluation, and responsibility/liability determinations. Site-specific data needs for the Site are presented in Table 2.

2.2 Task Description

The purpose of the FSP is to identify the scope, technical basis, and field investigation methodologies and procedures for the field data collection program to address data gaps identified in the *Site Closure Strategy*. In addition, the FSP provides requirements for site mobilization, equipment decontamination, management of investigation derived waste, and Quality Assurance/Quality Control (QA/QC) in all aspects of execution of field sampling activities. The FSP also identifies key project personnel and associated roles and responsibilities.

The FSP relies heavily on the review of available Site operational history and prior Site investigations. This information review resulted in the identification of a preliminary Conceptual Site Model (CSM) (Figure 6) and data gap analysis and development of the Site sampling strategy and approach described in the *Site Closure Strategy*.

2.3 Investigative Areas

The *Site Closure Strategy* (PARS, 2019a) identified investigative areas on the Site discussed during the TPP Meeting based on operational history and the results of earlier sampling efforts. Facilities used during uranium and thorium processing include Buildings 1, 6, 7, 8, and 9 (Figure 3). Other buildings in use at the time that have been removed include Building 3, the carpenter shop, and the locker room. Fixed and transferrable contamination as well as external gamma have been observed with the highest residual contamination levels being found in Building 8, as indicated in Table 1. MED/AEC-era activities are known to have generated significant quantities of dust and fine particulates, largely from grinding operations (Building 8). Fugitive emissions from these activities are likely the source of the contamination detected in Building 8. In addition, fugitive emissions are likely to have been released from the building to the surrounding area. During MED/AEC activities, dust and particulates from grinding operations were collected daily and oxidized (i.e., burned) in two areas adjacent to Building 8: (1) an area immediately to the north, identified as Old Burn Area III; and (2) an area immediately to the south between Buildings 8 and 7, identified as Old Burn Area IV (Figure 3). The presence of contamination in Old Burn Area III has been confirmed by soil cores. Contamination was found at depths of four to eight feet bgs. The locations of Old Burn Areas I, II, and IV are less clear. Earlier investigations indicated that Old Burn Area I was located to the northeast of the east end of the original footprint of Building 8 (Building 8 was extended to the east around 1957). Similarly, the location of Old Burn Area II was identified as being east of Building 6. Recent information provided by the Site representative at the TPP Meeting has identified the location of Old Burn Area IV as being in an alleyway between Buildings 7 and 8. Limited soil samples taken in the Old Burn Area I and II locations indicated the presence of only low levels of uranium and thorium. Old Burn Area IV has not been sampled.

Piccot (1949) identified the presence of a quench tank in Building 6 and indicated that spillage from the tank was common. No information on the coolant used during MED/AEC activities, construction of the tank, or closure/removal of the tank was found. However, a review of historic information on coolants used in the steel industry at the time MED/AEC activities were conducted indicated that vegetable or animal-based soluble oils were used as coolants rather than hydrocarbon-based oils. Historic documents also indicate a pickling tank and associated acid neutralization basin located in the northern portion of the Site may have been impacted by MED/AEC operations. Pickling activities may also have occurred coincident with quench basin operations.

Investigative areas were identified based on the results of previous investigations and discussions at the TPP Meeting and are defined to include facilities and the various potentially impacted media (i.e., soil, groundwater, surface water, sediment, sludge, and wastewater). Using a MARSSIM-like approach, these investigative areas were classified based on the potential for contamination. The "MARSSIM-like" approach results from applying the MARSSIM process to media other than just building surfaces and surface soil. Investigative areas are listed below.

- IA-01 Building Interior and Exterior Surfaces (for Buildings 8, 6, 7, 9, and the Main Office [Building 1]).

- IA-02 Building Exterior Areas that consist of soils under Building 8, Buffer Zone surrounding Building 8, Old Burn Areas I, II, III, and IV, Quench Basin Area, Pickling Tank Area, and Acid Neutralization Basin Area).
- IA-03 Soil Areas that consists of the original Site soil surface, both exposed and buried under fill.
- IA-04 Groundwater underlying potential sources of contamination and down gradient of these sources.
- IA-05 Surface Water from the Junk Ditch and sediments from the Junk Ditch and its banks.
- IA-06 Sediment from the building catch basins.
- IA-07 Wastewater consist of the Site combined sewer discharges to the City of Fort Wayne Sewage Treatment Plant (STP).
- IA-08 Sludge consisting of materials collected from storm water catchment basins in and around facilities engaged in MED/AEC activities.

In addition to consideration of site history, the investigative areas, individually or combined, will serve as exposure units or sources in risk assessment.

2.4 Constituents of Potential Concern

Site history indicates both uranium and thorium were processed at the site. Separation, purification, and enrichment of uranium would have resulted in removal of impurities, including any daughter products. Likewise, separation and purification of thorium would also have resulted in removal of thorium daughter products. Consequently, the list of constituents of potential concern (COPCs) consists of the uranium isotopes (U-234, U-235, U-238) and thorium isotopes (Th-228, Th-230, and Th-232) and their daughter products as a result of radioactive decay. These potential daughter products include:

- U-238 daughter products: Th-234, Pa-234m, U-234, Th-230, Ra-226, Rn-222, Po-218, Pb-214, Bi-214, Po-214, Pb-210, Bi-210, Po-210
- U-235 daughter products: Th-231, Pa-231, Ac-227, Th-227, Ra-223, Rn-219, Po-215, Pb-211, Bi-211, Tl-207
- Th-232 daughter products: Ra-228, Ac-228, Th-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208.

The isotope U-238 will reach secular equilibrium with Th-234, Pa-234m, and U-234 in a short time period, although the U-234 activity has the potential to be higher as a result of the uranium enrichment process. In-growth of Th-230 and subsequent daughter products would be very low at the Site due to the long half-lives of U-234 and Th-230. Ingrowth of U235 daughters is mainly due to Th-231 as the third daughter, Pa231 has a relatively long half-life compared to the time since uranium separation. The isotope Th-232 reaches secular equilibrium with the entire decay chain over a relatively short time frame (within 50 years) so all Th-232 daughters have the potential to be present at the Site. Gamma spectroscopy laboratory analysis for all the uranium and thorium daughter products will be performed to confirm absence or presence.

Spent nuclear reactor fuel was returned to several U.S.-based enrichment facilities for reprocessing beginning in the early 1950s, Typical radioactive materials in recycled uranium with the potential to have been recovered into uranium, including enriched or depleted uranium,

during reprocessing include Sr-90, Tc-99, Cs-137, Pu-238, Pu-239/Pu-240, and Am-241, some of which are fission products. Based on Site records, fissions products are not expected to be present at the Site. However, gamma spectroscopy laboratory analysis for the gamma-radionuclides, including Co-60, Cs-137, and Am-241, will be performed.

2.5 Applicable or Relevant and Appropriate Requirements

Applicable or relevant and appropriate requirements have not yet been developed for the project and will be developed in later stages of the Remedial Investigation.

2.6 Schedule

The final schedule for implementation of the SAP (i.e., the FSP and the QAPP) by USACE has not been developed. Key milestones in execution of the SAP follow:

- Approval of the SAP (both the FSP and the QAPP) by USACE,
- Availability of funding to execute the SAP, and
- Award of contract to execute the SAP.

The current project schedule calls for completion of the RI in 2019/2020.

3.0 PROJECT ORGANIZATION

The project organization and responsibilities of key project personnel are described below. The project organization chart is provided as Figure 7. The project will be managed by USACE out of the Buffalo District. Key subcontractor project personnel should be familiar with USACE requirements and concerns regarding the project to ensure the work is performed efficiently, safely and in accordance with USACE's policies, plans, and procedures.

3.1 Program Manager

The Program Manager is responsible for overall cost and schedule performance for the project and provides technical oversight of project performance for this contract. Duties include oversight to ensure that all contact requirements are addressed, identification and preparation of any required project change orders, and final dispute resolution related to project performance issues. All correspondence with the USACE Contracting Officer (KO) will be transmitted through his office. The Program Manager shall also provide a critical communication link for USACE outside the project team and will be positioned to coordinate with other senior company leadership to implement corrective actions, if required.

3.2 Project Manager

The Project Manager (PM) is responsible for assuring the day-to-day performance of the project meets contract requirements and USACE expectations. The PM, working with the Site Supervisor, is responsible for assuring that the project work scope is translated into executable work tasks and that those tasks are completed within cost and schedule requirements. The PM assures that staff assigned to the project align with project needs and that staff possess required training and certifications to execute the work. Working with the Site Supervisor (SS) and the QA/QC Officer, the PM assures that non-conformances are identified and addressed, and corrective actions are completed. The PM serves as the primary day-to-day point of contact with the USACE PM.

3.3 Site Supervisor

The SS is responsible for oversight and coordination of all project field activities including assuring field activities are conducted in accordance with project plans, procedures, and protocols. The SS is also responsible for the field documentation, preparation of field change orders, if required, and management of investigation derived waste. The SS serves as the PM's primary assistant in all aspects of project field execution, control, and oversight and is the secondary point of contact for the USACE PM. This position reports directly to the PM.

This position also responsible for implementation and documentation of all project QA/QC procedures and protocols related to field activities. These include but are not limited to characterization, handling, and packaging requirements for investigation derived waste; sample preservation, handling, packaging, and analytical requirements for field analyses; and requirements for decontamination of equipment between samples and sampling events.

3.4 RI Field Geologist

The RI Field Geologist is responsible for ensuring that the technical objectives of the field data collection program are met. The RI Field Geologist oversees the field program to assure that it is performed in a manner that provides the quantity and quality of technical data required for

project success. The RI Field Geologist will have site knowledge and history required to make technical decisions regarding the addition, deletion, or relocation of sample locations and/or numbers. The RI Field Geologist is responsible for the technical performance of field activities including drilling operations and field sampling activities and the adherence to required sample, custody and other related QA/QC field procedures. The RI Field Geologist reports directly to the SS.

3.5 Quality Assurance/Quality Control Officer

The Quality Assurance/Quality Control Officer is responsible for oversight QA/QC for the overall project in accordance with the requirements of the QAPP, work plans and related documentation, and management direction. The QA/QC Officer participates in all project field activities readiness reviews; approves variances during field activities before work proceeds; with the SS identifies non-conformances; evaluates, approves, and documents all non-conformances and their disposition; approves and oversees required project training; and designs and supervises audit/surveillance plans for the project. The QA/QC Officer reports directly to the PM but communicates all information transmitted, especially as it relates to non-conformances and audits/surveillances, with the SS and RI Field Geologist.

3.6 Site Safety and Health (SSH) Manager

The SSH Manager is responsible for developing the project Safety and Health Plan, assuring that project health and safety procedures provide protection to the project team for all project field activities, and providing oversight to assure that those procedures are implemented during execution of project field activities at all stages of the project. In those cases where a work stoppage has occurred as a result of safety and health concerns, the SSH Manager will review and approve actions taken to resolve the concern prior to any work restart. For issues or concerns that have a radiological component, the SSH Manager will coordinate with the Site Health Physicist (HP). The SSH Manager reports directly to the PM.

3.7 Site Safety and Health Officer

The SSH Officer is responsible for oversight of field activities daily to assure that safety and health procedures are being executed. The SSH Officer is responsible health and safety decisions at the project task level (i.e., day-to-day work elements) and for verifying the effectiveness of the safety and health program in protecting workers in the field. The SSH Officer works closely with the SS to assure all field work is performed safely and in compliance with the Safety and Health Plan. The SSH Officer coordinates with the Site HP on radiological matters and reports directly to the SSH Manager.

3.8 Site HP

The Site HP is responsible for developing the Site Radiological Safety Plan (RSP) and the associated implementing radiological safety procedures and assuring that the procedures are implemented throughout the project. The Site HP is responsible for resolving all issues or concerns related to health physics and will review and approve actions taken to resolve the concern prior to any work restart for all work stoppages related to radiological safety. The Site HP reports directly to the PM.

3.9 Site Radiation Safety (SRS) Officer

The SRS Officer is responsible for oversight of field activities daily to assure that radiological safety procedures are being executed. The SRS Officer is responsible radiological safety decisions at the project task level (i.e., day-to-day work elements) and for verifying the effectiveness of the radiological safety program in protecting workers in the field. The SRS Officer works closely with the SS to assure all field work is performed safely and in compliance with the RSP. The SRS Officer coordinates with the SSH Officer on project safety and health matters and reports directly to the Site Health Physicist.

4.0 FIELD SAMPLING PROGRAM STRATEGY

4.1 Records Review and Evaluation

Based on the review of the results of prior Site investigations and the additional sources of information cited, the *Site Closure Strategy*, including an initial CSM, DQOs and identification of data needs, a preliminary Site sampling strategy was developed. These reviews identified areas of known and potential contamination and provided an informed basis for ranking sampling locations based on the potential for contamination. This information was then factored into a two-part characterization approach that consists of judgmental samples biased towards areas of known contamination previously identified and identification of statistically based sampling requirements. In areas where known contamination exists, random or systematic samples are required coupled with biased samples targeting specific areas of known contamination.

4.2 Conceptual Site Model

Development of the CSM is based on analysis of the Site profile information consisting of the: (1) facility profile (the man-made features and potential sources of contamination); (2) physical profile (natural factors or conditions that may affect the release, fate, transport, and accessibility of contaminants in the environment); (3) release profile (movement and extent of contamination in the environment); (4) land use and exposure profile (information on present and potential future receptors and receptor locations for exposure scenarios); and (5) ecological (natural habitats and ecological receptors on and around the Site) and cultural resources (land uses, churches, schools, parks, historical sites, etc.) profile.

Based upon the available information, an initial CSM has been developed. It is recognized that development of the CSM is an iterative process, with the CSM being revised and refined as additional information becomes available and a more thorough understanding of the sources, exposure media, exposure route, and potential receptors is developed. A graphical representation of the CSM is presented on Figure 6. The *Site Closure Strategy* identifies the sources of COPCs, the potential interactions between the source(s) and the receptors (i.e., exposure medium and the exposure route), and the receptors as portrayed in the graphical representation of the CSM. These elements drive the development and design of the sampling strategy that is detailed in Section 5.

4.3 Data Gap Analysis

A data gap analysis was completed as part of the development of the site-specific DQOs at the TPP Meeting on December 4, 2018. The site-specific DQOs are presented in Section 2.1 and, along with associated data needs, in Table 2.

4.4 Preliminary Sampling Considerations

4.4.1 Identify Contaminants

Prior studies and investigations have identified uranium (U-238, U-235, and U-234) and its daughter products as the radionuclides of concern from the historical processing of natural U-billets into rods. Records indicate that the Site also processed a limited quantity of thorium in two separate operations in June 1946 and January 1947 (SEC Petition Evaluation Report, December 3, 2012 and Battelle-TBD-6000 Appendix J, October 10, 2014). Since the uranium

and thorium processed on Site were in metal form, uranium and thorium daughter products present would be limited to only those which may have resulted from radioactive decay/ingrowth since the end of MED/AEC activities on Site (i.e., approximately the last 60 years), as discussed in Section 2.4. The *Site Inspection* (PARS, 2018b) indicates that thorium was identified as a daughter of uranium but investigated in only a limited number of samples. Thorium was, in fact, processed on-Site and should be evaluated as a COPC in that context and investigated more fully. No other radionuclides are of concern based on process knowledge, although selected fission products will be included in laboratory analyses to confirm the process knowledge that the Site did not receive uranium contaminated with spent nuclear fuel fission products.

NIOSH (SEC Petition Evaluation Report, December 3, 2012, and Battelle-TBD-6000 Appendix J, October 10, 2014) reported that "a heavy flow of coolant" was used to control airborne contamination and ignition of pyrophoric uranium chips. Processing of thorium rods was also performed using coolants to control airborne emissions. The coolant used was not identified. However, a variety of cutting oils were available and used at that time at various sites (U.S. AEC, Nov. 4, 1952). Additives to these cutting oils could not be identified in a limited literature search. Of additional importance, the current owner of the property, Valbruna, has entered into the VRP with the State of Indiana for cleanup of steel mill-related contamination at the Site. During the operating period from 1928 through 1981, steel mill operations polluted Site soil and groundwater with chlorinated solvents, metals, and other contaminants. It is unclear if MED/AEC activities contributed in any way to the historical non-radiological contamination since commercial production lines used coolant/cutting oil and thus was not specific to MED/AEC actions and there is no historical information clearly establishing that use and/or production of coolant or cutting oil at the Site was conducted under the MED/AEC contract.

The list of COPCs consists of the uranium isotopes (U-234, U-235, U-238) and thorium isotopes (Th-228, Th-230, and Th-232) and their daughter products:

- U-238 daughter products: Th-234, Pa-234m, U-234, Th-230, Ra-226, Rn-222, Po-218, Pb-214, Bi-214, Po-214, Pb-210, Bi-210, Po-210
- U-235 daughter products: Th-231, Pa-231, Ac-227, Th-227, Ra-223, Rn-219, Po-215, Pb-211, Bi-211, Tl-207
- Th-232 daughter products: Ra-228, Ac-228, Th-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208.

4.4.2 Establish Screening Levels

Impacted and potentially impacted areas are identified and classified according to MARSSIM guidance as Class 1, Class 2, or Class 3 areas. Class 1 Areas are those that have, or had prior to remediation, a potential for radioactive contamination above the derived concentration guideline level for average concentrations over a wide area ($DCGL_w$) based on operating history or known contamination from radiation surveys. Per MARSSIM, DCGLs represent the residual levels of radioactive material that correspond to allowable radiation dose standards that are calculated (derived) by analysis of various pathways and scenarios (direct radiation, inhalation, ingestion, etc.) through which exposures could occur. Class 2 Areas are those that have or had potential for contamination or have known contamination below $DCGL_w$. Class 3 Areas are

those impacted areas not expected to be contaminated or expected to contain only very low levels of contamination (for example, fractions of the $DCGL_w$). Non-Impacted Areas are those not affected by MED/AEC-related activities. Based on Site operating history and survey information, facilities constructed after the date of cessation of MED/AEC activities, and facilities never used during MED/AEC operations were identified as non-impacted areas. This MARSSIM approach (tailored to the CSM, available data, Site conditions, etc.) for classifying and prioritizing potentially impacted areas of the Site was applied to facilities and areas of surface contamination and tailored to apply to subsurface contaminated areas (soils and sediments) and groundwater. Since DCGLs are not established for the Site, historical data were also compared to the NUREG 1757 (NRC 2006) guidance levels in support of classifying the site areas.

Screening levels adapted from other sources that will be used for building surfaces are presented below. The screening levels are derived by taking 50% of the Acceptable Surface Contamination Levels in Table I of Regulatory Guide 1.86 (USEPA, 1997). Based on information from previous investigations, the uranium surface screening levels represent alpha activity (α); however, because rough, dirty, or porous surfaces may selectively attenuate alpha radiation, both beta activity and alpha activity measurements will be taken to provide an accurate representation of the residual contamination present. If accurate alpha activity measurements cannot be taken, beta activity levels may be considered representative of uranium surface activity. This is reasonable and appropriate since it is likely that the gross alpha field screening results may be masked significantly by the presence of dust/residue and/or surface material condition effects on a rough surface such as scabbled or deteriorated concrete, or irregular surfaces such as corrugated steel used for the building walls.

Screening Levels for Building Surfaces

Nuclide[a]	Removable (dpm/100 cm^2)[b,e]	Average (dpm/100 cm^2)[b,c]	Maximum (dpm/100 cm^2)[b,d]
Natural U, U-235, U-238 and associated decay products[f]	500α	2,500α	7,500α
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	100	500	1,500
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	500	2,500	7,500

a Where surface contamination by both alpha- and beta/gamma-emitting nuclides exists, the limits established for alpha- and beta/gamma-emitting nuclides should apply independently.
b As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive materials as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency and geometric factors associated with the instrumentation.

c Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each object.
d The maximum contamination level applies to an area of not more than 100 cm^2.
e The amount of removable radioactive material per 100 cm2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.
SOURCE: Regulatory Guide 1.86 Termination of Operating Licenses for Nuclear Reactors, USEPA August 1997

4.4.3 Classification of Site Areas and Facilities by Contamination Potential

Investigative Areas were further evaluated and classified using the MARSSIM approach discussed as identified in the following paragraphs. As previously noted, this approach considered not only the operational history but was informed based on prior sampling and investigation activities as well as analysis of historical aerial photos. Several of the buildings have been changed (generally expanded) since MED/AEC operations; therefore discussion of building footprints in this plan is based on the building footprints that existed at the time of MED/AEC operations unless otherwise stated.

4.4.3.1 IA-01 Building Interior and Exterior Surfaces (Building 8, 6, 7, 9, and 1)

Class 1 Areas: Based on historical survey and sampling information, known contamination is limited to Processing Building 8. Because this area is an area of known contamination and has the highest potential for unidentified residual contamination, the building will receive the highest level of survey and characterization.

- Building 8: Processing

Class 2 Areas: Because survey data is limited and sample and survey designs were not developed using MARSSIM DQOs and methodologies, all other facilities where MED/AEC uranium operations were conducted are identified as Class 2 Areas, including:

- Building 6: 12-14 Inch Mill
- Building 7: Wire Mill
- Building 9: Processing and Final Operations

Class 3 Areas: Class 3 facilities have been identified based on Site operating history and prior surveys and include:

- Building 1: Main Office
- Buildings 1, 6, 7, 8, and 9 exterior surfaces

4.4.3.2 IA-02 Building Exterior Soil Areas (Soils Under Building 6/Quench Basin Area, Old Burn Areas I, II, III, and IV; Acid Neutralization Basin Area, Pickling Tank Area, and Buffer Zones)

Class 1 Areas: Eight Class 1 Areas were identified based on historic sampling information and Site operating history:

- Soils underlying Building 8, including the potential Pickling Tank Area (identified through aerial photograph review), to determine if contaminants migrated through the floor, and if so, the extent of migration.

- Soils underlying Building 7, to determine if contaminants migrated through the floor, and if so, the extent of migration.
- Soils underlying Building 6, including the potential Quench Basin Area, to determine if contaminants migrated through the floor, and if so, the extent of migration.
- Old Burn Area I north of Building 8.
- Old Burn Area II east of Building 6.
- Old Burn Area III north of Building 8.
- Old Burn Area IV located between Building 7 and Building 8.
- Acid Neutralization Basin Area northeast of Building 8 used for treatment of pickling acids.

Class 2 Areas: Five Class 2 Areas are identified to establish boundaries around the Class 1 areas and investigate potential contaminant migration:

- The Buffer Zone surrounding the current footprint of Building 8, excluding the Class 1 areas (Old Burn Area I and III).
- The Buffer Zone surrounding Old Burn Area I.
- The Buffer Zone surrounding Old Burn Area II.
- The Buffer Zone surrounding Old Burn Area III (extending north and west, including under the existing footprint of Building 9).
- The Buffer Zone surrounding the Acid Neutralization Basin Area.

Class 3 Areas: No Class 3 areas were identified.

4.4.3.3 IA-03 Soil Areas (Original Site Soil Surface, Both Exposed and Buried under Fill)

Class 1 Areas: No Class 1 Soil Areas were identified.

Class 2 Areas: No Class 2 Soil Areas were identified.

Class 3 Areas: The remainder of the Site is identified as a Class 3 Area.

4.4.3.4 IA-04 Groundwater (Groundwater Areas Underlying Potential Sources of Contamination and Down Gradient of these Sources)

Class 1 Areas: Areas immediately underlying and down gradient of identified areas of subsurface contamination (e.g. Burn Area III) are identified as Class 1 Groundwater Areas.

Class 2 Areas: No Class 2 Areas identified.

Class 3 Areas: No Class 3 Areas were identified.

4.4.3.5 IA-05 Surface Water and Sediments in Junk Ditch

Class 1 Areas: No Class 1 Areas were identified.

Class 2 Areas: No Class 2 Areas were identified.

Class 3 Areas: One Class 3 Surface Water Area and Class 3 Sediment Area was identified:

- Junk Ditch (COPCs resulting from re-solubilization from sediments into surface water and the sediments/potential dredged sediments placed on bank).

4.4.3.6 IA-06 Sediment from Inside Building Catch Basins

Class 1 Areas: Sediment located in catch basins inside Building 8, if present.

Class 2 Areas:

- Sediment located in catch basins inside Building 6, if present.
- Sediment located in catch basins inside Building 7, if present.
- Sediment located in catch basins inside Building 9, if present.

Class 3 Areas:

- Sediment located in catch basins inside Building 1, if present.

4.4.3.7 IA-07 Wastewater (Site Combined Sewer Discharges to the City of Fort Wayne STP)

Class 1 Areas: No Class 1 Areas were identified.

Class 2 Areas: No Class 2 Areas were identified.

Class 3 Areas: One Class 3 Wastewater Area was identified:

- The 30-inch sewer discharging from the Site to the City of Fort Wayne STP.

4.4.3.8 IA-08 Sludge (Materials Collected from Storm Water Catchment Basins in and Around Facilities Engaged in MED/AEC activities)

Class 1 Areas: No Class 1 Areas were identified.

Class 2 Areas: No Class 2 Areas were identified.

Class 3 Areas: One Class 3 Sludge Area was identified:

- Catch basins collecting runoff from the areas surrounding MED-related operations buildings feeding the 30-inch sewer.

4.5 Precursor Actions to Field Sampling Activities

Site preparation includes activities to be performed in advance of actual field work. These include but are not limited to mobilization/demobilization, obtaining consent for conducting the sampling, establishing property boundaries, evaluating physical characteristics of the Site to assure accessibility, accessing surfaces and land areas to be sampled, and establishing a reference coordinate system. Assuring accessibility may include removing equipment and materials that restrict access to internal and external surfaces or areas.

4.5.1 Mobilization, Temporary Facilities, Utility Location, and Demobilization

4.5.1.1 Mobilization

Prior to and during mobilization, the Contractor and USACE will coordinate closely with Valbruna to minimize disruption to existing Site operations.

The Contractor also will coordinate with Valbruna and the City of Fort Wayne officials and representatives from relevant public utilities identified by Indiana811 to discuss the proposed subsurface work, solicit information regarding underground utility services, and ensure compliance with local codes.

The Contractor will mobilize/establish the following:

- Field operations office trailer(s) equipped with electricity, heating, and air-conditioning.
- Storage container to stage and secure on-site equipment and supplies.
- Storage container to stage and secure archival samples (pending approval by Valbruna, see Section 6.7).
- Portable sanitary facilities and "bottled" potable water.
- Temporary investigation derived waste (IDW) storage area.
- Dumpster for non-contaminated trash disposal.
- Equipment decontamination area.

The associated Accident Prevention Plan (APP)/Site Safety and Health Plan (SSHP) presents detailed health and safety procedures to be followed during performance of Site activities. The field investigation activities are planned to generally be completed in modified level D personal protective equipment (PPE). Throughout the course of the field work, daily safety meetings will be held by the SSH Officer to discuss the planned activities, hazard potential, gain input from workers and to address concerns.

4.5.1.2 Temporary Facilities

4.5.1.2.1 Setup/Construction of Temporary Facilities

The Contractor shall procure, setup, and construct storage areas and other temporary facilities (e.g., toilets) required to implement the field activities. Activities may include, but are not limited to:

- Preparing lay down areas for materials, equipment, and sanitary facilities.
- Furnishing site utilities such as electric (if necessary).
- Providing traffic controls (to include signage).
- Identifying and marking all underground utilities within the work areas.
- Procurement of necessary tools, equipment, and materials.
- Providing government office requirements.

Specifications for temporary construction facilities and controls can be found in Appendix A (UFGS Section 01 50 00). This activity shall be coordinated with the site owner.

4.5.1.2.2 Temporary Facilities – Government Office Requirements

The contractor will provide the USACE Technical and Project Managers with a separate room in the office trailer to allow a workspace as well as take conference calls and hold meetings. The room will be equipped with, at a minimum, a table or work area for 2 people (with electrical outlets for computers, phones, printer), a file cabinet, chairs, monitors, and a 3-in-1 printer/scanner/copier able to print 8 ½ x 11, 8 ½ x 14 and 11x17 sheets (w/ paper and black/white and color ink cartridges throughout life of field effort).

The contractor will provide USACE Technical and Project Managers with wireless internet connection for the length of the contract. As USACE personnel do not have administrative rights to their computers, the wireless connection will be solely for the USACE computers. Verizon MIFI wireless box (unlimited capacity) has the capability to be used without directly installing software on the USACE computers. The setup will be for USACE personnel only and not shared between contractor and USACE computers.

Specifications for temporary construction facilities and controls can be found in Appendix A (UFGS Section 01 50 00). This activity shall be coordinated with the site owner.

4.5.1.3 Utility Location

All utilities must be located prior to initiating sampling activities. Indiana811 is a non-profit corporation created to protect underground utilities before anyone disturbs the earth. The system requires a minimum of two days' notice prior to the commencement of intrusive activities. Upon notification to the system, the utilities that may be present in an area are contacted to mark the location of their lines, indicate that no lines are present, or that there is a conflict at the proposed intrusive area and arrangements need to be made to avoid the utility prior to a contractor digging into the ground. Indiana811 will be notified a minimum of two days prior to drilling or digging. No intrusive sampling will be performed prior to receiving Indiana811 clearance. In addition, the Contractor will refer to any on-site drawings provided by Valbruna to assist with utility location. Other methods such as the use of ground penetrating radar (GPR) may be required. Utilities should either be isolated during sampling or steps taken to relocate sample locations to assure worker safety.

Prior to intrusive work at a specific location, the Contractor will complete the following procedure referred to here as the pre-digging survey:

- Review geophysical survey results to evaluate whether there are known utilities in the vicinity of the proposed location.
- Visually assess the area for overhead obstructions and obvious signs of possible underground obstructions (e.g., manholes, fire hydrants, pavement cuts, leachate lines, etc.)
- Meet with property owners to confirm that the proposed locations are clear of underground obstructions to the extent they are aware.

The Contractor will proceed with caution, and will not use excessive force to penetrate an obstruction and may employ methods such as vacuum excavation, air knifing, and/or hand

digging.

4.5.1.4 Demobilization

Complete work associated with the removal of temporary facilities, utilities, equipment, material and personnel. Demobilization includes, but may not be limited to:

- Decontamination of equipment, tools, and supplies;
- Disposal of used PPE and decontamination waste;
- Performing verification surveys on decontaminated equipment, tools, and supplies prior to release from the site (USACE may perform QA confirmatory surveys);
- Removal of all temporary facilities, security measures, access restrictions, and signage;
- Demolition, removal, and disposal of any installations used for temporary storage;
- Demolition, removal, and disposal of temporary equipment laydown areas constructed for the project;
- Demobilization of site personnel, equipment, tools, and supplies; and
- Completion of all contract submittals and performance of post-work activities associated with closing out the contract, including final invoicing and payment certifications.

Demobilization will be considered complete only after USACE has verified that all activities authorized under the contract have been completed to USACE's satisfaction.

4.5.1.4.1 Removal of Temporary Facilities

Dismantle and remove all temporary facilities from the site including any office trailers, storage and decontamination facilities, and other temporary facilities and utilities.

4.5.1.4.2 Final Decontamination

Clean and decontaminate all equipment and other facilities that came in contact with site soils.

4.5.1.4.3 Demobilization of Equipment and Facilities

Transport all temporary facilities from the site. Includes transportation, manifests, tolls, permits, escort vehicles, drivers, and equipment operators.

4.5.1.4.4 Restoration of Roads

The Contractor will ensure that road repair is included for this work effort. Repair road sections that have been damaged by field activities to the state they were in prior to these efforts.

4.5.2 Structural Survey of Buildings

Prior to starting field sampling activities, an engineering survey of the structures (Buildings 1, 6, 7, 8, and 9) to be sampled or entered should be performed. The purpose of the survey is to determine the condition of the structure including framing, floors, walls, and roofs to assure that mitigation measures can be taken to prevent collapse of structures during sampling. Adjacent, attached structures or improvements should also be evaluated. During the survey, any hazardous chemicals, gases, explosives, flammable materials, or similar dangerous substances present on-site should be identified and considered in sampling plans. Safety needs to protect samplers, Site workers, and the public should be determined.

4.5.3 Inventory of Building Interiors

Prior to sampling, facility interiors (Buildings 1, 6, 7, 8, and 9) shall be inventoried for any remaining MED/AEC related equipment. Also, potential conflicts between sampling locations and doorways, windows, or equipment should be identified and alternate sampling locations identified using a step-off or similar method.

4.5.4 Consent for Sampling

Prior to beginning field activities, USACE will coordinate and obtain consent from the Site owner to conduct field sampling activities. Appropriate local, State, and Federal officials as well as the Site owner and other affected parties will be notified of the sampling schedule.

4.5.5 Establish Property Boundaries

Property boundaries will be determined using available public information and will be established by an Indiana licensed surveyor. In addition, the surveys will be performed to provide benchmarks across the Site prior to the conduct of the sampling program, including the gamma walkover survey (GWS). The benchmarks will be located to tie the GWS reference coordinate system to the Indiana State Plane Coordinate System.

4.5.6 Site Walk to Identify Physical Characteristics of Site

Aspects of land areas and building structures may impact the ability to perform Site characterization activities. A Site walk down should be performed to identify site conditions that are different than identified in this FSP so that adjustments can be made as needed as well as identify additional sampling locations (e.g., catch basins).

4.6 Characterization Survey Design

4.6.1 Data Control for Decision Making

To address the need to implement a real-time decision-making approach with respect to data generation and evaluation, the Contractor will implement a data control system for field and analytical data. As field and analytical data are generated during the RI, the data will be reviewed, reduced, and presented in the form of tables and figures in real-time during the collection effort to allow for the identification of data gaps.

To implement this approach, steps will be taken during the project planning stage, i.e., prior to the field effort, to facilitate data sharing when the field investigation begins. The following tasks will be completed in the planning stage of the field effort:

- Create a Site-specific file transfer protocol (FTP) site for data sharing
- Create a database for all planned sample locations
- Create a translation for local reference grid to Indiana State Plane Coordinate System
- Prepare text file template with columns for x, y, z coordinates (planned and actual)
- Input data from prior investigations and from preliminary RI activities
- Develop a geographic information system (GIS) routine to develop and present maps of sample locations and results

Field equipment and laboratory instruments will be set up to provide data electronically, directly from the instruments (to the extent possible) to minimize transcription errors. During the field

effort coordination between the GIS operator, on-site laboratory director, and PM or SS dedicated to this project will be necessary. The following tasks will be completed daily during the field effort, to the extent possible, with the goal of presenting the results of the previous days' sampling on a daily basis:

- The SS and/or PM will consolidate, review and post the available results of sampling on the FTP site each day, posting QC results separately.
- The on-site laboratory director will review the data and then post the updated file to the FTP site.
- The GIS operator will identify which samples exceed screening criteria, and save and map these results to a Portable Document Format (PDF) file. The operator will also check for unplanned samples (e.g., drainage ditch samples, or additional samples collected to reduce the uncertainty in identifying impacted areas) that may be outside areas depicted on the maps and adjust the layouts accordingly. The PDF and text files will be uploaded to the FTP site.
- The PM and/or SS will download the latest map and identify data gaps and additional sample points needed to complete the delineation.
- If possible, the GIS software will be used to identify tentative data gaps based on the criteria outlined above for review by the USACE project engineer.

Files posted to the FTP site will be named according to the date, state (field, screened, mapping) and placed in directories labeled for each day of sampling.

4.6.2 Methodology for Selection of Statistical Based Sample Locations

Visual Sample Plan (VSP) version 7.11b, a software tool developed by DOE Pacific Northwest National Laboratory, was used to develop the sampling plan for random and systematic grid sample locations. VSP is a defensible sampling plan development tool based on statistical sampling theory and the statistical analysis of sample results to support confident decision making. It couples site, building, and sample location visualization capabilities with optimal sampling design and statistical analysis strategies. VSP is utilized in support of environmental characterization and remediation studies and sampling of soils, buildings, groundwater, sediment, surface water, and subsurface layers.

Approximate building dimensions are provided in the table below.

Building	Footprint[a] Length and Width	Wall Height	Internal Surface Area (ft^2)
1	90' by 170'	12'	36,840
6	96' by 300'	14'-34'	68,259
7	48' by 300'	14'-34'	50,200
7A	22' by 40'	14'	
8	60' by 300'	20'-38'	34,740
9	85' by 260'	34'-51'	63,582

[a] Footprints are established based on those that existed at the time of MED/AEC operations

Due to the complex shape of the Site buildings, drawings were prepared to represent each wall, floor, and roof of each building in two-dimensional space with appropriate orientation to support either internal building or external building sampling point location. To select the required sampling points for a given sampling strategy (e.g., random locations), the two-dimensional shapes were imported into VSP. The resulting sampling point locations are shown on each building drawing by section (e.g., wall, floor, or roof). Each section is provided with a starting reference point identified by a red corner point; a reference axis near the reference point indicating orientation of X-Y coordinates, and labels as appropriate to indicate section orientation in relation to other building sections. In addition, for internal roof sampling locations, the randomly selected points on buildings with slanted roofs were translated into equivalent floor coordinates.

4.6.3 Reference Coordinate System Grid

Reference Coordinate System Grid systems will be established at the Site to facilitate systematic selection of measuring/sampling locations, to provide a mechanism for referencing a measurement/sample back to a specific location so that the same survey point can be relocated at a later date, and to provide a convenient means for determining average activity levels.

4.6.4 Building Grid System

Surveys or samples in the interior or exterior of buildings on the Site will be based on a local coordinate system, as shown in the figures referenced in Section 5 and described in Section 4.6.2. In the event a survey or sample location is unsuitable, the nearest accessible location will be used as an alternate survey or sample point. The rationale for using the alternate and its locations will be documented.

4.6.5 Site Coordinate System

Soil sampling locations outside of buildings are identified in Section 5 as Indiana State Plane (NAD83) coordinates (in feet). In the event a location is unsuitable for soil sampling, the nearest accessible location will be used as an alternate sampling point. The rationale for using the alternate and its locations will be documented.

4.7 General Sampling Methodologies and Procedures

4.7.1 Instrumentation

The following Ludlum Measurements Inc. instruments (or equivalent) will be used for surveys and counting:

- For scanning,
    - Model 3019 microR meter
    - Model 2224-1 Alpha-Beta Scaler-Ratemeter w/ Model 43-89 detector
- For discrete measurements, Model 2224-1 Alpha-Beta Scaler-Ratemeter with Model 43-89 detector
- For gamma and walkover measurements, Model 2221 Ratemeter-Scaler with Model 44-20 detector
- For manual wipe counting, Model 3030E Alpha-Beta Scaler w/Model 43-10-1 with Alpha-Beta Sample Counter Head

- For large areas (i.e., smooth floors), Model 239-1F Series Floor Contamination Monitor.

4.7.2 Scanning and Direct Measurement Techniques for Radiological Surveys

The instruments listed in Section 4.7.1 will be used to perform radiological scans on interior/exterior surfaces of Buildings 1, 6, 7, 8, and 9 and surface scanning over outdoor areas of Class 1 and Class 2 buffer zones that are accessible to driving or walking. Results of the scan surveys will be used to identify the presence of elevated direct radiation in the surface and near surface bulk materials.

For large, open, and relatively smooth/flat areas, Model 239-1F Series Floor Contamination Monitor will be deployed. For outdoor areas where the surface is more rugged or uneven, a sodium iodide (NaI) detector will be used, with a minimum of one pass performed over an area. The data will be reviewed and additional passes will be performed, as needed, to ensure complete coverage. Regardless of the platform used, survey locations will be recorded using an on-board submeter-accurate GPS (or equivalent) and a suitable notebook-type computer (or similar). Scan survey results will be presented as a Site or survey area isocontour plot figure (result map) using a color scale to represent activity levels. Calibration of the detectors allows activity levels to be presented in units of counts per minute (CPM).

4.7.2.1 Instrument Efficiency

The instrument efficiency (ε_i) is defined as the ratio between the net count rate, in CPM, of the instrument and the surface emission rate of the calibration source for a specified geometry. The surface emission rate is the 2π particle fluence that is affected by both the attenuation and backscatter of the radiation emitted from the calibration source.

The equation below will be used to calculate the instrument efficiency in counts per particle, although efficiency is typically reported as having no units or unitless.

$$\varepsilon_i = \frac{R_{S+B} - R_B}{q_{2\pi}\left(\frac{W_A}{S_A}\right)} \quad \varepsilon_i = \frac{R_{S+B} - R_B}{q_{2\pi}\left(\frac{W_A}{S_A}\right)} \quad \varepsilon_i = \frac{R_{S+B} - R_B}{q_{2\pi}\left(\frac{W_A}{S_A}\right)}$$

Where:

R_{S+B}	=	the gross count rate of the calibration measurement (cpm)
R_B	=	the background count rate in cpm
$q_{2\pi}$	=	surface emission rate of the calibration source (NIST traceable) (particles per minute)
W_A	=	active area of the detector window (cm^2)
S_A	=	area of the source (cm^2)

The instrument efficiency is determined by obtaining static counts with the detector over a calibration source that has a NIST traceable surface emission rate. The 2π particle fluence rate is corrected for decay, attenuation, and scatter. Then the surface emission rate of the source must be corrected for the area subtended by the probe. Factors that can also affect the instruments efficiency are discussed below:

- Efficiency Check Sources. Efficiency check sources that emit alpha or beta radiation with energies similar to those expected from the contaminant in the field (similar to the expected radionuclide(s) of concern) will be selected.
- Source Geometry Factors. Instrument efficiency will usually be determined with an efficiency check source equal to or greater than the area of the probe. If a source that is smaller than the probe is used, a conversion factor is applied to the MDC to account for the active region of the probe.
- Source-to-detector Distance. The detector efficiency will be calculated at a source-to-detector distance that is the same as the detector-to-surface distance used in the field.

4.7.2.2 Surface Activity Measurements

Surveillance measurements are used to quantify surface activity levels mainly on remaining concrete surfaces. ISO 7503-1 (International Organization for Standardization [ISO] 1988), NUREG/CR-1507 (NRC, 2000), and Selection and Use of Portable Radiological Survey Instruments for Performing In Situ Radiological Assessments in Support of Decommissioning (ASTM, 1998) are used as technical guidance to ensure accuracy in the measurement of surface activity.

The equation that follows is used to calculate the surface activity in units of dpm per 100 cm^2.

$$A_S = \frac{R_{S+B} - R_B}{\varepsilon_i \varepsilon_s \frac{W_A}{100\,cm^2}}$$

$$A_S = \frac{R_{S+B} - R_B}{\varepsilon_i \varepsilon_s \frac{W_A}{100\,cm^2}}$$

$$A_S = \frac{R_{S+B} - R_B}{\varepsilon_i \varepsilon_s \frac{W_A}{100\,cm^2}}$$

Where:

A_S	=	total surface activity (dpm/100 cm^2)
R_{S+B}	=	the gross count rate of the measurement in cpm
R_B	=	the background count rate in cpm
ε_i	=	the instrument efficiency
ε_s	=	the contaminated surface efficiency
W_A	=	the area of the detector window (cm^2)

4.7.2.3 Count Detection Probability for Alpha Scans (≤ 126-cm^2 Probe)

Scanning for alpha emitters differs significantly from scanning for beta and gamma emitters in that the expected background response of most alpha detectors is very close to zero. Since the time a contaminated area is under the probe varies and the background count rate of some alpha instruments is less than 1 cpm, it is not reasonable to determine a fixed MDC for scanning. Instead, it is more practical to determine the probability of detecting an area of contamination at a predetermined DCGL for given scan rates.

For alpha survey instrumentation with backgrounds ranging from less than 1 to 3 cpm, a single count provides a surveyor sufficient cause to stop and investigate further. Therefore, the probability of detecting given levels of alpha surface contamination can be calculated by use of Poisson summation statistics.

Given a known scan rate and a surface contamination release limit, the probability of detecting a single count while passing over the contaminated area is given by:

$$P(n \geq 1) = 1 - e^{-\frac{GEd}{60v}}$$

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$$P(n \geq 1) = 1 - e^{-\frac{GEd}{60v}}$$

Where:

$P(n \geq 1)$	=	probability of observing a single count
G	=	contamination activity (dpm)
E	=	detector efficiency (4π)
d	=	width of detector in direction of scan centimeter (cm)
v	=	scan speed (cm/s)

Once a count is recorded and the guideline level of contamination is present, the surveyor should stop and wait until the probability of getting another count is at least 90 %. This time interval can be calculated by the following:

$$t = \frac{13,800}{CAE}$$

$$t = \frac{13,800}{CAE}$$

$$t = \frac{13,800}{CAE}$$

Where:

t	=	time period for static count(s)
C	=	contamination guideline (dpm/100 cm^2)
A	=	physical probe area (cm^2)
E	=	detector efficiency (4π)

4.7.2.4 Minimal Detectable Count Rate and Minimum Detectable Concentration for Beta Scans

The minimum detectable number of net source counts in the scan interval can be arrived at by multiplying the square root of the number of background counts (in the scan interval) by the detectability value associated with the desired performance (as reflected in d′) as shown in the following equation:

$$MDCR = d' \quad b_i \left(\begin{array}{c} 60 \\ i \end{array} \right)$$

$$MDCR = d' \quad b_i \left(\begin{array}{c} 60 \\ i \end{array} \right)$$

$$MDCR = d' \quad b_i \left(\begin{array}{c} 60 \\ i \end{array} \right)$$

Where:

$MDCR$	=	minimum detectable count rate (above background)
d'	=	index of sensitivity (α and β errors [performance criteria])
b_i	=	number of background counts in scan time interval (count)
i	=	scan or observation interval (s)

For scanning, the required rate of true positives will be 95%, and the false positives will be 60%. From Table 6.5 of MARSSIM, the value of d', representing this performance goal, is 1.38.

The minimum detectable number of net source counts in the interval is given by S_i. Therefore, for an ideal observer, the number of source counts required for a specified level of performance can be arrived at by multiplying the square root of the number of background counts by the detectability value associated with the desired performance (as reflected in d'), as shown in the equation below.

$$S_i = d' \quad b_i$$

The scan MDC is determined from the minimum detectable count rates (MDCR) by applying conversion factors that account for detector and surface characteristics and surveyor efficiency. As discussed below, the MDCR accounts for the background level, performance criteria (d′), and observation interval. The observation interval during scanning is the actual time that the detector can respond to the contamination source. This interval depends on the scan speed, detector size in the direction of the scan, and area of elevated activity.

The scan MDC for structure or equipment surfaces is calculated using the following equation:

$$Scan\ MDC = \frac{MDCR}{p\ \varepsilon_i \varepsilon_s \frac{W_A}{100\ cm^2}}$$

$$Scan\ MDC = \frac{MDCR}{p\ \varepsilon_i \varepsilon_s \frac{W_A}{100\ cm^2}}$$

$$Scan\ MDC = \frac{MDCR}{p\ \varepsilon_i \varepsilon_s \frac{W_A}{100\ cm^2}}$$

Where:

p	=	surveyor efficiency factor
ε_i	=	instrument efficiency (count per particle)
ε_s	=	contaminated surface efficiency (particle per disintegration)
W_A	=	area of the detector window (cm^2)

4.7.2.5 Minimum Detectable Concentration for Static Alpha and Beta Counts

The static MDC is the level of radioactivity that is practically achievable by the overall measurement process. The equation below is used to calculate instrument MDC in dpm per 100 cm^2 when the background and sample are counted for the same time intervals.

$$MDC = \frac{3 + 4.65\sqrt{R_B T_B}}{\varepsilon_s \varepsilon_i \frac{W_A}{100} T_B}$$

$$MDC = \frac{3 + 4.65\sqrt{R_B T_B}}{\varepsilon_s \varepsilon_i \frac{W_A}{100} T_B}$$

$$MDC = \frac{3 + 4.65\sqrt{R_B T_B}}{\varepsilon_s \varepsilon_i \frac{W_A}{100} T_B}$$

Where:

R_B	=	background count rate (cpm)
T_B	=	background counting time (min)
ε_i	=	instrument efficiency (count per particle)
ε_s	=	contaminated surface efficiency (particle per disintegration)
W_A	=	active area of the detector window (cm^2)

In the above equation, W_A is the size of the "active" area of the detector window. If the area of the detector window (cm^2) does not equal 100 cm^2, it is necessary to convert the detector response to units of dpm per 100 cm^2.

If the background and sample are counted for different time intervals, the equation below is used to calculate the MDC in dpm per 100 cm^2.

$$MDC = \frac{3 + 3.29\sqrt{R_B T_{S+B}\left(1 + \frac{T_{S+B}}{T_B}\right)}}{\varepsilon_i \varepsilon_s \frac{W_A}{100\ cm^2} T_{S+B}}$$

$$MDC = \frac{3 + 3.29\sqrt{R_B T_{S+B}\left(1 + \frac{T_{S+B}}{T_B}\right)}}{\varepsilon_i \varepsilon_s \frac{W_A}{100\ cm^2} T_{S+B}}$$

$$MDC = \frac{3 + 3.29\ \sqrt{R_B T_{S+B}\left(1 + \frac{T_{S+B}}{T_B}\right)}}{\varepsilon_i \varepsilon_s \frac{W_A}{100\ cm^2} T_{S+B}}$$

Where:

R_B	=	background count rate (cpm)
T_B	=	background counting time (min)
T_{S+B}	=	sample counting time (min)
ε_i	=	instrument efficiency (count per particle)
ε_s	=	contaminated surface efficiency (particle per disintegration)
W_A	=	active area of the detector window (cm^2)

4.7.2.6 Surface Efficiency (es) for Surface Activity Measurements

The surface efficiency term in the preceding equations is used to determine the 4π total efficiency for a particular surface and condition. Suitable values are based on the radiation and radiation energy, and are primarily impacted by the backscatter and self-absorption characteristics of the surface on which the contamination exists in the field. Backscatter is most affected by the energy of the radiation and the density of the surface material. Self-absorption characteristics or attenuation are also a function of the radiation's energy and surface condition. Surfaces typically encountered in the field include concrete, asphalt, wood, dry wall, plaster, carpet, and metal. Surface conditions include both physical effects, such as scabbled concrete, and the effect of surface coatings: dust, paint, rust, water, and oil.

The total counting system efficiency determined during instrument calibration will be used as the product of the instrument efficiency (ε_i) and the contaminated surface efficiency (ε_s) in the above listed equations. The methodology for this rationale is presented below.

MARSSIM guidance will be considered in establishing efficiency factors (calibration constants) used to reduce the instrument count rate data to units comparable to those used in the surface standards along with guidance from other sources including NUREG-1507 (NRC,1997), National Council on Radiation Protection (NCRP) Report 112 (NCRP, 1991), and ANSI N323A (ANSI, 1997).

As defined in MARSSIM and NUREG-1507, instrument efficiency is that derived by measuring the surface emission rate of a clean, calibrated and certified NIST traceable, reference source. The observed emission rate (counts per unit time) is compared to the certified emission rate (betas or alphas per unit time) to arrive at the instrument efficiency. The source efficiency relates the amount of activity truly present on the surface being measured to the observable particle emission rate. As such, the source efficiency captures the effects of backscatter, and self-absorption inherent in the surface being measured.

In addressing the issues associated with the derivation of the appropriate total efficiency for the measurement, MARSSIM states (page 6-24) that the use of a total efficiency derived from

measurements made on certified 4π activity traceable sources "…is not a problem, provided that the calibration source exhibits characteristics similar to the surface contamination (i.e., radiation energy, backscatter effects, source geometry, self-absorption)."

4.7.3 Surface and Subsurface Soil (Volumetric)

The Contractor will advance 209 base direct-push soil borings (includes background borings). The Contractor also may advance up to 42 contingent direct-push soil borings (assumes 20% of base boring locations per area) to investigate hotspots; and up to 22 buffer zone soil borings (assumes 20% of the proposed buffer zone soil borings per area) to further delineate the extent of contamination (see Sections 5.3 and 5.4). The decision to advance contingent and buffer zone soil borings will be determined in consultation with USACE based on field observations, historical and analytical data, etc. The exact location of the soil borings will be determined in the field based upon underground utility locations, overhead utility locations, and direct-push unit access. In the event a soil sample location is located on a piece of equipment or difficult to move heavy materials, or is otherwise unsuitable, the nearest accessible location will be used as an alternate sampling point or the original point will be accessed based upon interactions with Valbruna (material movement or drilling during non-business hours). The rationale for using the alternate and its locations will be documented.

Prior to any intrusive activities, the Contractor will obtain all necessary permits for conducting intrusive activities. At each location, the existing surface (i.e., concrete or asphalt) will be cored to allow access for sampling equipment. Direct-push boring locations in areas of suspected utilities may require preclearing. A hand auger may be used at these locations to 5 ft bgs to collect a sample if necessary. After hand augering is complete, direct-push methods will be utilized to finish the boring. Sampling procedures for background soil boring locations are described in Section 4.8. All work shall be completed under the direction of an experienced and qualified geologist or geotechnical engineer.

Surface soil samples, defined as soils collected from 0 to 0.5 feet bgs, will be collected prior to advancing the boring. These samples will be free of vegetation, roots, large rocks, and other debris. The samples will be obtained using a bucket hand auger, stainless steel trowel or spoon, or other suitable method consistent with ASTM D1452-09. The samples will then be homogenized in a stainless steel mixing bowl for sample collection.

After collecting the surface soil sample, the soil borings will be advanced and sampled using a track-mounted hydraulic direct-push unit using a dual tube sampling system to increase recovery and eliminate cave-in of the borehole which will facilitate the collection of representative subsurface soil samples as per ASTM D6282/D6282M14 (Appendix B) utilizing a 2-inch OD by 4- or 5-foot long acetate-lined Macrocore sampler. Soil borings will be advanced until groundwater is encountered, equipment refusal, or a maximum depth of 20 feet bgs, whichever comes first. In the case of shallow refusal (i.e., less than 5 feet bgs), the boring shall be properly abandoned and a new boring location will be selected approximately 5 ft from the original location in consultation with the onsite USACE representative. If after three attempts shallow refusal is still encountered, the boring location will be abandoned and the Contractor will move on to the next boring location.

Upon retrieval, each surface soil sample and sample core will be screened with a radiological detector and PID equipped with a 10.6 eV lamp. The soils will be classified for engineering

purposes and soil boring logs shall be prepared by an experienced and qualified geologist according to the unified soil classification system (USCS) as per ASTM D2487-11 and ASTMD2488-09a (Appendix B) including consistency, moisture content, color, etc. In addition, all soil boring logs shall show depth to the water table (if encountered), each geologic formation, and all radionuclide and PID scan measurements. All soil boring logs shall be converted into electronic format. Soil properties and sample locations will be documented in a field notebook, and later on the Drill Log Form (Appendix D) or similar form.

Soil samples will be collected from each boring in accordance with procedures provided in Section 5.3.1.2.2 and the DoD Environmental Field Sampling Handbook (Appendix C). Soil samples will be analyzed for the parameters listed in QAPP Worksheet# 15 and QA/QC samples will be collected at the frequency specified in QAPP Worksheet #20.

Soil samples collected during the advancement of the soil borings will be packaged and shipped in accordance with Section 7.0.

Upon completion of a direct-push soil boring, the borehole will be backfilled with 3/8-inch bentonite chips to within 1 foot bgs. If the water does not rise in the borehole, the bentonite will be hydrated with the proper amount of potable water. If settling occurs within the first 24 hours, the borehole will be topped off with additional bentonite chips. The top 1 foot will be repaired to match the surrounding surface (e.g. soil, gravel, asphalt, concrete).

A photograph log of direct-push boring activities, copies of the daily field notes, and drilling logs will be collected in accordance with Section 6.0 and included in the project report.

All downhole equipment will be decontaminated between each direct-push boring with a non-phosphate detergent and potable water in accordance with Section 9.0. All soil cuttings will be containerized in United States Department of Transportation (USDOT) approved 55-gallon drums. All IDW generated will be transported to the laydown/staging area and stored on-site pending disposal in accordance with Section 8.0.

4.7.4 Volumetric Facility Samples (Volumetric)

Physical samples of Building 8 will be necessary to provide individual radionuclide constituents as well as confirm uranium enrichment using inductively coupled plasma mass spectrometry (ICP-MS). The preferred collection method is to obtain drill cuttings. However, snips, saws, or other suitable cutting tools can be used as necessary to obtain and size reduce the samples. In the event a selected location for obtaining volumetric samples is unsuitable, the nearest accessible location will be used as an alternate sampling point. The rationale for using the alternate and its locations will be documented.

4.7.5 Groundwater

4.7.5.1 Monitoring Well Development

Development of existing monitoring wells may need to be performed based on appearance of the purge water (e.g., consistently cloudy/opaque) to remove sediment and enhance hydraulic communication with the aquifer. The selection of wells to be developed will be determined in consultation with the onsite USACE representative. All monitoring wells will be developed using the pump and surge development method as per ASTM D5521/D5521M-13 (Appendix B) and EM1110-1-4000 (Appendix C).

Prior to well development, a water level meter will be used to determine the depth to water and depth to bottom of each well to the nearest hundredth of a foot. During well development, water quality parameters (pH, specific conductivity, temperature, turbidity) will be measured and recorded. A monitoring well will be considered developed when a minimum of 5 well volumes has been removed, and water quality parameters have stabilized (most importantly turbidity). Water quality parameters must be measured within the following requirements for three consecutive measurements to be considered stable.

Well Development Stabilization Requirements

pH	+/- 0.1
Specific Conductivity (mS/cm)	3%
Turbidity (NTU)	10%
Temperature	+/- 1.8ºF/1ºC

The oxidation reduction potential (ORP) and dissolved oxygen (DO) parameters will be recorded as a weight of evidence for proper development, but not as a primary decision making parameter (especially in wells where surging may introduce cavitation or air introduction from the riser headspace).

If stabilization is not achieved in five well volumes, the development ceases and the well is allowed "to settle" for 24 hours. Afterwards, the well will be overpumped up to two well volumes (totaling 7 well volumes) to evacuate residual fines from the bottom of the well and water-quality parameters will be collected to conclude the development process (i.e., either show stabilization or reach two well volumes). Final flow rates and drawdown will be recorded on the development record.

Well development water quality parameters will be recorded on a Well Development Form (Appendix D) or similar form. A photograph log of well development activities, copies of the daily field notes, and well development logs will be collected in accordance with Section 6.0 and included in the project report.

All non-dedicated downhole equipment will be decontaminated between each monitoring well with a non-phosphate detergent and potable water in accordance with Section 9.0. All well development water will be containerized in USDOT approved 55-gallon drums. All IDW generated will be transported to the laydown/staging area and stored on-site pending disposal in accordance with Section 8.0.

4.7.5.2 Groundwater Level Monitoring

Groundwater levels will be collected and used to develop a groundwater contour elevation map in order to determine groundwater flow direction. A synoptic round of groundwater measurements will be collected over a minimum of a 24-hour period prior to the start of the sampling event. Groundwater levels will be collected from all existing well locations, excluding wells located on the GE property. Groundwater monitoring well locations are

depicted on Figure 5.

Depth to water and depth to bottom measurements will be collected using a water level meter to the nearest one hundredth of a foot as per ASTM D4750-87 (Appendix B). Water level measurements will be recorded on a Water Level Record Sheet (Appendix D) or similar form and included in the project report.

4.7.5.3 Groundwater Sampling

Groundwater samples will be collected from forty nine (49) existing monitoring well locations (includes background locations), depicted on Figure 5.

Monitoring wells will be purged prior to being sampled using low-flow sampling procedures found in ASTM D6771-02 (Appendix B). The low–flow sampling will be performed using a peristaltic or bladder pump using dedicated/disposable tubing. During the purging of the well, water quality parameters (pH, specific conductivity, ORP, temperature, DO, turbidity) will be measured using a Horiba U-52 multiparameter instrument with a flow-through cell and documented on a purge log. Purging will be completed after the water quality parameters stabilized. Water quality parameters must be measured within the following requirements for three consecutive measurements to be considered stable.

Well Sampling Stabilization Requirements

pH	+/- 0.1
Specific Conductivity (mS/cm)	3%
Turbidity (NTU)	10%
Oxygen Reduction Potential (mV)	+/-10
Dissolved Oxygen (mg/L)	10%
Temperature	+/- 1.8ºF/1ºC

Water quality parameters will be recorded on a Low Flow Purge Form (Appendix D) or similar form. The flow rate shall be set to a preferred drawdown threshold of 0.3 feet derived from low-flow pumping rates between 100 – 500 mL/min. Wells that do not achieve the field-parameter stabilization criteria will be sampled after three well volumes are withdrawn. Both filtered and unfiltered samples will be collected as necessary, with the collection of a filtered sample determined in the field based on turbidity readings (i.e., turbidity greater than 50 NTU). Groundwater samples will be analyzed for the parameters listed in QAPP Worksheet# 15 and QA/QC samples will be collected at the frequency specified in QAPP Worksheet #20.

Groundwater samples will be packaged and shipped in accordance with Section 7.0.

A photograph log of groundwater sampling activities, copies of the daily field notes, and well purge logs will be collected in accordance with Section 6.0 and included in the project report.

All non-dedicated downhole equipment will be decontaminated between each monitoring well with a non-phosphate detergent and potable water in accordance with Section 9.0. All well

purge water will be containerized in USDOT approved 55-gallon drums. All IDW generated will be transported to the laydown/staging area and stored on-site pending disposal in accordance with Section 8.0.

As a contingency, up to eight (8) monitoring wells located on the adjacent GE property may be sampled if evaluation of the analytical results from the on-site wells warrants additional sampling.

4.7.6 Surface Water/Wastewater

Surface water samples will be collected from 4 transects (3 on-site transects and 1 off-site background transect) across Junk Ditch for a total of twelve (12) surface water samples (includes background samples). Wastewater samples will be collected from a Site combined sewer access point located in the southeast portion of the Site for a total of two (2) wastewater samples.

Surface water samples from Junk Ditch will be collected in conjunction with sediment sample collection, with surface water collected first at each sample point, starting at downstream locations and moving upstream. Coordinates for the midpoint of each transect are provided on Table 9. Care will be made to not disturb sediment or introduce sediment into the sample while collecting surface water samples.

Surface water and wastewater samples will be collected using a one-time (disposable) 600 milliliter (mL) pre-cleaned (autoclaved) dip bucket secured to a swiveling head that is attached to an extendable aluminum pole. The sampler is designed to be inverted at the water surface, submerged, and rotated to fill the bucket at a desired depth. During sample collection, water quality parameters (pH, specific conductivity, ORP, temperature, DO, turbidity) will be measured using a Horiba U-52 multiparameter instrument and documented on a Surface Water Field Parameter Measurements Form (Appendix D) or similar form.

To optimally obtain samples and minimize the impacts of sediment on water samples (e.g., turbidity), the surface water samples that will be collected using a dip bucket will be collected in accordance with the procedures provided in the DoD Environmental Field Sampling Handbook (Appendix C).

Surface water and wastewater samples will be analyzed for the parameters listed in QAPP Worksheet# 15 and QA/QC samples will be collected at the frequency specified in QAPP Worksheet #20.

Surface water and wastewater samples will be packaged and shipped in accordance with Section 7.0.

A photograph log of surface water and wastewater sampling activities, copies of the daily field notes, and field sampling sheets will be collected in accordance with Section 6.0 and included in the project report.

All IDW generated will be transported to the laydown/staging area and stored on-site pending disposal in accordance with Section 8.0.

4.7.7 Sediment/Sludge

Sediment samples will be collected from 4 transects (3 on-site transects and 1 off-site background transect) across Junk Ditch. Three (3) samples from each transect will be obtained

from sediment within Junk Ditch. Samples also will be obtained from the eastern descending bank at the end of each of the on-site transect locations for a total of three (3) samples from each on-site transect resulting in a total of fifteen (15) sediment samples (includes background samples). If present, one (1) sample of sediment will be collected from catch basins in Buildings 6, 7, 8, and 9 (assume 5 catch basins per building). Sludge samples will also be collected from exterior catch basins within the area of interest as identified during a site walkover (assume 20 exterior catch basins) as well as a Site combined sewer access point located in the southeast portion of the Site for a minimum of two (2) sludge samples.

Sediment samples from Junk Ditch will be collected in conjunction with surface water sample collection, with surface water collected first at each sample point, starting at downstream locations and moving upstream. Coordinates for the midpoint of each transect are provided on Table 9.

Sediment and sludge samples will be collected using a bucket hand auger with a stainless steel bucket auger head attached to an extension rod and T-shaped bar. The hand auger will be advanced to collect the top 6-inches of sediment at each location within Junk Ditch and the catch basins. Sediment samples collected along the Junk Ditch stream bank will be collected from 0 to 2 feet bgs. Samples will be transferred to a larger container to allow for mixing and sampling. Upon retrieval, the soil scientist or geologist will screen each sample with a radiological detector and PID equipped with a 10.6 eV lamp. A description of sediment recovered and sample locations will be documented in a field notebook. This process will be repeated at each location.

Sediment and sludge samples will be analyzed for the parameters listed in QAPP Worksheet# 15 and QA/QC samples will be collected at the frequency specified in QAPP Worksheet #20.

Sediment and sludge samples will be packaged and shipped in accordance with Section 7.0.

A photograph log of sediment and sludge sampling activities, copies of the daily field notes, and field sampling sheets will be collected in accordance with Section 6.0 and included in the project report.

All sampling equipment will be decontaminated between each sampling location with a non-phosphate detergent and potable water in accordance with Section 9.0. All IDW generated will be transported to the laydown/staging area and stored on-site pending disposal in accordance with Section 8.0.

4.8 Background Reference Areas

Background samples of groundwater, Junk Ditch surface water and sediments, and soil will be obtained using the same sampling methods as used for the Site's investigative areas.

- Background groundwater samples will be obtained from ten (10) wells: MW-34S, MW-34D, MW-36S, MW-36D, MW-39S, MW-39D, MW-49S, MW-49D, MW-45S, and MW-45D.
- Junk Ditch surface water and sediments will be obtained from a location on the other side of Taylor Street prior to the Junk Ditch entry into the Site, as indicated in Section 5.6.

Background soil samples will be obtained from two (2) locations shown on Figure 28. Location coordinates are provided on Table 8. At each location, surface soil (0 to 0.5 feet [ft] bgs) and subsurface soil down to 20 ft bgs, groundwater or refusal, will be collected for field counting in 1-foot intervals (0 to 0.5 ft bgs, 0.5 to 1.0 ft bgs, and 1 ft subsequent intervals), producing a total of up to forty-two (42) background counting results. A total of five (5) samples from each location (10 volumetric samples total) consisting of the surface soil (0 to 0.5 ft bgs) and 5 ft composites (0.5 ft to 5 ft bgs, 5 ft to 10 ft bgs, 10 ft to 15 ft bgs, and 15 ft to 20 ft bgs) will be collected for laboratory analysis.

Background surveys will also be performed at ten (10) locations for each type of structural material estimated to be present at greater than 10% by volume in Buildings 1, 6, 7, 8, and 9. These background locations on the Site will be coordinated with Site personnel and the USACE Project Manager and/or lead HP.

5.0 FIELD ACTIVITIES

Field activities conducted under this plan will include performance of structural surveys of the facilities, radiological surveys of facility surfaces and surface soils, collection of volumetric samples for radiological analyses from physical structures, soils, sediments, and sludge, and collection of volumetric samples for radiological analyses from groundwater wells and surface water. The QAPP, which is Volume 2 of this SAP, contains information regarding laboratory analysis of samples.

5.1 Sampling Assumption Basis and Strategy

MARSSIM provides guidance on development of sampling strategy for both structures and soils. Of primary importance is a survey unit, which is a physical area of specific size and shape that requires a separate decision as to whether it is contaminated; these areas are usually developed based on prior preliminary survey data or available Site knowledge. Each Site Class (Class 1, 2, or 3) is composed of its own survey units based on previous survey and analytical data and Site history. The MARSSIM suggested areas for survey units are:

Suggested Survey Unit Area Size

Classification	Structures	Land Areas
Class 1	Up to 100 m^2 floor area	Up to 2,000 m^2
Class 2	100 to 1,000 m^2	2,000 to 10,000 m^2
Class 3	No limit	No limit

m^2 – square meters

Multiple techniques are available for estimating the number of samples for each survey unit, and no single method is prescribed in MARSSIM. The approach selected will depend on Site and contamination characteristics and characterization goals. Potential approaches listed in MARSSIM include use of:

- Classical statistics, which assumes normal contaminant distribution and relies heavily on previous survey and analytical data along with target remediation limits;
- Non-parametric methods such as the Sign Test, which also depends on target remediation limits, or the hypergeometric model, which is based on determination of highest contamination level for a given confidence limit;
- Grid sampling to locate hot spots; and,
- Judgmental samples.

While some prior data are available for the Site, definitive concentrations that drive risk are not currently known, limiting the use of statistical techniques dependent on these to estimate number of samples. Surrogate concentration limits from guidance documents such as NUREG 1757 (NRC 2006) for some of the areas with prior sampling results could be used to estimate number of samples; however, most areas and buildings do not have prior sampling data which can be used, and historical results from several areas were above guidance levels, limiting use

of many sample estimation methods. In addition, if prior samples were not representative of the area sampled, there is risk of underestimating the number of required samples.

An alternate approach to estimating number of samples required is to use a method independent of prior data. The hypergeometric model, based on binomial statistics and not dependent on previous data or specific data distribution type, is appropriate for estimating the number of samples needed for a given survey unit based on a desired confidence level in the data. Under this model, for a given confidence level of 1-α (e.g., 95%), no more than β (e.g., 5%) of the unsampled areas will have a result greater than the largest sample result. The number of samples prescribed by the model allows discovery of contaminated areas (grid cells) within a given population or survey unit with high probability. The number of samples required by the model is provided below for a range of confidence limits and coverages (1-β).

Confidence	**Coverage**	**α**	**β**	**Number Samples**
95%	95.0%	5%	5%	59
95%	90.0%	5%	10%	29
95%	85.0%	5%	15%	19
95%	80.0%	5%	20%	14
90%	95.0%	10%	5%	45
90%	90.0%	10%	10%	22
90%	85.0%	10%	15%	15
90%	80.0%	10%	20%	11

For example, a total of 59 samples will provide 95% confidence that no more than 5% of the unsampled area could have a result greater than the maximum result. Use of the hypergeometric model enables combining MARSSIM survey units together into a single population as long as the uncovered area does not exceed the specified survey unit size. Application of this approach can reduce the number of samples required for characterization compared to the percent level surveys prescribed by MARSSIM.

The size of the facility or area, desired confidence level and coverage, and appropriateness of the number of samples required by the model for a given confidence level and coverage are used to specify the number of samples. The term “coverage” represents the percent of the facility or area that can be represented at the given confidence level by the number of samples obtained. These factors have been considered and used to determine the appropriate number of samples, summarized in Table 3, necessary to characterize the Class 1, 2, and 3 facilities or areas described below.

5.2 IA-01 Facilities Interior and Exterior Surfaces

5.2.1 Interior Surfaces – Building 8

5.2.1.1 Classification of Building 8 Interior

Based on the previous radiological surveys, the interior of Building 8 is considered a Class 1 facility per MARSSIM guidance.

5.2.1.2 Survey Basis for Building 8 Interior

Interior surfaces of Building 8 will be surveyed at 100% per MARSSIM guidance using surface scanning and wipe testing. 100% coverage means that the entire surface area of the survey unit is covered by the field of view of the scanning instrument. In addition, interior equipment with the potential to have been present during MED/AEC processing operations will be surveyed at 100%; field samplers will require guidance from Site personnel (e.g., Valbruna or USACE) when determining equipment to survey. Also, surveys at locations identified by previous characterization efforts will be performed to confirm the prior results. These combined approaches will identify elevated levels of contamination to support exposure evaluation (e.g., risk assessment). Figure 8 illustrates approximate locations indicating elevated contamination areas identified by past characterization efforts.

In addition to surveys, volumetric samples will be obtained from five (5) locations with the highest survey results. The five (5) samples will provide information on radionuclide constituents present in the facility interior, provide confirmation of uranium enrichment using ICP-MS, and provide additional confidence in the survey results.

In addition to measurement of surface activity, counts of wipe samples (dry smears) will be obtained from selected surfaces when surface activity is greater than ten-times background. These wipes will serve as a qualitative indicator of whether the activity at the location is predominantly fixed or removable. Wipes are to be obtained from metal, plastic, glass, concrete, wood, and other solid surfaces.

Also, contingency surveys and volumetric (detritus) or wipe samples will be taken as necessary to adequately represent materials in the facility based on consultation with the USACE Project Manager. The USACE assumes an additional 10 contingency survey and wipe samples will be collected.

5.2.2 Interior Surfaces – Building 6, Building 7, and Building 9

5.2.2.1 Classification of Building 6, Building 7, and Building 9 Interior

The interior surfaces of Buildings 6, 7 (and a small attached structure designated 7A), and 9 have potential to be contaminated, although prior survey results indicated only low levels were found. Consequently, the interiors of these buildings are considered Class 2 per MARSSIM guidance.

5.2.2.2 Survey Basis for Building 6, Building 7, and Building 9 Interior

A two-tiered approach will be used for surveys in Buildings 6, 7, and 9. Surfaces where previous studies indicated contamination (hotspots) above background as well as immediate surrounding areas of these hotspots will be surveyed. Previous investigations detected one (1) hotspot in Building 6 and one (1) in Building 7. The immediate surrounding area will include one survey location in each cardinal direction. Figure 8 illustrates approximate locations indicating elevated contamination areas identified by past characterization efforts.

In addition, a total of fifty-nine (59) random direct measurement and wipe samples from each building will be obtained from the walls, ceilings, interior structures, and floors. Per the hypergeometric model, these random samples will provide 95% confidence that no more than 5% of the unsampled area would have results greater than the maximum result. Given the size of these buildings, this combination characterization approach of surveying prior areas of contamination coupled with the fifty-nine (59) random samples from each building will provide results with a high confidence level to support exposure evaluation. Figures 9, 10, and 11 show sampling locations for the interiors of Buildings 6, 7, and 9, respectively. The random points were selected using VSP based on a one-foot grid overlaid on the building interiors. Since detailed drawings of the facilities are not available, the selections were made using the estimated wall, floor, and roof dimensions. Each sampling point is based on the local wall, floor, or roof reference point (shown as a red dot on figures) and X and Y coordinate system for the particular wall, floor, or roof. Sample location coordinates are provided in Table 4. If a selected location is not accessible or available for sampling, the closest point will serve as an alternative sampling point.

In addition to measurement of internal building surface activity, counts of wipe samples (dry smears) will be obtained from selected surfaces when surface activity is greater than ten times background. These wipes will serve as a qualitative indicator of whether the activity at the location is predominantly fixed or removable. Wipes are to be obtained from metal, plastic, glass, concrete, wood, and other solid surfaces.

Also, contingency surveys and volumetric (detritus) or wipe samples will be taken as necessary to adequately represent materials in the facility based on consultation with the USACE Project Manager. The USACE assumes an additional 10 contingency survey and wipe samples will be collected.

5.2.3 Interior Surfaces – Building 1

5.2.3.1 Classification of Building 1 Interior

Based on Site operating history and limited survey data, the interior of Building 1, is a Class 3 facility.

5.2.3.2 Survey Basis for Building 1 Interior

Twenty-nine (29) random direct measurement and wipe samples distributed in the facility will be obtained. Per the hypergeometric model, these random samples will provide 95% confidence that no more than 10% of the unsampled area would have results greater than the maximum result. Given the historical Site data and the size of Building 1, the twenty-nine (29)

samples will provide high confidence in the absence of contamination in Building 1. Figure 12 shows sampling locations for the interior of Building 1. The random points were selected using VSP based on a one-foot grid overlaid on the building interior. Since detailed drawings of the facility are not available, the selections were made using the estimated wall, floor, and roof dimensions. Each sampling point is based on the local wall, floor, or roof reference point (shown as a red dot on figures) and X and Y coordinate system for the particular wall, floor, or roof. Sample locations are provided in Table 5. If a selected location is not accessible or available for sampling, the closest point will serve as an alternative sampling point.

In addition to measurement of internal building surface activity, counts of wipe samples (dry smears) will be obtained from selected surfaces when surface activity is greater than ten-times background. These wipes will serve as a qualitative indicator of whether the activity at the location is predominantly fixed or removable. Wipes are to be obtained from metal, plastic, glass, concrete, wood, and other non-particulate surfaces.

5.2.4 Exterior Surfaces – Buildings 1, 6, 7, 8, and 9

5.2.4.1 Classification of Buildings 1, 6, 7, 8, and 9 Exterior

The exteriors of Buildings 1, 6, 7, 8, and 9 are considered Class 3 areas based on site knowledge and the expected behavior of uranium and thorium during processing. The total exposed surface area of these buildings is 149,410 ft^2.

5.2.4.2 Survey Basis for Buildings 1, 6, 7, 8, and 9 Exterior

Exterior surfaces of Buildings 1, 6, 7, 8, and 9 will be surveyed Since dust and particulate migration and permanent settling on the outside of the building (i.e., dust and particulates not washed away by precipitation) would be unexpected, surveys will be limited to fifty-nine (59) randomly selected locations on the outside of Buildings 1, 6, 7, 8, and 9, which will provide 95% confidence that no more than 5% of the unsampled area would have results greater than the maximum result. These survey results will provide confirmation of the absence of contamination on the outside of the facility. Figures 13 through 17 provide exterior survey locations for each of Buildings 1, 6, 7, 8, and 9 obtained from VSP. The survey locations were randomly selected based on one-foot square grids overlaid on the exterior of each building. Since detailed drawings of the facilities are not available, the selections were made using the estimated wall, floor, and roof dimensions. Each survey point is based on the local wall, floor, or roof reference point (shown as a red dot on figures) and X and Y coordinate system for the particular wall, floor, or roof. The selected survey points for performing the exterior surveys are provided in Table 6. If a selected location is not accessible or available for survey, the closest point will serve as an alternative survey point.

In addition to the random survey locations, biased survey locations at exterior doorways, window frames, vents, and other openings providing a potential pathway for contamination migration outside of Buildings 1, 6, 7, 8, and 9 will be surveyed in one-half (0.5) feet intervals away from each side of the opening until the counts are less than twice background. The Contractor shall assume an additional fifty (50) bias locations will be surveyed.

In addition to measurement of surface activity, counts of wipe samples (dry smears) will be obtained from selected surfaces when surface activity is greater than ten times background. These wipes will serve as a qualitative indicator of whether the activity at the location is predominantly fixed or removable. Wipes are to be obtained from metal, plastic, glass, concrete, wood, and other non-particulate surfaces.

5.3 IA-02 Building Exterior Areas

5.3.1 Soils Under Building 6/Quench Basin Area, Building 7, and Building 8/Pickling Tank Area, Old Burn Areas I, II, III, and IV, Acid Neutralization Basin Area, Pickling Tank Area, and Buffer Zones

5.3.1.1 Classification of Soils Under Building 6/Quench Basin Area, Building 7, and Building 8/Pickling Tank Area, Old Burn Areas I, II, III, and IV, and Acid Neutralization Basin Area

The highest uranium and thorium soil contamination in prior sampling was found in core samples from the Old Burn Area III. Contamination was found at depths of four to eight feet bgs. Consequently, the footprint of the Old Burn Area III is considered a Class 1 Area. Lower levels of activity were also found in soil samples from Old Burn Areas I and II and Building 6, 7, and 8 soil cores (Table 1). Prior sampling was not performed at Old Burn Area IV or the Acid Neutralization Basin Area. Based on the previous results and Site history, soils under Building 6 (and in particular, soil near the Quench Basin Area), Building 7, Building 8 (and in particular, soil near the Pickling Tank Area), Old Burn Areas I, II, III, and IV, and the Acid Neutralization Basin Area are considered Class 1.

Due to the potential for migration of contamination from these Class 1 areas, a buffer area surrounding each is considered to contain Class 2 soils.

5.3.1.2 Survey and Sampling Basis – Class 1 Areas

5.3.1.2.1 Number of Sample Locations for Class 1 Areas

The number of soil sample locations for Class 1 soil areas in Table 3 were estimated using a maximum area allowed to exceed the results obtained from sampling. As an example, for an Old Burn Area III surface area of 699.4 m^2 and an allowable exceedance area of 100 m^2, a total of 20 sample locations provides 95% confidence with 85.7% coverage per the hypergeometric model. The VSP software recommends use of a triangular grid system in conjunction with model estimates to place the sample locations to maximize potential for contaminant hot spot detection. In practice, a larger number of sample locations than predicted by the model is required in order to complete the grid covering the whole area; for Old Burn Area III, a total of 29 sample locations is required. Per VSP, these 29 sample locations will result in 95% confidence in finding a hot spot that is 9 ft or smaller in diameter. The table below summarizes the estimated number of sample locations to be obtained from each Class 1 soil area as well as the Old Burn Area III Buffer Zone. In addition, each Class 1 area will have additional contingency sample locations to further investigate hotspots, as identified in Table 3.

Location	Area (m^2)	Excluded Coverage Area (m^2)	Required Coverage at 95% Confidence	Estimated Number Sample Locations Hypergeometric Model	Actual Number Sample Locations with Triangular Grid	Largest Detectable Hot Spot (ft)
Old Burn Area I	650.1	100	84.6%	18	20	10.3
Old Burn Area II	617.2	100	83.8%	17	19	10.1
Old Burn Area III	699.4	100	85.7%	20	29	9.0
Old Burn Area III Buffer Zone	1,818.6	100	94.5%	53	60	10.1
Old Burn Area IV	131.0	65.5	50%	5	7	9.2
Acid Neutralization Basin	42.1	10	76.2%	12	14	2.9
Building 6 Soils/Quench Basin Area	2,811.9	500	82.2%	16	23*	23
Building 7 Soils	1,337.8	500	62.6%	7	9	24
Building 8 Soils/Pickling Tank Area	2,619.9	500	80.9%	15	27**	27

*includes four (4) borings around assumed Quench Basin Area
**includes five (5) borings dissecting Pickling Tank Area

Detailed drawings outlining buildings and other site features, including suspected areas of contamination such as Old Burn Area III, are not available. In order to provide selections for sampling locations, the VSP software was used in conjunction with the Google Maps Satellite tile server (https://maps.googleapis.com/maps/api/staticmap?maptype=satellite&) with NAD_1983_ StatePlane_Indiana_East_FIPS_1301_Feet as the projection system. The Old Burn Areas I, II, III, and IV, and the Acid Neutralization Basin Area were defined in VSP based on historical and site visit information and historical photographic analysis. The translation of these areas into VSP in relation to Site Buildings 6, 7, 8, and 9 is shown in Figures 18 through 22 (red areas). For Building 6, 7, and 8 soils, current building footprints were outlined in VSP. VSP was then used to provide triangular grid point locations based on a one-foot grid over each Class 1 footprint. Sample locations are presented as either Indiana State Plane (NAD83) coordinates (feet) for Old Burn Area I, II, III, and IV and Acid Neutralization Basin Area soils or as local coordinates for Building 6, 7, and 8 soils.

Individual Class 1 area sample locations are provided in Figures 18 through 22, 24, 26, and 27. Sampling location coordinates are provided in Table 7. If a selected location is not accessible or available for sampling, the closest point will serve as an alternative sampling point.

5.3.1.2.2 Sampling of Class 1 Areas

Prior to sampling of each area, GWS will be performed over each Class 1 area footprint. For the Old Burn Areas I, II, and III and Acid Neutralization Basin Area, GWS will extend an additional 10 ft beyond the estimated boundaries, as allowable by adjacent buildings.

From each of the soil boring locations identified for the Class 1 areas, surface soil (0 to 0.5 ft bgs) and subsurface soil down to 20 feet bgs, groundwater, or refusal (whichever comes first), will be collected and measured using portable survey instruments to obtain counts for each one (1) ft soil interval (0 to 0.5 ft bgs, 0.5 to 1.0 ft bgs, and 1 ft subsequent intervals). In addition, from two (2) to three (3) soil samples for laboratory analyses will be collected from each borehole using the following guidelines:

1. One (1) sample from surface soil (0 to 0.5 ft bgs) [Note: for locations inside buildings, this would represent the first sample under the floor];

2. One (1) sample from the one (1) ft interval that exhibits the highest radiological scan measurement (if greater than or equal to twice background levels) on the soil core or visual or other evidence of impacts (staining, odor, etc.), with ICP-MS for uranium also specified for this core;

3. One (1) sample from the first one (1) ft interval that exhibits low radiological scan measurements (less than twice background) below the soil fractions with elevated counts or visual or other evidence of impacts to provide confirmation of vertical bounding of contamination;

4. If the boring does not present any evidence of contamination then one (1) sample will be collected from the 9.0-10.0 foot interval or (1) ft interval above the bottom of the boring if shallower than 10.0 ft to assist with risk-based exposures during the risk assessment.

If there are no elevated radiological measurements (greater than or equal to twice background levels), only two (2) soil samples, as described in (1) and (4) above, will be submitted to the laboratory for analysis. The remaining balance of soil in the soil core that is not initially collected for laboratory analysis will be collected separately for archival purposes per Section 6.7.

Surface soil samples will be collected after removal of vegetation, gravel, asphalt, concrete, or other non-soil surface. Alternate locations due to surface cover issues should only be used upon approval of the USACE Project Manager.

Contingency samples are specified in Table 3 for each Class 1 soil area. These samples are to be used in locations as necessary based on judgment placement to further investigate hotspots (e.g., placed in the space between grid points locations). Contingency samples will also be used in case additional sampling locations are needed to define the Building 6 Quench Basin Area or the Building 8 Pickling Tank Area. In addition, contingency samples will be used to investigate soils underneath large floor cracks. A flowchart illustrating the methodology for selecting volumetric soil samples for laboratory submittal is provided in Figure 23.

5.3.1.3 Survey and Sampling Basis – Class 2 Areas

Buffer Zone soils around Old Burn Area I, II, and III, the Acid Neutralization Basin Area, and Building 8 is considered Class 2. Initial estimates of the Buffer Zones footprints are illustrated in Figures 18 through 22 and 24 as the yellow areas around the Class 1 Areas (Note: The Building 8 Buffer Zone is not shown). As shown in Figure 18, the Old Burn Area III Buffer Zone is much larger due to elevated contamination levels indicated by the historical data; it extends north as well as west under the Building 9 footprint.

GWS along with survey of core samples will be used to aid in establishing the final Buffer Zone perimeters. Initial sampling locations are provided in Table 7 for the Old Burn Area III Buffer Zone. For the other Buffer Zone areas, the initial sampling points will be determined based on the GWS and elevated counting results in the Class 1 area, with the goal to definitively bound the area of Class 1 contamination. At the initial sampling points, surface soil (0 to 0.5 ft bgs) and subsurface soil down to 20 feet bgs, groundwater, or refusal (whichever comes first), will be collected and measured using portable survey instruments to obtain counts for each one (1) foot soil interval (0 to 0.5 ft bgs, 0.5 to 1.0 ft bgs, and 1 ft subsequent intervals). If survey results for any of the core intervals are greater than twice background or there is visual evidence of impacts (staining, odor, etc.), additional borings will be advanced approximately 3 ft out from the location of the elevated measurement at approximately 5 ft spacing and measured in order to bound the contamination in each Buffer Area.

In addition, from two (2) to three (3) soil samples for laboratory analyses will be collected from each borehole using the following guidelines:

1. One (1) sample from surface soil (0 to 0.5 ft bgs) [Note: for locations inside buildings, this would represent the first sample under the floor];

2. One (1) sample from the one (1) ft interval that exhibits the highest radiological scan measurement (if greater than or equal to twice background levels) on the soil core or visual or other evidence of impacts (staining, odor, etc.), with ICP-MS for uranium also specified for this core;

3. One (1) sample from the first one (1) ft interval that exhibits low radiological scan measurements (less than twice background) below the soil fractions with elevated counts or visual or other evidence of impacts to provide confirmation of vertical bounding of contamination;

4. If the boring does not present any evidence of contamination then one (1) sample will be collected from the 9.0-10.0 foot interval or (1) ft interval above the bottom of the boring if shallower than 10.0 ft to assist with risk-based exposures during the risk assessment.

If there are no elevated radiological measurements (greater than or equal to twice background levels), only two (2) soil samples, as described in (1) and (4) above, will be submitted to the laboratory for analysis. The remaining balance of soil in the soil core that is not initially collected for laboratory analysis will be collected separately for archival purposes per Section 6.7.

Surface soil samples will be collected after removal of vegetation, gravel, asphalt, concrete, or other non-soil surface. Alternate locations due to surface cover issues should only be used upon approval of the USACE Project Manager.

A flow chart describing volumetric soil sample selection for laboratory submittal is presented in Figure 23.

A flowchart illustrating the methodology for selecting Buffer Zone bounding soil sample locations is provided in Figure 25.

5.4 IA-03 Site Soils

5.4.1 Classification of Site Soils

The potential exists for uranium and thorium migration from known contaminated areas into other soils on the Site. Site soils are considered to be Class 3 since contamination is not expected to be widespread across the Site's footprint. However, sample results are required to confirm this assumption. At each location, surface soil (0 to 0.5 feet bgs) and subsurface soil down to 20 feet bgs, groundwater or refusal (whichever comes first), will be collected for field counting in 1-foot intervals (0 to 0.5 ft bgs, 0.5 to 1.0 ft bgs, and 1 ft subsequent intervals), producing a total of up to forty-two (42) background counting results.

5.4.2 Survey and Sampling Basis

A total of fifty-nine (59) random soil sample locations will be examined. The fifty-nine (59) locations will provide 95% confidence that no more than 5% of the unsampled soil locations would have results greater than the maximum result (per hypergeometric statistics). At each of the fifty-nine (59) locations, surface soil (0 to 0.5 ft bgs) and subsurface soil down to 20 feet bgs, groundwater, or refusal (whichever comes first), will be collected and measured using portable survey instruments to obtain counts for each one (1) foot soil interval (0 to 0.5 ft bgs, 0.5 to 1.0 ft bgs, and 1 ft subsequent intervals).

In addition, from two (2) to three (3) soil samples for laboratory analyses will be collected from each borehole using the following guidelines:

1. One (1) sample from surface soil (0 to 0.5 ft bgs) [Note: for locations inside buildings, this would represent the first sample under the floor];

2. One (1) sample from the one (1) ft interval that exhibits the highest radiological scan measurement (if greater than or equal to twice background levels) on the soil core or visual or other evidence of impacts (staining, odor, presence of fill, etc.), with ICP-MS for uranium also specified for this core;

3. One (1) sample from the first one (1) ft interval that exhibits low radiological scan measurements (less than twice background) below the soil fractions with elevated counts or visual or other evidence of impacts to provide confirmation of vertical bounding of contamination;

4. If the boring does not present any evidence of contamination then one (1) sample will be collected from the 9.0-10.0 foot interval or (1) ft interval above the bottom of the boring if shallower than 10.0 ft to assist with risk-based exposures during the risk assessment.

If there are no elevated radiological measurements (greater than or equal to twice background levels), only two (2) soil samples, as described in (1) and (4) above, will be submitted to the laboratory for analysis. The remaining balance of soil in the soil core that is not initially collected for laboratory analysis will be collected separately for archival purposes per Section 6.7.

Surface soil samples will be collected after removal of vegetation, gravel, asphalt, concrete, or other non-soil surface. Alternate locations due to surface cover issues should only be used upon approval of the USACE Project Manager.

A flow chart describing volumetric soil sample selection for laboratory submittal is presented in Figure 23.

Detailed drawings outlining buildings and other site features are not available; VSP was used in conjunction with the Google Maps Satellite tile server to delineate the site footprint. VSP provided random sampling point locations based on a five-feet grid over the Site footprint. Sample locations are presented as Indiana State Plane (NAD83) coordinates (feet).

The sample locations are shown in Figure 28. Sample locations are identified in Table 8. If a selected location is not accessible or available for sampling, the closest point will serve as an alternative sampling point.

5.5 IA-04 Groundwater

5.5.1 Classification of Groundwater

COPCs may have infiltrated from subsurface soils to groundwater. Areas immediately underlying and down gradient of identified areas of subsurface contamination (e.g. Burn Area III) are identified as Class 1 Groundwater Areas.

5.5.2 Sampling Basis

The selection of groundwater wells for sampling was informed based on earlier FUSRAP-related sampling efforts and groundwater monitoring under the VRP. Well selection considered the location versus the area of contamination, background locations, and groundwater gradients. GE property wells will only be sampled if evaluation of the analytical results from the on-site wells warrants further investigation.

The 49 wells (10 existing background wells and 39 existing investigative wells) that have been selected to be sampled are shown in Figure 5. These wells include:

Background Wells:

- Background MW Series Wells: MW-34S, MW-34D, MW-36S, MW-36D, MW-39S, MW-39D, MW-45S, MW-45D, MW-49S, MW-49D. Total of 10 wells.

Existing Wells:

- A Series Wells: A-18S, A-18D, A-19S, A-19D, A-20S, A-20D, A-21S, A-21D, A-22S, A-22D, A-23S, A-23D, A-24S, A-24D, A-27S, A-27D. Total of 16 wells.
- SB Series Wells: SB-15S, SB-15D, SB-16S, SB-16D, SB-17S, SB-17D. Total of 6 wells.
- MW Series Wells: MW-32S, MW-32D, MW-38S, MW-38D, MW-53S, MW-53D, MW-54S, MW-54D, MW-55S, MW-55D, MW-57S, MW-57D, MW-58S, MW-58D, MW-100, MW-101, MW-102. Total of 17 wells.

As a contingency, up to eight (8) additional monitoring wells located on the adjacent GE property may be sampled if evaluation of the analytical results from the on-site wells warrants additional sampling.

- GE Property Wells: MW-29S, MW-29D, MW-30S, MW-30D, MW-48S, MW-48D, MW-56S, MW-56D. Total of 8 wells.

5.6 IA-05 Surface Water and Sediments from Junk Ditch

5.6.1 Classification of Surface Water and Sediments

The lone major surface water feature on or near the Site is Junk Ditch, which runs along the western boundary of the Site. Because potential exists for migration of contamination from the Site during past flood events and as a result of runoff from the Site, Junk Ditch is a Class 3 surface water area. Sediments present in the Junk Ditch have the potential to be contaminated with MED/AEC-related COPCs either through settling or transport by runoff. Past dredging operations also potentially placed sediments on the banks of the Junk Ditch.

5.6.2 Sampling Basis

A total of twelve (12) surface water samples from four (4) transects (3 on-site transects and 1 off-site background transect), with three (3) samples from each transect (one at midstream, the others one-quarter from each bank), will be obtained from the Junk Ditch. Junk Ditch surface water sample locations are shown in Figure 29 and identified in Table 9. Judgment was used to select the Junk Ditch sample locations based on:

- Upstream background location south of Taylor Street prior to the Junk Ditch entry into the Site;
- Location at mid-point of the Site near a slight bend, which would promote sediment settling;
- Location further downstream at another slight bend; and,
- Location near the exit of the Site.

In addition, a total of fifteen (15) sediment samples from the same four (4) transects (includes background) will be collected. Three (3) samples from each transect (one at midstream, the others one-quarter from each bank) will be obtained from sediment within Junk Ditch (12 samples). Samples will also be obtained from the eastern descending bank at the end of each on-site transect (3 samples); these will be 0 to 2 feet bgs composite samples. The sample

locations are as shown in Figure 29 and identified in Table 9, co-located with surface water samples.

5.7 IA-06 Sediments in Building Catch Basins

5.7.1 Classification of Sediments

Sediments present in catch basins in Buildings 1, 6, 7, 8, and 9 have the potential to be contaminated with MED/AEC-related COPCs through settling transport by runoff. A walkover will be performed to identify catch basin sampling locations prior to initiating sampling activities.

5.7.2 Sampling Basis

If present, one (1) sediment sample will be collected from each catch basin identified in Buildings 6, 7, 8, and 9 during the walkover. USACE is estimating there are up to five (5) catch basins per building for a total of twenty (20) building interior catch basins.

5.8 IA-07 Wastewater

5.8.1 Classification of Wastewater

As Site runoff may enter the Site sanitary/stormwater (combined) sewer system, potential exists for radionuclides to have entered the Site's sewer system. Wastewaters are considered to be Class 3.

5.8.2 Sampling Basis

Two (2) judgmental samples will be obtained from a Site combined sewer access point. Access will be coordinated with the Site representative.

5.9 IA-08 Sludge

5.9.1 Classification of Sludge

As Site runoff may enter the Site combined sewer system, potential exists for radionuclides to have entered the combined sewer system and settled out as sediments in catch basins around the facilities. Detailed drawings of the stormwater collection system showing locations of the catch basins were not available during development of this SAP. A walkover will be performed to identify catch basin sampling locations prior to initiating sampling activities. Catch basin sediments are considered to be Class 3.

5.9.2 Sampling Basis

One (1) sludge sample will be collected from each exterior catch basin identified within the area of former MED/AEC operations during the walkover. USACE is estimating there are up to twenty (20) exterior catch basins within the area of interest. Two (2) judgmental samples will also be obtained from a Site combined sewer access point. Access will be coordinated with the Site representative.

5.10 Boring, Survey, and Sample Location Survey

A survey marker (e.g., annotated lath strip) shall be placed temporarily at each boring, radiological survey, and sample location (volumetric, Junk Ditch, catch basin, etc.), for later

surveying. The Contractor shall survey each location for coordinates (0.1-foot resolution) and elevation (0.01-foot resolution). The survey coordinates shall be geo-referenced to Indiana State Plane Coordinates (NAD 1983, feet) with NAVD 88 vertical datum. The Contractor shall submit the surveyed locations to USACE for review and acceptance.

6.0 FIELD OPERATIONS DATA MMENT AND DOCUMENTATION

6.1 Daily Quality Control Reports

A Daily Quality Control Report (DQCR) will be prepared documenting each day of project field operations. The DQCR will be signed by the SS/Contractor Quality Control System Manager and submitted electronically to the USACE PM on a weekly basis (or as otherwise agreed to). The DQCR will include, at a minimum, the following information:

- A daily summary of Site activities;
- Weather information;
- Field instrument measurements;
- Identification of all field and control samples collected;
- QA sample tables that match up primary, replicate QA/QC, and other field control samples (e.g., blanks);
- Copies of chain of custody (COC) forms, field-generated analytical results, and any other project forms that are generated;
- Results of quality control activities performed including field instrument calibrations;
- List of Contractor/Subcontractors and area of responsibility for work performed;
- List of Site visitors;
- List of on-site equipment;
- Any deviations from the FSP including the justification for the deviation;
- Any problems encountered during daily field activities; and,
- A summary of any instructions received from USACE or government personnel.

6.2 Field Logbooks

All information pertinent to the field investigative activities, including field instrumentation calibration data, will be recorded in field logbooks. Each logbook will have the Site name and project name and number on the inside front cover. Sufficient information will be recorded in the logbooks to permit reconstruction of all conducted field investigative activities. The logbooks will be bound and the pages will be consecutively numbered and water resistant. Entries in the logbooks will be made in black waterproof ink and will include, at a minimum, a description of all accomplished activities, names of individuals involved in field investigative activities, date and time of drilling, excavation, and/or sampling at each location, weather conditions, a description of any problems encountered, and all field measurements. Lot numbers, manufacturer names, and expiration dates of standard solutions used for field instrument calibration will be recorded in the field logbooks. A summary of each day's activities will also be recorded in the logbooks. If any recorded information is noticed to be in error, the original entry will be crossed out so that the original entry is still legible and will be replaced with the new entry. All such changes will be initialed by the SS.

At the conclusion of each workday, the person responsible for maintaining the logbook will sign and date the day's documentation entries. Information recorded on other project documents will not be repeated in the logbooks (e.g., boring logs, drum logs, etc.), although a summary of other project related field documentation will be included where deemed necessary. All field logbooks will be kept in the possession of the SS or the recording author, or in a secure place when not being utilized for field work. Upon completion of the field activities, all logbooks will become part of the final project evidence file.

The title page of each logbook will be labeled as follows:

- Logbook title: Joslyn RI Field Investigation;
- Project name: Joslyn RI Field Investigation;
- USACE contract number and project delivery order number;
- Start date for field investigative activities recorded in the logbook; and,
- End date for field investigative activities recorded in the logbook.

As previously described, logbook entries will include, but not be limited, to the following information:

- Name and title of author and SS;
- Date and times of arrival and departure from site;
- Description of the sampling and/or monitoring activity;
- Name and address of the field contact(s);
- Names and responsibilities of field crew members;
- Names, affiliations, and purpose of any Site visitors;
- Level of PPE worn at the Site and/or specific sampling locations;
- Weather conditions on the day of sampling and any additional environmental conditions or observations relevant to the field activities;
- Field instrumentation or equipment used, and purpose of use (e.g., health and safety screening or sample selection for laboratory analysis);
- Sample collection method and sample handling procedures such as filtration and executed preservation techniques including the distinction between composite and grab samples;
- Number and volume of sample(s) collected with each sample given a unique sampling identification;
- Document the sample locations - the exact locations of sampling points will be documented for purposes of generating an accurate representation of the Site conditions using the field investigative data and defining data gaps that could impact the project objectives;
- Location, description and log of sampling point photographs;
- Identification of sample numbers, volumes, and containers (number, size, type) used for each sample collected. Note the day and time of each sample, identify any associated QC samples or any factors that may affect quality. Also, identify the name of the sample collector;
- Record of any field measurements, field screening/analytical results generated, calibration methods used, field results, and QC information;
- Identify decontamination procedures employed for sampling equipment;
- Document appropriate references to maps and photographic logs of the Site;
- Record information on scheduling modifications, change orders, sampling or drilling decisions, changes, and/or modifications accepted by the USACE;
- Information regarding access agreements, if applicable;
- Describe the number of shipping coolers packed, note COC numbers or attach a copy of the COC, and record the mode of transportation, and applicable tracking numbers;
- Decontamination procedures;

- IDW documentation including types and numbers of containers (or drums), contents, type, and approximate volume of waste, and waste classification (hazardous or non-hazardous);
- Record name and location of all receiving laboratories and couriers;
- Information on sample preservation methods;
- Maintain appropriate documentation for IDW. Note contents and volumes of waste generated, storage, and disposal methods used. In addition, record all analytical methods and sampling results for the IDW in order to generate waste disposal characterization as necessary;
- Type, matrix, and characterization method for generated IDW.

Field data collected during invasive soil sampling will be recorded on boring logs formatted for the field investigative activities at the Site.

6.3 Photographic Records

Photographs will be taken to document visual information such as sample locations, field conditions, indications of visual contamination, or additional items as determined by an USACE. In some cases, a photograph of the actual sample collected may be required from two or more reference points to facilitate relocating the sampling point at a later date or at locations as specified by USACE. All photographs will be digitized images with descriptive captions and unique identifiers. Coordinates of each photograph will be recorded using global positioning system (GPS) and tabulated in Excel format. A Site photo map will also be included with the Site photographs and clearly indicate the location and direction of each photograph.

For each photograph taken during the field investigative activities, field logbook entries will include the following items:

- Date and time;
- Photographer (name and signature);
- Site name;
- General direction faced and description;
- Unique identifier in sequential order for each photograph; and,
- Site photo map.

In addition to the information recorded in the field logbook, one or more photograph reference maps will be prepared. Photographs taken to document sampling points will include two or more permanent reference points within the photograph to facilitate relocating the point at a later date.

6.4 Sample Documentation

This section describes the sample documentation requirements that will be followed during field sampling activities.

6.4.1 Sample Numbers

A sample numbering system will be used to enable tracking and management of environmental samples and the resulting laboratory and/or field analytical data. Each sample will be assigned a unique alpha-numeric sample number that includes a matrix-specific code and a unique

numeric code. Numeric codes will run consecutively through the entire course of the project and will not be re-used for the same sample matrix. Separate groups of numeric codes will be used for regular field samples and field duplicate samples for ease of identification and tracking in the field. The following provides an example numbering system, describes the sample numbering system components, and provides examples of sample numbers.

Investigative Area/Building codes:

Investigative area or building codes allow for quick identification of the building of area:

IA indicates an Investigative Area.

BI indicates an interior building sample.

BE indicates an exterior building sample.

Sample Matrix Codes:

The sample matrix code indicates from which matrix (media) the sample was collected from.

SS Surface soil (0 to 6 inch depth)

SB Subsurface soil (>6 inch depth)

SD Sediment

SW Surface water

MWxxx indicates a groundwater sample, where xxx is the well ID (e.g., 29S)

UW Utility-based aqueous sample

BM Building material

WP Radiation wipe

FB Field Blank (equipment rinsate blank)

Sample Numbers:

0001 - 8999 Regular field samples (each medium)

9000 – 9999 Field duplicate samples (each medium)

6.4.2 Sample Labels

Sample labels will be affixed to all containers during sampling activities at the time of sample collection and securely affixed to the container prior to shipment. Sample label information will include, but not be limited to, the following:

- Sampling contractor identification;
- Sample identification (ID) number;
- Site name;
- Sample station number;
- Requested analysis;
- Type of sample (discreet, grab, or composite);
- Type of chemical preservative present in container;
- Date and time of sample collection; and,
- Sampler's name and signature or initials.

6.4.3 Chain of Custody Records

COC forms will be completed and will accompany each sample at all times. An example COC form is presented in Appendix D. Data on the forms will include the sample ID, date sampled, time sampled, project name, project number, and signatures of those in possession of the sample. Forms will accompany those samples shipped to the designated laboratory so that sample possession information can be maintained. The field team will retain a separate copy of the COC reports at the field office. Additionally, the sample ID; date and time collected; collection location; and analysis will be documented in the field logbook.

The individual responsible for shipping the samples from the field to the laboratory will be responsible for completing the COC form. This individual will also inspect the form for completeness and accuracy. In addition, this individual will be responsible for determining the shipping classification for samples under USDOT Regulatory Requirements. After the form has been inspected and determined to be satisfactorily completed, the responsible individual will sign, date, and note the time of transfer on the form. For commercial carriers, the COC form will be placed in a sealable plastic bag and placed inside the cooler used for sample transport after the field copy of the form has been detached. For laboratory couriers, the COC form will be placed in a sealable plastic bag on the top of the cooler for the courier to accept custody. The field copy of the form will be appropriately filed and kept at the Site for the duration of the field investigative activities. Shipping containers will be secured using strapping tape and COC seals.

COC seals will be placed on each cooler used for sample transport. These seals will consist of a tamper-proof adhesive material placed across the lid and body of the coolers in such a manner that if the cooler is opened, the seals will be broken. COC seals placed in this manner will ensure that no sample tampering occurs between the time of sample placement in the coolers to the time the coolers are opened for analysis at the laboratory. Cooler custody seals will be signed and dated by the individual responsible for completing the COC form contained within the cooler.

The Contracted Analytical Laboratory (i.e., the Laboratory) will document the receipt of analytical samples by accepting custody of the samples from the accepted shipping company. In addition, the Laboratory will check the condition of the shipping coolers and enclosed samples upon receipt and will immediately inform the Contractor if any sample containers are broken or if any tampering occurred with the seals on the cooler(s). The Contractor shall, in turn, notify the USACE Buffalo District PM, Contracting Officers Representative, and/or

Project Chemist of such concerns and will recommend corrective actions. This documentation will be accomplished by completing the cooler receipt checklist as provided in the QAPP.

An example cooler receipt checklist will be provided by the Laboratory at the start of the project. Copies of the completed checklists will be e-mailed to both the USACE Buffalo District PM and the Project Chemist immediately after they have been completed at the Laboratory. The original completed checklists will be transmitted with the final analytical results from the Laboratory.

6.4.4 Field Analytical Records

As discussed in previous sections, documentation of all field activities will be maintained using field logbooks and applicable field forms (i.e., field sample sheets, instrument calibration logs, etc.). Field instrumentation used for measurement or analysis will be calibrated in accordance with the manufacturer's recommendations with the calibration procedures. Calibration checks will also be performed as recommended by the manufacturer during the course of field investigative activities.

Calibration records will be maintained in the field logbook. Additionally, all field personnel will be properly trained in the operation and calibration of the field instrumentation. Any field instrumentation out of calibration will be immediately re-calibrated. When field instrumentation is out of calibration or damaged, an evaluation will be made to ascertain the validity of previous results since the last acceptable (or valid) calibration check. If it is necessary to ensure the acceptability of suspect data, the originally required tests will be repeated, if possible. Data or measurements since the last acceptable (or valid) calibration will be noted as suspect in the field logbook and further evaluated to determine the suitability of the data for its intended use.

Malfunctioning equipment will be replaced and any questionable measurements will be documented in the field logbook. The SS will be responsible for ensuring that the field instrumentation are of the proper range, type, and accuracy for the measurements being performed and all field instrumentation are properly calibrated. Field instrumentation will undergo response verification checks as recommended by the manufacturer to detect anomalies in the data being generated. If an unacceptable response is obtained, the data will be labeled suspect, the problem documented in the field logbook, and appropriate corrective actions immediately implemented. Corrective actions will be approved by the USACE prior to implementation.

Field analytical and monitoring data not collected via instrumentation or on logs will be recorded in the field logbooks on a daily basis. At the end of each week, this data will be extracted from the logbooks and incorporated into the project analytical database. All field analytical and monitoring data will be used together with laboratory analytical data to evaluate the nature and extent of contamination.

6.5 Records

6.5.1 Responsibilities

The Site HP will evaluate radiological information and verify that adequate documentation is maintained. The RI Field Geologist is responsible for the maintenance, storage, and transfer of documents. Any deviation from the requirements will be reported immediately to the PM. Health Physics Technicians and other field personnel will record documentation neatly and in accordance with these and work plan procedures and requirements.

6.5.2 Controlled Records

The following is a list of field records that may be produced during the project:

- Instrument Calibration Records
- Instrument Source Check Records
- Radiation Survey Forms
- Medical Information
- Training Records
- Dosimetry Records
- Project Field Logs
- Project Reports
- Radioactive Material Transportation Records
- Radioactive Material Disposal Records
- Radioactive Source Transfer Receipts
- Sample Collection Forms
- Sample COC Records
- Emergency Response Documentation
- Document Distribution and Transmittal Forms
- Respirator Issue Logs and History Records
- Bioassay Records
- Personnel and Equipment Contamination and Decontamination Reports

6.5.3 Quality Control

The PM will verify that quality records are accurate, neatly and properly prepared, properly maintained, and periodically reviewed during the project. The RI Field Geologist or delegated representative will periodically review the status of controlled documents, and document the findings to the Program Manager. The PM will verify that required records are present at the end of the project and that records are safely maintained during transfer or shipment to the archival location.

6.6 Field Documentation Procedures/Data Management and Retention

Hard copies of original Site and field logbooks, COC forms, field data with analytical results and associated QA/QC information, and other field-related information will be indexed, catalogued into appropriate file groups and series, and archived. The project data will be archived to appropriate electronic media. Originals of field data (for example, logbooks) will be scanned and archived in portable document format (e.g., PDF file). A data archive information package will be prepared that describes the data system, file format, and method of archive. Sufficient documentation will accompany the archived data to describe the source,

contents, and structure of the data. Necessary field data will be incorporated into the final Quality Control Summary Report (along with laboratory and other relevant data) in either hard copy or electronic versions, as described in the QAPP (Volume 2 of this SAP).

6.7 Archival of Samples

During soil sampling, the remaining balance of soil in the soil core that is not initially collected for laboratory analysis will be collected separately for archival purposes. For example, if a Geoprobe advances a 4-ft macrocore from 4.0 to 8.0 feet below grade and the 5.5 to 7.0 foot increment is sampled, then the balance of the macrocore is placed in two archive bags (e.g., remaining soil from 4.0-5.5 ft in one bag and 7.0 to 8.0 ft in another bag). If only the top or bottom of the core is sampled, then the balance is archived in one bag (e.g., 7.0-8.0 ft is sampled, so 4.0-7.0 ft of the core soil is archived in one bag). The archived soil will be placed in a plastic bag and labelled as described in Section 6.4.2. These samples will be archived for a minimum of six (6) months based on direction provided by the USACE Project Manager and stored in a storage unit staged on-site The USACE Project Manager will determine any subsequent analyses needed from the archived samples.

7.0 SAMPLE PACKAGING AND SHIPPING REQUIREMENTS

7.1 Sample Handling and Tracking System

Samples will be handled to avoid contamination from outside sources during and after collection. Samplers will wear non-powdered latex or nitrile gloves when handling the samples and gloves shall be changed after collecting each sample. Surfaces on which samples are placed will be clean or covered with clean plastic sheeting or aluminum foil. Samples will be screened for radioactivity before shipping to ensure there is no exceedance of the radioactivity limits the Laboratory is licensed to accept.

Unique sample identification numbers will be used during sampling activities. Sample identification numbers shall be associated with the sample type and location (e.g., wall, floor, or roof). This will allow the sample results to be easily tied back to a specific sample location.

The COC maintains and documents the possession of samples from the time of collection until the data derived from the samples is obtained. An accurate record must be maintained to trace the possession of each sample from the moment of collection until received by the Laboratory to document COC.

7.2 Sample Custody

A sample, or other physical evidence, is in custody if it is in the actual possession of a sampler, is in the view of a sampler after being in their physical possession, was in the physical possession of a sampler and then secured to prevent tampering and is placed in a secure area.

7.3 COC Documentation

Sample custody procedures will be in accordance with USEPA Region 4 guidance (USEPA 2001). The COC record(s) will accompany the samples from the field to the analytical laboratory.

7.4 Sample Labels

Sample labels will be attached to each sample container just before or at the time of sample collection. The labels shall be waterproof paper or plastic with gummed backs or waterproof tags as appropriate. Labels shall be completed with black indelible ink and shall include, at a minimum, the following information:

- Unique sample number
- Sample matrix
- Analysis to be performed
- Sampler's initials
- Date and time of collection

7.5 Corrections to Documentation

All original recorded data shall be written in indelible black ink. No accountable, serialized documents will be destroyed or thrown away, even if they are illegible or contain inaccuracies that require a replacement document. If an error is made, it will be corrected by making a single line through the error (initialed and dated) and entering the correct information.

7.6 Sample Delivery

The shipment of samples from the field to the Laboratory will be typically within 48 hours of collection. The samples will be packaged and shipped in accordance with ASTM D6911-15 (Appendix B), USEPA Region 4 guidance (USEPA 2002), and USDOT requirements. Samples requiring analyses with short holding times will be identified and designated as such on the COC and shipped on the date of collection, if possible. The sample containers will be individually sealed in plastic bags. Samples requiring temperature preservation will be packaged in a cooler with ice packs or bagged ice. The cooler will be lined with a plastic bag and the drain spout will be taped shut to prevent leakage. Absorbent and/or packing material will be added to the cooler, as needed. If a commercial carrier is used, the COC record will be sealed in a plastic bag and taped to the inside of the cooler lid. The cooler will be sealed with strapping tape for shipping and custody seals will be placed on the outside.

8.0 INVESTIGATION-DERIVED WASTE

8.1 Investigation-Derived Waste Collection and Containerization

Soil cuttings will be collected and contained in labeled, open-top USDOT-approved 55-gallon drums equipped with plastic drum liners and sealed with bung-top lids. Other solid IDW including expendable sampling equipment, PPE, and trash will be segregated as potentially contaminated or non-contaminated material on the basis of visual inspection (e.g., soiled versus non-soiled), usage of the waste material (e.g., outer sampling gloves versus glove liners), and field screening of the material using available field instrumentation (e.g., photo-ionization detector and radiation detectors). Non-contaminated IDW will be contained in trash bags and will be placed in a rented dumpster for periodic disposal at a municipal landfill.

Liquid IDW generated from monitoring well purging will be collected in labeled USDOT-approved 55-gallon closed-top drums with a minimum of 10 percent headspace. Liquid IDW generated from decontamination activities and rinses will also be collected in labeled USDOT-approved 55-gallon closed-top drums with a minimum of 10% headspace and segregated by waste stream.

During project activities, waste generation will be minimized to the greatest extent practical and shall comply with EPA 540/G-91/009, *Management of Investigation-Derived Wastes During Site Inspections*, and applicable Indiana State and local regulations. Waste will be minimized by limiting access to restricted areas, reuse and decontamination of equipment, and use of non-hazardous materials.

8.2 Waste Container Labeling

Drums and other IDW storage containers will be labeled as they are generated and collected for proper identification of the stored wastes. The following procedure will be used for waste container labeling.

Weather-resistant, commercially available Empty, Pending Analysis, Hazardous, Non-hazardous, and/or Radioactive Material labels, as appropriate, will be affixed on the upper one third of each storage container. Each label will be placed on a smooth part of the container and will not be affixed across drum bungs, seams, ridges, or dents. Container labels will be protected in a manner to prevent damage or degradation of the recorded information. Additional label information may be recorded directly on a clean, dry drum surface using an indelible paint marker.

Information documented on container labels will be recorded with a permanent marker or paint pen, and will also be recorded in the IDW log. Information to be recorded on each label will include the following:

- Project name and site identification
- Container number
- Generation date(s)
- Contents / source of waste
- Physical characteristic of the waste
- Emergency contact information

All containers, including those that are empty, must be labeled appropriately. A Pending Analysis label will be affixed to applicable containers until characterization of the IDW is complete. After characterization, the Pending Analysis label will be replaced by either a Hazardous, Non-Hazardous, and/or Radioactive Material label, as appropriate.

Radioactive material labels will be affixed to those containers when radiological results from the environmental samples statistically exceed the background concentration. Liquid IDW will be labeled as radioactive material if an exceedance is noted.

8.3 IDW Field Staging Area

Subject to the review and approval of USACE, the RI Field Geologist will designate a primary IDW Field Staging Area (FSA) for the project. Solid and liquid IDW will be stored in an FSA until such time that the IDW is characterized for disposal.

Each FSA will be visibly marked and any waste containers will be placed on top of plastic sheeting and/or pallets. Liquid waste containers will be stored on approved spill collection pallets and will be covered with tarps to limit surface water collection. IDW will be segregated by type (e.g., drill cuttings, decontamination fluids, well development and purge water, etc.) so that the IDW generated can be identified with a given operation. Waste containers will be stored in a manner to accommodate inspection and sampling, if necessary, and to facilitate safe handling of the containers.

IDW stored within the on-site FSA will be inspected on a regular basis while Alliant personnel are on Site from the time of containerization and placement in the FSA to the time of ultimate disposition. Inspections of the FSA and associated IDW containers will be conducted a minimum of weekly while Alliant personnel are on Site and will be documented in the field notebook. IDW containers will be visually inspected for leaks, improper seals, or other damage or unsafe condition. Any container damage or unsafe condition associated with the FSA will be reported to USACE, the Field Geologist, and appropriate regulatory agencies, if necessary.

8.4 IDW Characterization and Classification for Disposal

IDW (liquid and solid) generated as part of this investigation will be characterized for disposal based on disposal characterization samples. Analytical parameters for IDW are based on known Site contaminants. Soils and groundwater will be analyzed for U, Th, Gross Alpha/Beta, and Gamma Emitters.

Potentially contaminated PPE and expendable sampling equipment and other items not amenable for sampling will be scanned for radiation and characterized for disposal based on its physical description, radiological screening, and general knowledge of the types and degree of contamination at the Site.

All IDW will be segregated into appropriately labeled containers according to the characterization sample results. For example, IDW categories can be hazardous waste, non-hazardous waste, low-level radioactive waste, and mixed low-level radioactive waste. All containers will be labeled, marked, and shipped according to appropriate local, state, and federal transportation regulations.

8.5 Disposal of IDW

The Contractor will coordinate IDW for disposal at appropriately licensed or permitted facilities as determined by characterization samples and submit its name and relevant information to USACE for approval. USACE will review and verify that the disposal facilities proposed by the Contractor are properly licensed/permitted to accept and dispose of the contaminated materials. The Contractor will prepare waste manifests and other shipping documents, as appropriate. A representative of the USACE will sign the respective waste manifests and other shipping documents.

The Contractor shall comply with EM-1110-35-1, "Management Guidelines for Working with Radioactive and Mixed Waste" and EP-200-1-2, "Process and Procedures for RCRA Manifesting" (Appendix C). The Contractor shall submit the waste manifests to USACE for review and approval and shall not ship any contaminated material for disposal until:

- The off-site sampling results have been provided to and approved by the USACE COR, and,
- Per Department of Defense Regulation 4500.9-R, all shipping papers are signed by the USACE COR or hazardous material manifest certifying official designated by the USACE Buffalo District.

The Contractor shall be responsible for any package or contaminated materials rejected by the disposal facility for non-compliance with the requirements of the waste acceptance criteria (specific to each waste disposal facility) at no additional costs to the Government. The Contractor shall not redirect a shipment without first obtaining USACE approval.

All other work required to complete transportation to the disposal facility (loading, marking, labeling, manifesting, bills of lading, monitoring, and dosimetry program, Health Physics support, etc.), which is not otherwise specified, shall be considered incidental to and included in the costs required to complete the work.

The Contractor shall submit the Certification of Disposal and any shipment records to USACE within 10 days of receipt of contaminated material by disposal facility.

9.0 DECONTAMINATION

Non-disposable sampling equipment shall be decontaminated thoroughly before use and prior to reuse in accordance with USEPA requirements, including USEPA procedure SESDPROC-205-R3, *Field Equipment Cleaning and Decontamination*, or equivalent, and requirements of this SAP. If removable contamination is found and the portion of the tool that contacts the sample cannot be decontaminated, the tool will not be used to collect additional samples. This check by the SRS Officer will be documented in the field logbook.

Initial decontamination activities may take place near the sampling area (i.e., wiping down of equipment to remove contamination). This may include wiping the cutting portion of the tool with moist paper towels, which will avoid generating a separate waste stream for decontamination water. Paper towels will be managed and disposed as secondary waste along with used personal protective equipment and disposable sampling equipment. If a sampling tool (e.g., blades, coring bites) is used at more than one sample location and samples are being collected for only radiological analysis, the SRS Officer may survey (e.g., direct frisk, large area wipe) the equipment to ensure there is no detectable contamination prior to reuse for collection of additional samples.

Disposable sampling equipment (e.g., blades, coring bits) shall be kept sealed until just prior to sampling to prevent contamination. Disposable equipment will be used where practical to minimize the opportunity for cross-contamination.

10.0 REFERENCES

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TABLES

Table 1. Summary of Historical Data

Receiving and Storage Area - Melt Shop - 1946	
dpm	**pCi**
2000	901
8000	3604
800	360
500	225
300	135
300	135
18000	8108
10000	4505
30000	13514
300	135

Rolling and Quench Area - 1946	
dpm	**pCi**
3000	1351
4500	2027
2000	901
15000	6757

Heat Treatment Area - 1946	
dpm	**pCi**
1000	450
4000	1802
600	270
200	90
200	90
2000	901
1600	721
1600	721
2500	1126
2000	901
1200	541
800	360
1000	450
1000	450
500	225
10000	4505
25000	11261

Cold Finishing - 1946	
dpm	**pCi**
10000	4505
20000	9009
20000	9009
30000	13514
3000	1351
3000	1351
8000	3604

Threading Machine - 1946	
dpm	**pCi**
1100	495
300	135
5000	2252

Straightener Area - 1976	
dpm	**pCi**
300	135

Building 8 - 2004			Boreholes - 2004			
gamma cpm	**beta dpm/100cc**	**alpha dpm/100 cc**	**Hole**	**Depth (ft)**	**U-235 (pCi/g)**	**U-238 (pCi/g)**
5000	3700	11	P-1	3-6	0	3.078
20000	1111000	1645	P-2	5-8	0	2.43
80000		2632	P-3	6-8	0	3.75
20000			P-3	8-10	0	2.12
15000	667000	1096	P-4	6-8	0	2.66
20000			P-5	6-10	0	6.22
8000	370000	1096	A	5-7	0	2.45
			B	5-7	0.679	6.49
			C	4-8	0	2.8
			D	4-8	2.07	73.5

Boreholes - 2004

cpm

Depth (ft)	P-1	P-2	P-3	P- 4	P-5	A	B	C
Background	2467	2467	2467	2467	2467	3820	4210	5730
0	3658	3290	3746	3050	4154	4620	4820	6560
1	3115	3132	4356	3966	4463	6030	8920	4940
2	9115	6318	8991	5126	8291	7550	11560	2230
3	15118	7364	11733	3147	7680	3030	10360	6740
4	16281	10414	3334	13235	6745	11650	13303	16720
5	14302	12682	14238	12961	13028	20710	20900	21450
6	13359	13831	15173	13782	14813	18790	21110	19850
7	12747	14302	14627	14363	15028	18890	19920	19050
8	13160	14026	15102	14470	14428	13930	13710	19070
9	12336	13204	14241	13762	13913	13520	15630	19360
10	10559	9681	10864	10412	12792	15510	14130	14570

Soil Samples - 2007

Area	FIELD ID	LAB SDG	U-234 (pCi/g)	U235/236 (pCi/g)	U-238 (pCi/g)	Th-228 (pCi/g)	Th-230 (pCi/g)	Th-232 (pCi/g)
III	GP010001	F6H050196	1720	71	1780	0.44	2.35	0.62
III	GP020506	F6H050196	1.67	0.09	1.58	1	2.17	1.01
III	GP030001	F6H050196	84	4.8	83			
III	GP040102	F6H050196	12.9	0.31	12			
I	GP050405	F6H050196	2.35	0.113	2.48	1.16	2.06	1.11
I	GP060405	F6H050196	2.08	0.12	2.37			
I	GP070506	F6H050196	1.66	0.042	1.76			
II	GP080405	F6H050196	1.79	0.101	1.51			
II	GP090405	F6H050196	1.44	0.125	1.46	0.81	1.85	0.76
II	GP100708	F6H050196	1.41	0.121	1.82			
LA	GP110405	F6H050196	1.63	0.067	1.57	0.88	2.16	1.01
6	GP130506	F6H050196	1.75	0.025	1.69	0.88	1.73	0.91
6	GP150304	F6H050196	1.88	0.139	1.88	0.76	1.89	0.78
7	GP160809	F6H050196	1.29	0.08	1.43	0.8	1.99	1.01
9	GP170405	F6H050196	1.41	0.168	1.84	0.62	1.55	0.75
9	GP180304	F6H050196	1.86	0.066	1.89			
9	GP190304	F6H050196	1.27	0.072	1.31			
8	GP210405	F6H050196	3.63	0.17	3.92			
8	GP220405	F6H050196	2.23	0.14	2.17			
8	GP230506	F6H050196	1.44	0.036	1.42	0.96	2.1	0.93
8	GP240506	F6H050196	1.97	0.113	2.48			
8	GP250405	F6H050196	2.53	0.12	2.37	0.98	2.53	1.42
8	GP260405	F6H050196	2.06	0.136	2.64			
8	GP270405	F6H050196	1.99	0.104	1.94	0.84	1.78	0.76

Screening Values NUREG-1757 (pCi/g)		
Thorium-228	228Th	4.7
Thorium-230	230Th	1.8
Thorium-230+C	230Th+C	0.6
Thorium-232	232Th	1.1
Uranium-234	234U	13
Uranium-235	235U	8
Uranium-235+C	235U+C	0.29
Uranium-238	238U	14
Uranium-238+C	238U+C	0.5

C=Isotope+Daughter Limit

Table 2. Data Quality Objectives and Data Needs

Project Data Quality Objective	Data Needed
1. Conduct a structural survey and an inventory of building content/structures to support FS alternatives and evaluations.	Compile observations from structural survey and field sampling activities to determine whether any MED-related equipment remains on-site and, if so, survey for both fixed and removable impacts. Based on the structural survey, identify any safety concerns for future RI/FS activities.
2. Identify the underground utility system within the Site, including if possible, utilities in place at the time of MED/AEC activities and utilities installed afterward.	Obtain all available utility drawings from property owner (Valbruna).
3. Acquire information to define the fate and transport of contaminants from the Site.	Determine if uranium has been discharged to off-site surface water bodies or through the utilities. o Sample the on-Site sewer/storm drainage system's main outfall and catch basins. o Investigate management (past and planned dredging) of Junk Ditch including disposition of dredged materials. o Sample the sediment and surface water in Junk Ditch and assess potential ecological concerns. Determine if uranium in the subsurface soils has infiltrated to groundwater. o Determine if monitoring well layout is adequate to assess potential groundwater impacts (review existing monitoring well locations, potentiometric groundwater maps and subsurface conditions). o Collect groundwater samples. The need for additional monitoring wells closer to the source term will be evaluated based on sampling results and hydrologic flow conditions. Determine movement/placement of fill on-Site. Areas on Site that received fill originating from portions of the Site potentially impacted by MED/AEC activities will be sampled. Areas on Site that were potentially impacted by MED/AEC activities and received fill will be sampled. Collect background data for potentially impacted media in order to distinguish naturally occurring radioactivity from on-site releases.

Table 2. Data Quality Objectives and Data Needs (Continued)

Project Data Quality Objective	Data Needed
4. Gather sufficient data to complete a Baseline Human Health Risk Assessment (HHRA).	See DQO 6. Ensure the planned sample quantities and types will satisfy an HHRA.
5. Define extent of isotopic uranium and thorium in surface soils, subsurface soils, and buildings to support risk assessment (using Nuclear Regulatory Commission screening levels for human health and Department of Energy [DOE, 2002] for ecological) and development and evaluation of FS alternatives (volume determination).	Investigate soil and building impacts, survey potentially impacted areas and collect samples. Assess potential habitats on-Site to determine if an ecological risk assessment is needed.
6. Determine the extent of MED/AEC related constituents present at the Site (i.e., uranium and thorium and associated daughter products, and the media and locations in which they are present).	Perform investigations of areas suspected or known to be impacted by MED/AEC-related activities (may include: facilities, soil, groundwater, sediment, and surface water). Survey building interiors for both fixed and removable impacts. Collect volumetric samples of building materials for isotopic ratios (to help determine criteria for future clean up requirements).
7. Determine if isotopic uranium and/or thorium has contaminated underground utilities.	Sample Site's main sanitary/storm sewer outfall and catch basins located near former MED/AEC operations.
8. Determine whether surface water and sediments have been impacted by isotopic uranium or thorium above screening levels (screening levels for these media will need to be researched and developed during RI/FS tasks, although levels provided by DOE [2002] or NRC [2006] may be used for initial screening).	See DQO 3 and 5. Limited on-Site sediment sampling. Surface water sampling to be conducted to investigate potential for re-solubilization.

Table 2. Data Quality Objectives and Data Needs (Continued)

Project Data Quality Objective	Data Needed
9. Determine whether groundwater has been impacted by isotopic uranium or thorium above screening levels; and if so, determine nature and extent to support risk assessment, and development and evaluation of FS alternatives.	Sample groundwater wells. As noted previously, the need for additional monitoring wells closer to the source term will be evaluated based on sampling results.
10. Provide sufficient characterization data to allow completion of subsequent Feasibility Study (FS), Remedial Design (RD), and Remedial Action (RA).	Delineate extent of any required removal action.
11. Determine the magnitude of any chemical contamination to support establishing transportation and disposal requirements (e.g., waste classification) and associated costs to be included in various FS alternatives.	Obtain waste classification requirements. Obtain and review Valbruna's previous waste characterization sampling results.
12. Provide adequate sample volume for additional or reanalysis of each sample, if needed.	Archive collected samples in the event subsequent laboratory radionuclide analyses is required to support site-specific DQOs.

Table 3. Sampling Summary

IA	Survey Unit or Area	Sampling Strategy / Collection Method	Number of Planned Sampling Locations	Number of Survey Samples	Number of Planned Volumetric Samples[a]	Number of Contingency Sampling Locations[b]	Number of Contingency Volumetric Samples*	Total Number of Planned and Contingency Volumetric Samples[a]
IA-01	Building 8 Interior	Survey with volumetric samples at 5 highest activity locations; wipes at locations 10× background / Survey Instruments and Dry Wipes / Volumetric Samples by Drill Cuttings, Snips, Other as Appropriate	100%	100%	5	10	10	15
	Building 6 Interior	Surveys at random locations; wipes at locations 10× background / Survey Instruments and Dry Wipes /	64	64	0	10	10	10
	Building 7 Interior		64	64	0	10	10	10
	Building 9 Interior		59	59	0	10	10	10
	Building 1 Interior		29	29	0	0	0	0

IA	Survey Unit or Area	Sampling Strategy / Collection Method	Number of Planned Sampling Locations	Number of Survey Samples	Number of Planned Volumetric Samples[a]	Number of Contingency Sampling Locations[b]	Number of Contingency Volumetric Samples*	Total Number of Planned and Contingency Volumetric Samples[a]
IA-02	Buildings 1, 6, 7, 8, and 9 Exterior	Volumetric Samples by Drill Cuttings, Snips, Other as Appropriate Surveys at random locations; surveys around building openings; wipes at locations 10× background / Survey Instruments and Dry Wipes / Volumetric Samples by Drill Cuttings, Snips, Other as Appropriate	109 (59 random and 50 bias locations)	109 (59 random and 50 bias locations)	0	0	0	0
	Old Burn Area I	Systematic selection of core sample locations /	20	surface and subsurface soil intervals (0-0.5 ft bgs, 0.5-1.0 ft bgs,	60	4	12	72
	Old Burn Area II		19		57	4	12	69

IA	Survey Unit or Area	Sampling Strategy / Collection Method	Number of Planned Sampling Locations	Number of Survey Samples	Number of Planned Volumetric Samples[a]	Number of Contingency Sampling Locations[b]	Number of Contingency Volumetric Samples*	Total Number of Planned and Contingency Volumetric Samples[a]
IA-03	Old Burn Area III	Push Tube and Hand Auger	29	1 ft subsequent intervals)	87	6	18	105
	Old Burn Area III Buffer Zone		60[c]		180[c]	0	0	180[c]
	Old Burn Area IV		7		21	1	3	24
	Acid Neutralization Basin		14		42	3	9	51
	Building 6 Soils/Quench Basin Area		23[d]		69	5	15	84
	Building 7 Soils		9		27	2	6	33
	Building 8 Soils/Pickling Tank Area		27[e]		81	5	15	96
	Other Buffer Zones	Judgmental/ Push Tube and Hand Auger	50[c]	surface and subsurface soil intervals (0-0.5 ft bgs, 0.5-1.0 ft bgs, 1 ft subsequent intervals)	150[c]	0	0	150[c]
	Other Site Soils	Random selection of core sample locations / Push Tube and Hand Auger	59	surface and subsurface soil intervals (0-0.5 ft bgs, 1 ft subsequent intervals)	177	12	36	213

IA	Survey Unit or Area	Sampling Strategy / Collection Method	Number of Planned Sampling Locations	Number of Survey Samples	Number of Planned Volumetric Samples[a]	Number of Contingency Sampling Locations[b]	Number of Contingency Volumetric Samples*	Total Number of Planned and Contingency Volumetric Samples[a]
IA-04	Groundwater Wells	Downgradient wells / Low Flow Pump	39	0	39	8	8	47
IA-05	Surface Water (Junk Ditch)	Judgmental (stream bends) / Dipper and Hand Auger	3 (transects)	0	9	0	0	9
	Sediments (Junk Ditch)		3 (transects)	0	12	0	0	12
IA-06	Building 1 Catch Basin	Judgmental /Scoop or Hand Auger	0	0	0	0	0	0
	Building 6 Catch Basin		5	0	5	0	0	5
	Building 7 Catch Basin		5	0	5	0	0	5
	Building 8 Catch Basin		5	0	5	0	0	5
	Building 9 Catch Basin		5	0	5	0	0	5
IA-07	Wastewater	Judgmental / Dipper, or Other Suitable Method	1	0	2	0	0	2
IA-08	Sludge (sanitary sewer/exterior catch basins)	Judgmental / Scoop or Hand Auger	21	0	22	0	0	22

IA	Survey Unit or Area	Sampling Strategy / Collection Method	Number of Planned Sampling Locations	Number of Survey Samples	Number of Planned Volumetric Samples[a]	Number of Contingency Sampling Locations[b]	Number of Contingency Volumetric Samples*	Total Number of Planned and Contingency Volumetric Samples[a]
Back-ground	Soils	Judgmental / Push Tube or Hand Auger	2	surface and subsurface soil intervals (0-0.5 ft bgs, 1 ft subsequent intervals)	10	0	0	10
Back-ground	Groundwater Wells	Judgmental / Low Flow Pump	10	0	10	0	0	10
Background	Surface Water (Junk Ditch)	Judgmental / Dipper and Hand Auger	1 (transect)	0	3	0	0	3
Background	Sediment (Junk Ditch)		1 (transect)	0	3	0	0	3
Background Surveys	Non-MED Buildings	Survey Instruments	0	100	0	0	0	0

Notes:

[a]The number of samples represents the maximum number of samples to be collected.
[b]Assumes 20% of base boring locations to investigate hotspots.
cAssume 20% of borings and samples will be performed/collected.
[d]includes four (4) borings around assumed Quench Basin Area
[e]includes five (5) borings dissecting Pickling Tank Area

Table 4. Sampling Point Locations for Interiors of Buildings 6, 7, and 9

Sample No.	X Coord. (ft)	Y Coord. (ft)	Sample Area
		Building 6	
1	244.5	1.5	Bldg 6 North Wall
2	10.5	7.5	Bldg 6 North Wall
3	251.5	14.5	Bldg 6 North Wall
4	67.5	15.5	Bldg 6 North Wall
5	161.5	22.5	Bldg 6 North Wall
6	275.5	24.5	Bldg 6 North Wall
7	110.5	28.5	Bldg 6 North Wall
8	259.5	32.5	Bldg 6 North Wall
9	190.5	8	Bldg 6 Sloping Roof North
10	181.5	12	Bldg 6 Sloping Roof North
11	52.5	14	Bldg 6 Sloping Roof North
12	223.5	14	Bldg 6 Sloping Roof North
13	206.5	18	Bldg 6 Sloping Roof North
14	8.5	20	Bldg 6 Sloping Roof North
15	200.5	28	Bldg 6 Sloping Roof North
16	182.5	30	Bldg 6 Sloping Roof North
17	108.5	31	Bldg 6 Sloping Roof North
18	60.5	38	Bldg 6 Sloping Roof North
19	58.5	39	Bldg 6 Sloping Roof North
20	50.5	40	Bldg 6 Sloping Roof North
21	114.5	40	Bldg 6 Sloping Roof North
22	39.5	48	Bldg 6 Sloping Roof North
23	13.5	5.5	Bldg 6 Middle Wall
24	253.5	15.5	Bldg 6 Middle Wall
25	11.5	16.5	Bldg 6 Middle Wall
26	108.5	16.5	Bldg 6 Middle Wall
27	242.5	19.5	Bldg 6 Middle Wall
28	91.5	4.5	Bldg 6 South Wall
29	203.5	2.5	Bldg 6 South Wall

Sample No.	X Coord. (ft)	Y Coord. (ft)	Sample Area
30	131.5	1.5	Bldg 6 South Wall
31	287.5	1.5	Bldg 6 South Wall
32	218.5	2.5	Bldg 6 Floor
33	81.5	14.5	Bldg 6 Floor
34	141.5	15.5	Bldg 6 Floor
35	199.5	15.5	Bldg 6 Floor
36	202.5	30.5	Bldg 6 Floor
37	225.5	35.5	Bldg 6 Floor
38	44.5	41.5	Bldg 6 Floor
39	151.5	46.5	Bldg 6 Floor
40	124.5	59.5	Bldg 6 Floor
41	245.5	63.5	Bldg 6 Floor
42	83.5	64.5	Bldg 6 Floor
43	96.5	66.5	Bldg 6 Floor
44	30.5	69.5	Bldg 6 Floor
45	290.5	69.5	Bldg 6 Floor
46	115.5	71.5	Bldg 6 Floor
47	139.5	75.5	Bldg 6 Floor
48	54.5	77.5	Bldg 6 Floor
49	262.5	78.5	Bldg 6 Floor
50	92.5	80.5	Bldg 6 Floor
51	187.5	81.5	Bldg 6 Floor
52	148.5	84.5	Bldg 6 Floor
53	162.5	88.5	Bldg 6 Floor
54	39.5	89.5	Bldg 6 Floor
55	97.5	95.5	Bldg 6 Floor
56	222.5	95.5	Bldg 6 Floor
57	23.5	44.5	Bldg 6 West Wall
58	20.5	87.5	Bldg 6 West Wall
59	6.5	43.5	Bldg 6 East Wall
		Building 7	
1	183.5	1.5	Bldg 7 North Wall
2	256.5	1.5	Bldg 7 North Wall
3	195.5	9.5	Bldg 7 North Wall
4	51.5	10.5	Bldg 7 North Wall
5	240.5	16.5	Bldg 7 North Wall
6	111.5	18.5	Bldg 7 North Wall
7	288.5	22.5	Bldg 7 North Wall
8	20.5	27.5	Bldg 7 North Wall
9	138.5	28.5	Bldg 7 North Wall
10	140.5	28.5	Bldg 7 North Wall

Sample No.	X Coord. (ft)	Y Coord. (ft)	Sample Area
11	115.5	31.5	Bldg 7 North Wall
12	178.5	33.5	Bldg 7 North Wall
13	274.5	10.5	Bldg 7 South Wall
14	161.5	8.5	Bldg 7 South Wall
15	76.5	5.5	Bldg 7 South Wall
16	146.5	0.5	Bldg 7 South Wall
17	199.5	0.5	Bldg 7 South Wall
18	63.5	3	Bldg 7 Roof
19	54.5	5	Bldg 7 Roof
20	82.5	7	Bldg 7 Roof
21	209.5	7	Bldg 7 Roof
22	67.5	8	Bldg 7 Roof
23	278.5	8	Bldg 7 Roof
24	191.5	15	Bldg 7 Roof
25	287.5	16	Bldg 7 Roof
26	107.5	18	Bldg 7 Roof
27	148.5	21	Bldg 7 Roof
28	168.5	21	Bldg 7 Roof
29	169.5	25	Bldg 7 Roof
30	101.5	36	Bldg 7 Roof
31	281.5	37	Bldg 7 Roof
32	56.5	39	Bldg 7 Roof
33	185.5	39	Bldg 7 Roof
34	64.5	45	Bldg 7 Roof
35	98.5	48	Bldg 7 Roof
36	106.5	2.5	Bldg 7 Floor
37	230.5	3.5	Bldg 7 Floor
38	280.5	7.5	Bldg 7 Floor
39	80.5	11.5	Bldg 7 Floor
40	30.5	12.5	Bldg 7 Floor
41	226.5	13.5	Bldg 7 Floor
42	262.5	23.5	Bldg 7 Floor
43	106.5	28.5	Bldg 7 Floor
44	194.5	29.5	Bldg 7 Floor
45	210.5	29.5	Bldg 7 Floor
46	16.5	31.5	Bldg 7 Floor
47	133.5	33.5	Bldg 7 Floor
48	155.5	37.5	Bldg 7 Floor
49	55.5	38.5	Bldg 7 Floor
50	35.5	43.5	Bldg 7 Floor
51	51.5	45.5	Bldg 7 Floor

Sample No.	X Coord. (ft)	Y Coord. (ft)	Sample Area
52	8.5	0.5	Bldg 7 West Wall
53	3.5	9.5	Bldg 7 West Wall
54	6.5	43.5	Bldg 7 West Wall
55	7.5	14.5	Bldg 7 East Wall
56	26.5	0.5	Bldg 7A North Wall
57	1.5	6.5	Bldg 7A Floor
58	20.5	10.5	Bldg 7A Floor
59	18.5	19.5	Bldg 7A Roof
		Building 9	
1	236.5	1.5	Bldg 9 West Wall
2	137.5	4.5	Bldg 9 West Wall
3	183.5	12.5	Bldg 9 West Wall
4	45.5	24.5	Bldg 9 West Wall
5	90.5	24.5	Bldg 9 West Wall
6	175.5	25.5	Bldg 9 West Wall
7	236.5	26.5	Bldg 9 West Wall
8	219.5	29.5	Bldg 9 West Wall
9	259.5	32.5	Bldg 9 East Wall
10	145.5	28.5	Bldg 9 East Wall
11	162.5	22.5	Bldg 9 East Wall
12	40.5	19.5	Bldg 9 East Wall
13	31.5	16.5	Bldg 9 East Wall
14	209.5	16.5	Bldg 9 East Wall
15	226.5	8.5	Bldg 9 East Wall
16	126.5	1.5	Bldg 9 East Wall
17	107.5	8	Bldg 9 West Roof
18	196.5	10	Bldg 9 West Roof
19	206.5	13	Bldg 9 West Roof
20	83.5	20	Bldg 9 West Roof
21	102.5	20	Bldg 9 West Roof
22	89.5	22	Bldg 9 West Roof
23	25.5	25	Bldg 9 West Roof
24	254.5	26	Bldg 9 West Roof
25	149.5	29	Bldg 9 West Roof
26	2.5	32	Bldg 9 West Roof
27	86.5	42	Bldg 9 West Roof
28	85.5	2	Bldg 9 East Roof
29	19.5	4	Bldg 9 East Roof
30	219.5	8	Bldg 9 East Roof
31	221.5	8	Bldg 9 East Roof
32	135.5	14	Bldg 9 East Roof

Sample No.	X Coord. (ft)	Y Coord. (ft)	Sample Area
33	166.5	16	Bldg 9 East Roof
34	21.5	19	Bldg 9 East Roof
35	48.5	20	Bldg 9 East Roof
36	49.5	24	Bldg 9 East Roof
37	230.5	31	Bldg 9 East Roof
38	41.5	42	Bldg 9 East Roof
39	40.5	1.5	Bldg 9 Floor
40	57.5	1.5	Bldg 9 Floor
41	212.5	1.5	Bldg 9 Floor
42	92.5	14.5	Bldg 9 Floor
43	222.5	14.5	Bldg 9 Floor
44	259.5	17.5	Bldg 9 Floor
45	2.5	18.5	Bldg 9 Floor
46	192.5	27.5	Bldg 9 Floor
47	189.5	30.5	Bldg 9 Floor
48	57.5	31.5	Bldg 9 Floor
49	145.5	31.5	Bldg 9 Floor
50	12.5	33.5	Bldg 9 Floor
51	46.5	42.5	Bldg 9 Floor
52	221.5	49.5	Bldg 9 Floor
53	63.5	51.5	Bldg 9 Floor
54	129.5	53.5	Bldg 9 Floor
55	128.5	58.5	Bldg 9 Floor
56	35.5	66.5	Bldg 9 Floor
57	93.5	66.5	Bldg 9 Floor
58	244.5	71.5	Bldg 9 Floor
59	143.5	72.5	Bldg 9 Floor

Table 5. Sampling Point Locations for Interior of Building 1

Sample No.	X Coord. (ft)	Y Coord. (ft)	Sample Area
		Building 1	
1	118.5	6.5	Bldg 1 North Wall
2	23.5	10.5	Bldg 1 North Wall
3	129.5	10.5	Bldg 1 South Wall
4	149.5	0.5	Bldg 1 Roof
5	136.5	3.5	Bldg 1 Roof
6	40.5	6.5	Bldg 1 Roof
7	5.5	28.5	Bldg 1 Roof
8	111.5	28.5	Bldg 1 Roof
9	34.5	42.5	Bldg 1 Roof
10	115.5	50.5	Bldg 1 Roof
11	133.5	56.5	Bldg 1 Roof
12	17.5	60.5	Bldg 1 Roof
13	24.5	61.5	Bldg 1 Roof
14	81.5	65.5	Bldg 1 Roof
15	23.5	77.5	Bldg 1 Roof
16	152.5	83.5	Bldg 1 Roof
17	132.5	3.5	Bldg 1 Floor
18	137.5	10.5	Bldg 1 Floor
19	61.5	14.5	Bldg 1 Floor
20	18.5	26.5	Bldg 1 Floor
21	133.5	32.5	Bldg 1 Floor
22	45.5	34.5	Bldg 1 Floor
23	1.5	38.5	Bldg 1 Floor
24	134.5	38.5	Bldg 1 Floor
25	158.5	43.5	Bldg 1 Floor
26	37.5	62.5	Bldg 1 Floor
27	148.5	64.5	Bldg 1 Floor
28	101.5	70.5	Bldg 1 Floor
29	3.5	44.5	Bldg 1 West Wall

Table 6. Sampling Point Locations for Exteriors of Buildings 1, 6, 7, 8, and 9

Sample No.	X Coord. (ft)	Y Coord. (ft)	Sample Area
		Building 1	
1	36.5	8.5	Bldg 1 South Wall
2	35.5	6.5	Bldg 1 Roof
3	150.5	35.5	Bldg 1 Roof
4	124.5	52.5	Bldg 1 Roof
5	33.5	61.5	Bldg 1 Roof
6	117.5	88.5	Bldg 1 Roof
7	8.5	87.5	Bldg 1 East Wall
		Building 6	
8	243.5	10.5	Bldg 6 North Wall
9	281.5	8.5	Bldg 6 North Wall
10	238.5	16.5	Bldg 6 Sloping Roof North Section
11	207.5	20.5	Bldg 6 Sloping Roof North Section
12	246.5	20.5	Bldg 6 Sloping Roof North Section
13	284.5	30.5	Bldg 6 Sloping Roof North Section
14	61.5	31.5	Bldg 6 Sloping Roof North Section
15	38.5	44.5	Bldg 6 Sloping Roof North Section
16	60.5	10.5	Bldg 6 Middle Wall
17	84.5	3.5	Bldg 6 Middle Wall
18	69.5	0	Bldg 6 Middle Wall
19	223.5	6.5	Bldg 6 South Wall
		Building 7	
20	4.5	21.5	Bldg 7 North Wall
21	227.5	20.5	Bldg 7 North Wall
22	286.5	16.5	Bldg 7 North Wall
23	218.5	8.5	Bldg 7 Roof
24	67.5	15.5	Bldg 7 Roof
25	48.5	21.5	Bldg 7 Roof
26	234.5	23.5	Bldg 7 Roof
27	43.5	34.5	Bldg 7 Roof
28	81.5	36.5	Bldg 7 Roof
29	19.5	19.5	Bldg 7 East Wall

		Building 8	
30	163.5	11.5	Bldg 8 North Wall
31	119.5	2.5	Bldg 8 North Wall
32	144.5	8.5	Bldg 8 South Wall
33	67.5	15.5	Bldg 8 South Wall
34	43.5	18.5	Bldg 8 South Wall
35	102.5	4.5	Bldg 8 North Side Roof
36	208.5	10.5	Bldg 8 North Side Roof
37	196.5	11.5	Bldg 8 North Side Roof
38	55.5	23.5	Bldg 8 North Side Roof
39	162.5	24.5	Bldg 8 North Side Roof
40	131.5	26.5	Bldg 8 North Side Roof
41	82.5	5.5	Bldg 8 South Side Roof
42	114.5	14.5	Bldg 8 South Side Roof
43	192.5	15.5	Bldg 8 South Side Roof
44	60.5	30.5	Bldg 8 South Side Roof
		Building 9	
45	149.5	24.5	Bldg 9 West Wall
46	171.5	16.5	Bldg 9 West Wall
47	50.5	6.5	Bldg 9 West Wall
48	106.5	0	Bldg 9 West Wall
49	245.5	30.5	Bldg 9 East Wall
50	44.5	18.5	Bldg 9 West Side Roof
51	146.5	18.5	Bldg 9 West Side Roof
52	171.5	18.5	Bldg 9 West Side Roof
53	89.5	19.5	Bldg 9 West Side Roof
54	39.5	35.5	Bldg 9 West Side Roof
55	142.5	41.5	Bldg 9 West Side Roof
56	135.5	0.5	Bldg 9 East Side Roof
57	19.5	39.5	Bldg 9 East Side Roof
58	20.5	39.5	Bldg 9 East Side Roof
59	17.5	41.5	Bldg 9 East Side Roof

Table 7. Sampling Point Locations for Class 1 Soils and Class 2 Buffer Zone

X Coord (ft)*	Y Coord (ft)*	Label	Sample Area
	Old Burn Area I		
465331.6	2121500.8	1	Old Burn Area I
465352.5	2121500.8	2	Old Burn Area I
465321.2	2121517.8	3	Old Burn Area I
465342.1	2121517.8	4	Old Burn Area I
465363	2121517.8	5	Old Burn Area I
465269	2121534.8	6	Old Burn Area I
465289.9	2121534.8	7	Old Burn Area I
465310.8	2121534.8	8	Old Burn Area I
465331.6	2121534.8	9	Old Burn Area I
465352.5	2121534.8	10	Old Burn Area I
465258.5	2121551.8	11	Old Burn Area I
465279.4	2121551.8	12	Old Burn Area I
465300.3	2121551.8	13	Old Burn Area I
465321.2	2121551.8	14	Old Burn Area I
465342.1	2121551.8	15	Old Burn Area I
465269	2121568.8	16	Old Burn Area I
465289.9	2121568.8	17	Old Burn Area I
465310.8	2121568.8	18	Old Burn Area I
465331.6	2121568.8	19	Old Burn Area I
465352.5	2121568.8	20	Old Burn Area I
	Old Burn Area II		
465394.8	2121220.6	1	Old Burn Area II
465405.1	2121237.2	2	Old Burn Area II
465425.6	2121237.2	3	Old Burn Area II
465446.1	2121237.2	4	Old Burn Area II
465394.8	2121253.9	5	Old Burn Area II
465415.3	2121253.9	6	Old Burn Area II
465435.8	2121253.9	7	Old Burn Area II
465405.1	2121270.5	8	Old Burn Area II
465425.6	2121270.5	9	Old Burn Area II
465446.1	2121270.5	10	Old Burn Area II
465394.8	2121287.2	11	Old Burn Area II
465415.3	2121287.2	12	Old Burn Area II
465435.8	2121287.2	13	Old Burn Area II
465405.1	2121303.8	14	Old Burn Area II
465425.6	2121303.8	15	Old Burn Area II
465446.1	2121303.8	16	Old Burn Area II
465394.8	2121320.5	17	Old Burn Area II

X Coord (ft)*	Y Coord (ft)*	Label	Sample Area
465415.3	2121320.5	18	Old Burn Area II
465435.8	2121320.5	19	Old Burn Area II
	Old Burn Area III		
465072.9	2121488.7	1	Old Burn Area III
465091.6	2121488.7	2	Old Burn Area III
465026.3	2121503.7	3	Old Burn Area III
465045.0	2121503.7	4	Old Burn Area III
465063.6	2121503.7	5	Old Burn Area III
465082.2	2121499.0	6	Old Burn Area III
465101.2	2121498.6	7	Old Burn Area III
465026.2	2121518.6	8	Old Burn Area III
465044.8	2121518.6	9	Old Burn Area III
465063.4	2121518.6	10	Old Burn Area III
465074.4	2121511.0	11	Old Burn Area III
465026.3	2121533.8	12	Old Burn Area III
465045.0	2121533.8	13	Old Burn Area III
465063.6	2121533.8	14	Old Burn Area III
465055.6	2121527.0	15	Old Burn Area III
465055.1	2121510.9	16	Old Burn Area III
465025.5	2121548.6	17	Old Burn Area III
465044.1	2121548.6	18	Old Burn Area III
465062.7	2121548.6	19	Old Burn Area III
465055.0	2121540.3	20	Old Burn Area III
465026.3	2121563.9	21	Old Burn Area III
465045.0	2121563.9	22	Old Burn Area III
465063.6	2121563.9	23	Old Burn Area III
465082.2	2121563.9	24	Old Burn Area III
465100.9	2121563.9	25	Old Burn Area III
465035.7	2121578.9	26	Old Burn Area III
465054.3	2121578.9	27	Old Burn Area III
465072.9	2121578.9	28	Old Burn Area III
465091.6	2121578.9	29	Old Burn Area III
	Old Burn Area III Bufferzone		
464946.9	2121500.7	1	Old Burn Area III Bufferzone
464967.4	2121500.7	2	Old Burn Area III Bufferzone
464988.0	2121500.7	3	Old Burn Area III Bufferzone
465008.5	2121500.7	4	Old Burn Area III Bufferzone
464957.2	2121517.3	5	Old Burn Area III Bufferzone
464977.7	2121517.3	6	Old Burn Area III Bufferzone
464998.2	2121517.3	7	Old Burn Area III Bufferzone
465018.8	2121517.3	8	Old Burn Area III Bufferzone
464946.9	2121534.0	9	Old Burn Area III Bufferzone

X Coord (ft)*	Y Coord (ft)*	Label	Sample Area
464967.4	2121534.0	10	Old Burn Area III Bufferzone
464988.0	2121534.0	11	Old Burn Area III Bufferzone
465008.5	2121534.0	12	Old Burn Area III Bufferzone
464957.2	2121550.7	13	Old Burn Area III Bufferzone
464977.7	2121550.7	14	Old Burn Area III Bufferzone
464998.2	2121550.7	15	Old Burn Area III Bufferzone
465018.8	2121550.7	16	Old Burn Area III Bufferzone
464946.9	2121567.4	17	Old Burn Area III Bufferzone
464967.4	2121567.4	18	Old Burn Area III Bufferzone
464988.0	2121567.4	19	Old Burn Area III Bufferzone
465008.5	2121567.4	20	Old Burn Area III Bufferzone
464957.2	2121584.1	21	Old Burn Area III Bufferzone
464977.7	2121584.1	22	Old Burn Area III Bufferzone
464998.2	2121584.1	23	Old Burn Area III Bufferzone
465018.8	2121584.1	24	Old Burn Area III Bufferzone
465039.3	2121584.1	25	Old Burn Area III Bufferzone
465059.8	2121584.1	26	Old Burn Area III Bufferzone
465080.4	2121584.1	27	Old Burn Area III Bufferzone
465100.9	2121584.1	28	Old Burn Area III Bufferzone
464946.9	2121600.8	29	Old Burn Area III Bufferzone
464967.4	2121600.8	30	Old Burn Area III Bufferzone
464988.0	2121600.8	31	Old Burn Area III Bufferzone
465008.5	2121600.8	32	Old Burn Area III Bufferzone
465029.0	2121600.8	33	Old Burn Area III Bufferzone
465049.6	2121600.8	34	Old Burn Area III Bufferzone
465070.1	2121600.8	35	Old Burn Area III Bufferzone
465090.6	2121600.8	36	Old Burn Area III Bufferzone
464957.2	2121617.5	37	Old Burn Area III Bufferzone
464977.7	2121617.5	38	Old Burn Area III Bufferzone
464998.2	2121617.5	39	Old Burn Area III Bufferzone
465018.8	2121617.5	40	Old Burn Area III Bufferzone
465039.3	2121617.5	41	Old Burn Area III Bufferzone
465059.8	2121617.5	42	Old Burn Area III Bufferzone
465080.4	2121617.5	43	Old Burn Area III Bufferzone
465100.9	2121617.5	44	Old Burn Area III Bufferzone
464946.9	2121634.1	45	Old Burn Area III Bufferzone
464967.4	2121634.1	46	Old Burn Area III Bufferzone
464988.0	2121634.1	47	Old Burn Area III Bufferzone
465008.5	2121634.1	48	Old Burn Area III Bufferzone
465029.0	2121634.1	49	Old Burn Area III Bufferzone
465049.6	2121634.1	50	Old Burn Area III Bufferzone
465070.1	2121634.1	51	Old Burn Area III Bufferzone

X Coord (ft)*	Y Coord (ft)*	Label	Sample Area
465090.6	2121634.1	52	Old Burn Area III Bufferzone
464957.2	2121650.8	53	Old Burn Area III Bufferzone
464977.7	2121650.8	54	Old Burn Area III Bufferzone
464998.2	2121650.8	55	Old Burn Area III Bufferzone
465018.8	2121650.8	56	Old Burn Area III Bufferzone
465039.3	2121650.8	57	Old Burn Area III Bufferzone
465059.8	2121650.8	58	Old Burn Area III Bufferzone
465080.4	2121650.8	59	Old Burn Area III Bufferzone
465100.9	2121650.8	60	Old Burn Area III Bufferzone
	Old Burn Area IV		
465133.2	2121404	1	Old Burn Area IV
465152.1	2121404	2	Old Burn Area IV
465171	2121404	3	Old Burn Area IV
465189.8	2121404	4	Old Burn Area IV
465208.7	2121404	5	Old Burn Area IV
465227.5	2121404	6	Old Burn Area IV
465246.4	2121404	7	Old Burn Area IV

X Coord (ft)**	Y Coord (ft)**	Label	Sample Area
		Building 8 Soil	
39.2728	10.9678	1	Building 8 Soil
81.5105	10.9678	2	Building 8 Soil
123.7481	10.9678	3	Building 8 Soil
165.9857	10.9678	4	Building 8 Soil
208.2234	10.9678	5	Building 8 Soil
250.461	10.9678	6	Building 8 Soil
292.6987	10.9678	7	Building 8 Soil
334.9363	10.9678	8	Building 8 Soil
377.1739	10.9678	9	Building 8 Soil
419.4116	10.9678	10	Building 8 Soil
461.6492	10.9678	11	Building 8 Soil
18.154	46.4486	12	Building 8 Soil
60.3916	46.4486	13	Building 8 Soil
102.6293	46.4486	14	Building 8 Soil
144.8669	46.4486	15	Building 8 Soil
187.1046	46.4486	16	Building 8 Soil
229.3422	46.4486	17	Building 8 Soil
271.5798	46.4486	18	Building 8 Soil
313.8175	46.4486	19	Building 8 Soil
356.0551	46.4486	20	Building 8 Soil
398.2927	46.4486	21	Building 8 Soil
440.5304	46.4486	22	Building 8 Soil
349	33	23	Building 8 Soil (Pickling Tank Area)
349	19	24	Building 8 Soil (Pickling Tank Area)
349	5.5	25	Building 8 Soil (Pickling Tank Area)
349	-5.5	26	Building 8 Soil (Pickling Tank Area)
349	-14.5	27	Building 8 Soil (Pickling Tank Area)
		Building 7 Soil	
21	5	1	Building 7 Soil
127	5	2	Building 7 Soil
233	5	3	Building 7 Soil
75	21	4	Building 7 Soil
180	21	5	Building 7 Soil
21	40	6	Building 7 Soil
127	40	7	Building 7 Soil
233	40	8	Building 7 Soil
277	21	9	Building 7 Soil
		Building 6 Soil	
35.3523	5.8136	3	Building 6 Soil
85.0895	5.8136	4	Building 6 Soil
134.8267	5.8136	5	Building 6 Soil

X Coord (ft)**	Y Coord (ft)**	Label	Sample Area
184.5639	5.8136	6	Building 6 Soil
234.3011	5.8136	7	Building 6 Soil
284.0383	5.8136	8	Building 6 Soil
333.7755	5.8136	9	Building 6 Soil
60.2209	47.7892	10	Building 6 Soil
109.9581	47.7892	11	Building 6 Soil
159.6953	47.7892	12	Building 6 Soil
209.4325	47.7892	13	Building 6 Soil
259.1697	47.7892	14	Building 6 Soil
308.9069	47.7892	15	Building 6 Soil
35.3523	89.7648	16	Building 6 Soil
85.0895	89.7648	17	Building 6 Soil
134.8267	89.7648	18	Building 6 Soil
184.5639	89.7648	19	Building 6 Soil
234.3011	89.7648	20	Building 6 Soil
284.0383	89.7648	21	Building 6 Soil
TBD	TBD	20	Building 6 Soil (Quench Basin)
TBD	TBD	21	Building 6 Soil (Quench Basin)
TBD	TBD	22	Building 6 Soil (Quench Basin)
TBD	TBD	23	Building 6 Soil (Quench Basin)

*Coordinates for exterior borings are based on NAD_1983_StatePlane_Indiana_East_FIPS_1301_Feet

**Coordinates for borings inside buildings are based on using the southwest corner of the building as a reference point (e.g., For Building 8 - 349 feet east of southwest corner and 33 feet north of south wall).

TBD – Sample location to be determined in the field.

Table 8. Background Soil and Random Soil Sampling Point Locations for Remaining Site Footprint

X Center (ft)*	Y Center (ft)*	Label	Sample Area
Remaining Site Soils			
464609.7	2120123.1	1	Remaining Site Soils
464409.7	2120183.1	2	Remaining Site Soils
464589.7	2120183.1	3	Remaining Site Soils
464629.7	2120183.1	4	Remaining Site Soils
464189.7	2120283.1	5	Remaining Site Soils
464069.7	2120343.1	6	Remaining Site Soils
464509.7	2120403.1	7	Remaining Site Soils
465169.7	2120423.1	8	Remaining Site Soils
465419.7	2121575.4	9	Remaining Site Soils
464689.7	2120503.1	10	Remaining Site Soils
464369.7	2120543.1	11	Remaining Site Soils
464729.7	2120543.1	12	Remaining Site Soils
465229.7	2120603.1	13	Remaining Site Soils
464229.7	2120623.1	14	Remaining Site Soils
464809.7	2120623.1	15	Remaining Site Soils
465046.2	2120708.2	16	Remaining Site Soils
464049.7	2120723.1	17	Remaining Site Soils
464829.7	2120743.1	18	Remaining Site Soils
465420.1	2121544.1	19	Remaining Site Soils
465007.0	2120920.1	20	Remaining Site Soils
464669.7	2120803.1	21	Remaining Site Soils
463849.7	2120863.1	22	Remaining Site Soils
464852.1	2120868.2	23	Remaining Site Soils
464709.7	2120883.1	24	Remaining Site Soils
465369.7	2120883.1	25	Remaining Site Soils
464649.7	2120903.1	26	Remaining Site Soils
463969.7	2120923.1	27	Remaining Site Soils
464869.7	2120943.1	28	Remaining Site Soils
465409.7	2120963.1	29	Remaining Site Soils
464810.4	2121631.7	30	Remaining Site Soils
463809.7	2121023.1	31	Remaining Site Soils
463929.7	2121063.1	32	Remaining Site Soils
463989.7	2121083.1	33	Remaining Site Soils
464749.7	2121103.1	34	Remaining Site Soils
465084.4	2121705.4	35	Remaining Site Soils
465475.9	2121547.8	36	Remaining Site Soils
463949.7	2121143.1	37	Remaining Site Soils
463789.7	2121183.1	38	Remaining Site Soils

X Center (ft)*	Y Center (ft)*	Label	Sample Area
Remaining Site Soils			
464189.7	2121243.1	39	Remaining Site Soils
465369.7	2121243.1	40	Remaining Site Soils
464809.7	2121323.1	41	Remaining Site Soils
465513.5	2121400.5	42	Remaining Site Soils
464409.7	2121423.1	43	Remaining Site Soils
464809.7	2121443.1	44	Remaining Site Soils
463809.7	2121523.1	45	Remaining Site Soils
464089.7	2121523.1	46	Remaining Site Soils
464429.7	2121523.1	47	Remaining Site Soils
463889.7	2121563.1	48	Remaining Site Soils
465389.7	2121563.1	49	Remaining Site Soils
464409.7	2121603.1	50	Remaining Site Soils
464049.7	2121663.1	51	Remaining Site Soils
464129.7	2121663.1	52	Remaining Site Soils
465269.7	2121663.1	53	Remaining Site Soils
464009.7	2121743.1	54	Remaining Site Soils
464429.7	2121763.1	55	Remaining Site Soils
464089.7	2121843.1	56	Remaining Site Soils
464009.7	2121903.1	57	Remaining Site Soils
464129.7	2121983.1	58	Remaining Site Soils
464189.7	2121983.1	59	Remaining Site Soils
Background Soils			
463783.2	2121343.0	BS-1	Background Soils
464135.6	2120239.4	BS-2	Background Soils

*Coordinates: NAD_1983_StatePlane_Indiana_East_FIPS_1301_Feet

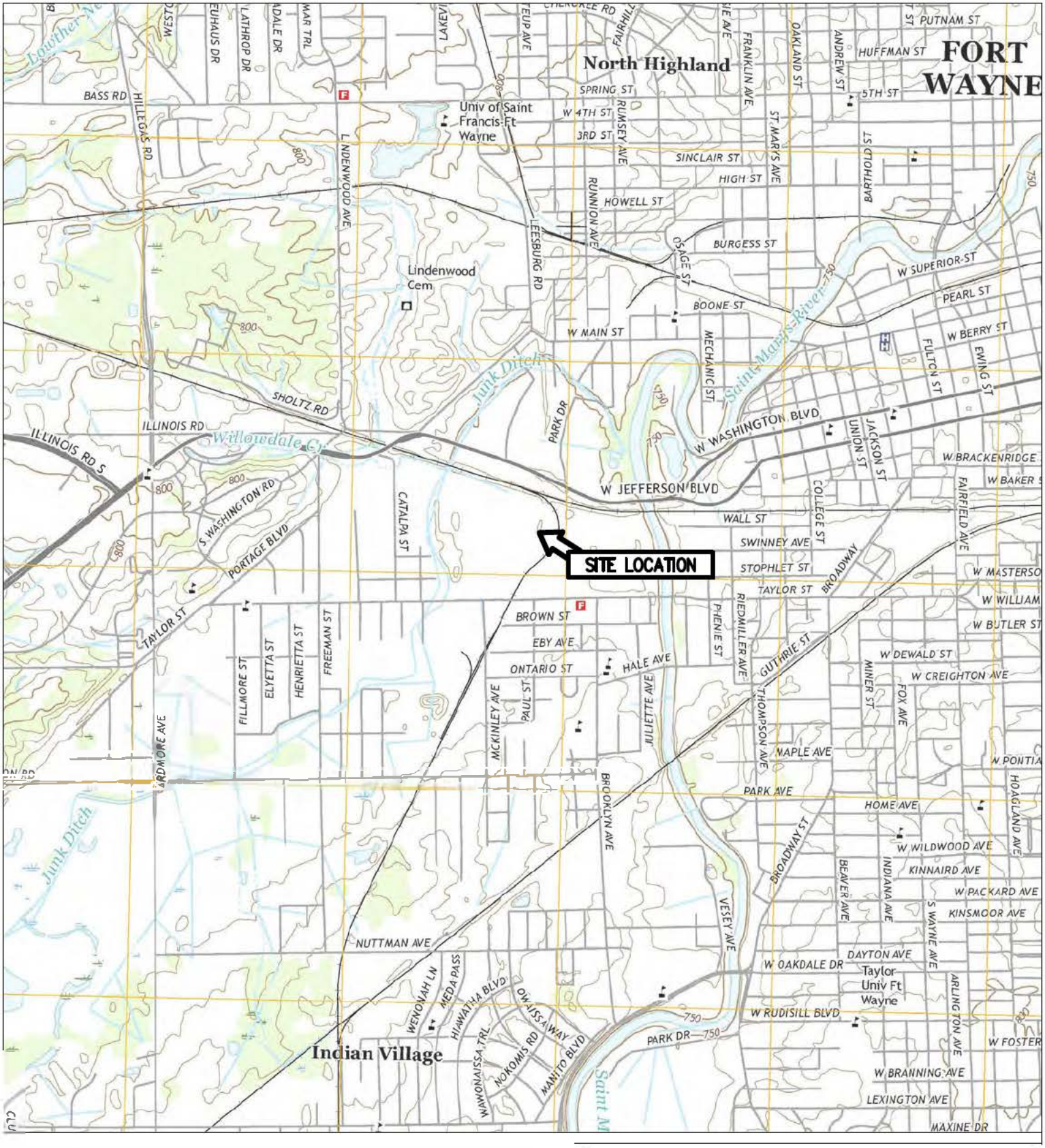
Table 9. Junk Ditch Surface Water and Sediment Sampling Locations

X Center (ft)*	Y Center (ft)*	Sample Area
463913.3	2119928.3	Junk Ditch Background (South)
463741.1	2120990.6	Junk Ditch Location 1
463747.3	2121451.3	Junk Ditch Location 2
464001.2	2121981.9	Junk Ditch Location 3 (North)

*Coordinates: NAD_1983_StatePlane_Indiana_East_FIPS_1301_Feet

VOLUME 1 – FIELD SAMPLING PLAN
REMEDIAL INVESTIGATION DESIGN
FORMER JOSLYN MANUFACTURING AND SUPPLY COMPANY
FORT WAYNE, INDIANA
MAY 2019

FIGURES



Fort Wayne East, IN
USGS Quadrangle 2016
Contour Interval: 20 Feet

QUADRANGLE LOCATION

SCALE IN FEET
250 0 500 1,000 1,500 2,000

FIGURE 1
SITE LOCATION
FORMER JOSLYN MANUFACTURING AND SUPPLY COMPANY
2400 TAYLOR ST
FORT WAYNE, IN

PARS ENVIRONMENTAL, INC.
500 HORIZON DRIVE SUITE 540 ROBBINSVILLE, NEW JERSEY

DRAWN BY:	MN	JOB NUMBER:	129908-01
CHECKED BY:	HB	DATE:	11/26/18

LEGEND

= SITE BOUNDARY

SCALE IN FEET

50 0 100 200 300

FIGURE 2
SITE PLAN
FORMER JOSLYN MANUFACTURING AND SUPPLY COMPANY
2400 TAYLOR ST
FORT WAYNE, IN

PARS ENVIRONMENTAL, INC.
500 HORIZON DRIVE SUITE 540 ROBBINSVILLE, NEW JERSEY

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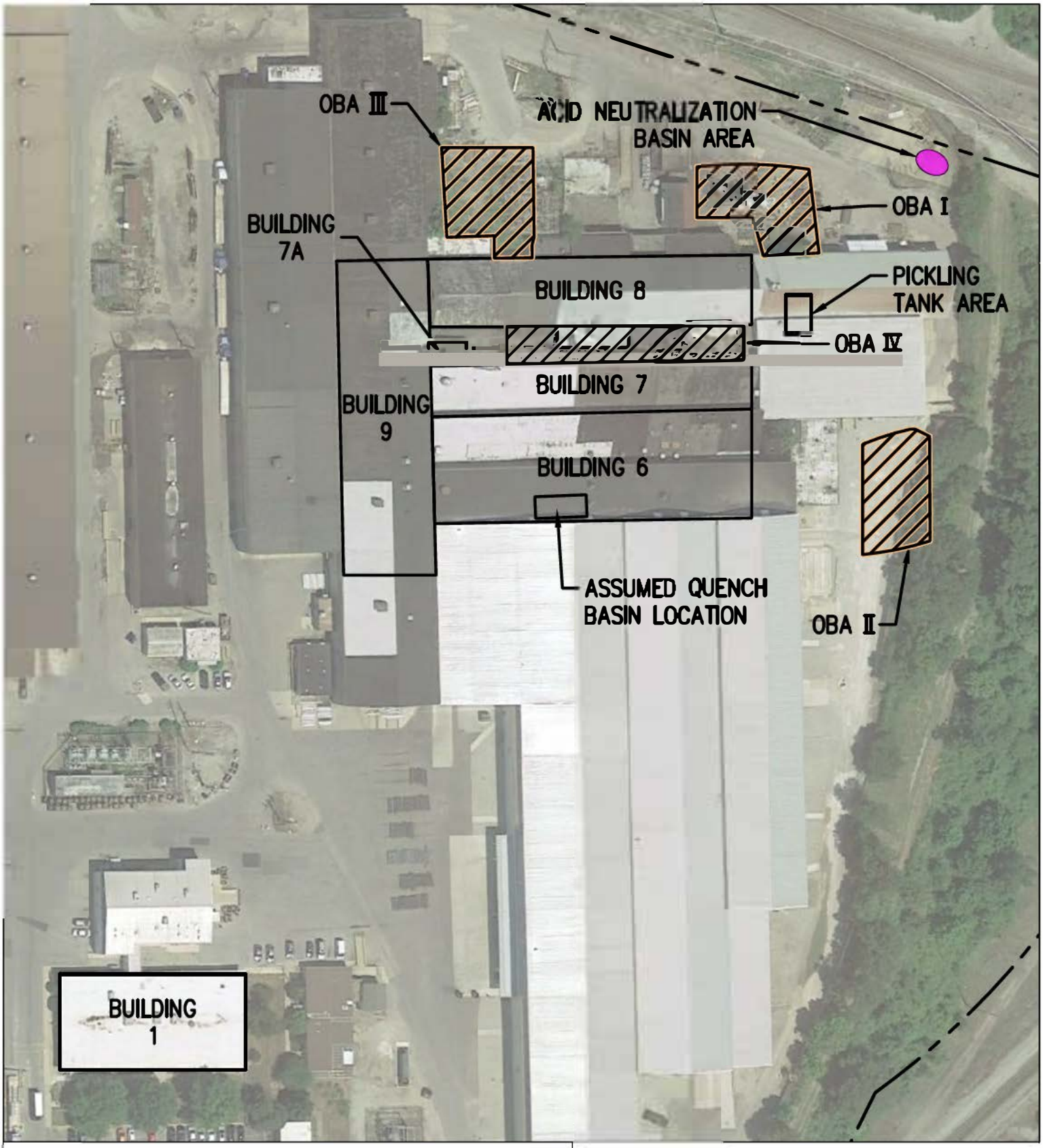

LEGEND

= SITE BOUNDARY

OBA = OLD BURN AREA

NOTE:
ADDITIONAL INVESTIGATIVE AREAS INCLUDING JUNK DITCH, FACILITY SEWERS, SITE-WIDE SOILS AND GROUNDWATER ARE NOT SHOWN IN FIGURE 3.

SCALE IN FEET
20 0 40 80 120

FIGURE 3
MED/AEC ERA INVESTIGATION AREAS
FORMER JOSLYN MANUFACTURING AND SUPPLY COMPANY
2400 TAYLOR ST
FORT WAYNE, IN

PARS ENVIRONMENTAL, INC.
500 HORIZON DRIVE SUITE 540 ROBBINSVILLE, NEW JERSEY

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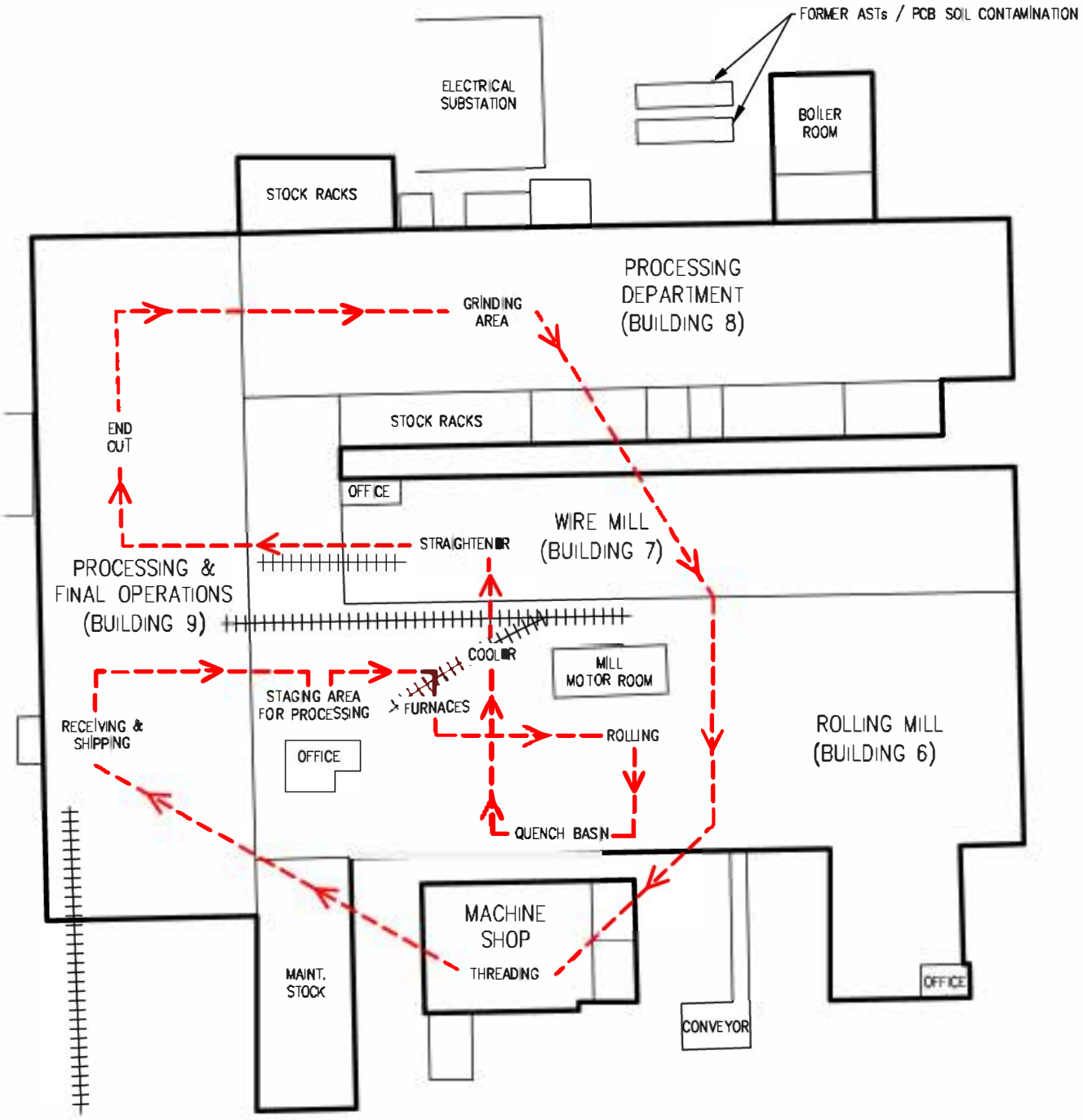

LEGEND

= BUILDING OUTLINE

= PROCESS FLOW

= RAILROAD TRACKS

NOTE:
THIS FIGURE IS HISTORIC AND DOES NOT REPRESENT CURRENT SITE CONDITIONS

SCALE IN FEET

10 0 20 40 60

FIGURE 4
HISTORIC OPERATIONAL PROCESS FLOW DIAGRAM
FORMER JOSLYN MANUFACTURING AND SUPPLY COMPANY
2400 TAYLOR ST
FORT WAYNE, IN

PARS ENVIRONMENTAL, INC.
500 HORIZON DRIVE SUITE 540 ROBBINSVILLE, NEW JERSEY

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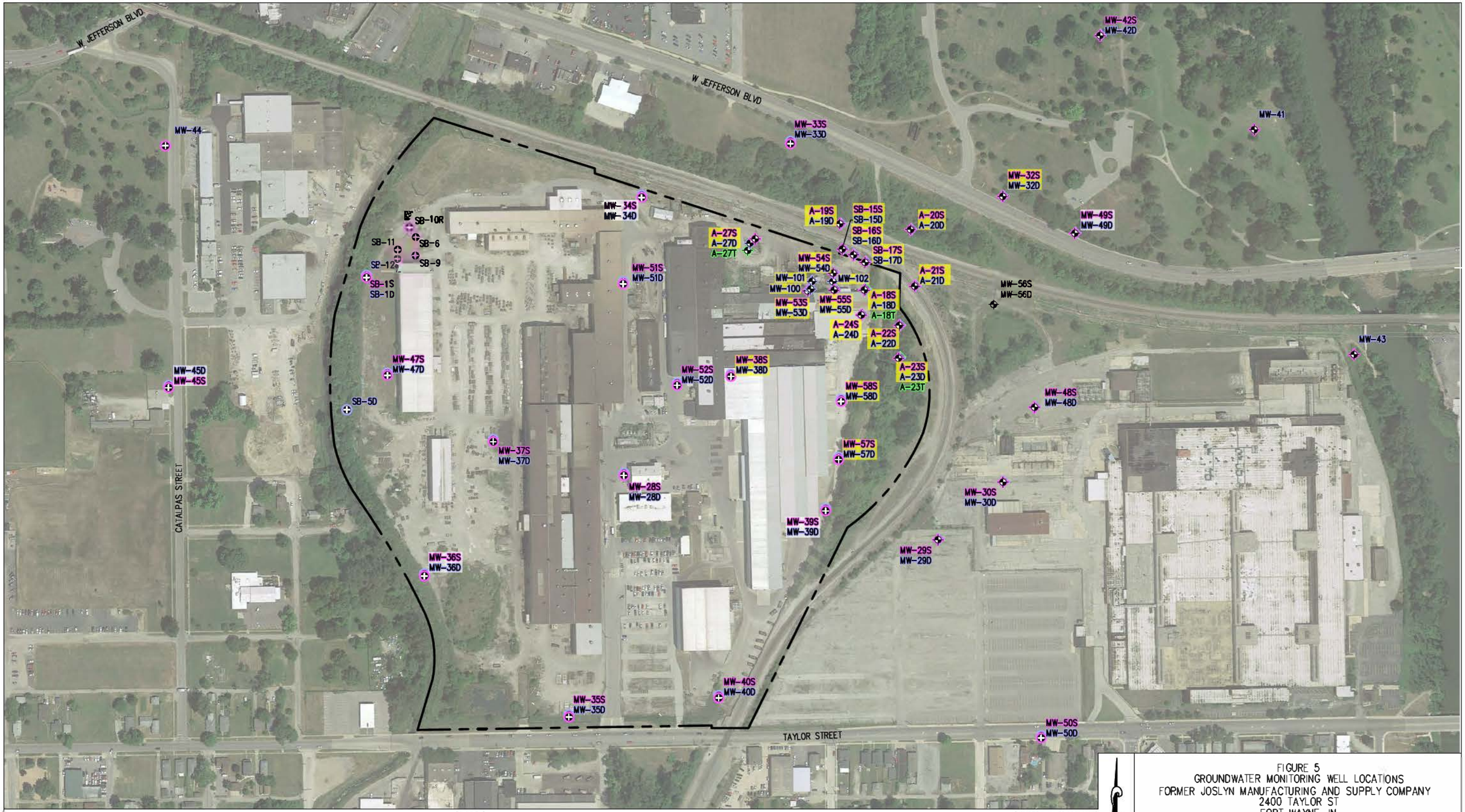

LEGEND

- = SITE BOUNDARY
- = FORT WAYNE STAINLESS WELLS
- = VALBRUNA STAINLESS STEEL WELLS
- = SCREEN INTERVAL – DEEP
- = SCREEN INTERVAL – SHALLOW
- = SCREEN INTERVAL – TRAFALGAR
- = WELLS TO BE SAMPLED
- = BACKGROUND WELLS TO BE SAMPLED

SCALE IN FEET

50 0 100 200 300

FIGURE 5
GROUNDWATER MONITORING WELL LOCATIONS
FORMER JOSLYN MANUFACTURING AND SUPPLY COMPANY
2400 TAYLOR ST
FORT WAYNE, IN

PARS ENVIRONMENTAL, INC.
500 HORIZON DRIVE SUITE 540 ROBBINSVILLE, NEW JERSEY

DRAWN BY: MN
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JOB NUMBER: 129908-01
DATE: 2/19/19

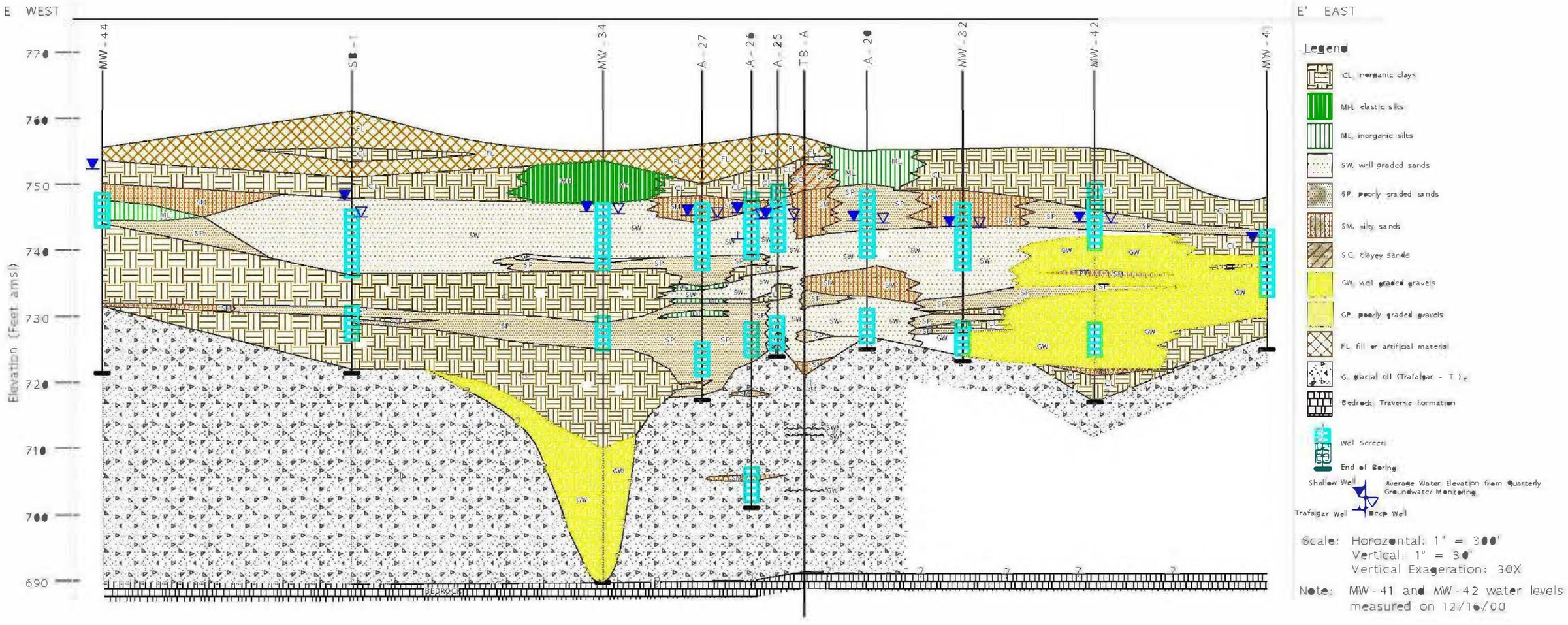

FIGURE 5A
GEOLOGIC CROSS-SECTION E – E'
FORMER JOSLYN MANUFACTURING AND SUPPLY COMPANY
2400 TAYLOR ST
FORT WAYNE, IN

PARS ENVIRONMENTAL, INC.
500 HORIZON DRIVE SUITE 540 ROBBINSVILLE, NEW JERSEY

DRAWN BY:	MN	JOB NUMBER:	129908-01
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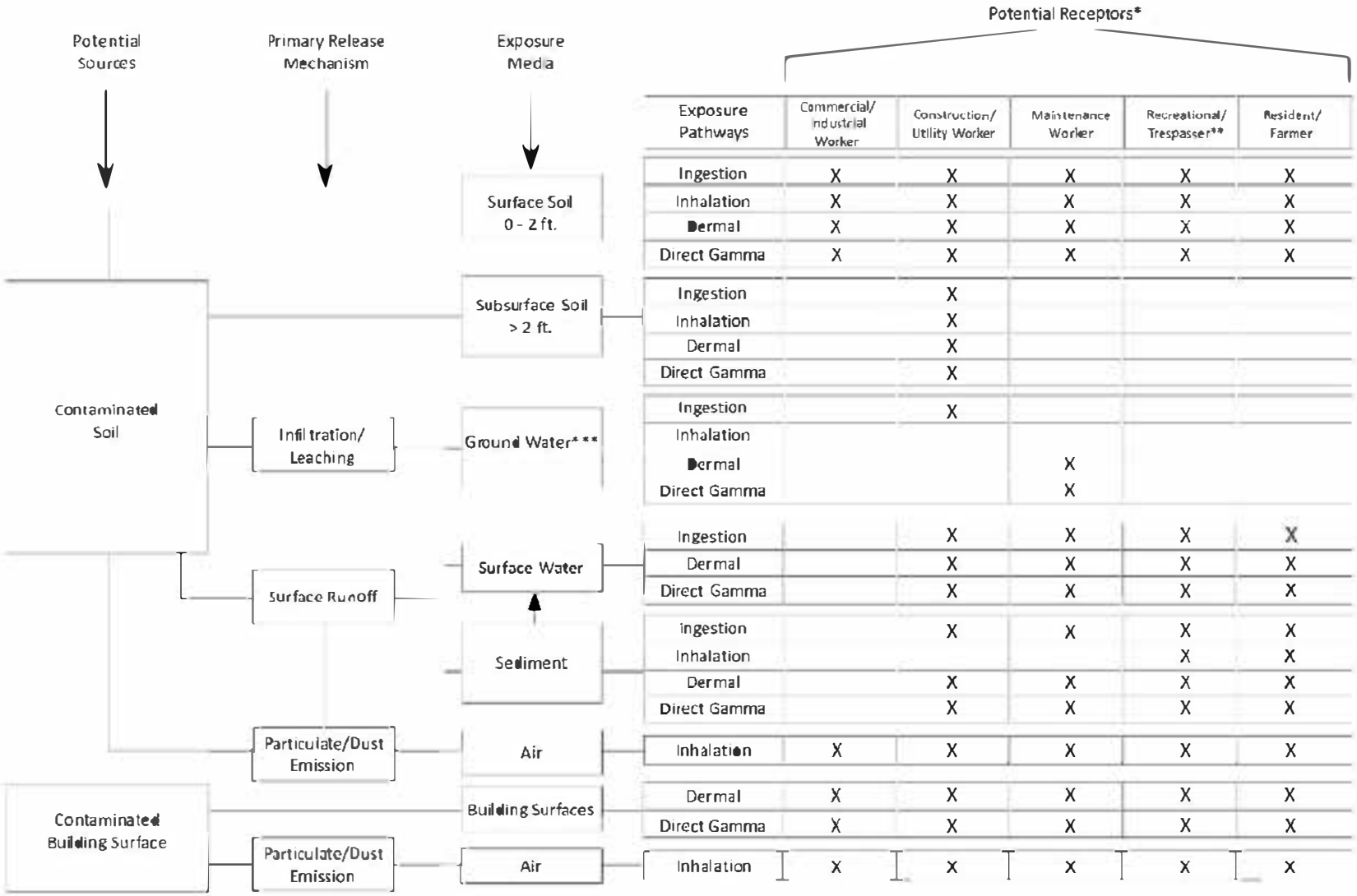

FIGURE 6
CONCEPTUAL SITE MODEL
FORMER JOSLYN MANUFACTURING AND SUPPLY COMPANY
2400 TAYLOR ST
FORT WAYNE, IN

* INDICATES A POTENTIAL RECEPTOR BUT DOES NOT DISTINGUISH "COMPLETE" VS "INCOMPLETE" PATHWAYS.
** DEED RESTRICTIONS PROHIBIT FUTURE RESIDENTIAL LAND USE OF SITE PER COUNTY LAND USE DESIGNATION. RECREATIONAL LAND USE INCLUDED IN THE RESIDENTIAL DESIGNATION. POTENTIAL RECEPTOR IS TRESPASSER ONLY.
*** DEED RESTRICTIONS PROHIBIT WELLS ON-SITE TO DEPTH OF 75 FEET.
"X" DENOTES "COMPLETE" PATHWAY.

PARS ENVIRONMENTAL, INC.
500 HORIZON DRIVE SUITE 540 ROBBINSVILLE, NEW JERSEY

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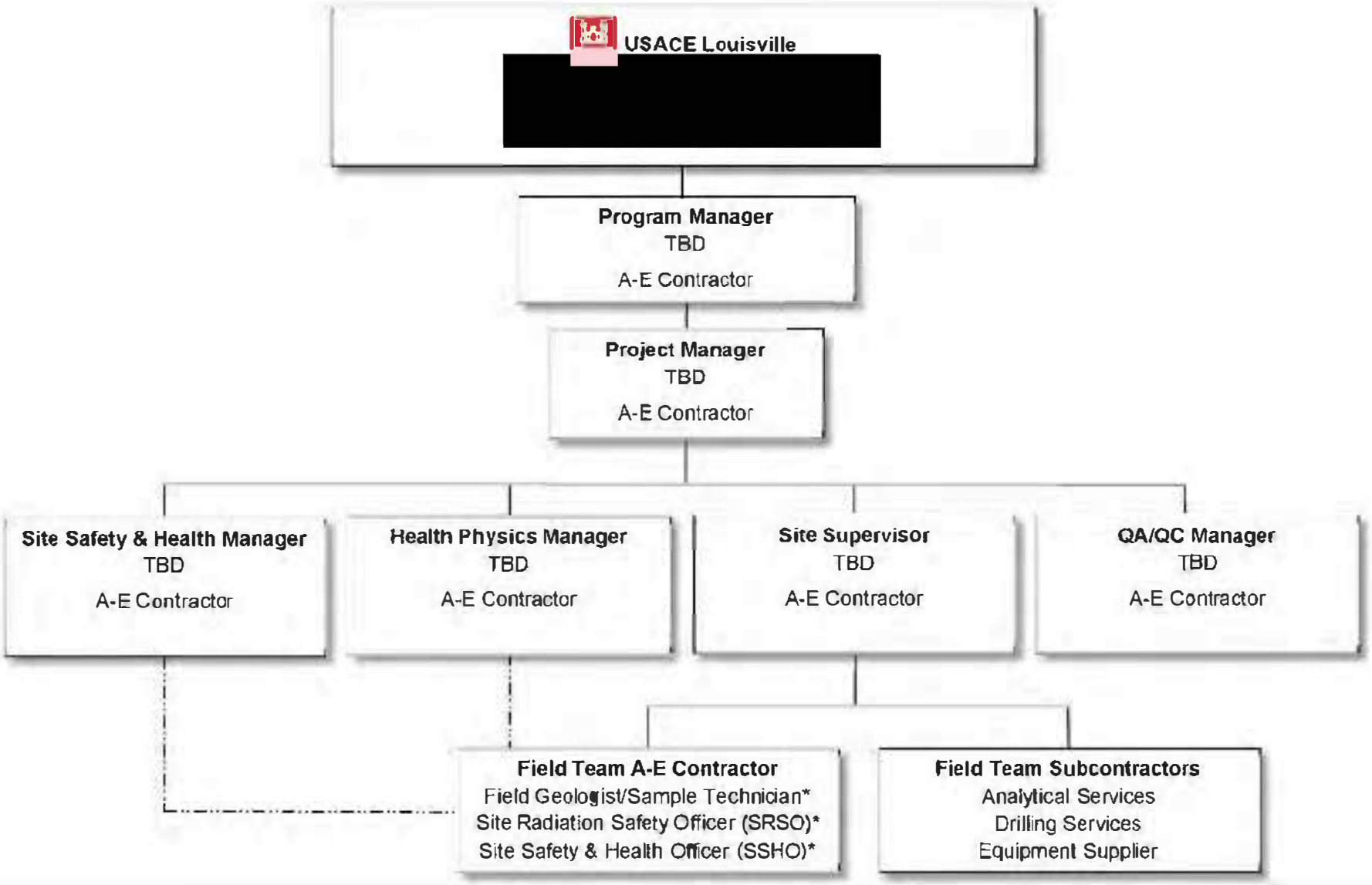

FIGURE 7
PROJECT ORGANIZATION CHART
FORMER JOSLYN MANUFACTURING AND SUPPLY COMPANY
2400 TAYLOR ST
FORT WAYNE, IN

PARS ENVIRONMENTAL, INC.
500 HORIZON DRIVE SUITE 540 ROBBINSVILLE, NEW JERSEY

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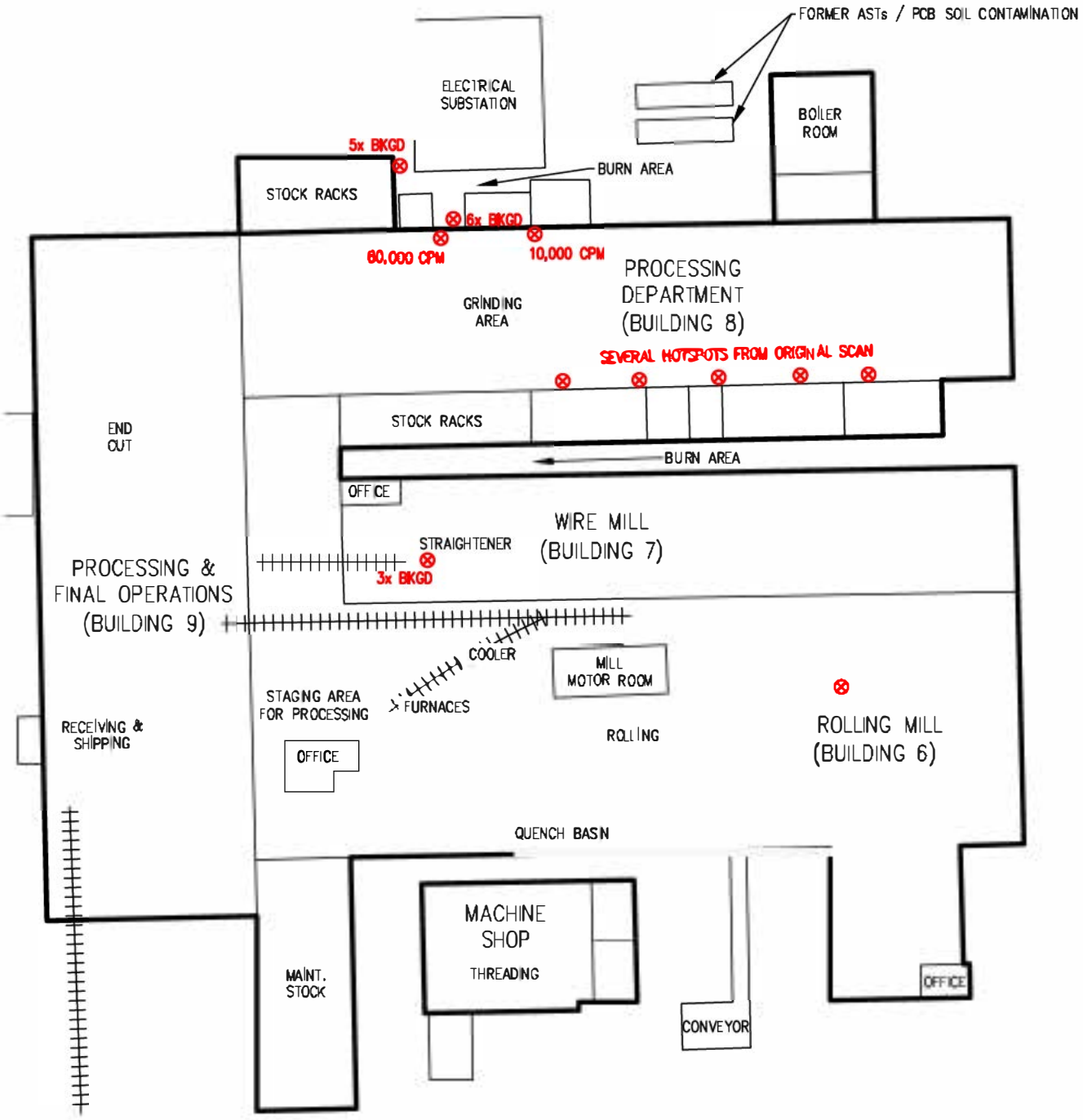


LEGEND

= BUILDING OUTLINE

= RAILROAD TRACKS

= LOCATION OF READING

CPM = COUNTS PER MINUTE

BKGD = BACKGROUND

NOTE:
THIS FIGURE IS HISTORIC AND DOES NOT REPRESENT CURRENT SITE CONDITIONS

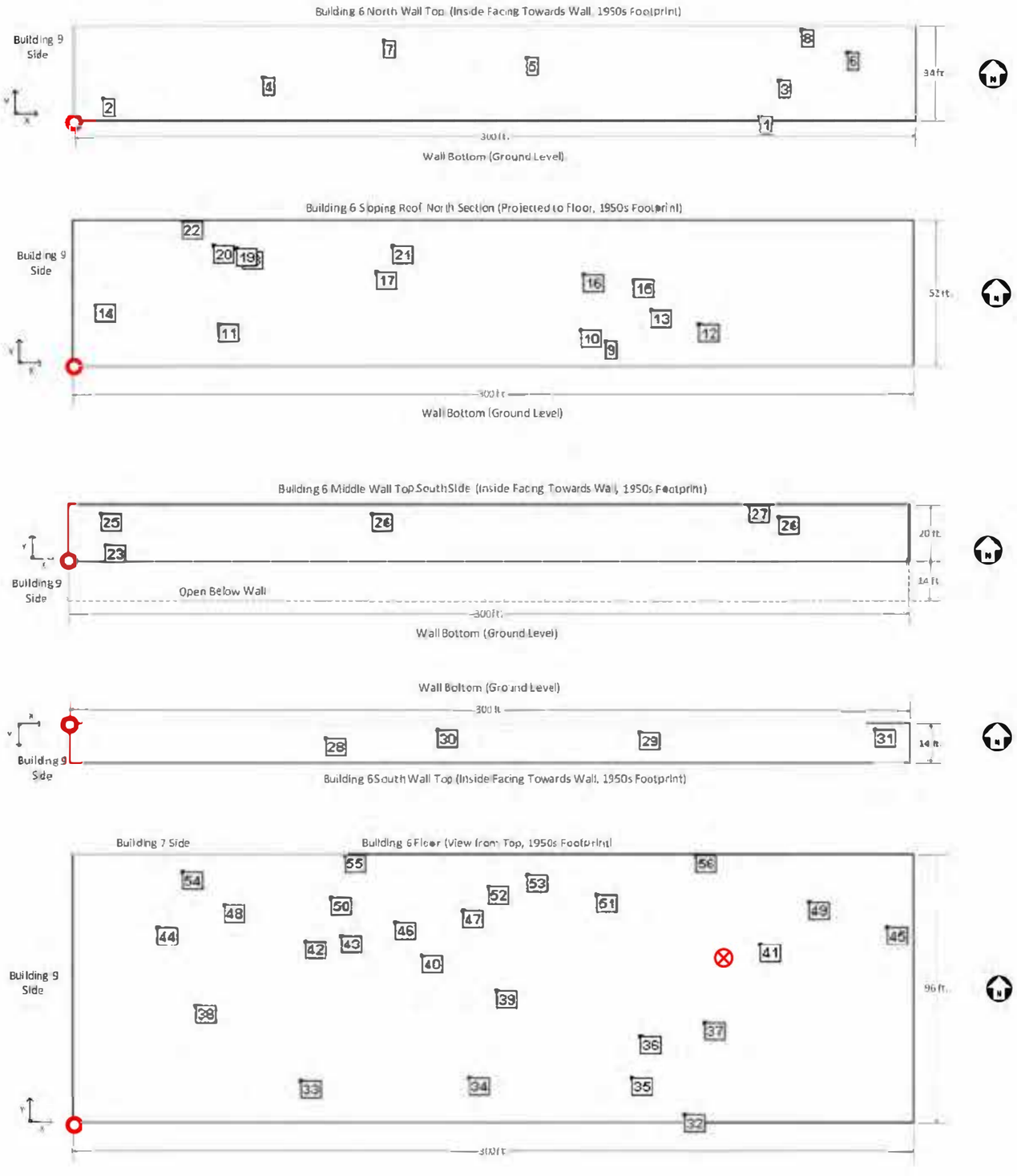
SCALE IN FEET

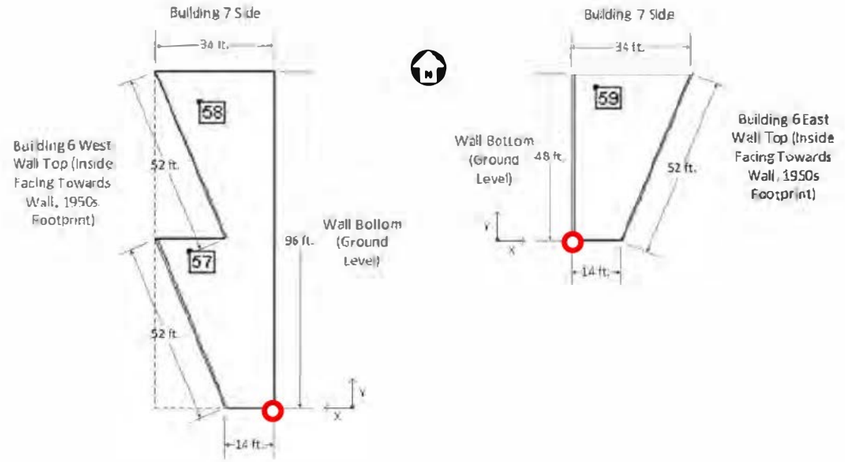
10 0 20 40 60

FIGURE 8
HISTORIC SURVEY RESULTS FROM BUILDING INTERIORS
FORMER JOSLYN MANUFACTURING AND SUPPLY COMPANY
2400 TAYLOR ST
FORT WAYNE, IN

PARS ENVIRONMENTAL, INC.
500 HORIZON DRIVE SUITE 540 ROBBINSVILLE, NEW JERSEY

DRAWN BY: MN
CHECKED BY: HB
JOB NUMBER: 129908-01
DATE: 11/26/18





LEGEND

- = REFERENCE POINT
- ⊗ = HISTORIC SURVEY LOCATION (SEE FIGURE 8)

NOTE:
SAMPLE LOCATION COORDINATES ARE LISTED IN TABLE 4 INCLUDED IN THE FIELD SAMPLING PLAN

FIGURE 9
SAMPLING (SURVEY) LOCATIONS FOR BUILDING 6 INTERIOR
FORMER JOSLYN MANUFACTURING AND SUPPLY COMPANY
2400 TAYLOR ST
FORT WAYNE, IN

PARS ENVIRONMENTAL, INC.
500 HORIZON DRIVE SUITE 540 ROBBINSVILLE, NEW JERSEY

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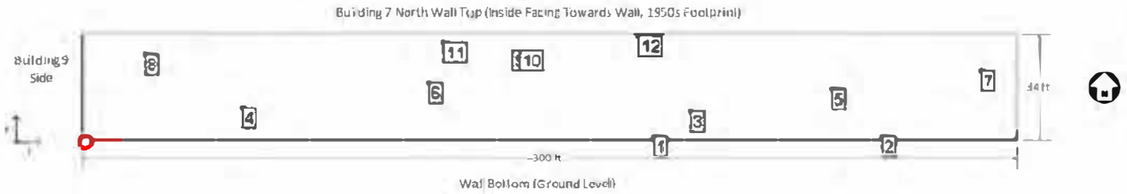
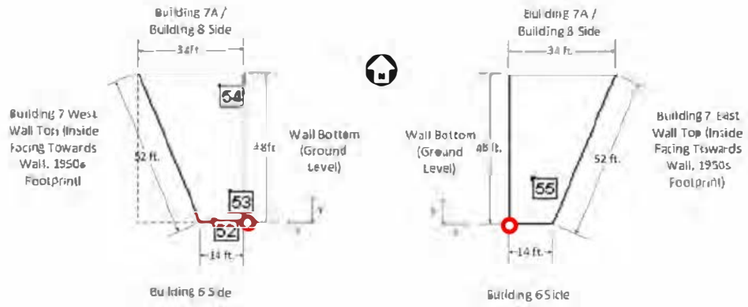
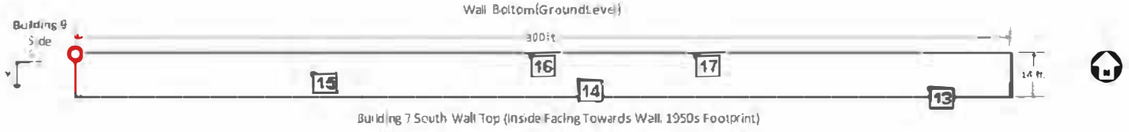
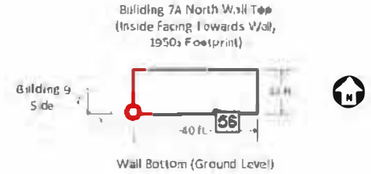
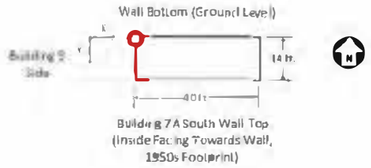
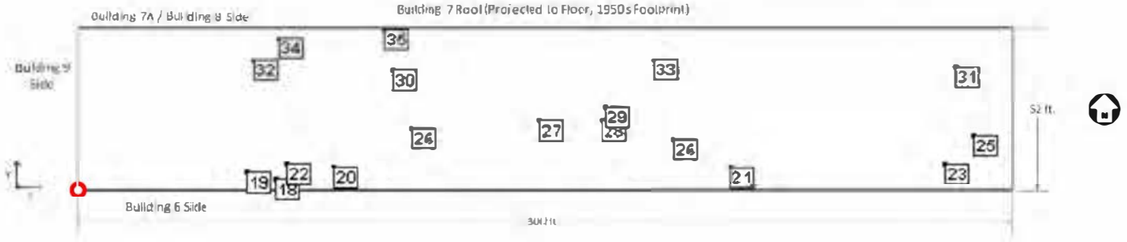


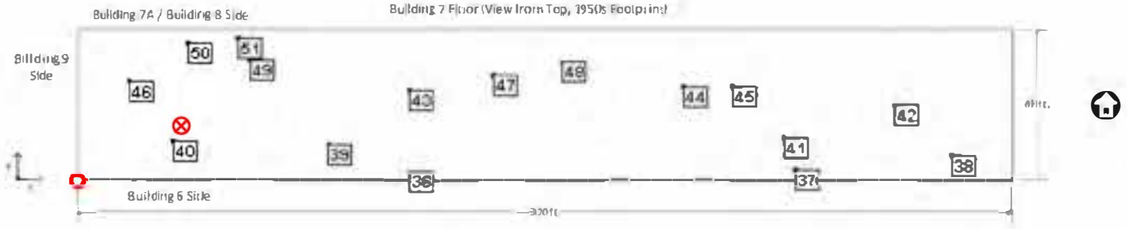












LEGEND

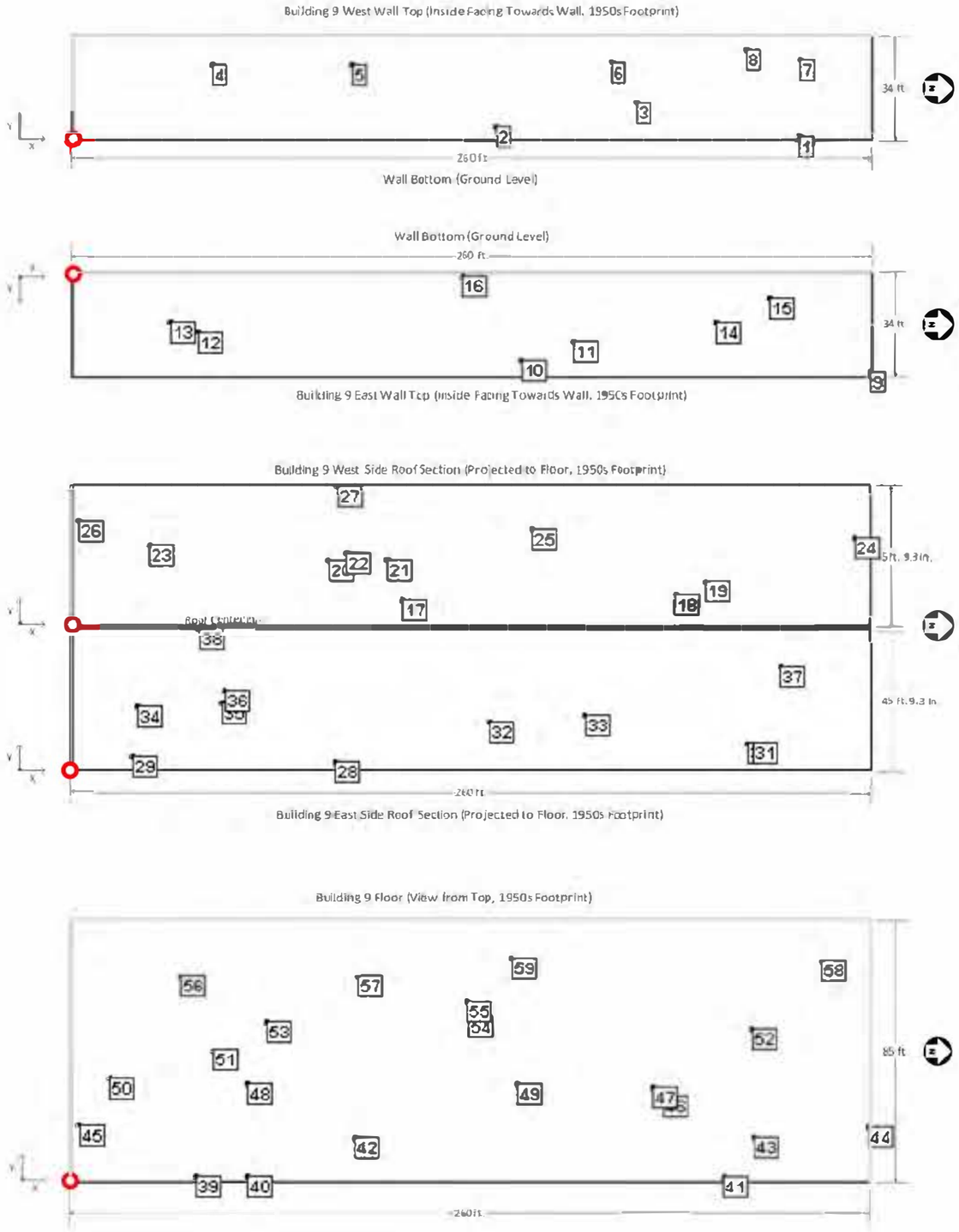
- ○ = REFERENCE POINT
- ⊗ = HISTORIC SURVEY LOCATION (SEE FIGURE 8)

NOTE:
SAMPLE LOCATION COORDINATES ARE LISTED IN TABLE 4 INCLUDED IN THE FIELD SAMPLING PLAN

FIGURE 10
SAMPLING (SURVEY) LOCATIONS FOR BUILDING 7 INTERIOR
FORMER JOSLYN MANUFACTURING AND SUPPLY COMPANY
2400 TAYLOR ST
FORT WAYNE, IN

PARS ENVIRONMENTAL, INC.
500 HORIZON DRIVE SUITE 540 ROBBINSVILLE, NEW JERSEY

DRAWN BY:	MN	JOB NUMBER:	129908-01
CHECKED BY:	HB	DATE:	4/30/19



LEGEND

O = REFERENCE POINT

NOTE:
SAMPLE LOCATION COORDINATES ARE LISTED IN TABLE 4 INCLUDED IN THE FIELD SAMPLING PLAN

FIGURE 11
SAMPLING (SURVEY) LOCATIONS FOR BUILDING 9 INTERIOR
FORMER JOSLYN MANUFACTURING AND SUPPLY COMPANY
2400 TAYLOR ST
FORT WAYNE, IN

PARS ENVIRONMENTAL, INC.
500 HORIZON DRIVE SUITE 540 ROBBINSVILLE, NEW JERSEY

DRAWN BY:	MN	JOB NUMBER:	129908-01
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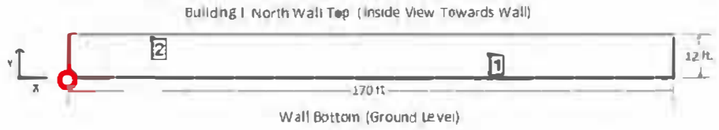
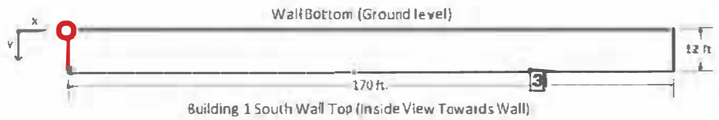
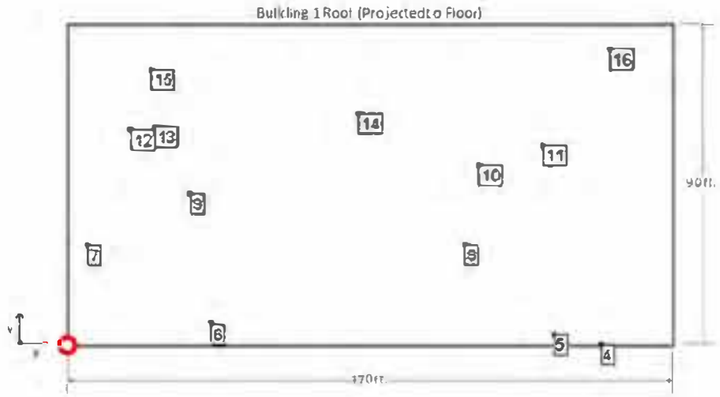
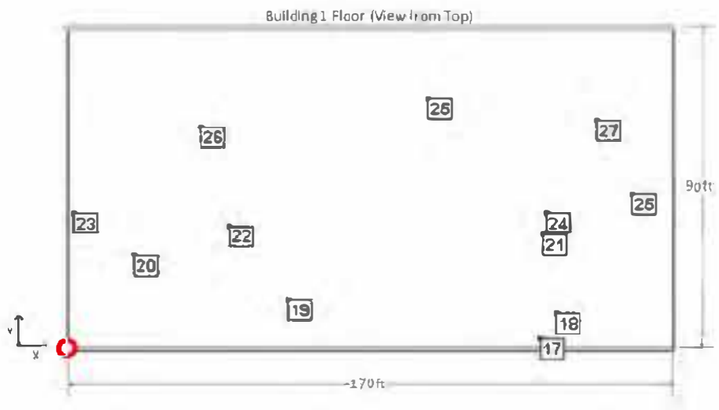
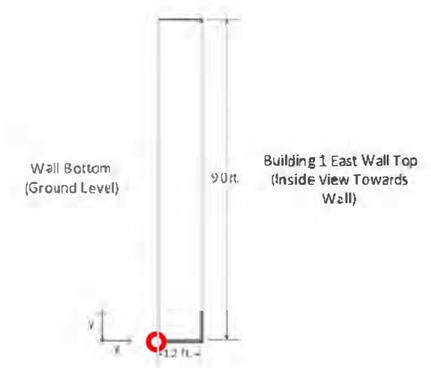










LEGEND

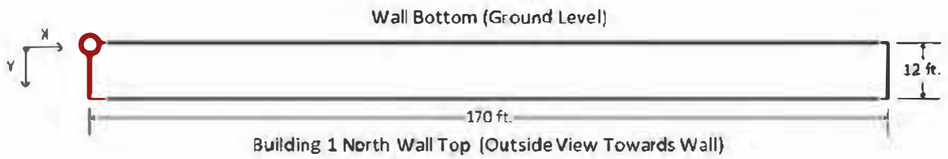
O = REFERENCE POINT

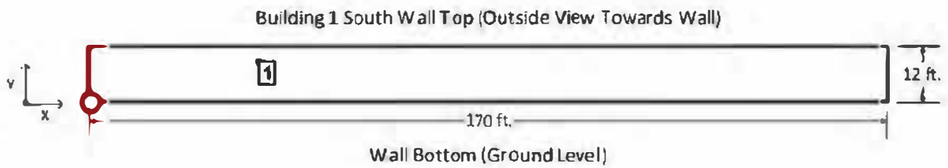
NOTE:
SAMPLE LOCATION COORDINATES ARE LISTED IN TABLE 5 INCLUDED IN THE FIELD SAMPLING PLAN

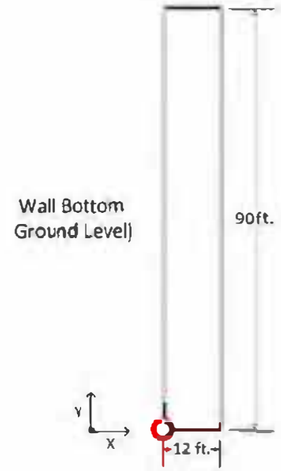
FIGURE T2
SAMPLING (SURVEY) LOCATIONS FOR BUILDING 1 INTERIOR
FORMER JOSLYN MANUFACTURING AND SUPPLY COMPANY
2400 TAYLOR ST
FORT WAYNE, IN

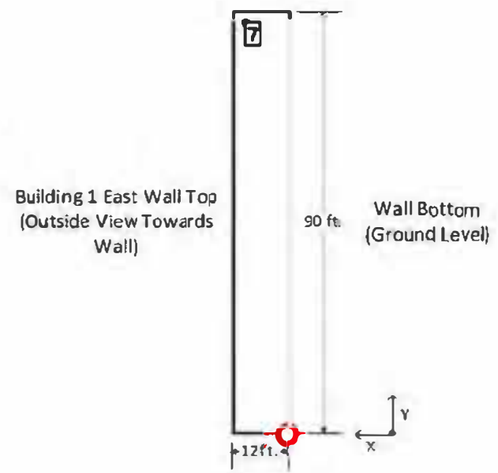
PARS ENVIRONMENTAL, INC.
500 HORIZON DRIVE SUITE 540 ROBBINSVILLE, NEW JERSEY

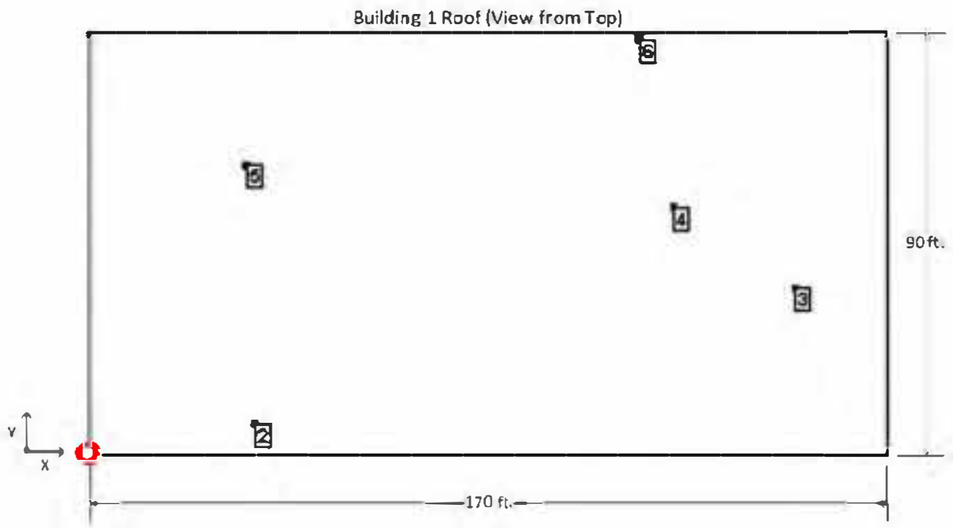
DRAWN BY:	MN	JOB NUMBER:	129908-01
CHECKED BY:	HB	DATE:	4/30/19











LEGEND

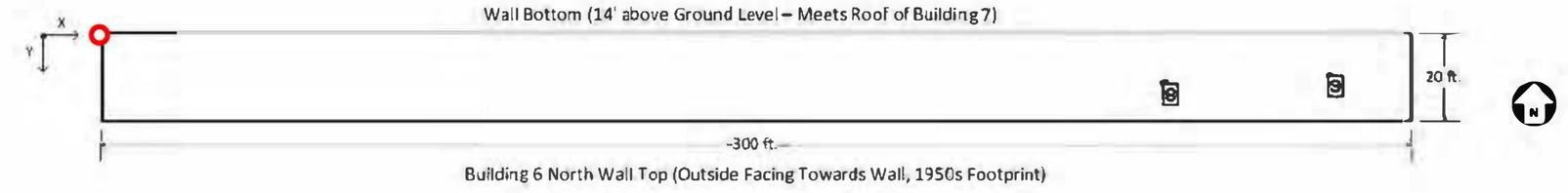
O = REFERENCE POINT

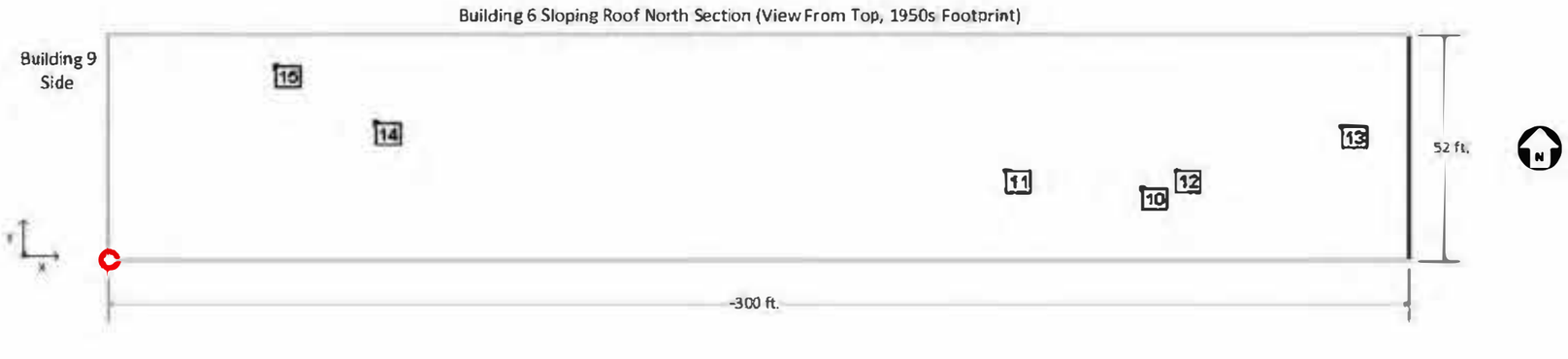
NOTE:
SAMPLE LOCATION COORDINATES ARE LISTED IN TABLE 6 INCLUDED IN THE FIELD SAMPLING PLAN

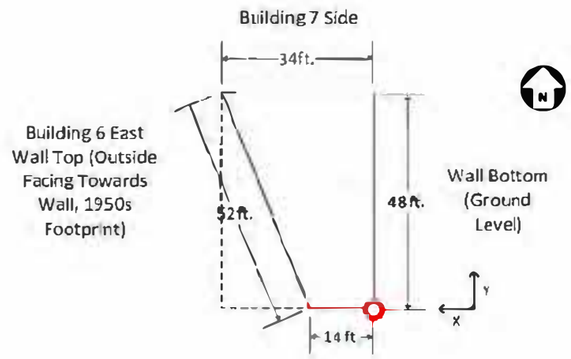
FIGURE 13
SAMPLING (SURVEY) LOCATIONS FOR BUILDING 1 EXTERIOR
FORMER JOSLYN MANUFACTURING AND SUPPLY COMPANY
2400 TAYLOR ST
FORT WAYNE, IN

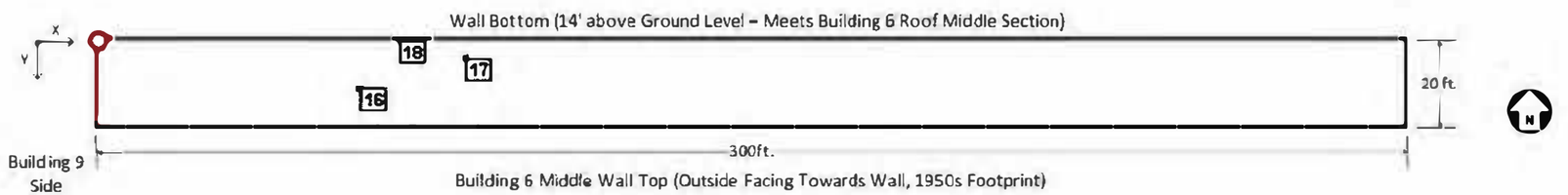
PARS ENVIRONMENTAL, INC.
500 HORIZON DRIVE SUITE 540 ROBBINSVILLE, NEW JERSEY

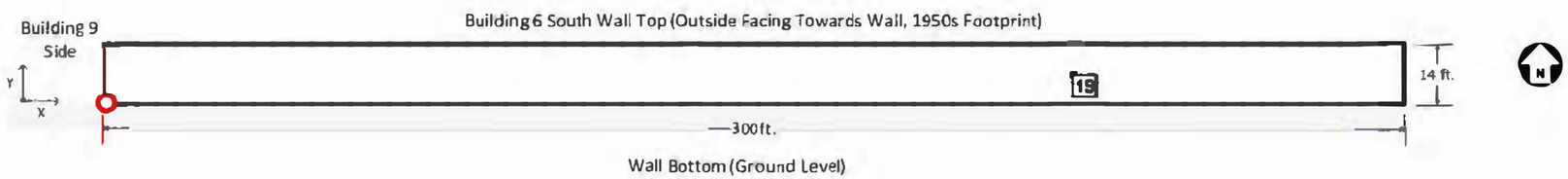
DRAWN BY:	MN	JOB NUMBER:	129908-01
CHECKED BY:	HB	DATE:	4/30/19











LEGEND

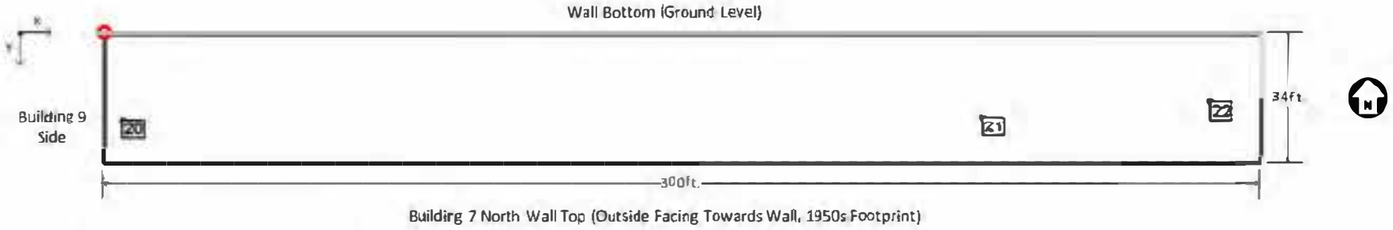
O = REFERENCE POINT

NOTE:
SAMPLE LOCATION COORDINATES ARE LISTED IN TABLE 6 INCLUDED IN THE FIELD SAMPLING PLAN

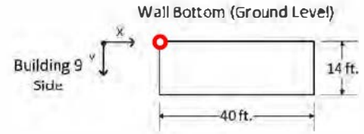
FIGURE T4
SAMPLING (SURVEY) LOCATIONS FOR BUILDING 6 EXTERIOR
FORMER JOSLYN MANUFACTURING AND SUPPLY COMPANY
2400 TAYLOR ST
FORT WAYNE, IN

PARS ENVIRONMENTAL, INC.
500 HORIZON DRIVE SUITE 540 ROBBINSVILLE, NEW JERSEY

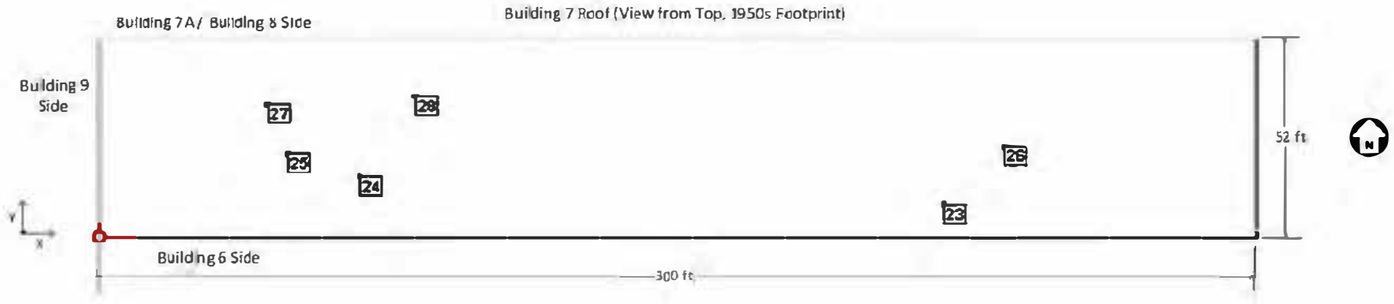
DRAWN BY:	MN	JOB NUMBER:	129908-01
CHECKED BY:	HB	DATE:	4/30/19

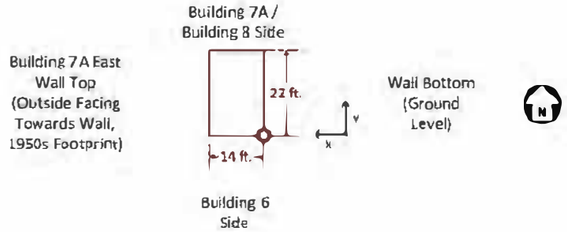


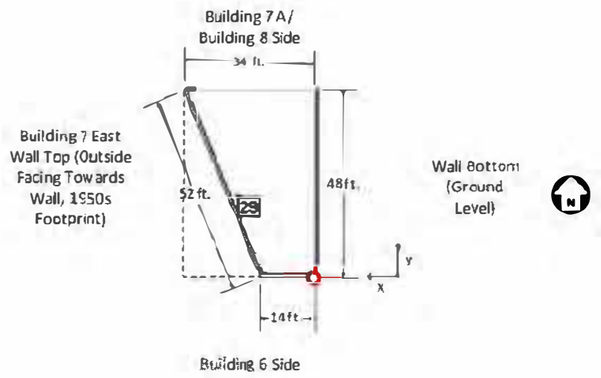
Building 7 North Wall Top (Outside Facing Towards Wall, 1950s Footprint)

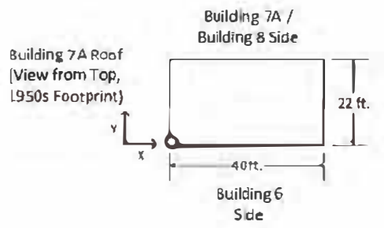


Building 7A North Wall Top (Outside Facing Towards Wall, 1950s Footprint)









LEGEND

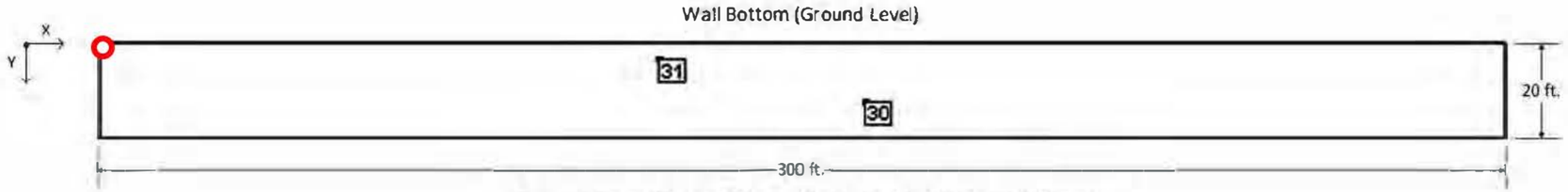
O = REFERENCE POINT

NOTE:
SAMPLE LOCATION COORDINATES ARE LISTED IN TABLE 6 INCLUDED IN THE FIELD SAMPLING PLAN

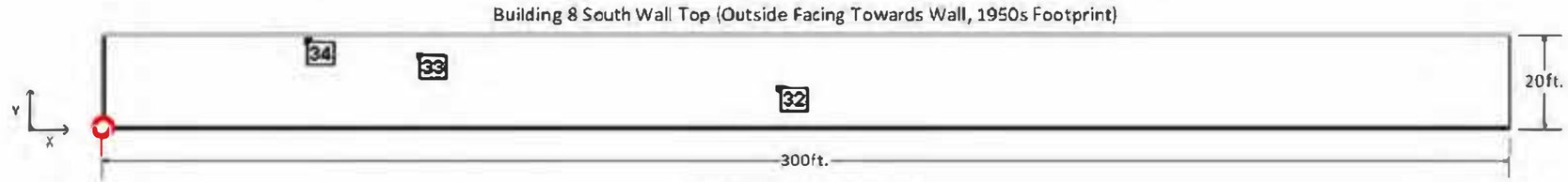
FIGURE 15
SAMPLING (SURVEY) LOCATIONS FOR BUILDING 7 EXTERIOR
FORMER JOSLYN MANUFACTURING AND SUPPLY COMPANY
2400 TAYLOR ST
FORT WAYNE, IN

PARS ENVIRONMENTAL, INC.
500 HORIZON DRIVE SUITE 540 ROBBINSVILLE, NEW JERSEY

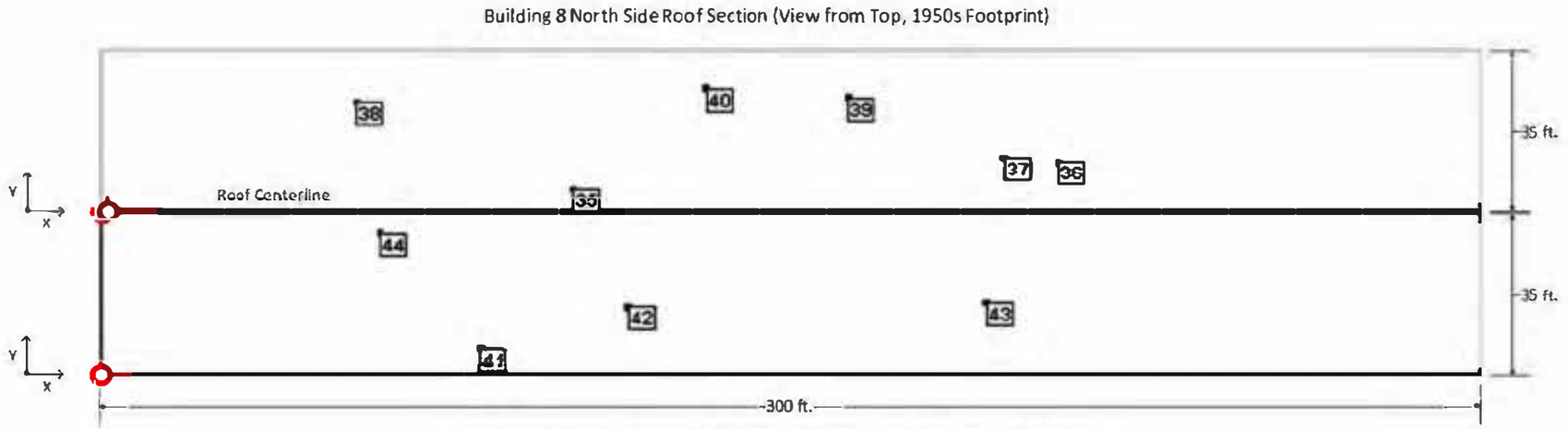
DRAWN BY:	MN	JOB NUMBER:	129908-01
CHECKED BY:	HB	DATE:	4/30/19



Building 8 North Wall Top (Outside Facing Towards Wall, 1950s Footprint)



Wall Bottom (Ground Level)



Building 8 South Side Roof Section View from Top, 1950s Footprint)

LEGEND

O = REFERENCE POINT

NOTE:
SAMPLE LOCATION COORDINATES ARE LISTED IN TABLE 6 INCLUDED IN THE FIELD SAMPLING PLAN

FIGURE 16
SAMPLING (SURVEY) LOCATIONS FOR BUILDING 8 EXTERIOR
FORMER JOSLYN MANUFACTURING AND SUPPLY COMPANY
2400 TAYLOR ST
FORT WAYNE, IN

PARS ENVIRONMENTAL, INC.
500 HORIZON DRIVE SUITE 540 ROBBINSVILLE, NEW JERSEY

DRAWN BY:	MN	JOB NUMBER:	129908-01
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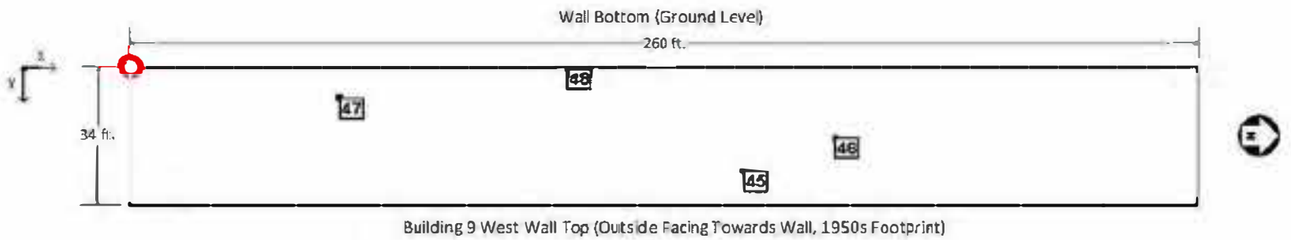
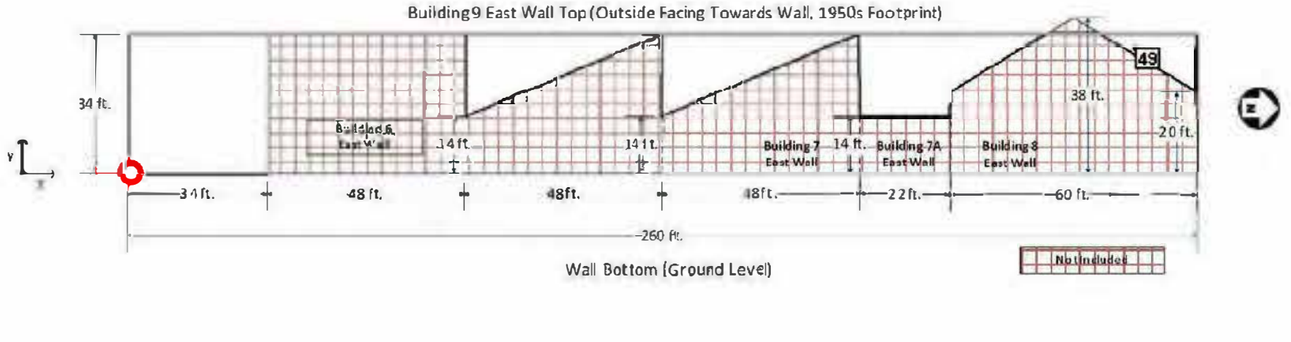
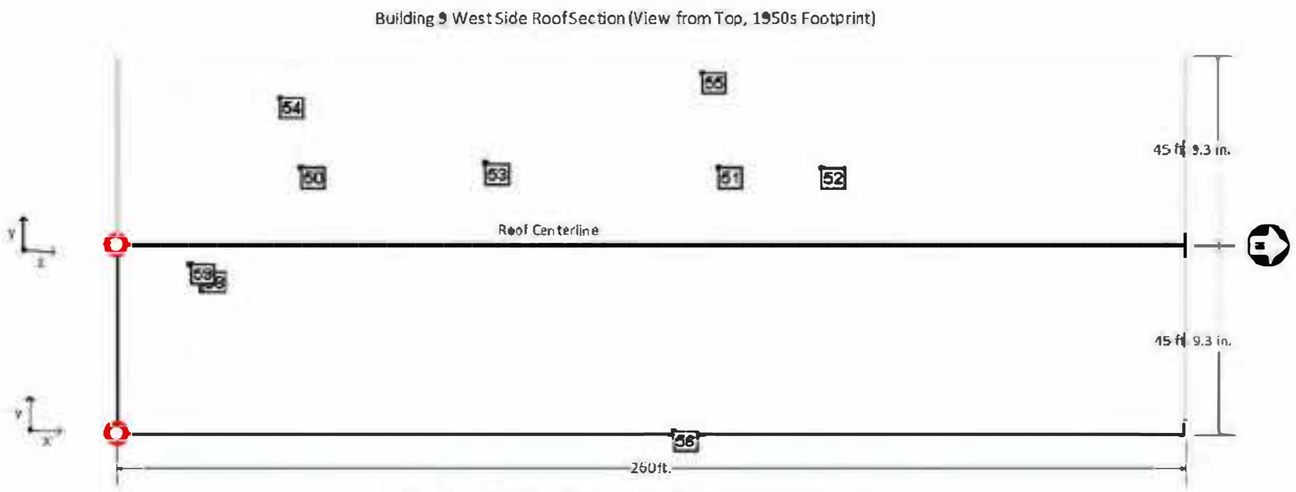


Building 9 West Wall Top (Outside Facing Towards Wall, 1950s Footprint)





LEGEND

O = REFERENCE POINT

NOTE:
SAMPLE LOCATION COORDINATES ARE LISTED IN TABLE 6 INCLUDED IN THE FIELD SAMPLING PLAN

FIGURE 17
SAMPLING (SURVEY) LOCATIONS FOR BUILDING 9 EXTERIOR
FORMER JOSLYN MANUFACTURING AND SUPPLY COMPANY
2400 TAYLOR ST
FORT WAYNE, IN

PARS ENVIRONMENTAL, INC.
500 HORIZON DRIVE SUITE 540 ROBBINSVILLE, NEW JERSEY

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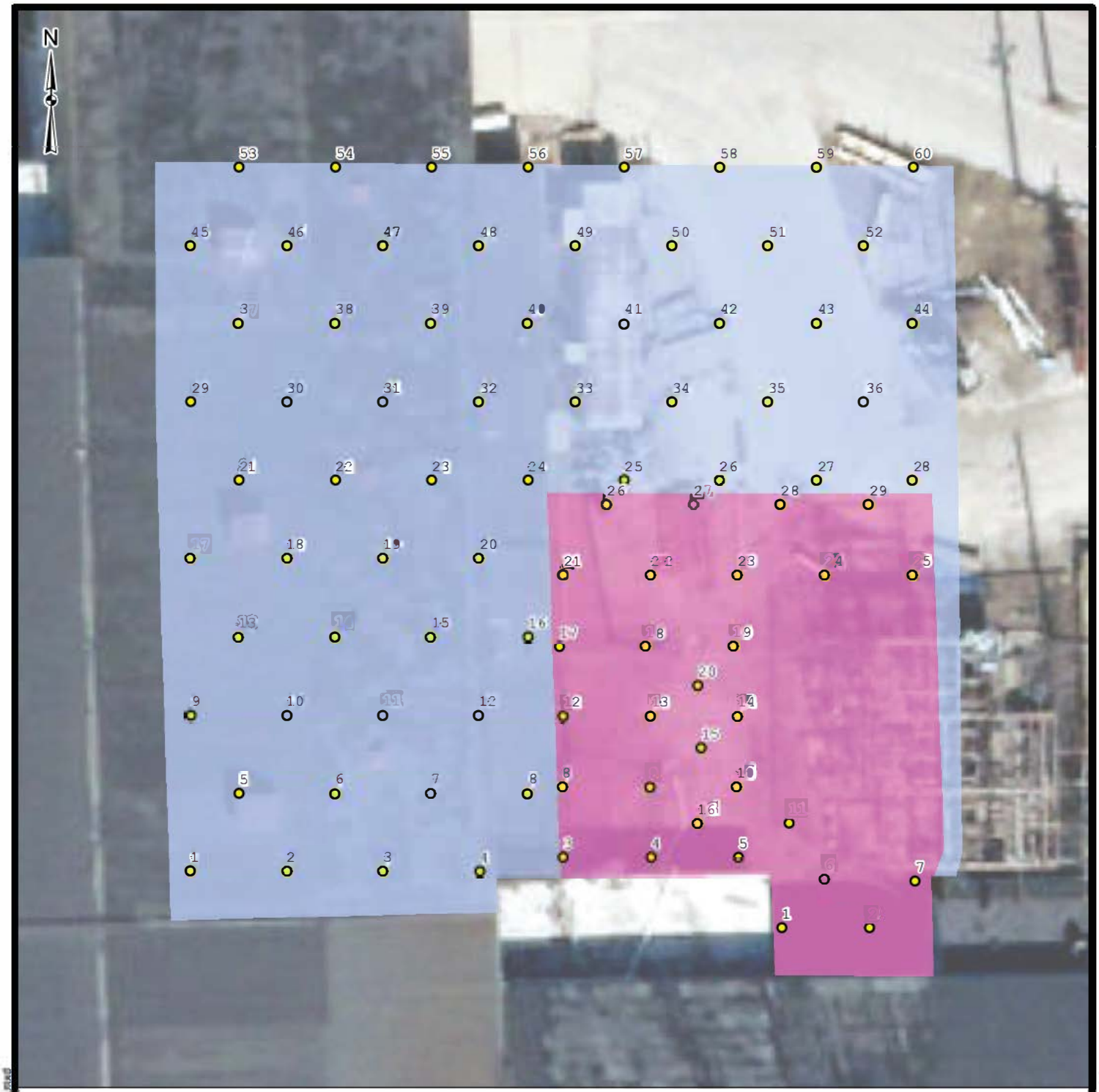

Legend

- Soil Sample Location
- Class 1 Soil
- Class 2 Buffer Zone

0 10 20 40 Feet

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
BUFFALO, NY

US Army Corps of Engineers
Buffalo District

SAMPLING LOCATIONS FOR OLD BURN AREA III

Document Name: 190701_BAreaIII_SOmxd
Drawn By: H5TDESPM
Date Saved: 03 Dec 2019
Time Saved: 10:19:06 AM

JOSLYN MANUFACTURING & SUPPLY CO
FT. WAYNE, INDIANA

FIGURE 18

Document Path: K:\Jobs\GIS\MXDs\2019\SoilJ190701_BAreaIII_SO.mxd

LEGEND

[#] = SAMPLE LOCATION

= CLASS 1 SOIL

= CLASS 2 BUFFER ZONE

NOTE:
SAMPLE LOCATION COORDINATES ARE LISTED IN TABLE 7 INCLUDED IN THE FIELD SAMPLING PLAN

FIGURE 19
SAMPLING LOCATIONS FOR OLD BURN AREA I
FORMER JOSLYN MANUFACTURING AND SUPPLY COMPANY
2400 TAYLOR ST
FORT WAYNE, IN

PARS ENVIRONMENTAL, INC.
500 HORIZON DRIVE SUITE 540 ROBBINSVILLE, NEW JERSEY

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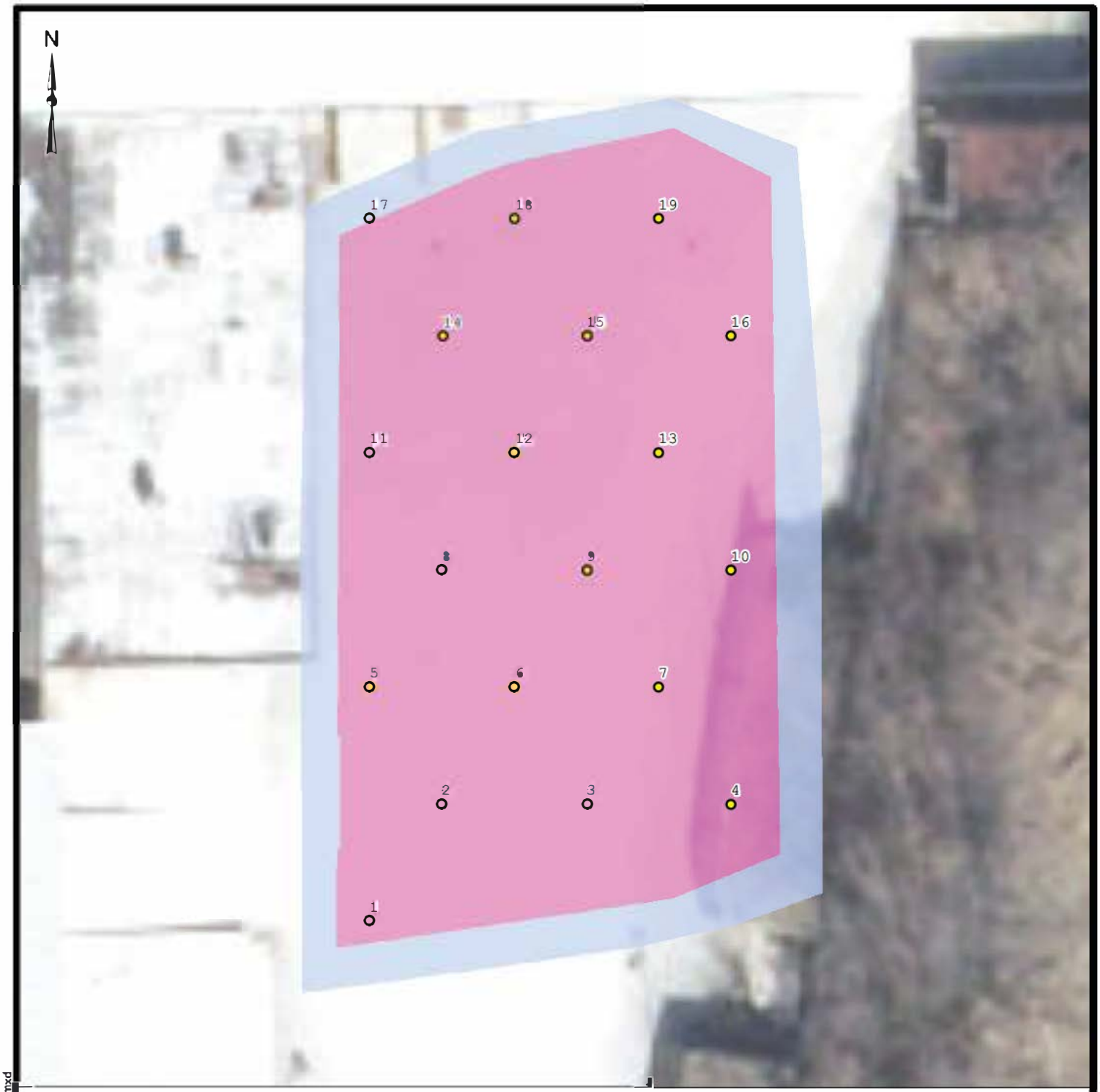

Legend

- Soil Sample Location
- Class 1 Soil
- Class 2 Buffer Zone

0 10 20 40 Feet

US Army Corps of Engineers Buffalo District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
BUFFALO, NY

SAMPLING LOCATIONS FOR OLD BURN AREA II

Document Name: 190701_BAreaII_SO.mxd
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Date Saved: 03 Dec 2019
Time Saved: 9:36:17 AM

JOSLYN MANUFACTURING & SUPPLY CO
FT. WAYNE, INDIANA

FIGURE 20

Document Path: K:\Jobs\GIS\MXDs\2019\Soil\190701_BAreaII_SO.mxd

Legend

- Soil Sample Location
- Class 1 Soil

0 15 30 60 Feet

US Army Corps of Engineers Buffalo District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
BUFFALO, NY

SAMPLING LOCATIONS FOR OLD BURN AREA IV
(BETWEEN BUILDINGS 7 & 8)

Document Name: 190701_BArealV_SO.mxd
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JOSLYN MANUFACTURING & SUPPLY CO
FT. WAYNE, INDIANA

FIGURE 21

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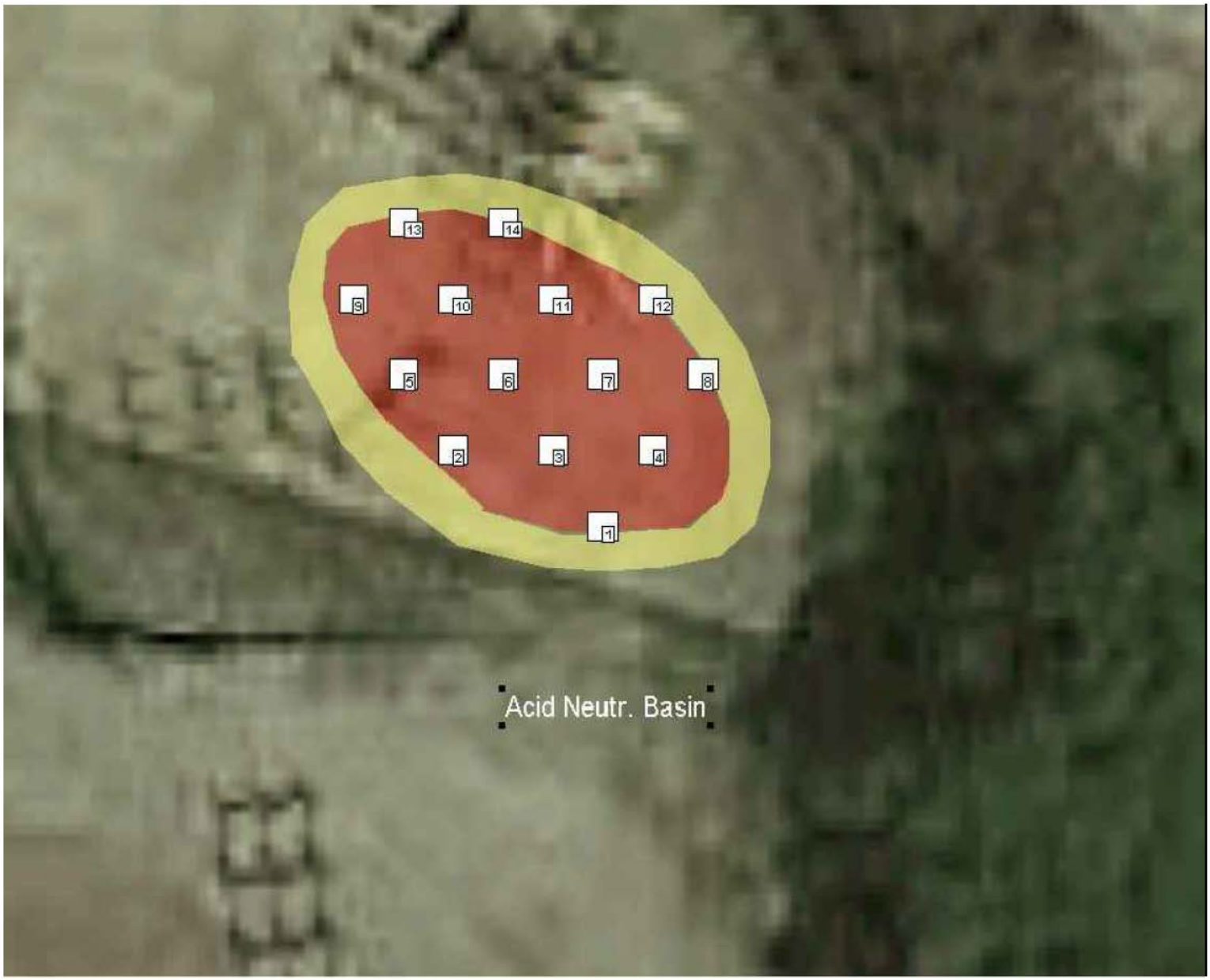


LEGEND

[#] = SAMPLE LOCATION

= CLASS 1 SOIL

= CLASS 2 BUFFER ZONE

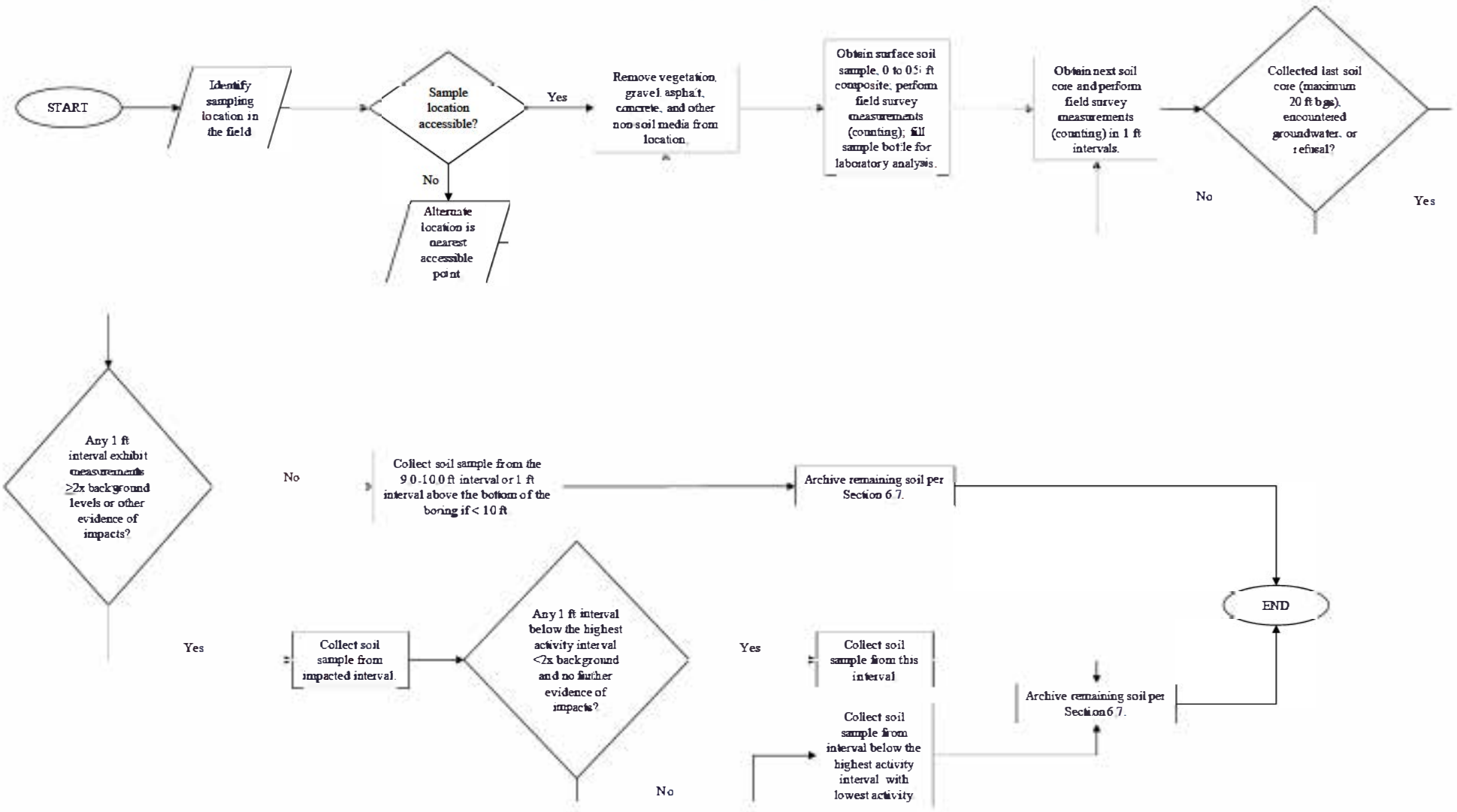
NOTE:
SAMPLE LOCATION COORDINATES ARE LISTED IN TABLE 7 INCLUDED IN THE FIELD SAMPLING PLAN

FIGURE 22
SAMPLING LOCATIONS FOR ACID NEUTRALIZATION BASIN AREA
FORMER JOSLYN MANUFACTURING AND SUPPLY COMPANY
2400 TAYLOR ST
FORT WAYNE, IN

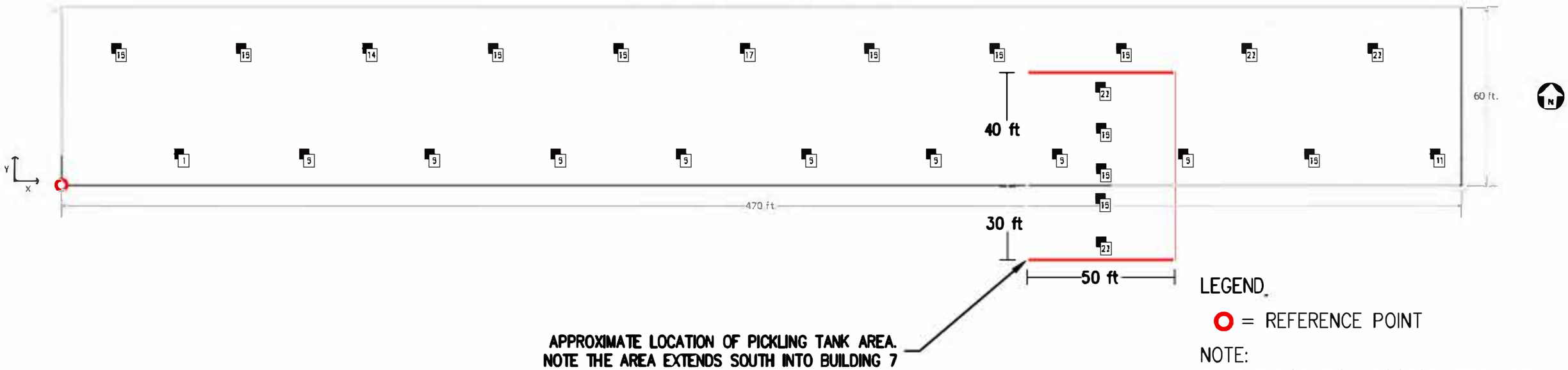
PARS ENVIRONMENTAL, INC.
500 HORIZON DRIVE SUITE 540 ROBBINSVILLE, NEW JERSEY

DRAWN BY:	MN	JOB NUMBER:	129908-01
CHECKED BY:	HB	DATE:	4/30/19

FIGURE 23
METHODOLOGY FOR SELECTING VOLUMETRIC SOIL SAMPLES
FORMER JOSLYN MANUFACTURING AND SUPPLY COMPANY
FORT WAYNE, INDIANA



Building 8 Floor (View from Top, Current Footprint)



LEGEND

O = REFERENCE POINT

NOTE:
SAMPLE LOCATION COORDINATES ARE LISTED IN TABLE 7 INCLUDED IN THE FIELD SAMPLING PLAN

FIGURE 24
SYSTEMATIC SOIL SAMPLING LOCATIONS FOR BUILDING 8
FORMER JOSLYN MANUFACTURING AND SUPPLY COMPANY
2400 TAYLOR ST
FORT WAYNE, IN

PARS ENVIRONMENTAL, INC.
500 HORIZON DRIVE SUITE 540 ROBBINSVILLE, NEW JERSEY

DRAWN BY:	MN	JOB NUMBER:	129908-01
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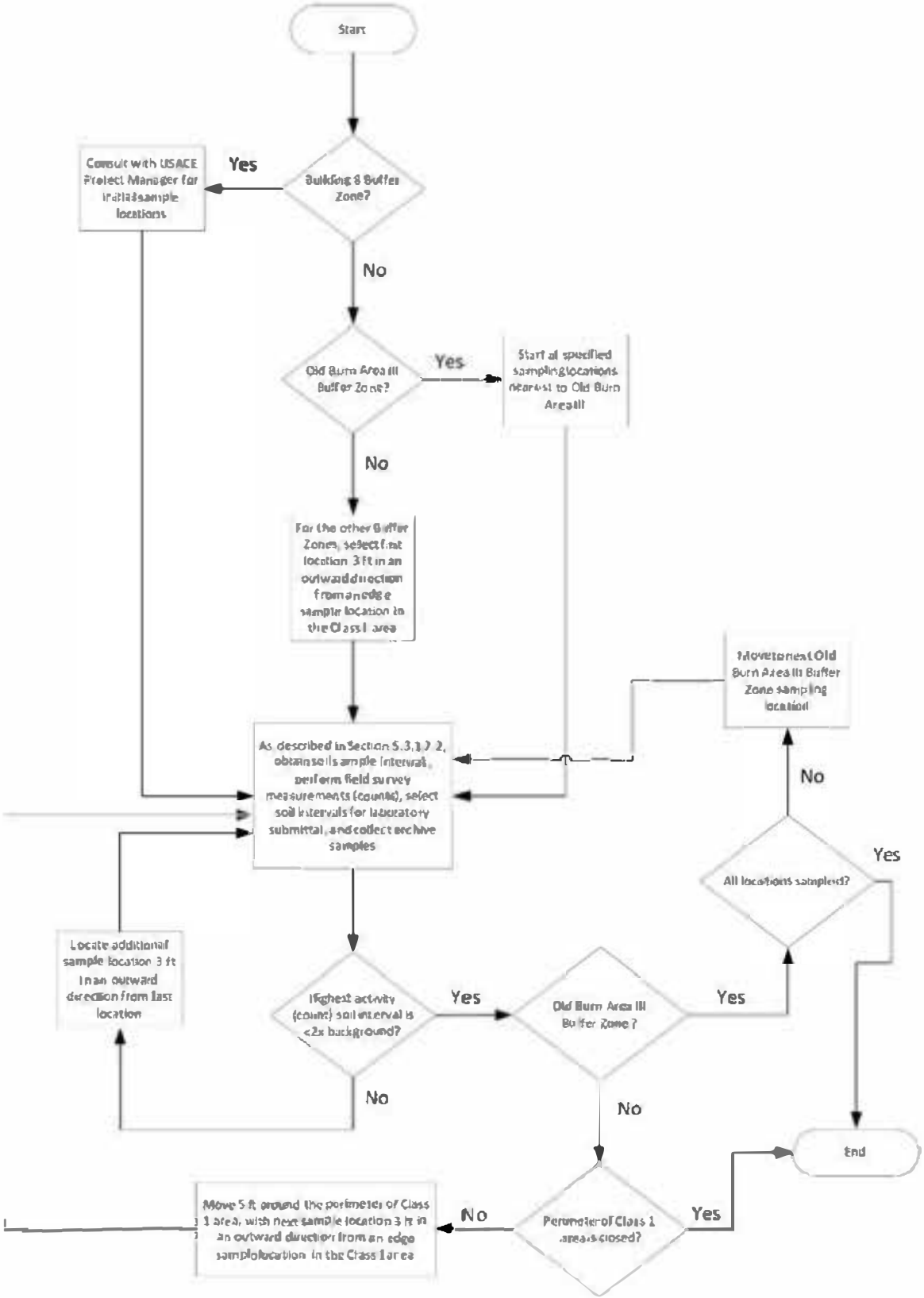
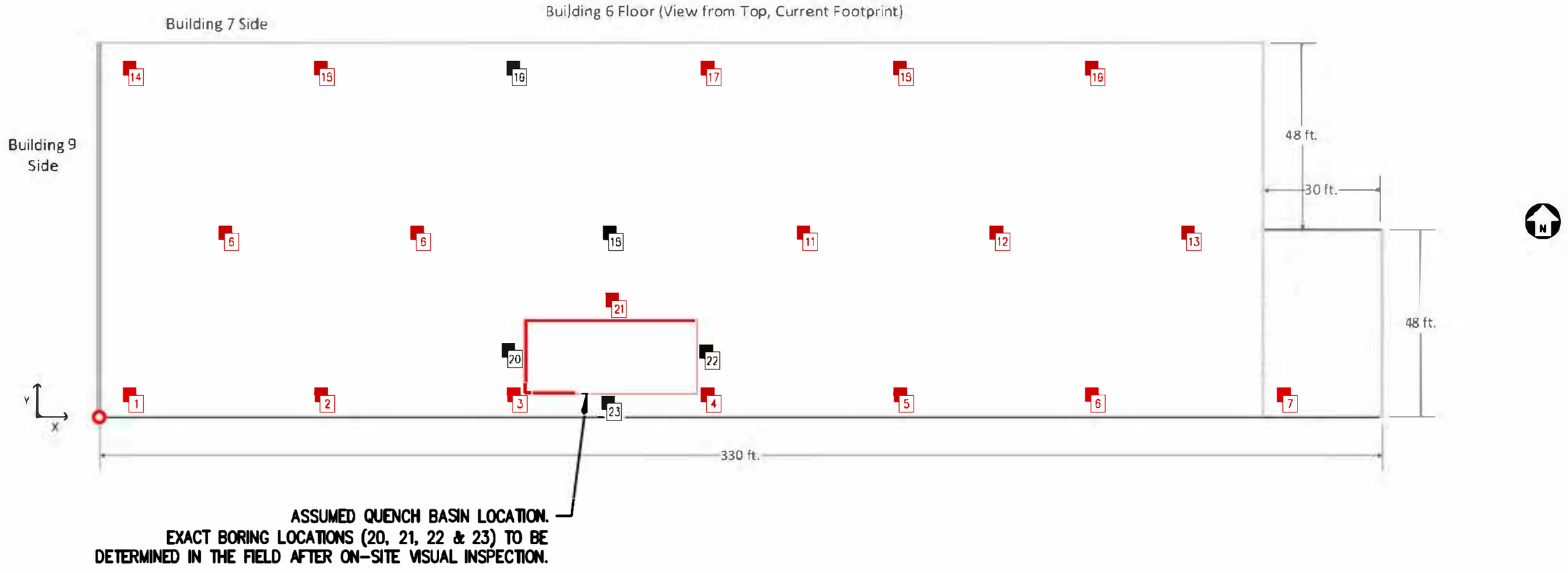


FIGURE 25
METHODOLOGY FOR SELECTING BUFFER ZONE BOUNDING SOIL SAMPLING
FORMER JOSLYN MANUFACTURING AND SUPPLY COMPANY
2400 TAYLOR ST
FORT WAYNE, IN

PARS ENVIRONMENTAL, INC.
500 HORIZON DRIVE SUITE 540 ROBBINSVILLE, NEW JERSEY

DRAWN BY:	MR	JOB NUMBER:	129908-01
CHECKED BY:	HB	DATE:	5/22/19

Building 6 Floor (View from Top, Current Footprint)



ASSUMED QUENCH BASIN LOCATION.
EXACT BORING LOCATIONS (20, 21, 22 & 23) TO BE DETERMINED IN THE FIELD AFTER ON-SITE VISUAL INSPECTION.

LEGEND

O = REFERENCE POINT

NOTE:
SAMPLE LOCATION COORDINATES ARE LISTED IN TABLE 7 INCLUDED IN THE FIELD SAMPLING PLAN

FIGURE 26
SYSTEMATIC SOIL SAMPLING LOCATIONS FOR BUILDING 6
FORMER JOSLYN MANUFACTURING AND SUPPLY COMPANY
2400 TAYLOR ST
FORT WAYNE, IN

PARS ENVIRONMENTAL, INC.
500 HORIZON DRIVE SUITE 540 ROBBINSVILLE, NEW JERSEY

DRAWN BY:	MN	JOB NUMBER:	129908-01
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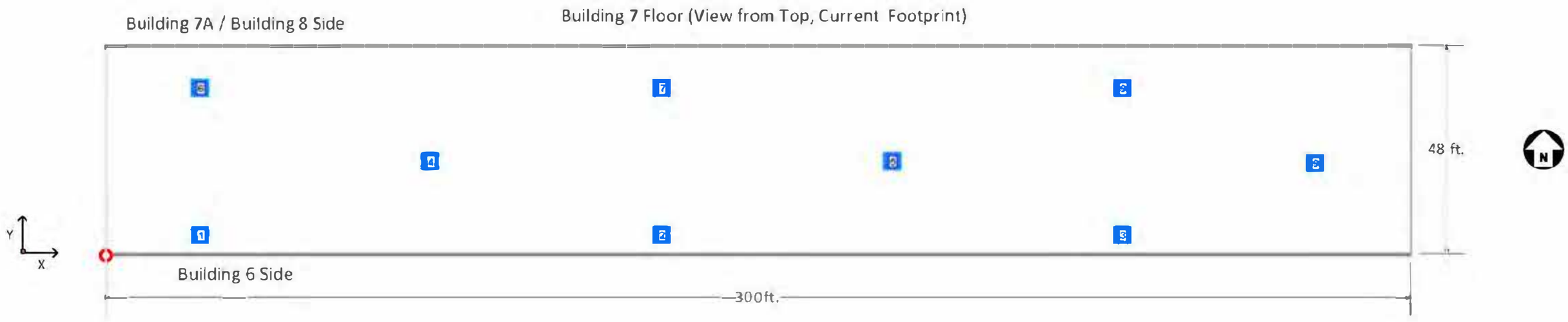

LEGEND

O = REFERENCE POINT

NOTE:
SAMPLE LOCATION COORDINATES ARE LISTED IN TABLE 7 INCLUDED IN THE FIELD SAMPLING PLAN

FIGURE 27
SYSTEMATIC SOIL SAMPLING LOCATIONS FOR BUILDING 7
FORMER JOSLYN MANUFACTURING AND SUPPLY COMPANY
2400 TAYLOR ST
FORT WAYNE, IN

PARS ENVIRONMENTAL, INC.
500 HORIZON DRIVE SUITE 540 ROBBINSVILLE, NEW JERSEY

DRAWN BY:	MN	JOB NUMBER:	129908-01
CHECKED BY:	HB	DATE:	4/30/19

Legend

- Soil Sample Location
- Background Soil Sample Location
- Site Boundary

0 150 300 600 Feet

US Army Corps of Engineers Buffalo District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
BUFFALO, NY

BACKGROUND AND RANDOM SOIL SAMPLING LOCATIONS FOR SITE FOOTPRINT

Document Name: 190701_SitewideSoils.mxd
Drawn By: H5TDESPM
Date Saved: 05 Jun 2020
Time Saved: 12:46:13 PM

JOSLYN MANUFACTURING & SUPPLY CO
FT. WAYNE, INDIANA

FIGURE 28

Document Path: D:_Projects\C19\GIS\ArcMap Files\2020\Soil\190701_SitewideSoils.mxd

LEGEND

= SITE BOUNDARY = SURFACE WATER & SEDIMENT SAMPLE TRANSECT LOCATION

NOTE:
SAMPLE LOCATION COORDINATES ARE LISTED IN TABLE 9 INCLUDED IN THE FIELD SAMPLING PLAN

SCALE IN FEET
50 0 100 200 300

FIGURE 29
JUNK DITCH SURFACE WATER AND SEDIMENT SAMPLE LOCATIONS
FORMER JOSLYN MANUFACTURING AND SUPPLY COMPANY
2400 TAYLOR ST
FORT WAYNE, IN

PARS ENVIRONMENTAL, INC.
500 HORIZON DRIVE SUITE 540 ROBBINSVILLE, NEW JERSEY

DRAWN BY:	MN	JOB NUMBER:	129908-01
CHECKED BY:	HB	DATE:	3/5/19

VOLUME 1 – FIELD SAMPLING PLAN
REMEDIAL INVESTIGATION DESIGN
FORMER JOSLYN MANUFACTURING AND SUPPLY COMPANY
FORT WAYNE, INDIANA
MAY 2019

APPENDICES

APPENDIX A

UFGS Section 01 50 00

****
USACE / A AC / A CEC / ASA i **U S 01 50 00 (May 2018)**
Change 1 02/19

Prepar ng Act v ty: USACE i **Supersed ng**
U S 01 50 00 (August 2009)

U I IED ACILITIES UIDE SPECI ICATIO S

References are n agreement w th UMRL dated Apr l 2019
********** **i**

SECTION TABLE OF CONTENTS

DIVISION 01 - GENERAL REQUIREMENTS

SECTION 01 50 00

TEMPORARY CONSTRUCTION FACILITIES AND CONTROLS

05/18 i

PART 1 GENERAL

1.1 REFERENCES
1.2 SUBMITTALS
1.3 CONSTRUCTION SITE PLAN
1.4 BACKFLOW PREVENTERS CERTIFICATE
1.4.1 Backflow Tester Certificate
1.4.2 Backflow Prevention Training Certificate
1.5 DOD CONDITION OF READINESS (COR)

PART 2 PRODUCTS

2.1 TEMPORARY SIGNAGE
2.1.1 Bulletin Board
2.1.2 Project Identification Signs **i**
2.1.3 Warning Signs
2.2 TEMPORARY TRAFFIC CONTROL
2.2.1 Haul Roads
2.2.2 Barricades
2.3 FENCING
2.3.1 Polyethylene Mesh Safety Fencing **i**
2.3.2 Chain Link Panel Fencing
2.3.3 Post-Driven Chain Link Fencing
2.4 TEMPORARY WIRING
2.5 BACKFLOW PREVENTERS

PART 3 EXECUTION

3.1 EMPLOYEE PARKING
3.2 TEMPORARY BULLETIN BOARD
3.3 AVAILABILITY AND USE OF UTILITY SERVICES
3.3.1 Temporary Utilities
3.3.2 Payment for Utility Services
3.3.3 Meters and Temporary Connections
3.3.4 Advance Deposit

3.3.5 Fina f R ading
3.3.6 f U i i i s a Sp cia Loca ions f
3.3.6.1 U i i i s a Guam by Con ac o o Sp cia P oj c s
3.3.6.2 U i i y S vic s a idway
3.3.7 U i i y S vic s o Di go Ga cia P oj c s
3.3.7.1 Con ac o -Own d and Op a d Radio T communica ions f
3.3.7.2 O -Is and
3.3.8 U i i y S vic s o Wak Is and
3.3.9 T phon s a idway, Wak , and Di go Ga cia
3.3.10 E c ici y
3.3.11 Wa
3.3.12 Sani a ion
3.3.13 T phon
3.3.14 Obs uc ion Ligh ing o C an s
3.3.15 Fi P o c ion
3.4 TRAFFIC PROVISIONS
3.4.1 ain nanc o T a ic
3.4.2 P o c ion o T a ic
3.4.3 Rush Hou R s ic ions
3.4.4 Dus Con o
3.4.5 Comm cia V hic s In/Ou o NAVSTA/NAS No o k, VA
3.5 CONTRACTOR'S TE PORARY FACILITIES
3.5.1 Qua i y Con o anag R co ds and Fi d O ic
3.5.2 Sa y Sys ms
3.5.3 Adminis a iv Fi d O ic s
3.5.4 S o ag A a
3.5.5 Supp m n a S o ag A a
3.5.6 App a anc o T ai s
3.5.7 T ai s o S o ag Bui dings
3.5.8 ain nanc o S o ag A a
3.5.9 N w Bui ding
3.5.10 S cu i y P ovisions
3.5.11 S o ag Siz and Loca ion
3.5.12 S o ag in Exis ing Bui dings
3.5.13 W a h P o c ion o T mpo a y Faci i i s and S o d a ia s f
3.5.13.1 Bui ding and Si S o m P o c ion
3.6 GOVERN ENT FIELD OFFICE
3.6.1 R sid n Engin 's O ic
3.6.2 T ai -Typ obi O ic
3.7 PLANT CO UNICATIONS
3.8 TE PORARY PROJECT SAFETY FENCING
3.9 DU PSTERS
3.10 CLEANUP
3.11 RESTORATION OF STORAGE AREA

-- End o S c ion Tab o Con n s -- f

SECTION 01 50 00

TEMPORARY CONSTRUCTION FACILITIES AND CONTROLS
05/18

****
OTE: Th s spec f cat on covers the requ rements for temporary construct on fac l t es, safety systems, construct on traff c prov s ons, construct on s gnage and controls over contractor operat ons requ red for use n all projects.

Adhere to UFC 1-300-02 Un f ed ac l t es u de Spec f cat ons (U S) ormat Standard when ed t ng th s gu de spec f cat on or prepar ng new project spec f cat on sect ons. Ed t th s gu de spec f cat on for project spec f c requ rements by add ng, delet ng, or rev s ng text. or bracketed tems, choose appl cable tem(s) or nsert appropr ate nformat on.

Remove nformat on and requ rements not requ red n respect ve project, whether or not brackets are present. i

Comments, suggest ons and recommended changes for th s gu de spec f cat on are welcome and should be subm tted as a Criteria Change Request (CCR).
****

PART 1 GENERAL

********** i
OTE: TO DOW LOAD U S RAPHICS go to:

htt ://www.wbdg.org/ffc/dod/unified-facilities-guide-s ecifications-ufgs/for

On the draw ngs, show:

1. Locat on of temporary bu ld ngs and storage areas, f spec f ed;

2. Locat on of temporary ut l ty connect ons, f spec f ed.
****

1.1 REFERENCE

E: his paragraph is used to list the publications cited in the te t of the guide specification. he publications are referred to in the te t by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the te t will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WATER WORK A OCIATION (AWWA)

AWWA C511	(2017) Reduced-Pressure Principle Backflow Prevention Assembly	**x**

FOUNDATION FOR CRO -CONNECTION CONTROL AND HYDRAULIC RE EARCH (FCCCHR)

FCCCHR List	(continuously updated) List of Approved Backflow Prevention Assemblies
FCCCHR Manual	(10th Edition) Manual of Cross-Connection Control

NATIONAL FIRE PROTECTION A OCIATION (NFPA)

NFPA 241 **x**	(2013; Errata 2015) tandard for afeguarding Construction, Alteration, and Demolition Operations	
NFPA 70	(2017; ERTA 1-2 2017; TIA 17-1; TIA 17-2; TIA 17-3; TIA 17-4; TIA 17-5; TIA 17-6; TIA 17-7; TIA 17-8; TIA 17-9; TIA 17-10; TIA 17-11; TIA 17-12; TIA 17-13; TIA 17-14; TIA 17-15; TIA 17-16; TIA 17-17) National Electrical Code	**x**

U. . ARMY CORP OF ENGINEER (U ACE)

EM 385-1-1 **x**	(2014) afety and Health Requirements Manual

U.S. FEDER ON DM N S R ON (F)

F C 70/7460-1 (2015; Rev) O struction Marking and b ighting

U.S. FEDER H GHW Y DM N S R ON (FHW)

MU CD (2015) Manual on Uniform raffic Control Devices

1.2 SUBM S b

****

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project.

The Guide Specification technical editors have designated those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" following a submittal item indicates that the submittal is required for the Sustainability eNotebook to fulfill federally mandated sustainable requirements in accordance with Section 01 33 29 SUSTAINABILITY REPORTING. Locate the "S" submittal under the SD number that best describes the submittal item.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

****

Government approval is required for su mittals with a "G" designation; su mittals not having a "G" designation are for [Contractor Quality Control approval.][information only. When used, a designation following the "G" designation identifies the office that will review the su mittal for the Government.] Su mittals with an "S" are for inclusion in the b

Sustainabi it ot book, in conformanc to S ction 01 33 29 SUSTAI ABILIT REPORTI G. Submit th fo owing in accordanc with S ction 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Pr construction Submitta s

****
NOTE: The following submittal must be included for NAVFAC SE projects at the Charleston Air Force Base and for other NAVFAC SE projects, as determined by the Contracting Officer, based on project size, scope, complexity, and visibility.
****

Construction Sit P an; G[, [_____]]

Traffic Contro P an; G[, [_____]]

Hau Road P an; G[, [_____]]

SD-03 Product Data

****
NOTE: Include the following for all projects connecting to a potable water supply.
****

Backf ow Pr v nt rs; G[, [_____]]

SD-06 T st R ports

Backf ow Pr v nt r T sts

SD-07 C rtificat s

Backf ow T st r C rtification

****
NOTE: Include the following for all projects connecting to a potable water supply.
****

Backf ow Pr v nt rs C rtificat of Fu Approva

1.3 CO STRUCTIO SITE PLA

Prior to th start of work, submit a sit p an showing th ocations and dim nsions of t mporar faci iti s (inc uding a outs and d tai s, quipm nt and mat ria storag ar a (onsit and offsit), and acc ss and hau rout s, av nu s of ingr ss/ gr ss to th f nc d ar a and d tai s of th f nc insta ation. Id ntif an ar as which ma hav to b grav d to pr v nt th tracking of mud. Indicat if th us of a supp m nta or oth r staging ar a is d sir d. Show ocations of saf t and construction f nc s, sit trai rs, construction ntranc s, trash dumpst rs, t mporar sanitar faci iti s, and work r parking ar as.

1.4 BACKFLOW PREVE TERS CERTIFICATE

C rtificat of Fu Approva from FCCCHR List, Univ rsit of South rn Y

California 4a ing ha 4 h d ign iz and mak of ach backflow pr v n r ha a i fac orily pa d h compl4 qu nc of p rformanc ing and valua ion for h r p c iv l v l of approval. C r ifica of Provi ional Approval will no b acc p abl .

1. .1 Backflow T r C r ifica

Prior o ing ubmi o h Con rac ing Offic r c r ifica ion i u d by h S a or local r gula ory ag ncy a ing ha h backflow r ha ucc fully compl d a c r ifica ion cour pon or d by h r gula ory ag ncy. T r mu no b affilia d wi h any company par icipa ing in any o h r pha of hi Con rac .

1. .2 Backflow Pr v n ion Training C r ifica

Submi a c r ifica r cogniz d by h S a or local au hori y ha a h Con rac or ha compl d a l a 10 hour of raining in backflow pr v n r in alla ion . Th c r ifica mu b curr n .

1.5 DOD CONDITION OF READINESS (COR)

DOD will 4 h Condi ion of R adin (COR) ba d on h w a h r for ca for u ain d wind 50 kno (60mph or 95 km/hr) or gr a r. Con ac h Con rac ing Offic r for h curr n COR ing.

Moni or w a h r condi ion a minimum of wic a day and ak appropria ac ion according o h aprov d Em rg ncy Plan in h acc p d Accid n Pr v n ion Plan EM-385-1-1 S c ion 01 Em rg ncy Planning and h in ruc ion b low.

Unl o h rwi dir c d by h Con rac ing Offic r comply wi h:

a. Condi ion FOUR (Su ain d wind of 93 km/hr 50 kno or gr a r xp c d wi hin 72 hour): Normal daily job i cl anup and good hou k ping prac ic . Coll c and or in pil or con ain r crap lumb r wa ma rial and rubbi h for r moval and di po al a h clo of ach work day. Main ain h con ruc ion i including orag ar a fr of accumula ion of d bri . S ack form lumb r in n a pil l han on m f high. R mov all d bri ra h or obj c ha could b com mi il hazard .

b. Condi ion THREE (Su ain d wind of 93 km/hr 50 kno or gr a r xp c d wi hin 8 hour): Main ain "Condi ion FOUR" r quir m n and comm nc curing op ra ion n c ary for "Condi ion ONE" which canno b compl d wi hin 18 hour . C a all rou in ac ivi i which migh in rf r wi h curing op ra ion . Comm nc curing and ow all g ar and por abl quipm n . Mak pr para ion for curing building . R vi w r quir m n p r aining o "Condi ion TWO" and con inu ac ion a n c ary o a ain "Condi ion THREE" r adin .

c. Condi ion TWO (Su ain d wind of 93 km/hr 50 kno or gr a r xp c d wi hin 2 hour): Cur ail or c a rou in ac ivi i un il curing op ra ion i compl . R inforc or r mov form work and caffolding. S cur machin ry ool quipm n ma rial or r mov from h job i . Exp nd v ry ffor o cl ar all mi il hazard and loo quipm n from g n ral ba ar a .

d. Condi ion ONE. (Su ain d wind of 93 km/hr 50 kno or gr a r xp c d wi hin 12 hour): S cur h job i and l av Gov rnm n

premises.

P a P ODUC S

.1 EMPO Y SIGN GE

.1.1 Bulletin Bo rd

Within [one] [_____] c lend r d y[s] of mobiliz tion on site nd prior to the commencement of work ctivities, provide cle r we therproof covered bulletin bo rd not less th n 915 by 1 0 mm 36 by 48 inches in size for displ ying the Equ l Employment Opportunity poster, copy of the w ge decision cont ined in the contr ct, W ge te Inform tion poster, S fety nd He lth Inform tion s required by EM 385-1-1 Section 01 nd other inform tion pproved by the Contr cting Officer. Coordin te requirements herein with 01 35 6 GOVE NMEN L S FE Y EQUI EMEN S.

.1. Project Identific tion Signs

he requirements for the signs, their content, nd loc tion re [s indic ted][nd][s specified in Section 01 58 00 P OJEC IDEN IFIC ION]. Erect signs within 15 d ys fter receipt of the notice to proceed. Correct the d t required by the s fety sign d ily, with light colored met llic or non-met llic numer ls.

.1.3 W rning Signs

Post tempor ry signs, t gs, nd l bels to give workers nd the public dequ te w rning nd c ution of construction h z rds ccording to the EM 385-1-1 Section 04. tt ch signs to the perimeter fencing every 150 feet w rning the public of the presence of contruction h z rds. Signs must require un uthorized persons to keep out of the construction site. Correct the d t required by s fety signs d ily.

. EMPO Y FFIC CON OL

. .1 H ul o ds

Construct ccess nd h ul ro ds necess ry for proper prosecution of the work under this contr ct in ccord nce with EM 385-1-1 Section 04. Construct with suit ble gr des nd widths; sh rp curves, blind corners, nd d ngerous cross tr ffic re be voided. Submit h ul ro d pl n for pprov l. Provide necess ry lighting, signs, b rric des, nd distinctive a m rkings for the s fe movement of tr ffic. he method of dust control, lthough option l, must be dequ te to ensure s fe oper tion t ll times. Loc tion, gr de, width, nd lignment of construction nd h uling ro ds re subject to pprov l by the Contr cting Officer. Lighting must be dequ te to ssure full nd cle r visibility for full width of h ul ro d nd work re s during ny night work oper tions.

. . B rric des

Erect nd m int in tempor ry b rric des to limit public ccess to h z rdous re s. Whenever s fe public ccess to p ved re s such s ro ds, p rking re s or sidew lks is prevented by construction ctivities or s otherwise necess ry to ensure the s fety of both pedestri n nd vehicul r tr ffic b rric des will be required. Securely pl ce b rric des cle rly visible with dequ te illumin tion to provide sufficient visu l w rning of the h z rd during both d y nd night.

2.3 FENC N

TE: Fencing requirements must be eva uated based on the exposure potentia of the construction site to the pub ic. The pub ic is considered as any non-construction personne . Minimum fencing may range from ny on fabric (reinforced by a top supporting cab e to provide adequate strength to provide needed physica protection) to 2400 mm 8 foot chain ink fencing. l

Provide fencing along the construction site and at all open excavations and **l** tunnels to control access by unauthorized personnel. Safety fencing must be highly visible to be seen by pedestrians and vehicular traffic. Specific fencing requirements are as described herein. All fencing will meet the requirements of EM 385-1-1.

2.3.1 Polyethylene Mesh Safety Fencing

Temporary safety fencing must be a high visibility orange colored, high density polyethylene grid, a minimum of 48 inches high and maximum mesh size of 2 inches. Fencing must extend from the grade to a minimum of 48 inches above the grade and be tightly secured to T-posts spaced as necessary to maintain a rigid and taut fence. Fencing must remain rigid and taut with a minimum of 200 pounds of force exerted on it from any direction with less than 4 inches of deflection. **l**

2.3.2 Chain Link Panel Fencing

TE: Se ect 6 feet high chain ink fencing un ess 8 feet is needed for additiona security.

Temporary panel fencing must be galvanized steel chain link panels [6] [8] feet high. Multiple fencing panels may be linked together at the bases toform long spens as needed. Each panel base must be weighted down using **l** sand bags or other suitable materials in order for the fencing to withstand anticipated winds while remaining upright. Fencing must remain rigid and taut with a minimum of 200 pounds of force exerted on it from any direction with less than 4 inches of deflection.

2.3.3 Post-Driven Chain Link Fencing

Temporary post-driven fencing must be galvanized chain link fencing [6] [8] feet high supported by an tightly secured to galvanized steel posts driven below grade. Fence posts must be located on minimum 10 foot centers. Posts may be set in various sufaces such as sand, soil, ashpalt or concrete as necessary. Chain link fencing must remain rigid and taut with a minimum of 200 pounds of force exerted on it from any direction with less than 4 inches of deflection. Fencing and posts must be completely removed at the completion of construction and any surfaces disturbed or damaged must be restored to its original condition. Underground utilities must be located and identified prior to setting fence posts. Fence must be equipped with a lockable gate. ate must remain locked when construction personnel are not present. **l**

2.4 TEMP h I ING

Provide temporary wiring in accordance wit EM 385-1-1 Section 11, NFP 241 and NFP 70. Include mont ly inspection and testing of all equipment and apparatus.

2.5 B CKFL P EVENTE S

****
NOTE: Include the following for all projects connecting to a potable water supply.

Consider using a lead free, brass body backflow preventer assembly on water lines 50 mm 2 inches or smaller. For water lines greater than 50 mm 2 inches, consider using a cast-iron body backflow preventer assembly.

For NAVFAC SW, information on FCCCHR List approved reduced pressure principle backflow devices may be obtained from the Navy Public Works Center, San Diego, Utilities Department, (619) 556-7964.

For NAVFAC Hawaii projects include the bracketed text containing NAVFAC Hawaii Water Utilities.
****

educed pressure principle type conforming to t e applicable requirements C511. Provide backflow preventers complete wit [65 kg][150 pound] [_____] flanged [cast iron], [bronze][brass] mounted gate valve [and strainer], [304][_____] stainless steel or bronze, internal parts. [T e particular make, model/design, and size of backflow preventers to be installed must be included in t e latest edition of t e List of pproved Backflow Prevention ssemblies issued by t e FCCCH List and be accompanied by a Certificate of Full pproval from FCCCH List.] [fter installation conduct Backflow Preventer Tests and provide test reports verifying t at t e installation meets t e FCCCH Manual Standards.] [fter installation, N VF C Hawaii ater Utilities s all test and certify backflow preventer. If h t e temporary water connection needs to be moved to anot er location during construction, t e Contractor s all notify t e Contracting fficer in writing a minimum of 5 working days prior to movement. T e relocated backflow preventer s all be re-tested and re-certified by N VF C Hawaii ater Utilities.]

P T 3 EXECUTI N

****
NOTE: Delete inapplicable paragraphs, selecting desired options for electricity, water, gas, heating and ventilating, sanitary, and fire protection facilities.
****

3.1 EMPL EE P KING

Construction contract employees will park privately owned ve icles in an area designated by t e Contracting fficer. T is area will be wit in reasonable walking distance of t e construction site. Employee parking must not interfere wit existing and establis ed parking requirements of h

the gover e t t ll t o .

3.2 TEMPORARY BULLETIN BOARD

Lo te the bullet bo rd t the proje t te o p uou pl e e ly e ble to ll e ployee , pproved by the Co tr t g Off er.

3.3 AVAILABILITY AND USE OF UTILITY SERVICES c

3.3.1 Te por ry Ut l t e

Prov de te por ry ut l t e requ red for o tru t o . M ter l y be ew or u ed, u t be dequ te for the requ red u ge, ot re te u fe o d t o , d ot v ol te ppl ble ode d t d rd .

3.3.2 P y e t for Ut l ty Serv e

****

NOTE: Use the following subparts related to payment of utilities for Army and Navy projects only. NASA does not normally charge for the use of utilities.

This paragraph must be coordinated with the Contracting Officer. Coordinate with FAR 52.236-14 Availability and Use of Utility Services. Choose one of the following options. For NAVFAC, delete the article if utility service is covered in a Section "Special Conditions for Projects at (_____)"; used for some stations on a regional basis.

Government utilities listed in this paragraph may be furnished, if available without interfering with Government needs. Indicate the point at which the Government will deliver each utility specified and should show pertinent data such as voltage, L/min gal/min, and pipe sizes on the general layout plan or other appropriate drawing. Information regarding the types of utilities available, the rates, the points of connection' and the quantities available should be obtained from the Government.

****

. The Gover e t w ll ke ll re o bly requ red ut l t e v l ble fro ex t g outlet d uppl e , pe f ed the o tr t. U le otherw e prov ded the o tr t, the ou t of e h ut l ty erv e o u ed w ll be h rged to or p d t prev l g r te h rged c to the Gover e t or, where the ut l ty produ ed by the Gover e t, t re o ble r te deter ed by the Co tr t g Off er. C refully o erve y ut l t e fur hed w thout h rge.

b. Re o ble ou t of the follow g ut l t e w ll be de v l ble [w thout h rge.] [t the prev l g r te .] [t the follow g r te :]

Ut l ty Serv e

Co t ($) per U t c

le t i ity q

Potable Wate

Salt Wate

Comp e ed Ai

Steam

Natu al Ga

Sanita y Sewe

. The point at whi h the Go e nment will deli e u h utilitie o e i e and the uantity a ailable i a indi ated. Pay all o t in u ed in onne ting, on e ting, and t an fe ing the utilitie to the wo k. Make onne tion , in luding [p o iding ba kflow-p e enting de i e on onne tion to dome ti wate line ;] [p o iding mete ;] and p o iding t an fo me ; and make di onne tion . [Unde no i um tan e will tap to ba e fi e hyd ant be allowed fo obtaining dome ti wate .]

3.3.3 Mete and Tempo a y Conne tion

P o ide and maintain ne e a y tempo a y onne tion , di t ibution line , and mete ba e (Go e nment will p o ide mete) e ui ed to mea u e the amount of ea h utility u ed fo the pu po e of dete mining ha ge . Notify the Cont a ting Offi e , in w iting, 5 wo king day befo e final ele t i al onne tion i de i ed o that a utilitie ont a t an be e tabli hed. The Go e nment will p o ide a mete and make the final hot onne tion afte in pe tion and app o al of the Cont a to ' tempo a y wi ing in tallation. Do not make the final ele t i al onne tion.

3.3.4 Ad an e Depo it

An ad an e depo it fo utilitie on i ting of an e timated month' u age o a minimum of $50.00 will be e ui ed. The la t monthly bill fo the fi al yea will no mally be off et by the depo it and adju tment will be billed o etu ned a app op iate. Se i e to be ende ed fo the next fi al yea , beginning 1 O tobe , will e ui e a new depo it. Notifi ation of the due date fo thi depo it will be mailed p io to the end of the u ent fi al yea .

3.3.5 Final Mete Reading

Bef o e ompletion of the wo k and final a eptan e of the wo k by the Go e nment, notify the Cont a ting Offi e , in w iting, 5 wo king day befo e te mination i de i ed. The Go e nment will take a final mete eading, di onne t e i e, and emo e the mete . Then emo e all the tempo a y di t ibution line , mete ba e , and a o iated pa aphe nalia. Pay all out tanding utility bill befo e final a eptan e of the wo k by the Go e nment.

3.3.6 Utilitie at Spe ial Lo ation

****

NOTE: Fo N F ojects choose one of the following o tions. Fo the fi st o tion, in the fi st set of b ackets, inse t the name of the acti ity to which a lication should be made. Include the second b acketed ex ession fo ojects located at M S he y Point.

****

a. [Reasonable amounts of utilities will be made available at the prevailing Government rates. These rates may be obtained upon application to the Commanding Officer, [_____], by way of the Contracting Officer. Making connections, provide transformers and meters, and disconnections; and provide backflow preventer devices on connections to domestic water lines. [Neither potable water nor sanitary facilities will be available at the main Contractor laydown area at Marine Corps Air Station (MCAS), Cherry Point, NC.]]

****

NOTE: Use the following o tion fo ojects located in gentina and the zo es and fo i Fo ce ojects in the N F tlantic. Use this a ag a h fo othe acti ities only when a o ed by the acti ity.

****

b. [Reasonable amounts of utilities will be made available without charge. Make connections, provide transformers and meters, make disconnections; and provide backflow preventer devices on connections to domestic water lines. Under no circumstances will taps to base fire **v** hydrants be allowed for obtaining domestic water.]

****

NOTE: Use the following o tion only fo M ON funded and non-a o iated funds ojects at Ma ine o s Base, am Lejeune and Ma ine o s i Station (Helico te (H)), New Ri e .

****

[Reasonable amounts of utilities will be made available at the prevailing Government rates and may be obtained upon application to the Base Maintenance Officer, Bldg. 1202, Marine Corps Base, Camp Lejeune. A refundable security deposit to the Resident Officer in Charge of Construction shall be made prior to application for services. Provide transformers, meter bases, electrical service poles and drops for electrical services, and backflow preventer devices on connections to domestic water lines. Final taps and tie-ins to the Government utility grid will be made by Base Maintenance who will also provide and seal a 120 or 208 volt, three-wire kWh meter. Tap-in cost, if any, shall be the responsibility of the Contractor. Tampering or movement of a sealed meter without notification to base maintenance is grounds for discontinuance of electrical service. Provide larger meters required if they are not available from the Government. The Contractor is responsible for the cost of utility services required until the date of **v** Government acceptance. Under no circumstances will taps to base fire **v** hydrants be allowed for obtaining domestic water.]

[3.3.6.1 Utilities at Guam by Contractor for Special Projects

Contact the Government of Guam for water and electricity.

][3.3.6.2 U erv ces a M dwa

a. Po ab e wa er s ra oned dur ng dr per ods and no ava ab e for cons ruc on purposes dur ng he on hs of June and Ju .

b. E ec r ca power ava ab e, pr ar vo age s 2400 vo 3 phase, 3 w re, 60 c c e AC. econdar vo ages a be 120/208 or 120/240 vo s.

c. Prov de new e ers for po ab e wa er, brack sh wa er and e ec r c . The cos of u serv ces furn shed a be reduced b he cos he Govern en wou d nor a pa for co parab e e ers f, a he end of he job, he e ers are de vered o he Govern en n good cond on.

][3.3.7 U erv ces for D ego Garc a Projec s

a. Po ab e wa er w be ade ava ab e o Con rac or's off ce and hous ng. The preva ng ra e for po ab e wa er s $2.07 per housand ga ons.

b. No charge for brack sh wa er.

c. E ec r ca power ava ab e s pr ar , 2400 vo 3 phase, 3 w re, 60 m c c e AC, secondar vo ages a be 120/208 or 120/240 vo s. The preva ng ra e for e ec r c s $0.0647 per k owa hour (KWH).

d. ewage cos s a $1.09 per 3800 L KGAL.

e. Prov de new e ers for po ab e wa er and e ec r c . The cos of u serv ces furn shed a be reduced b he cos he Govern en wou d nor a pa for co parab e e ers f, a he end of he job, he m e ers are de vered o he Govern en n good cond on.

[3.3.7.1 Con rac or-Owned and Opera ed Rad o Te eco un ca ons

****
NOTE: Use for Diego Garcia projects.
****

A rans er/rece ver and an enna a be erec ed upon approva b he Con rac ng Off cer. ub for approva , 30 ca endar da s pr or o he use of he equ p en , he pe of rad o equ p en power and band w d h of he equ p en .

][3.3.7.2 Off-Is and

****
NOTE: Use for Diego Garcia projects.
****

The Govern en w prov de ar essage co un ca on fro D ego Garc a a no cos . The Con rac or s respons b e for he cos of re rans ng essages hrough co erc a sources. Process essages hrough he Con rac ng Off cer. Messages w be screened and ed use of co un ca on fac es w be per ed. Pr va e essages w be per ed on for e ergenc es. The Nav vo ce co un ca on s s e s no onger ava ab e for use. A oca vendor prov des co erc a vo ce and e e pe serv ces for [$3.32][_____] per nu e.

]]3.3.8 Uti it vic s fo Wak Is and

[a. Potab wat ma not b avai ab fo const uction du ing d iods. D sa iniz d wat avai ab du ing d iods at $1300.00 da fo 114-150 kL 30,000-40,000 ga ons da .

b. Avai ab ima vo tag is 4160 vo ts, 3 has , 3 wi , 60 c c . conda is 120/208 vo ts, 3 has , 60 c c .]

[3.3.9 T hon s at Midwa , Wak , and Di go Ga cia

On-Is and s vic ma b obtain d if in s a avai ab . Mak a ang m nts th ough th Cont acting Offic . Th vai ing at fo cab o wi ss is $100.00 hon . Th is no cha g fo on-is and t hon s vic . [Cu nt at s a [$_____] month fo ach ivat t hon in us an insta ation cha g of [$_____] fo ach inst um nt and [$_____] month fo two- a t in s us [$_____] month fo ach xt nsion. Pa fo th cost of th wi ing on uns in xc ss of two s ans]. Long distanc s vic s a usua avai ab at comm cia at s. p Th Nav Radio Communication st m o D f ns witch N two k wi not b avai ab fo us . [Limit d t t w it ci cuit s vic is avai ab .]

]3.3.10 E ct icit

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accordance M 385-1-1 Sec on 02. Ven la e e un s o con rol odors and fumes and emp y and clean em a leas once a ee or more of en f requ red by e Con rac ng Off cer. Prov de self-clos ng doors. T e ex er or of e un s all ma c e base s andard color. Loca e e fac l y be nd e cons ruc on fence or ou of e publ c v e .]

3.3.13 Telep one

Ma e arrangemen s and pay all cos s for elep one fac l es des red.

3.3.14 Obs ruc on L g ng of Cranes

Prov de a m n mum of 2 av a on red or g n ens y e obs ruc on l g s on emporary s ruc ures (nclud ng cranes) over 30 me er 100 fee above ground level. L g cons ruc on and ns alla on mus comply FAA AC 70/7460-1. L g s mus be opera onal dur ng per ods of reduced v s b l y, dar ness, and as d rec ed by e Con rac ng Off cer.

3.3.15 F re Pro ec on

Prov de emporary f re pro ec on equ pmen for e pro ec on of personnel and proper y dur ng cons ruc on. Remove debr s and flammable ma er als [da ly][ee ly][mon ly] o m n m ze po en al azards.

3.4 TRAFFIC PROVISIONS

3.4.1 Ma n enance of Traff c

a. Conduc opera ons n a manner a ll no close any oroug fare or n erfere n any ay raff c on ra l ays or g ays excep r en perm ss on of e Con rac ng Off cer a leas 15 calendar days pr or o e proposed mod f ca on da e, and prov de a Traff c Con rol Plan de a l ng e proposed con rols o raff c movemen for approval. T e plan mus be n accordance S a e and local regula ons and e MUTCD, Par VI. [Ma e all no f ca ons and ob a n any perm s requ red for mod f ca on o raff c movemen s ou s de S a on's jur sd c on.]. Con rac or may move overs zed and slo -mov ng ve cles o e or s e prov ded requ remen s of e g ay au or y ave been me .

b. Conduc or so as o m n m ze obs ruc on of raff c, and ma n a n raff c on a leas alf of e road ay d a all mes. Ob a n k approval from e Con rac ng Off cer pr or o s ar ng any ac v y a ll obs ruc raff c.

c. Prov de, erec , and ma n a n, a con rac ors expense, l g s, barr ers, s gnals, passage ays, de ours, and o er ems, a may be requ red by e L fe Safe y S gnage, over ead pro ec on au or y av ng jur sd c on.

3.4.2 Pro ec on of Traff c

Ma n a n and pro ec raff c on all affec ed roads dur ng e cons ruc on per od excep as o er se spec f cally d rec ed by e Con rac ng Off cer. Measures for e pro ec on and d vers on of raff c, nclud ng e prov s on of a c men and flagmen, erec on of barr cades, plac ng of l g s around and n fron of equ pmen e or , and e erec on and ma n enance of adequa e arn ng, danger, and d rec on s gns, ll be as

required b e e nd loc l u ori ies ving jurisdic ion. Pro ec e r veling public from d m ge o person nd proper . Minimize e in erference wi public r ffic on ro ds selec ed for uling m eri l o nd from e si e. Inves ig e e dequ c of exis ing ro ds nd eir llow ble lo d limi . on r c or is responsible for e rep ir of n d m ge o ro ds c used b cons ruc ion oper ions.

3.4.3 Rus Hour Res ric ions

Do no in erfere wi e pe k r ffic flows preceding nd during norm l oper ions for [_____] wi ou no ific ion o nd pprov l b e on r c ing Officer.

3.4.4 Dus on rol

Dus con rol me ods nd procedures mus be pproved b e on r c ing Officer. oordin e dus con rol me ods wi 01 57 19 TEMPORARY ENVIRONMENTAL ONTROL .

[3.4.5 ommerci l Ve icles In/Ou of NAV TA/NA Norfolk, VA

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NOTE: Use the following paragraphs only for projects located at Naval Station (NAVSTA) or Naval Air Station (NAS), Norfolk, VA.

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. Defini ions. ommerci l v ns nd rucks re differen i ed s follows:

(1) losed ruck. A ruck enclosed on four sides, op, nd bo om o w ic en r c n be m de onl roug end or side doors nd o w ic se l c n be pplied.

(2) Open ruck. A ruck w ic is ei er full open, suc s fl bed, C or con ined b wooden sl s or sidebo rds; or n ruck o w ic se l c nno be pplied.

(3) ommerci l ve icles. A common con r c or commerci l ruck wi ou dec l issued b Norfolk, VA.

(4) Tr iler. A non-self-propelled enclosed c rgo con iner used for e r nspor ion of goods, e.g., r iler pulled b ruck.

b. Ins ruc ions nd direc ions. Ensure commerci l rucks nd r ilers follow e ins ruc ions below o provide for effec ive con rol over eir en r nd exi from e b se, movemen wi in e b se, nd o reduce conges ion bo e g es nd wi in e b se. In gener l, commerci l rucks nd common c rriers re required o en er nd exi roug specified g es nd process immedi el o ruck con rol poin for c rgo m nifes c eck. T e driver s ll be issued M eri l Movemen on rol nd G e P ss, rou ing ins ruc ions, nd direc ions o dep r e b se vi design ed exi poin w ere e p ss is o be urned in.

(1) ommon con r c nd commerci l rucks going o e re of Building LP-84 (MA Termin l), NA Norfolk s ll en er nd exi G e 22. G e 22 ours of oper ions re 5:30 .m. roug 6:30 p.m. nd 10:30 p.m. roug 3:00 .m., 7 d s week. T e g e is closed on olid s.

(2) Othe t a t a d e ial t u ks, ex ept as ted bel w a e all wed t e te the Naval Base th ugh a y Gate a d exit th ugh Gate 2

(3) C t a t a d e ial t u ks whi h e te the base ay depa t th ugh Gate 5, Gate 4, a d Gate 22 ly The exit T u k C t l P i t at Gate 4 is pe ated f 7:00 a t 5:00 p

(4) F ete- a d asphalt- a yi g t u ks, the Reside t Offi e i Cha ge f C st u ti (ROICC), N f lk VA shall a a ge e t y a d exit th ugh a y gate the tha Gate 2

(5) C t a t vehi les with bla k N f lk Naval Base de als shall be g a ted uti e a ess t the base at all ti es These t u ks shall t e te exit the base th ugh Gate 2 These t u ks a e subje t t a d he ks a d sea hes at exit gates like the pe s al a d e ial vehi les t e su e that G ve e t p pe ty is t bei g take ff the base with ut auth izati a d d u e tati

M ve e t a d Exit

(1) Mate ial ve e t t l a d gate pass A Mate ial M ve e t C t l a d Gate Pass (5ND GEN 5510/1) is equi ed f the e val f G ve e t, publi , p ivate p pe ty f NAVSTA a d NAS N f lk plex via e ial va s a d t u k

(a) The Mate ial M ve e t C t l a d Gate Pass shall be igi ated by the Naval Base P li e T u k C t l Offi e , a d shall be give. t d ive s f e ial t u ks f ete ti du i g t a sit t i te ediate st ps a d t the exit gates The pass shall be p ese ted by the d ive t the T u k C t l Offi e at the exit t u k st p If the d ive has e tha e delive y pi kup p i t, the d ive shall p ese t the pass at ea h st p s the ew a tivity ay fill i app p iate i f ati the pass A py f the pass shall be etai ed by ea h a tivity afte app p iate i f ati has bee e te ed; e ai i g pies f the pass shall be etu ed t the d ive Passes a e subje t t eview by the Naval Base P li e Depa t e t du i g t a sit a d withi a d a eas by a tivity ffi ials f ve ifi ati f a g te t a d t dete i e if d ive s a e t a siti g p ptly a d by the p pe ute F t aile s expe ti g t be pi ked up a d depa t utside. al w ki g h u s, p e-p epa ed passes shall be p vided by the a tivity duty ffi e auth ized supe visi g pe s p i t l se f w ki g h u s T u ki g pa ies expe ti g t pi k up t aile s afte w ki g h u s sh uld be i st u ted t pi k up a Mate ial M ve e t C t l a d Gate Pass f the esp sible a tivity The a tivity duty ffi e ffi ial shall tify Base P li e Headqua te s t lea the t u k f exit at Gate 5 if the seal a d Mate ial M ve e t C t l a d Gate Pass a e i de

(b) Whe filli g ut a Mate ial M ve e t C t l a d Gate Pass, the last a tivity whe e busi ess is du ted the base is esp sible t e su e that the igi al f the pass is give t the d ive t tu i t the T u k C t l ffi e at the t u k t l st ps

(c) The M N e Movemen Con o nd G e P ss sh be u ned n by he veh c e d ve o b se po ce off ce uck con o s op when he dep u es f om he b se.

(d) Gove nmen o comme c veh c es dep ng v B se, o fo k w h Gove nmen , pub c, o p v e p ope y sh possess M e Movemen Con o nd G e P ss f ed ou by n v off ce o equ v en g de c v n w h n he d ve 's ch n of comm nd. The M e Movemen Con o nd G e P ss sh be nspec ed nd ve f ed du ng ndom g e dep u e se ches.

(2) C Se s

( ) Comme c , se b e, c osed N e s nd ucks, fu , p N y fu , o emp y, des ned o e ve he b se sh be se ed upon dep u e f om ny c v y. The se numbe nd e o uck numbe sh be en e ed on he M N e Movemen Con o nd G e P ss.

(b) Comme c c osed e s nd ucks ece ved emp y fo o d ng w h Gove nmen m e sh h ve vy c se ff xed o c go doo s f e o d ng nd p o o dep ng h ough des gn ed g es.

(c) C osed e s nd ucks wh ch h ve been on y p N y o ded o off- o ded sh be se ed comp e e y he end of wo k ng hou s w h vy c se .

(d) App c on of vy c se s s he espons b y of he c v y n ch ge of o d ng nd un o d ng of e s nd ucks.

(e) The v B se Po ce Dep men w conduc ndom checks of con en s, se s, nd fo ms of e s nd ucks on he v B se comp ex.

(f) A uck d ve whose v n o uck does no h ve p ope y comp e ed M e Movemen Con o nd G e P ss o c se w be efused ex c e nce. N

]3.5 CO TRACTOR'S TEMPORARY FACILITIES

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NOTE: For NASA projects use the following paragraph and insert NASA center regulatory document number and time period compliance.
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Con c o -owned o - e sed e s mus be den f ed by Gove nmen ss gned numbe s. S ze nd oc on of he numbe w comp y w h [_____]. App y he numbe o he e w h n [14][_____] c end d ys of no f c on, o soone , f d ec ed by he Gove nmen . Tempo y f c es w mee equ emen s s den f ed n EM 385-1-1 Sec on 04.

[3.5.1 Qu y Con o M n ge Reco ds nd F e d Off ce

********** N
NOTE: Include this paragraph when project has separate QC Manager and project Superintendent. Edit to suit the size and location of the project.

****

Provide o e obsi e a office wi approxima ely [9][18][_____] sq are me er [100][200][_____] sq are fee of sef l floor area for e excl sive se of e QC Ma ager. Provide a wea er ig s r c re wi adeq a e [ea i g a d cooli g,] oile facili ies, lig i g, ve ila io , a 1200 by 2400 mm 4 by 8 foo pla able, a s a dard size office desk a d c air, comp er s a io , a d worki g comm ica io s facili ies. [Provide ei er a 1,500 wa radia ea er a d a wi dow-mo ed air co di io er ra ed a 2.6 kW 9,000 B s mi im m or a wi dow-mo ed ea p mp of e same mi im m ea i g a d cooli g ra i gs.] Provide a door wi a cyli der lock a d wi dows wi locki g ardware. Make ili y co ec io s. Loca e [as direc ed][w ere i dica ed]. File q ali y co rol records i e office a d make available a all imes o e Gover me . Af er comple io of e work, remove e e ire s r c re from e si e.

]3.5.2 Safe y Sys ems

Pro ec e i egri y of a y i s alled safe y sys ems or perso el safe y devices. Ob ai prior approval from Co rac i g Officer if e ra ce i o sys ems servi g safe y devices is req ired. If i is emporarily ecessary o remove or disable perso el safe y devices i order o accomplis co rac req ireme s, provide al er a ive mea s of pro ec io prior o removi g or disabli g a y perma e ly i s alled safe y devices or eq ipme a d ob ai approval from e Co rac i g Officer.

3.5.3 Admi is ra ive Field Offices

Provide a d mai ai admi is ra ive field office facili ies wi i e co s r c io area a e desig a ed si e. Gover me office a d ware o se facili ies will [o] be available o e Co rac or's perso el.

3.5.4 S orage Area

Co s r c u a emporary 1.8 m 6 foo ig c ai li k fe ce aro d railers a d ma erials. I cl de plas ic s rip i ser s, colored [gree][brow], so a visibili y ro g e fe ce is obs r c ed. Fe ce pos s may be drive , i lie of co cre e bases, w ere soil co di io s permi . Do o place or s ore railers, ma erials, or eq ipme o side e fe ced area less s c railers, ma erials, or eq ipme are assig ed a separa e a d dis i c s orage area by e Co rac i g Officer away from e vici i y of e co s r c io si e b wi i e i s alla io bo daries. Trailers, eq ipme , or ma erials m s o be ope o p blic view wi e excep io of ose i ems w ic are i s ppor of o goi g work o a y give day. Do o s ockpile ma erials o side e fe ce i prepara io for e ex day's work. Park mobile eq ipme , s c as rac ors, w eeled lif i g eq ipme , cra es, r cks, a d like eq ipme wi i e fe ced area a e e d of eac work day.

3.5.5 S ppleme al S orage Area

Upo req es , a d pe di g availabili y, e Co rac i g Officer will desig a e a o er or s ppleme al area for e se a d s orage of railers, eq ipme , a d ma erials. T is area may o be i close proximi y of e co s r c io si e b will be wi i e i s alla io bo daries. T e area will be mai ai ed i a clea a d orderly fas io a d sec red if eeded o pro ec s pplies a d eq ipme . U ili ies will o be provided o is area by e Gover me .

3.5.6 Appe[e f T ile s

. T ile s whi h e usted, h ve peeli g p i t e the wise i eed f ep i will t be ll wed I st ll ti p pe ty. T ile s must p ese t le d e t exte i ppe e d be i st te f g d ep i .

b. P i t i d e with f ility st d ds] d m i t i the temp y f ilities. F ilu e t d s will be suffi ie t e s t equi e thei em v l.

3.5.7 T ile s St ge Buildi gs

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NOTE: Use this paragraph for projects located on the Naval Base Complex, Norfolk, Virginia.

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. T ile s st ge buildi gs will be pe mitted, whe e sp e is v il ble, subje t t the pp v l f the C t ti g Offi e . The t ile s buildi gs sh ll be i g d diti , f ee f m visible d m ge ust d dete i ti , d meet ll ppli ble s fety equi eme ts. T ile s sh ll be dw thy d mply with ll pp p i te st te d l l vehi le equi eme ts. F ilu e t m i t i st ge t ile s buildi gs t these st d ds m y esult i the em v l f - mplyi g u its t the C t t 's expe se. A sig t sm lle th 600 by 600 mm 24 by 24 i hes sh ll be spi u usly pl ed the t ile depi ti g the mp y me, busi ess ph e umbe , d eme ge y ph e umbe . T ile s must be h ed t esist high wi ds d must meet ppli ble st te f l l st d ds f [h i g m bile t ile s. C di te h i g with EM 385-1-1 Se ti 04.

b. NAVFACENGCOM LANT T ile Sig . A sig sh ll be m u ted the t ile buildi g th t sh ws the mp y me, ph e umbe , eme ge y ph e umbe d f ms t the f ll wi g equi eme ts d sket h :

G phi p el [	Alumi um, p i ted blue
C py [	S ee p i ted vi yl die- ut, white
Typef e	U ive s 65 u/l [

See Sket[h N [. 01500 (g phi).

3.5.8 M i te e f St ge A e

. Keep fe i g i st te f g d ep i d p pe lig me t. G ssed u p ved e s, whi h e t est blished dw ys, d will be t ve sed with st u ti equipme t the vehi les, will be ve ed with l ye f g vel s e ess y t p eve t utti g d the t ki g f mud t p ved est blished dw ys, sh uld the C t t ele t t t ve se them with st u ti equipme t the vehi les. M w d m i t i g ss l ted withi the b u d ies f the st u ti site f the du ti f the p je t. G ss d veget ti l g fe es, buildi gs, u de t ile s, d i e s t essible t m we s will be edged t immed e tly.

b. Cut gr r u l weed) withi the c tructi d t r ge ite t m ximum 100 mm 4 i ch height t le t ce week duri g the gr wi g e , whether r t re i vi ible t the public t i t i r de t c tr l. Trim the gr r u d e ce t time gr cutti g. M i t i gr r weed t ckpiled e rth de cried b ve.

3.5.9 New Buildi g

I the eve t ew buildi g i c tructed r the temp r ry pr ject ield ice, it will be mi imum 3.6 m 12 eet i width, 5 m 16 eet i le gth d h ve mi imum 2.1 m 7 eet he dr m. Equip the buildi g with ppr ved electric l wiri g, t le t e d uble c ve ie ce utlet d the required witche d u e t pr vide 110-120 v lt p wer. Pr vide w rk t ble with t l, de k with ch ir, tw dditi l ch ir , d e leg l ize ile c bi et th t c be l cked. The buildi g mu t be w terpr , upplied with he ter, h ve mi imum tw d r , electric light , teleph e, b ttery per ted m ke detect r l rm, u icie t umber dju t ble wi d w r dequ te light d ve til ti , d upply ppr ved dri ki g w ter. Appr ved it ry cilitie mu t be ur i hed. Scree the wi d w d d r d pr vide the d r with de d b lt type l cki g device r p dl ck d he vy duty h p b lted t the d r. D r hi ge pi will be -rem v ble. Arr ge the wi d w t pe d t be ecurely te ed r m the i ide. Pr tect gl p el i wi d w by b r r he vy me h cree t preve t e y cce . I w rm we ther, ur i h ir f c diti i g c p ble m i t i i g the ice t 50 perce t rel tive humidity d r m temper ture 11 degree C 20 degree F bel w the ut ide temper ture whe the ut ide temper ture i 35 degree C 95 degree F. A y ew buildi g erected r temp r ry ield ice mu t be m i t i ed duri g f the li e the c tr ct. U le therwi e directed by the C tr cti g O icer, rem ve the buildi g r m the ite up c mpleti d ccept ce the w rk.

3.5.10 Security Pr vi i

Pr vide dequ te ut ide ecurity lighti g t the temp r ry cilitie . The C tr ct r will be re p ible r the ecurity it w equipme t.

[3.5.11 St r ge Size d L c ti

The [r ed][e cl ed][pe] ite v il ble r t r ge mu t be [c i ed t the i dic ted per ti re][withi 300 m 1,000 eet the per ti re][i dic ted]. The t r ge re will be ppr xim tely [_____] qu re f meter qu re eet.

][3.5.12 St r ge i Exi ti g Buildi g

The C tr ct r will be w rki g [i][r u d] exi ti g buildi g[ ]; the t r ge m teri l [will be ll wed i [_____] qu re meter qu re t f re][where i dic ted][will t be ll wed i the buildi g[ ]]. [Pr vide 2.4 m 8 t high ecurity e ce with l ck ble g te r u d the t r ge re . Rem ve t the c mpleti w rk.]

]3.5.13 We ther Pr tecti Temp r ry F cilitie d St red M teri l

T ke ece ry prec uti t e ure th t r pe i g d ther critic l pe i g i the buildi g re m it red c re ully. T ke immedi te cti required t e l uch pe i g whe r i r ther detrime t l we ther i immi e t, d t the e d e ch w rkd y. E ure th t the pe i g re c mpletely e led t pr tect m teri l d equipme t i the buildi g f

from damag

Building and Sit Storm Prot ction

Wh n a warning of gal forc winds is issu d, tak pr cautions to minimiz dang r to p rsons, and prot ct th work and n arb Gov rnm nt prop rt Pr cautions must includ , but ar not limit d to, closing op nings; r moving loos mat rials, tools and quipm nt from xpos d locations; and r moving or s curing scaffolding and oth r t mporar work Clos op nings in th work wh n storms of l ss r int nsit pos a thr at to th work or an n arb Gov rnm nt prop rt

6 GOVERNMENT FIELD OFFICE

6 R sid nt Engin r's Offic

Provid th [Gov rnm nt R sid nt Engin r] [Gov rnm nt Engin r] with an offic , approximat l 9 squar m t rs 200 squar f t in floor ar a, locat d wh r dir ct d and providing spac h at, [air conditioning unit,] l ctric light and pow r, and toil t faciliti s consisting of on lavator and on wat r clos t compl t with conn ctions to wat r and s w r mains Provid a mail slot in th door or a lockabl mail box mount d on th surfac of th door Includ a 200 b 2400 mm 4 b 8 foot plan tabl ,[comput r work spac] a standard siz offic d sk and chair, and t l phon At compl tion of th proj ct, th offic will r main th prop rt of th Contractor and b r mov d from th sit Utiliti s will b conn ct d and disconn ct d in accordanc with local cod s and to th satisfaction of th Contracting Offic r Complianc with saf t and app aranc r quir m nts for t mporar faciliti s stat d in pr vious paragraphs is r quir d y

6 2 Trail r-T p Mobil Offic

Th option is availabl to, furnish and maintain a trail r-t p mobil offic acc ptabl to th Contracting Offic r to m t th r quir m nts of th minimum faciliti s sp cifi d abov S cur l anchor th trail r to th ground at all four corn rs to guard against mov m nt during high winds Coordinat r quir m nts for prop r anchoring with EM 8 - - S ction 04

7 PLANT COMMUNICATIONS

Wh n v r th individual l m nts of th plant ar locat d so that op ration b normal voic b tw n th s l m nts is not satisfactor , install a satisfactor m ans of communication, such as t l phon or oth r suitabl d vic s and mak availabl for us b Gov rnm nt p rsonn l

8 TEMPORARY PROJECT SAFETY FENCING

As soon as practicabl , but not lat r than da s aft r th dat stablish d for comm nc m nt of work, furnish and r ct t mporar proj ct saf t f ncing at th work sit Maintain th saf t f ncing during th lif of th contract and, upon compl tion and acc ptanc of th work, r mov from th work sit

9 DUMPSTERS

********** y

NOTE: Use this paragraph for NAVFAC SE projects only. Use the bracketed item where visibility to the public is an issue.

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Equip du p wi h a cu cov and pain h anda d in alla ion colo . K p du p clo d, xc p wh n b ing load d wi h a h and d b i .[Loca du p b hind h con uc ion f nc o ou of h public vi w.] E p i du p a l a onc a w k, o a n d d o k p h i f of d b i and a h. If n c y a , p ovid 200 li 55 gallon a h con ain pain d h da k in alla ion colo o coll c d b i in h con uc ion i a a. Fo la g d oli ion , la g du p wi hou lid a acc p abl , bu u no hav d b i high han h id b fo p ing.

3.10 CLEANUP

R ov con uc ion d b i , wa a ial , packaging a ial and h lik f o h wo k i dail . An di o ud which i ack d on o pav d o u fac d oadwa u b cl an d awa . S o an alvag abl a ial ul ing f o d oli ion ac ivi i wi hin h f nc d a a d c ib d abov o a h uppl n al o ag a a. N a l ack o d a ial no in ail , wh h n w o alvag d.

3.11 RESTORATION OF STORAGE AREA

Upon co pl ion of h p oj c ov h bull in boa d, ign , ba icad , haul oad , and an o h po a p oduc f o h i . Af oval of ail , a ial , and quip n f o wi hin h f nc d a a, ov h f nc . R o a a u d du ing h p fo anc of h con ac o h o iginal o b condi ion. R ov g av l u d o av g a d a a and o h a a o i o iginal condi ion, y including op oil and ding a n c a .

-- End of S c ion --

APPENDIX B

ASTM Standard Practices

ASTM – D1452-09	Standard Practice for Soil Exploration and Sampling by Auger Borings
ASTM – D2487-11	Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM – D2488-09a	Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)
ASTM – D4750-87 (Reapproved 2001)	Standard Practice for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)
ASTM – D5521/D5521M-13	Standard Practice for Development of Groundwater Monitoring Wells in Granular Aquifers
ASTM – D6282/D6282M-14	Standard Practice for Direct Push Soil Sampling for Environmental Site Characterizations
ASTM – D6771-02	Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations
ASTM – D6911-15	Standard Practice for Packaging and Shipping Environmental Samples for Laboratory Analysis

Designation: D1452 – 09

Standard Practice for Soil Exploration and Sampling by Auger Borings[1]

This standard is issued under the fixed designation D1452; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This practice covers equipment and procedures for the use of earth augers in shallow depth geotechnical exploration. This practice does not apply to hollow-stem augers. Uses of hollow-stem auger drilling methods for geotechnical exploration are addressed in Test Method D6151.

1.2 This practice does not include considerations for geoenvironmental site characteristics and installation of monitoring wells which are discussed in Guide D5784.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.4 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026 unless superseded by this method.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D1586 Test Method for Penetration Test (SPT) and Split-Barrel Sampling of Soils

D1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes

D2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)

D5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock

D4750 Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well) (Withdrawn 2010)[3]

D5784 Guide for Use of Hollow-Stem Augers for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices

D6026 Practice for Using Significant Digits in Geotechnical Data

D6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling

3. Terminology

3.1 *Definitions*—For common definitions of terms in this standard, refer to Terminology D653.

4. Significance and Use

4.1 Auger borings often provide the simplest method of soil exploration and sampling. They may be used for any purpose where disturbed samples can be used and are valuable in connection with groundwater level determination and indication of changes in strata and advancement of hole for split-barrel penetration tests and sampling (Test Method D1586) and

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluations.

Current edition approved Feb. 15, 2009. Published March 2009. Originally approved in 1957. Last previous edition approved in 2007 as D1452 – 07a. DOI: 10.1520/D1452-09.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

***A Summary of Changes section appears at the end of this standard**

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thin-walled tube sampling (Practice D1587). Equipment required is simple and readily available. Depths of auger explorations are, however, limited by groundwater conditions, soil characteristics, and the equipment used.

5. Apparatus

5.1 *Hand-Operated Augers:*

5.1.1 *Helical Augers,* (Fig. 1(a)) small lightweight augers generally available in sizes from 1 through 3 in. (25.4 through 76.2 mm).

5.1.1.1 *Spiral-Type Auger,* consisting of a flat thin metal strip, machine twisted to a spiral configuration of uniform pitch; having at one end, a sharpened or hardened point, with a means of attaching a shaft or extension at the opposite end.

5.1.1.2 *Ship-Type Auger*—Similar to a carpenter's wood bit. It is generally forged from steel and machined to the desired size and configuration. It is normally provided with sharpened and hardened nibs at the point end and with an integral shaft extending through its length for attachment of a handle or extension at the opposite end.

5.1.2 *Open Tubular Augers,* (Fig. 1(b)) ranging in size from 1.5 through 8 in. (38.1 through 203.2 mm) and having the common characteristic of appearing essentially tubular when viewed from the digging end.

5.1.2.1 *Orchard-Barrel Type,* (Fig. 1(c)) consisting essentially of a tube having cutting lips or nibs hardened and sharpened to penetrate the formation on one end and an adaptor fitting for an extension or handle on the opposite end.

5.1.2.2 *Open-Spiral Type,* consisting of a flat thin metal strip that has been helically wound around a circular mandrel to form a spiral in which the flat faces of the strip are parallel to the axis of the augered hole. The lower helix edges are hard-faced to improve wear characteristics. The opposite end is fitted with an adaptor for extension.

5.1.2.3 *Closed-Spiral Type*—Nearly identical to the open-spiral type except the pitch of the helically wound spiral is much less than that of the open-spiral type.

5.1.3 *Post-Hole Augers,* generally 2 through 8 in. (50.8 through 203.2 mm), and having in common a means of blocking the escape of soil from the auger.

5.1.3.1 *Clam-Shell Type,* (Fig. 2(a)) consisting of two halves, hinged to allow opening and closing for alternately digging and retrieving. It is not usable deeper than about 3.5 ft (1.07 m).

5.1.3.2 *Iwan Type,* (Fig. 2(b)) consisting of two tubular steel segments, connected at the top to a common member to form a nearly complete tube, but with diametrically opposed openings. It is connected at the bottom by two radial blades pitched to serve as cutters which also block the escape of contained soil. Attachment of handle or extension is at the top connector.

5.2 *Machine-Operated Augers:*

5.2.1 *Helical Augers,* (Fig. 3(a)) generally 4 through 48 in. (101.6 through 1219 mm), consisting essentially of a center shaft fitted with a shank or socket for application of power, and having one to six complete 360° (6.28-rad) spirals for conveyance and storage of cut soil. Cutter bits and pilot bits are available in moderate and hard formation types and normally replaceable in the field. They are normally operated by heavy-duty, high-torque machines, designed for heavy construction work.

5.2.2 *Stinger Augers,* generally 3 through 30 in. (76.2 through 762 mm), are similar to the helical auger in 5.2.1, but lighter and generally smaller. They are commonly operated by light-duty machines for post and power pole holes.

5.2.3 *Disk Augers,* (Fig. 3(b)) generally 10 through 30 in. (254 through 762 mm), consisting essentially of a flat, steel disk with diametrically opposed segments removed and having a shank or socket located centrally for application of power. Replaceable cutter bits, located downward from the leading edges of the remaining disk, dig and load soil that is held on the disk by valves or shutters hinged at the disk in order to close the removed segments. The disk auger is specifically designed to be operated by machines having limited vertical clearance between spindle and ground surface.

5.2.4 *Bucket Auger,* (Fig. 3(c)) generally 12 through 48 in. (304.8 through 1219 mm), consisting essentially of a disk auger, without shank or socket, but hinge-mounted to the bottom of a steel tube or bucket of approximately the same diameter as the disk auger. A socket or shank for power application is located in the top center of the bucket diametral cross piece provided for the purpose.

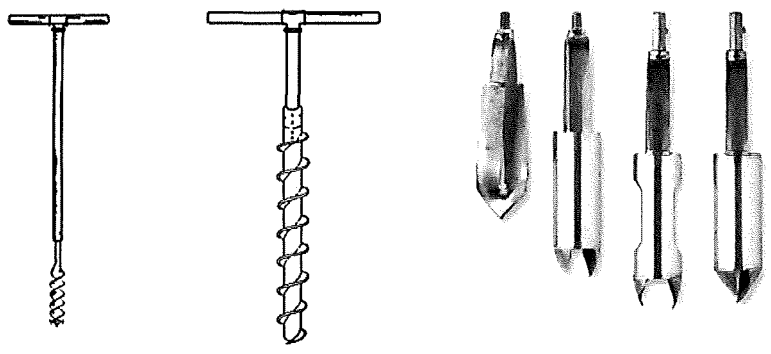

FIG. 1 Hand Augers

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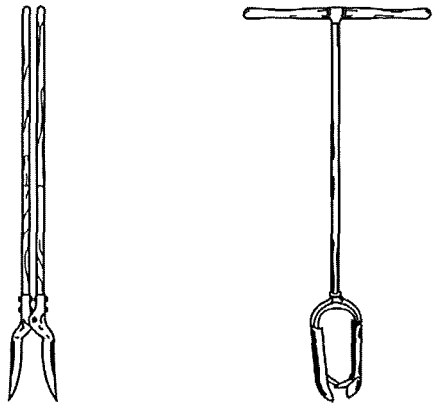

FIG. 2 Post-Hole Augers

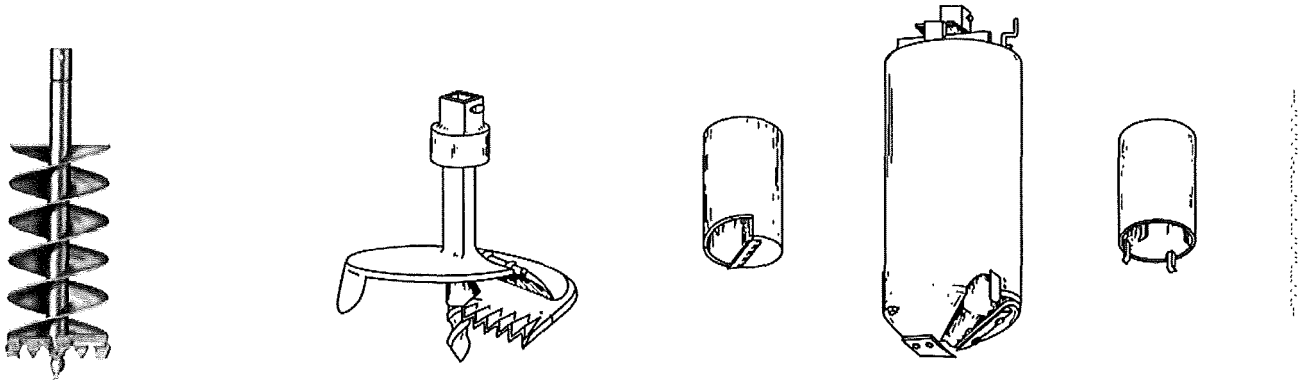

FIG. 3 Machine-Operated Augers

5.3 *Casing* (when needed), consisting of pipe of slightly larger diameter than the auger used.

5.4 *Accessory Equipment*—Labels, field log sheets, sample jars, sealing wax, sample bags, and other necessary tools and supplies.

6. Procedure

6.1 Make the auger boring by rotating and advancing the desired distance into the soil. Withdraw the auger from the hole and remove the soil for examination and test. Return the empty auger to the hole and repeat the procedure. Continue the sequence until the required depth is reached.

6.2 Casing is required in unstable soil in which the bore hole fails to stay open and especially when the boring is extended below the groundwater level. The inside diameter of the casing must be slightly larger than the diameter of the auger used. The casing shall be driven to a depth not greater than the top of the next sample and shall be cleaned out by means of the auger. The auger can then be inserted into the bore hole and turned below the bottom of the casing to obtain a sample.

6.3 The soil auger can be used both for boring the hole and for bringing up disturbed samples of the soil encountered. The structure of a cohesive soil is completely destroyed and the moisture may be changed by the auger. Seal all samples in a jar or other airtight container and label appropriately. If more than one type of soil is picked up in the sample, prepare a separate container for each type of soil.

6.4 *Monitoring Water Level*—It is advisable to monitor groundwater levels, if present, in the drill hole during and after removal of the drilling equipment. Groundwater elevation should be measured and documented during drilling to include datum, date and time measured. Method or equipment used to determine depth of groundwater level, such as Test Method D4750 should also be noted. If groundwater is not encountered or if the level is of doubtful reliability, such information should also be documented.

6.4.1 The user is cautioned that there are many factors which can influence borehole water level measurements and the interpretation of borehole water level measurements. These factors are not described or discussed in this practice. The

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interpretation and application of borehole water level information should be done by a trained specialist. Installation of piezometers should be considered where complex groundwater conditions prevail.

7. Data Sheet/Form

7.1 Report information in accordance with Guide D5434. The data obtained in boring shall be recorded on the field logs and shall include the following:

7.1.1 Date of start and completion of boring,

7.1.2 Identifying number of boring,

7.1.3 Reference datum including direction and distance of boring relative to reference line of project or other suitable reference points,

7.1.4 Type and size of auger used in boring,

7.1.5 Depth of changes in strata,

7.1.6 Description of soil in each major stratum in accordance with Practice D2488,

7.1.7 Groundwater elevation and location of seepage zones, when found,

7.1.8 Datum, date and time of borehole water-level measurement and method or equipment used, and

7.1.9 Condition of augered hole upon removal of auger, that is, whether the hole remains open or the sides cave, when such can be observed.

8. Keywords

8.1 auger borings; geotechnical exploration; sampling; soil explorations

APPENDIX

(Nonmandatory Information)

X1. EXAMPLE DATA SHEET

X1.1 Fig. X1.1 provides an example data sheet.

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DRILLERS BORING LOG

Project: _____ Project No.: _____ Boring No.: _____

Location: Sheet _____ of _____

Date Started: _____ Date Completed: _____ Drill Crew: Boring Location Station _____ Offset _____

Elevation

Strata Depth From	Strata Depth To	Soil Description and Remarks	Sample Type	Sample No.	Depth From	Depth To

Method Of Drilling:

Auger _____ Size: _____

Weather _____

Non-Drilling Time (Hrs.)

Boring Layout _____ Moving _____

Hauling Water _____ Standby _____

Water Level @ _____ Date _____

@ Date

@ Date

Cave-in Depth

@ Date

FIG. X1.1

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SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this standard since the last issue (D1452 – 07a) that may impact the use of this standard. (Approved Feb. 15, 2009.)

(1) Added Referenced Documents.
(2) Added Figs. 1-3.
(3) Other minor revisions throughout.

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Designation: D2487 – 11

Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)[1]

This standard is issued under the fixed designation D2487; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This practice describes a system for classifying mineral and organo-mineral soils for engineering purposes based on laboratory determination of particle-size characteristics, liquid limit, and plasticity index and shall be used when precise classification is required.

NOTE 1—Use of this standard will result in a single classification group symbol and group name except when a soil contains 5 to 12 % fines or when the plot of the liquid limit and plasticity index values falls into the crosshatched area of the plasticity chart. In these two cases, a dual symbol is used, for example, GP-GM, CL-ML. When the laboratory test results indicate that the soil is close to another soil classification group, the borderline condition can be indicated with two symbols separated by a slash. The first symbol should be the one based on this standard, for example, CL/CH, GM/SM, SC/CL. Borderline symbols are particularly useful when the liquid limit value of clayey soils is close to 50. These soils can have expansive characteristics and the use of a borderline symbol (CL/CH, CH/CL) will alert the user of the assigned classifications of expansive potential.

1.2 The group symbol portion of this system is based on laboratory tests performed on the portion of a soil sample passing the 3-in. (75-mm) sieve (see Specification E11).

1.3 As a classification system, this standard is limited to naturally occurring soils.

NOTE 2—The group names and symbols used in this test method may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. See Appendix X2.

1.4 This standard is for qualitative application only.

NOTE 3—When quantitative information is required for detailed designs of important structures, this test method must be supplemented by laboratory tests or other quantitative data to determine performance characteristics under expected field conditions.

1.5 This standard is the ASTM version of the Unified Soil Classification System. The basis for the classification scheme is the Airfield Classification System developed by A. Casagrande in the early 1940s.[2] It became known as the Unified Soil Classification System when several U.S. Government Agencies adopted a modified version of the Airfield System in 1952.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

C117 Test Method for Materials Finer than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing

C136 Test Method for Sieve Analysis of Fine and Coarse Aggregates

C702 Practice for Reducing Samples of Aggregate to Testing Size

D420 Guide to Site Characterization for Engineering Design and Construction Purposes (Withdrawn 2011)[4]

D422 Test Method for Particle-Size Analysis of Soils

D653 Terminology Relating to Soil, Rock, and Contained Fluids

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

Current edition approved May 1, 2011. Published June 2011. Originally approved in 1966. Last previous edition approved in 2010 as D2487 – 10. DOI: 10.1520/D2487-11.

[2] Casagrande, A., "Classification and Identification of Soils," *Transactions*, ASCE, 1948, p. 901.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[4] The last approved version of this historical standard is referenced on www.astm.org.

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D1140 Test Methods for Amount of Material in Soils Finer than No. 200 (75-μm) Sieve
D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
D2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)
D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
D4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)
D4318 Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
D4427 Classification of Peat Samples by Laboratory Testing
D6913 Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis
E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

3. Terminology

3.1 *Definitions:*

3.1.1 Except as listed below, all definitions are in accordance with Terminology D653.

NOTE 4—For particles retained on a 3-in. (75-mm) U.S. standard sieve, the following definitions are suggested:
Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) U.S. standard sieve, and
Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

3.1.2 *clay*—soil passing a No. 200 (75-μm) U.S. standard sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents and that exhibits considerable strength when air dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid limit falls on or above the "A" line.

3.1.3 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) U.S. standard sieve with the following subdivisions:

Coarse—passes 3-in. (75-mm) sieve and retained on ¾-in. (19-mm) sieve, and

Fine—passes ¾-in. (19-mm) sieve and retained on No. 4 (4.75-mm) sieve.

3.1.4 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.5 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.6 *peat*—a soil composed of vegetable tissue in various stages of decomposition usually with an organic odor, a dark-brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

3.1.7 *sand*—particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75-μm) U.S. standard sieve with the following subdivisions:

Coarse—passes No. 4 (4.75-mm) sieve and retained on No. 10 (2.00-mm) sieve,

Medium—passes No. 10 (2.00-mm) sieve and retained on No. 40 (425-μm) sieve, and

Fine—passes No. 40 (425-μm) sieve and retained on No. 200 (75-μm) sieve.

3.1.8 *silt*—soil passing a No. 200 (75-μm) U.S. standard sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4 or if the plot of plasticity index versus liquid limit falls below the "A" line.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *coefficient of curvature, Cc*—the ratio $(D_{30})^2/(D_{10} \times D_{60})$, where D_{60}, D_{30}, and D_{10} are the particle sizes corresponding to 60, 30, and 10 % finer on the cumulative particle-size distribution curve, respectively.

3.2.2 *coefficient of uniformity, Cu*—the ratio D_{60}/D_{10}, where D_{60} and D_{10} are the particle diameters corresponding to 60 and 10 % finer on the cumulative particle-size distribution curve, respectively.

4. Summary

4.1 As illustrated in Table 1, this classification system identifies three major soil divisions: coarse-grained soils, fine-grained soils, and highly organic soils. These three divisions are further subdivided into a total of 15 basic soil groups.

4.2 Based on the results of visual observations and prescribed laboratory tests, a soil is catalogued according to the basic soil groups, assigned a group symbol(s) and name, and thereby classified. The flow charts, Fig. 1 for fine-grained soils, and Fig. 3 for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name.

5. Significance and Use

5.1 This standard classifies soils from any geographic location into categories representing the results of prescribed laboratory tests to determine the particle-size characteristics, the liquid limit, and the plasticity index.

5.2 The assigning of a group name and symbol(s) along with the descriptive information required in Practice D2488 can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.3 The various groupings of this classification system have been devised to correlate in a general way with the engineering behavior of soils. This standard provides a useful first step in any field or laboratory investigation for geotechnical engineering purposes.

5.4 This standard may also be used as an aid in training personnel in the use of Practice D2488.

5.5 This standard may be used in combination with Practice D4083 when working with frozen soils.

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TABLE 1 Soil Classification Chart

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification	
				Group Symbol	Group Name[B]
COARSE-GRAINED SOILS	Gravels (More than 50 % of coarse fraction retained on No. 4 sieve)	Clean Gravels (Less than 5 % fines[C])	Cu ≥ 4 and 1 ≤ Cc ≤ 3[D]	GW	Well-graded gravel[E]
			Cu < 4 and/or [Cc < 1 or Cc > 3][D]	GP	Poorly graded gravel[E]
		Gravels with Fines (More than 12 % fines[C])	Fines classify as ML or MH	GM	Silty gravel[E,F,G]
			Fines classify as CL or CH	GC	Clayey gravel[E,F,G]
More than 50 % retained on No. 200 sieve	Sands (50 % or more of coarse fraction passes No. 4 sieve)	Clean Sands (Less than 5 % fines[H])	Cu ≥ 6 and 1 ≤ Cc ≤ 3[D]	SW	Well-graded sand[I]
			Cu < 6 and/or [Cc < 1 or Cc > 3][D]	SP	Poorly graded sand[I]
		Sands with Fines (More than 12 % fines[H])	Fines classify as ML or MH	SM	Silty sand[F,G,I]
			Fines classify as CL or CH	SC	Clayey sand[F,G,I]
FINE-GRAINED SOILS	Silts and Clays Liquid limit less than 50	Inorganic	PI > 7 and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
			PI < 4 or plots below "A" line[J]	ML	Silt[K,L,M]
		organic	$\frac{\text{Liquid limit – oven dried}}{\text{Liquid limit – not dried}} < 0.75$	OL	Organic clay[K,L,M,N] Organic silt[K,L,M,O]
50 % or more passes the No. 200 sieve	Silts and Clays Liquid limit 50 or more	Inorganic	PI plots on or above "A" line	CH	Fat clay[K,L,M]
			PI plots below "A" line	MH	Elastic silt[K,L,M]
		organic	$\frac{\text{Liquid limit – oven dried}}{\text{Liquid limit – not dried}} < 0.75$	OH	Organic clay[K,L,M,P] Organic silt[K,L,M,Q]
HIGHLY ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve.
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] Gravels with 5 to 12 % fines require dual symbols:
GW-GM well-graded gravel with silt
GW-GC well-graded gravel with clay
GP-GM poorly graded gravel with silt
GP-GC poorly graded gravel with clay
[D] $Cu = D_{60}/D_{10}$ $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
[E] If soil contains ≥15 % sand, add "with sand" to group name.
[F] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[G] If fines are organic, add "with organic fines" to group name.
[H] Sands with 5 to 12 % fines require dual symbols:
SW-SM well-graded sand with silt
SW-SC well-graded sand with clay
SP-SM poorly graded sand with silt
SP-SC poorly graded sand with clay
[I] If soil contains ≥15 % gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to <30 % plus No. 200, add "with sand" or "with gravel," whichever is predominant.
[L] If soil contains ≥30 % plus No. 200, predominantly sand, add "sand" to group name.
[M] If soil contains ≥30 % plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 4 and plots on or above "A" line.
[O] PI < 4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.

NOTE 5—Notwithstanding the statements on precision and bias contained in this standard: The precision of this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D3740 does not in itself assure reliable testing. Reliable testing depends on several factors; Practice D3740 provides a means for evaluating some of those factors.

6. Apparatus

6.1 In addition to the apparatus that may be required for obtaining and preparing the samples and conducting the prescribed laboratory tests, a plasticity chart, similar to Fig. 4, and a cumulative particle-size distribution curve, similar to Fig. 5, are required.

NOTE 6—The "U" line shown on Fig. 4 has been empirically determined to be the approximate "upper limit" for natural soils. It is a good check against erroneous data, and any test results that plot above or to the left of it should be verified.

7. Sampling

7.1 Samples shall be obtained and identified in accordance with a method or methods, recommended in Guide D420 or by other accepted procedures.

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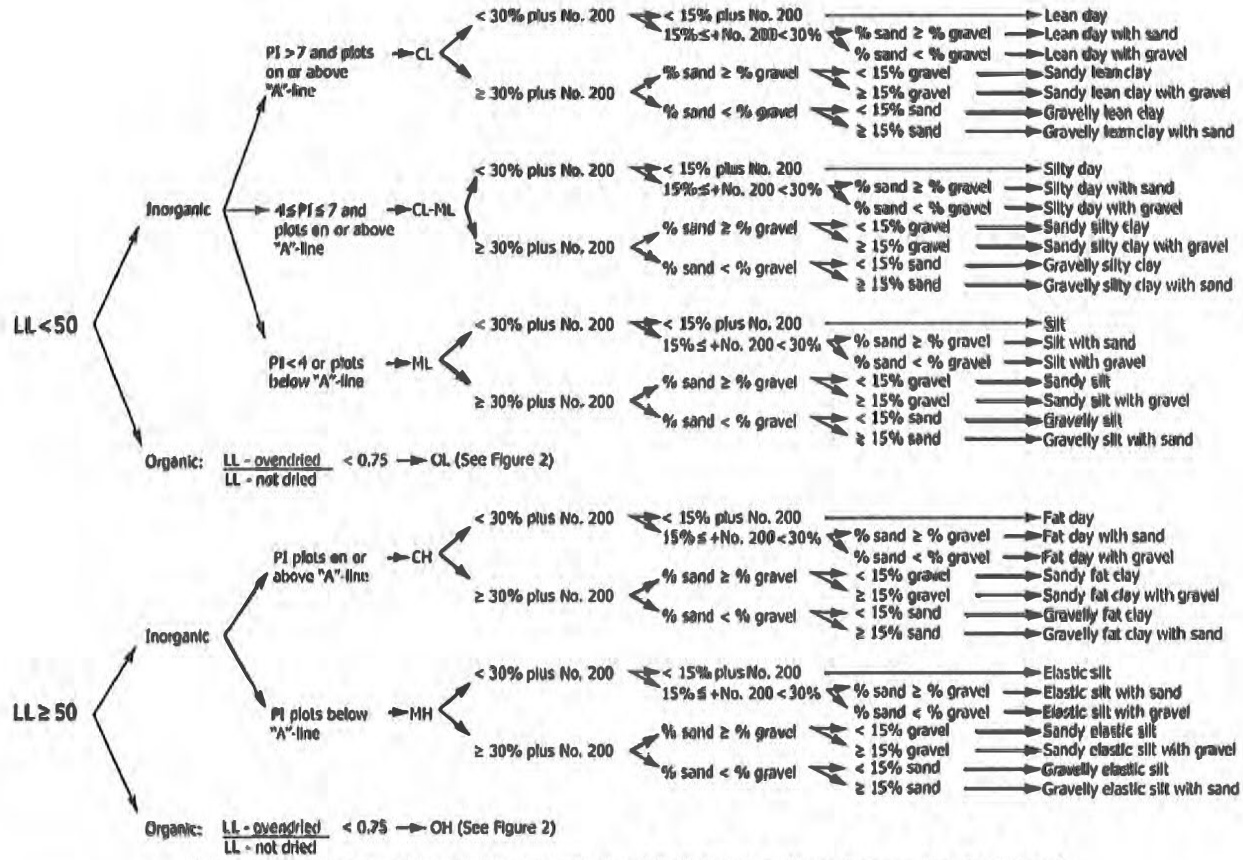

FIG. 1 Flow Chart for Classifying Fine-Grained Soil (50 % or More Passes No. 200 Sieve)

7.2 Test Methods D6913 provides guidance on selecting size of specimen. Two test methods are provided in this standard. The methods differ in the significant digits recorded and the size of the specimen (mass) required. The method to be used may be specified by the requesting authority; otherwise Method A shall be performed. Whenever possible, the field samples should have weights two to four times larger than shown.

7.3 If the field sample or test specimen is smaller than the minimum recommended amount, the report shall include an appropriate remark.

8. Classification of Peat

8.1 A sample composed primarily of vegetable tissue in various stages of decomposition and has a fibrous to amorphous texture, a dark-brown to black color, and an organic odor should be designated as a highly organic soil and shall be classified as peat, PT, and not subjected to the classification procedures described hereafter.

8.2 If desired, classification of type of peat can be performed in accordance with Classification D4427.

9. Preparation for Classification

9.1 Before a soil can be classified according to this standard, generally the particle-size distribution of the minus 3-in. (75-mm) material and the plasticity characteristics of the minus No. 40 (425-μm) sieve material must be determined. See 9.8 for the specific required tests.

9.2 The preparation of the soil specimen(s) and the testing for particle-size distribution and liquid limit and plasticity index shall be in accordance with accepted standard procedures. Two procedures for preparation of the soil specimens for testing for soil classification purposes are given in Appendixes X3 and X4. Appendix X3 describes the wet preparation method and is the preferred method for cohesive soils that have never dried out and for organic soils.

9.3 When reporting soil classifications determined by this standard, the preparation and test procedures used shall be reported or referenced.

9.4 Although the test procedure used in determining the particle-size distribution or other considerations may require a hydrometer analysis of the material, a hydrometer analysis is not necessary for soil classification.

9.5 The percentage (by dry weight) of any plus 3-in. (75-mm) material must be determined and reported as auxiliary information.

9.6 The maximum particle size shall be determined (measured or estimated) and reported as auxiliary information.

9.7 When the cumulative particle-size distribution is required, a set of sieves shall be used which include the following sizes (with the largest size commensurate with the

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maximum particle size) with other sieve sizes as needed or required to define the particle-size distribution:

3-in. (75-mm)
¾-in. (19.0-mm)
No. 4 (4.75-mm)
No. 10 (2.00-mm)
No. 40 (425-μm)
No. 200 (75-μm)

9.8 The tests required to be performed in preparation for classification are as follows:

9.8.1 For soils estimated to contain less than 5 % fines, a plot of the cumulative particle-size distribution curve of the fraction coarser than the No. 200 (75-μm) sieve is required. A semi-log plot of percent passing versus partical-size or sieve size/sieve number is plotted as shown in Fig. 5.

9.8.2 For soils estimated to contain 5 to 15 % fines, a cumulative particle-size distribution curve, as described in 9.8.1, is required, and the liquid limit and plasticity index are required.

9.8.2.1 If sufficient material is not available to determine the liquid limit and plasticity index, the fines should be estimated to be either silty or clayey using the procedures described in Practice D2488 and so noted in the report.

9.8.3 For soils estimated to contain 15 % or more fines, a determination of the percent fines, percent sand, and percent gravel is required, and the liquid limit and plasticity index are required. For soils estimated to contain 90 % fines or more, the percent fines, percent sand, and percent gravel may be estimated using the procedures described in Practice D2488 and so noted in the report.

10. Preliminary Classification Procedure

10.1 Class the soil as fine-grained if 50 % or more by dry weight of the test specimen passes the No. 200 (75-μm) sieve and follow Section 3.1.3.

10.2 Class the soil as coarse-grained if more than 50 % by dry weight of the test specimen is retained on the No. 200 (75-μm) sieve and follow Section 12.

11. Procedure for Classification of Fine-Grained Soils (50 % or more by dry weight passing the No. 200 (75-μm) sieve)

11.1 The soil is an inorganic clay if the position of the plasticity index versus liquid limit plot, Fig. 4, falls on or above the "A" line, the plasticity index is greater than 4, and the presence of organic matter does not influence the liquid limit as determined in 11.3.2.

NOTE 7—The plasticity index and liquid limit are determined on the minus No. 40 (425 μm) sieve material.

11.1.1 Classify the soil as a *lean clay*, CL, if the liquid limit is less than 50. See area identified as CL on Fig. 4.

11.1.2 Classify the soil as a *fat clay*, CH, if the liquid limit is 50 or greater. See area identified as CH on Fig. 4.

NOTE 8—In cases where the liquid limit exceeds 110 or the plasticity index exceeds 60, the plasticity chart may be expanded by maintaining the same scale on both axes and extending the "A" line at the indicated slope.

11.1.3 Classify the soil as a *silty clay*, CL-ML, if the position of the plasticity index versus liquid limit plot falls on or above the "A" line and the plasticity index is in the range of 4 to 7. See area identified as CL-ML on Fig. 4.

11.2 The soil is an inorganic silt if the position of the plasticity index versus liquid limit plot, Fig. 4, falls below the "A" line or the plasticity index is less than 4, and presence of organic matter does not influence the liquid limit as determined in 11.3.2.

11.2.1 Classify the soil as a *silt*, ML, if the liquid limit is less than 50. See area identified as ML on Fig. 4.

11.2.2 Classify the soil as an *elastic silt*, MH, if the liquid limit is 50 or greater. See area identified as MH on Fig. 4.

11.3 The soil is an organic silt or clay if organic matter is present in sufficient amounts to influence the liquid limit as determined in 11.3.2.

11.3.1 If the soil has a dark color and an organic odor when moist and warm, a second liquid limit test shall be performed on a test specimen which has been oven dried at 110 ± 5°C to a constant weight, typically over night.

11.3.2 The soil is an organic silt or organic clay if the liquid limit after oven drying is less than 75 % of the liquid limit of the original specimen determined before oven drying.

11.3.3 Classify the soil as an *organic silt* or *organic clay*, OL, if the liquid limit (not oven dried) is less than 50 %. Classify the soil as an *organic silt*, OL, if the plasticity index is less than 4, or the position of the plasticity index versus liquid limit plot falls below the "A" line. Classify the soil as an *organic clay*, OL, if the plasticity index is 4 or greater and the position of the plasticity index versus liquid limit plot falls on or above the "A" line. See area identified as OL (or CL-ML) on Fig. 4.

11.3.4 Classify the soil as an *organic clay* or *organic silt*, OH, if the liquid limit (not oven dried) is 50 or greater. Classify the soil as an *organic silt*, OH, if the position of the plasticity index versus liquid limit plot falls below the "A" line. Classify the soil as an *organic clay*, OH, if the position of the plasticity index versus liquid-limit plot falls on or above the "A" line. See area identified as OH on Fig. 4.

11.4 If less than 30 % but 15 % or more of the test specimen is retained on the No. 200 (75-μm) sieve, the words" with sand" or "with gravel" (whichever is predominant) shall be added to the group name. For example, lean clay with sand, CL; silt with gravel, ML. If the percent of sand is equal to the percent of gravel, use "with sand."

11.5 If 30 % or more of the test specimen is retained on the No. 200 (75-μm) sieve, the words "sandy" or" gravelly" shall be added to the group name. Add the word "sandy" if 30 % or more of the test specimen is retained on the No. 200 (75-μm) sieve and the coarse-grained portion is predominantly sand. Add the word "gravelly" if 30 % or more of the test specimen is retained on the No. 200 (75-μm) sieve and the coarse-grained portion is predominantly gravel. For example, sandy lean clay, CL; gravelly fat clay, CH; sandy silt, ML. If the percent of sand is equal to the percent of gravel, use "sandy."

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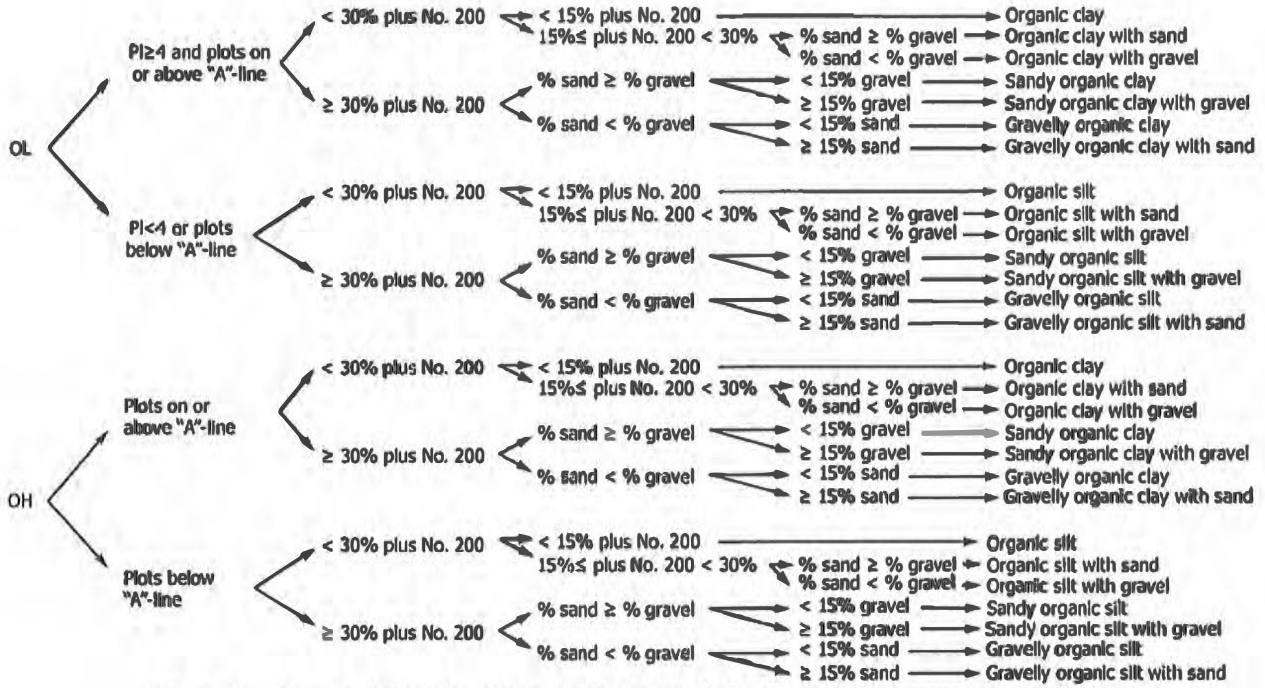

FIG. 2 Flow Chart for Classifying Organic Fine-Grained Soil (50 % or More Passes No. 200 Sieve)

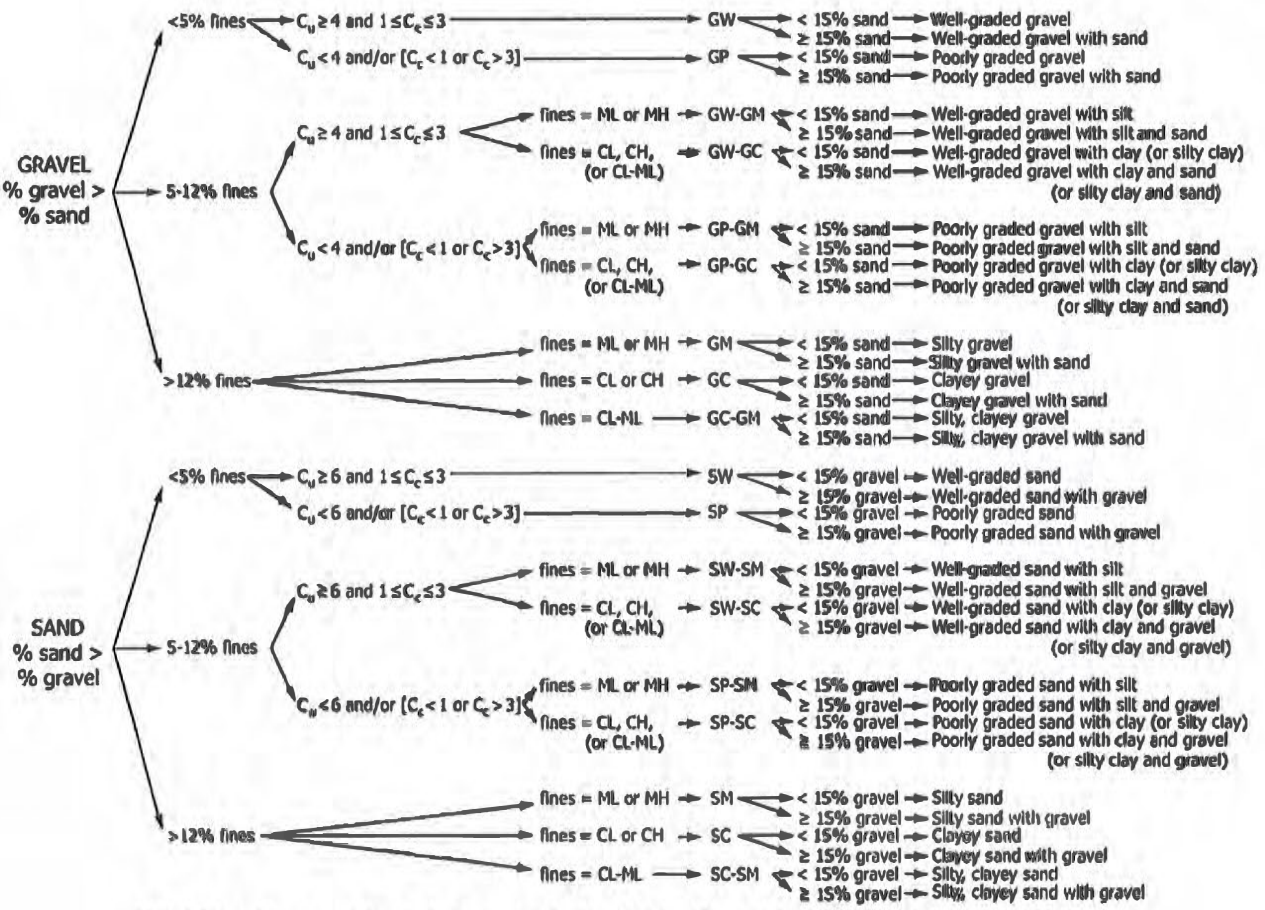

FIG. 3 Flow Chart for Classifying Coarse-Grained Soils (More Than 50 % Retained on No. 200 Sieve)

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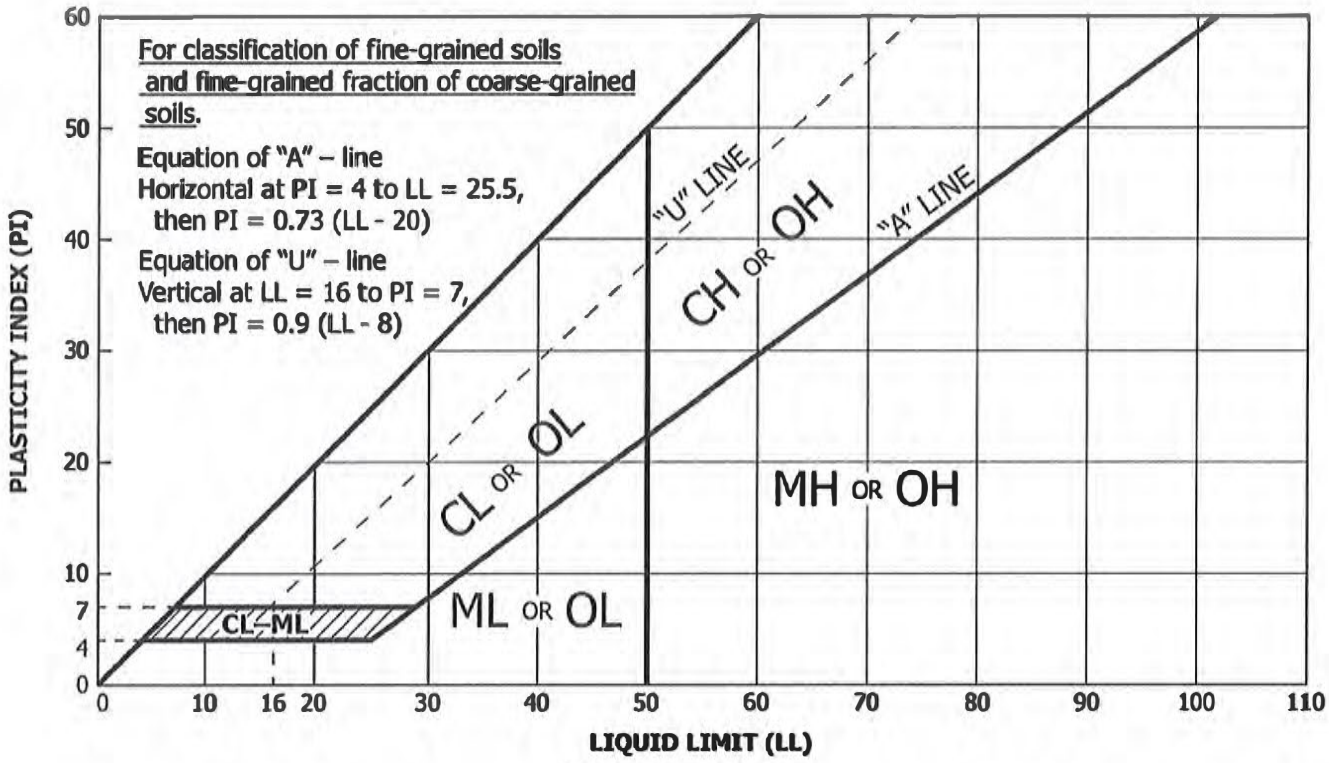
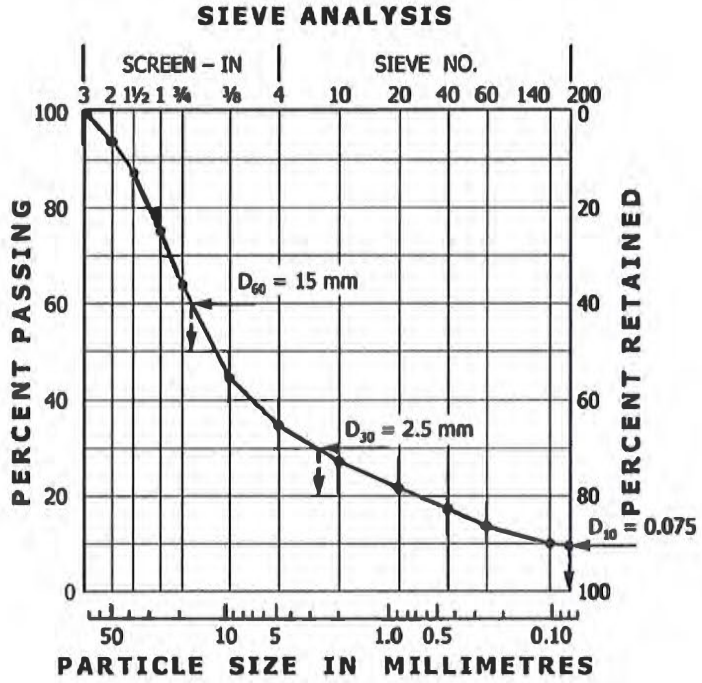


FIG. 4 Plasticity Chart



$$Cu = \frac{D_{60}}{D_{10}} = \frac{15}{0.075} = 200 \qquad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}} = \frac{(2.5)^2}{0.075 \times 15} = 5.6$$

FIG. 5 Cumulative Particle-Size Plot

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12. Procedure for Classification of Coarse-Grained Soils
(more than 50 % retained on the No. 200 (75-μm) sieve)

12.1 Class the soil as gravel if more than 50 % of the coarse fraction [plus No. 200 (75-μm) sieve] is retained on the No. 4 (4.75-mm) sieve.

12.2 Class the soil as sand if 50 % or more of the coarse fraction [plus No. 200 (75-μm) sieve] passes the No. 4 (4.75-mm) sieve.

12.3 If 12 % or less of the test specimen passes the No. 200 (75-μm) sieve, plot the cumulative particle-size distribution, Fig. 5, and compute the coefficient of uniformity, *Cu*, and coefficient of curvature, *Cc*, as given in Eqs 1 and 2.

$$Cu = D_{60}/D_{10} \quad (1)$$

$$Cc = (D_{30})^2/(D_{10} \times D_{60}) \quad (2)$$

where:

D_{10}, D_{30}, and D_{60} = the particle-size diameters corresponding to 10, 30, and 60 %, respectively, passing on the cumulative particle-size distribution curve, Fig. 5.

NOTE 9—It may be necessary to extrapolate the curve to obtain the D_{10} diameter.

12.3.1 If less than 5 % of the test specimen passes the No. 200 (75-μm) sieve, classify the soil as a *well-graded gravel*, GW, or *well-graded sand*, SW, if Cu is greater than or equal to 4.0 for gravel or greater than 6.0 for sand, and Cc is at least 1.0 but not more than 3.0.

12.3.2 If less than 5 % of the test specimen passes the No. 200 (75-μm) sieve, classify the soil as *poorly graded gravel*, GP, or *poorly graded sand*, SP, if either the *Cu* or the *Cc* criteria for well-graded soils are not satisfied.

12.4 If more than 12 % of the test specimen passes the No. 200 (75-μm) sieve, the soil shall be considered a coarse-grained soil with fines. The fines are determined to be either clayey or silty based on the plasticity index versus liquid limit plot on Fig. 4. (See 9.8.2.1 if insufficient material available for testing) (see Note 7).

12.4.1 Classify the soil as a *clayey gravel*, GC, or *clayey sand*, SC, if the fines are clayey, that is, the position of the plasticity index versus liquid limit plot, Fig. 4, falls on or above the "A" line and the plasticity index is greater than 7.

12.4.2 Classify the soil as a *silty gravel*, GM, or *silty sand*, SM, if the fines are silty, that is, the position of the plasticity index versus liquid limit plot, Fig. 4, falls below the "A" line or the plasticity index is less than 4.

12.4.3 If the fines plot as a silty clay, CL-ML, classify the soil as a *silty, clayey gravel*, GC-GM, if it is a gravel or a *silty , clayey sand*, SC-SM, if it is a sand.

12.5 If 5 to 12 % of the test specimen passes the No. 200 (75-μm) sieve, give the soil a dual classification using two group symbols.

12.5.1 The first group symbol shall correspond to that for a gravel or sand having less than 5 % fines (GW, GP, SW, SP), and the second symbol shall correspond to a gravel or sand having more than 12 % fines (GC, GM, SC, SM).

12.5.2 The group name shall correspond to the first group symbol plus "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example, well-graded gravel with clay, GW-GC; poorly graded sand with silt, SP-SM (See 9.8.2.1 if insufficient material available for testing).

NOTE 10—If the fines plot as a *silty clay*, CL-ML, the second group symbol should be either GC or SC. For example, a poorly graded sand with 10 % fines, a liquid limit of 20, and a plasticity index of 6 would be classified as a poorly graded sand with silty clay, SP-SC.

12.6 If the specimen is predominantly sand or gravel but contains 15 % or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example, poorly graded gravel with sand, clayey sand with gravel.

12.7 If the field sample contained any cobbles or boulders or both, the words "with cobbles," or "with cobbles and boulders" shall be added to the group name. For example, silty gravel with cobbles, GM.

13. Report

13.1 The report should include the group name, group symbol, and the results of the laboratory tests. The particle-size distribution shall be given in terms of percent of gravel, sand, and fines. The plot of the cumulative particle-size distribution curve shall be reported if used in classifying the soil. Report appropriate descriptive information according to the procedures in Practice D2488. A local or commercial name or geologic interpretation for the material may be added at the end of the descriptive information if identified as such. The test procedures used shall be referenced.

NOTE 11—*Example: Clayey Gravel with Sand and Cobbles* (GC)—46 % fine to coarse, hard, subrounded gravel; 30 % fine to coarse, hard, subrounded sand; 24 % clayey fines, LL = 38, PI = 19; weak reaction with HCl; original field sample had 4 % hard, subrounded cobbles; maximum dimension 150 mm.

In-Place Conditions—firm, homogeneous, dry, brown,
Geologic Interpretation—alluvial fan.

NOTE 12—Other examples of soil descriptions are given in Appendix X1.

14. Precision and Bias

14.1 Criteria for acceptability depends on the precision and bias of Test Methods D422, D1140 and D4318.

15. Keywords

15.1 Alterberg limits; classification; clay; gradation; gravel; laboratory classification; organic soils; sand; silt; soil classification; soil tests

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APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF DESCRIPTIONS USING SOIL CLASSIFICATION

X1.1 The following examples show how the information required in 13.1 can be reported. The appropriate descriptive information from Practice D2488 is included for illustrative purposes. The additional descriptive terms that would accompany the soil classification should be based on the intended use of the classification and the individual circumstances.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—73 % fine to coarse, hard, subangular gravel; 23 % fine to coarse, hard, subangular sand; 4 % fines; Cc = 2.7, Cu = 12.4.

X1.1.2 *Silty Sand with Gravel (SM)*—61 % predominantly fine sand; 23 % silty fines, LL = 33, PI = 6; 16 % fine, hard, subrounded gravel; no reaction with HCl; (field sample smaller than recommended). *In-Place Conditions*—Firm, stratified and contains lenses of silt 1 to 2 in. thick, moist, brown to gray; in-place density = 106 lb/ft^3 and in-place moisture = 9 %.

X1.1.3 *Organic Clay (OL)*—100 % fines, LL (not dried) = 32, LL (oven dried) = 21, PI (not dried) = 10; wet, dark brown, organic odor, weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—74 % fine to coarse, hard, subangular reddish sand; 26 % organic and silty dark-brown fines, LL (not dried) = 37, LL (oven dried) = 26, PI (not dried) = 6, wet, weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—78 % fine to coarse, hard, subrounded to subangular gravel; 16 % fine to coarse, hard, subrounded to subangular sand; 6 % silty (estimated) fines; moist, brown; no reaction with HCl; original field sample had 7 % hard, subrounded cobbles and 2 % hard, subrounded boulders with a maximum dimension of 18 in.

X2. USING SOIL CLASSIFICATION AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, ETC.

X2.1 The group names and symbols used in this standard may be used as a descriptive system applied to materials that exist in situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, etc.).

X2.2 Materials such as shells, crushed rock, slag, etc., should be identified as such. However, the procedures used in this standard for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, a classification in accordance with this standard may be assigned to aid in describing the material.

X2.3 If a classification is used, the group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how soil classifications could be incorporated into a description system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2- to 4-in. pieces of shale from power auger hole, dry, brown, no reaction with HCl. After laboratory processing by slaking in water for 24 h, material classified as "Sandy Lean Clay (CL)"—61 % clayey fines, LL = 37, PI = 16; 33 % fine to medium sand; 6 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; "Poorly Graded Sand with Silt (SP-SM)"—91 % fine to medium sand; 9 % silty (estimated) fines; dry, reddish-brown, strong reaction with HCl.

X2.4.3 *Broken Shells*—65 % gravel-size broken shells; 31 % sand and sand-size shell pieces; 4 % fines; Cc = 2.4, Cu = 1.9; would be classified as "Poorly Graded Gravel with Sand (GP)".

X2.4.4 *Crushed Rock*—Processed gravel and cobbles from Pit No. 7; "Poorly Graded Gravel (GP)"—89 % fine, hard, angular gravel-size particles; 11 % coarse, hard, angular sand-size particles, dry, tan; no reaction with HCl; Cc = 2.4, Cu = 0.9.

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X3. PREPARATION AND TESTING FOR CLASSIFICATION PURPOSES BY THE WET METHOD

X3.1 This appendix describes the steps in preparing a soil sample for testing for purposes of soil classification using a wet-preparation procedure.

X3.2 Samples prepared in accordance with this procedure should contain as much of their natural water content as possible and every effort should be made during obtaining, preparing, and transportating the samples to maintain the natural moisture.

X3.3 The procedures to be followed in this standard assume that the field sample contains fines, sand, gravel, and plus 3-in. (75-mm) particles and the cumulative particle-size distribution plus the liquid limit and plasticity index values are required (see 9.8). Some of the following steps may be omitted when they are not applicable to the soil being tested.

X3.4 If the soil contains plus No. 200 (75-μm) particles that would degrade during dry sieving, use a test procedure for determining the particle-size characteristics that prevents this degradation.

X3.5 Since this classification system is limited to the portion of a sample passing the 3-in. (75-mm) sieve, the plus 3-in. (75-mm) material shall be removed prior to the determination of the particle-size characteristics and the liquid limit and plasticity index.

X3.6 The portion of the field sample finer than the 3-in. (75-mm) sieve shall be obtained as follows:

X3.6.1 Separate the field sample into two fractions on a 3-in. (75-mm) sieve, being careful to maintain the natural water content in the minus 3-in. (75-mm) fraction. Any particles adhering to the plus 3-in. (75-mm) particles shall be brushed or wiped off and placed in the fraction passing the 3-in. (75-mm) sieve.

X3.6.2 Determine the air-dry or oven-dry weight of the fraction retained on the 3-in. (75-mm) sieve. Determine the total (wet) weight of the fraction passing the 3-in. (75-mm) sieve.

X3.6.3 Thoroughly mix the fraction passing the 3-in. (75-mm) sieve. Determine the water content, in accordance with Test Method D2216, of a representative specimen with a minimum dry weight as required in 7.2. Save the water-content specimen for determination of the particle-size analysis in accordance with X3.8.

X3.6.4 Compute the dry weight of the fraction passing the 3-in. (75-mm) sieve based on the water content and total (wet) weight. Compute the total dry weight of the sample and calculate the percentage of material retained on the 3-in. (75-mm) sieve.

X3.7 Determine the liquid limit and plasticity index as follows:

X3.7.1 If the soil disaggregates readily, mix on a clean, hard surface and select a representative sample by quartering in accordance with Practice C702.

X3.7.1.1 If the soil contains coarse-grained particles coated with and bound together by tough clayey material, take extreme care in obtaining a representative portion of the No. 40 (425-μm) fraction. Typically, a larger portion than normal has to be selected, such as the minimum weights required in 7.2.

X3.7.1.2 To obtain a representative specimen of a basically cohesive soil, it may be advantageous to pass the soil through a ¾-in. (19-mm) sieve or other convenient size so the material can be more easily mixed and then quartered or split to obtain the representative specimen.

X3.7.2 Process the representative specimen in accordance with the Wet Preparation Method in Test Method D4318.

X3.7.3 Perform the liquid-limit test in accordance with Test Method D4318, except the soil shall not be air dried prior to the test.

X3.7.4 Perform the plastic-limit test in accordance with Test Method D4318, except the soil shall not be air dried prior to the test, and calculate the plasticity index.

X3.8 Determine the particle-size distribution as follows:

X3.8.1 If the water content of the fraction passing the 3-in. (75-mm) sieve was required (X3.6.3), use the water-content specimen for determining the particle-size distribution. Otherwise, select a representative specimen in accordance with Practice C702 with a minimum dry weight as required in 7.2.

X3.8.2 If the cumulative particle-size distribution including a hydrometer analysis is required, determine the particle-size distribution in accordance with Test Method D422. See 9.7 for the set of required sieves.

X3.8.3 If the cumulative particle-size distribution without a hydrometer analysis is required, determine the particle-size distribution in accordance with Test Method C136. See 9.7 for the set of required sieves. The specimen should be soaked until all clayey aggregations have softened and then washed in accordance with Test Method C117 prior to performing the particle-size distribution.

X3.8.4 If the cumulative particle-size distribution is not required, determine the percent fines, percent sand, and percent gravel in the specimen in accordance with Test Method C117, being sure to soak the specimen long enough to soften all clayey aggregations, followed by Test Method C136 using a nest of sieves which shall include a No. 4 (4.75-mm) sieve and a No. 200 (75-μm) sieve.

X3.8.5 Calculate the percent fines, percent sand, and percent gravel in the minus 3-in. (75-mm) fraction for classification purposes.

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X4. AIR-DRIED METHOD OF PREPARATION OF SOILS FOR TESTING FOR CLASSIFICATION PURPOSES

X4.1 This appendix describes the steps in preparing a soil sample for testing for purposes of soil classification when air-drying the soil before testing is specified or desired or when the natural moisture content is near that of an air-dried state.

X4.2 If the soil contains organic matter or mineral colloids that are irreversibly affected by air drying, the wet-preparation method as described in Appendix X3 should be used.

X4.3 Since this classification system is limited to the portion of a sample passing the 3-in. (75-mm) sieve, the plus 3-in. (75-mm) material shall be removed prior to the determination of the particle-size characteristics and the liquid limit and plasticity index.

X4.4 The portion of the field sample finer than the 3-in. (75-mm) sieve shall be obtained as follows:

X4.4.1 Air dry and weigh the field sample.

X4.4.2 Separate the field sample into two fractions on a 3-in. (75-mm) sieve.

X4.4.3 Weigh the two fractions and compute the percentage of the plus 3-in. (75-mm) material in the field sample.

X4.5 Determine the particle-size distribution and liquid limit and plasticity index as follows (see 9.8 for when these tests are required):

X4.5.1 Thoroughly mix the fraction passing the 3-in. (75-mm) sieve.

X4.5.2 If the cumulative particle-size distribution including a hydrometer analysis is required, determine the particle-size distribution in accordance with Test Method D422. See 9.7 for the set of sieves that is required.

X4.5.3 If the cumulative particle-size distribution without a hydrometer analysis is required, determine the particle-size distribution in accordance with Test Method D1140 followed by Test Method C136. See 9.7 for the set of sieves that is required.

X4.5.4 If the cumulative particle-size distribution is not required, determine the percent fines, percent sand, and percent gravel in the specimen in accordance with Test Method D1140 followed by Test Method C136 using a nest of sieves which shall include a No. 4 (4.75-mm) sieve and a No. 200 (75-μm) sieve.

X4.5.5 If required, determine the liquid limit and the plasticity index of the test specimen in accordance with Test Method D4318.

X5. ABBREVIATED SOIL CLASSIFICATION SYMBOLS

X5.1 In some cases, because of lack of space, an abbreviated system may be useful to indicate the soil classification symbol and name. Examples of such cases would be graphical logs, databases, tables, etc.

X5.2 This abbreviated system is not a substitute for the full name and descriptive information but can be used in supplementary presentations when the complete description is referenced.

X5.3 The abbreviated system should consist of the soil classification symbol based on this standard with appropriate lower case letter prefixes and suffixes as:

Prefix	Suffix
s = sandy	s = with sand
g = gravelly	g = with gravel
	c = cobbles
	b = boulders

X5.4 The soil classification symbol is to be enclosed in parentheses. Some examples would be:

Group Symbol and Full Name	Abbreviated
CL, Sandy lean clay	s(CL)
SP-Sm, Poorly graded sand with silt and gravel	(SP-SM)g
GP, poorly graded gravel with sand, cobbles, and boulders	(GP)scb
ML, gravelly silt with sand and cobbles	g(ML)sc

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SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this practice since the last issue, D2487–10, that may impact the use of this practice. (Approved May 1, 2011.)

(1) Deleted reference to Practice D2217 in 11.3.2 and X3.7.2.

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Designation: D2488 – 09a

Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)[1]

This standard is issued under the fixed designation D2488; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils (either intact or disturbed).

NOTE 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (see Appendix X2).

1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements see Section 8.

1.6 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D1452 Practice for Soil Exploration and Sampling by Auger Borings

D1586 Test Method for Penetration Test (SPT) and Split-Barrel Sampling of Soils

D1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes

D2113 Practice for Rock Core Drilling and Sampling of Rock for Site Investigation

D2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)

3. Terminology

3.1 *Definitions:*

3.1.1 Except as listed below, all definitions are in accordance with Terminology D653.

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

Current edition approved June 15, 2009. Published July 2009. Originally approved in 1966. Last previous edition approved in 2009 as D2488 – 09. DOI: 10.1520/D2488-09A.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

*A Summary of Changes section appears at the end of this standard

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NOTE 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:
Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and
Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

3.1.2 *clay*—soil passing a No. 200 (75-µm) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid limit falls on or above the "A" line (see Fig. 3 of Test Method D2487).

3.1.3 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on a ¾-in. (19-mm) sieve.

fine—passes a ¾-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

3.1.4 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.5 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.6 *peat*—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

3.1.7 *sand*—particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75-µm) sieve with the following subdivisions:

coarse—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

medium—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-µm) sieve.

fine—passes a No. 40 (425-µm) sieve and is retained on a No. 200 (75-µm) sieve.

3.1.8 *silt*—soil passing a No. 200 (75-µm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the "A" line (see Fig. 3 of Test Method D2487).

4. Summary of Practice

4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.

4.2 The soil can be given an identification by assigning a group symbol(s) and name. The flow charts, Fig. 1a and Fig. 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it into a specific group, borderline symbols may be used, see Appendix X3.

NOTE 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols*.
Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D2487 where two symbols are required. Two symbols are required when the soil has between 5 and 12 % fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.
Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see Appendix X3).

5. Significance and Use

5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.2 The descriptive information required in this practice should be used to supplement the classification of a soil as determined by Test Method D2487.

5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D2487, it shall be clearly stated in reports and all other appropriate documents, that the classification symbol and name are based on visual-manual procedures.

5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.

5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.

NOTE 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may also be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manual characteristics.

5.6 When describing and identifying soil samples from a given boring, test pit, or group of borings or pits, it is not necessary to follow all of the procedures in this practice for every sample. Soils which appear to be similar can be grouped together; one sample completely described and identified with the others referred to as similar based on performing only a few of the descriptive and identification procedures described in this practice.

5.7 This practice may be used in combination with Practice D4083 when working with frozen soils.

NOTE 5—Notwithstanding the statements on precision and bias contained in this standard: The precision of this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D3740 does not in itself assure reliable testing. Reliable testing

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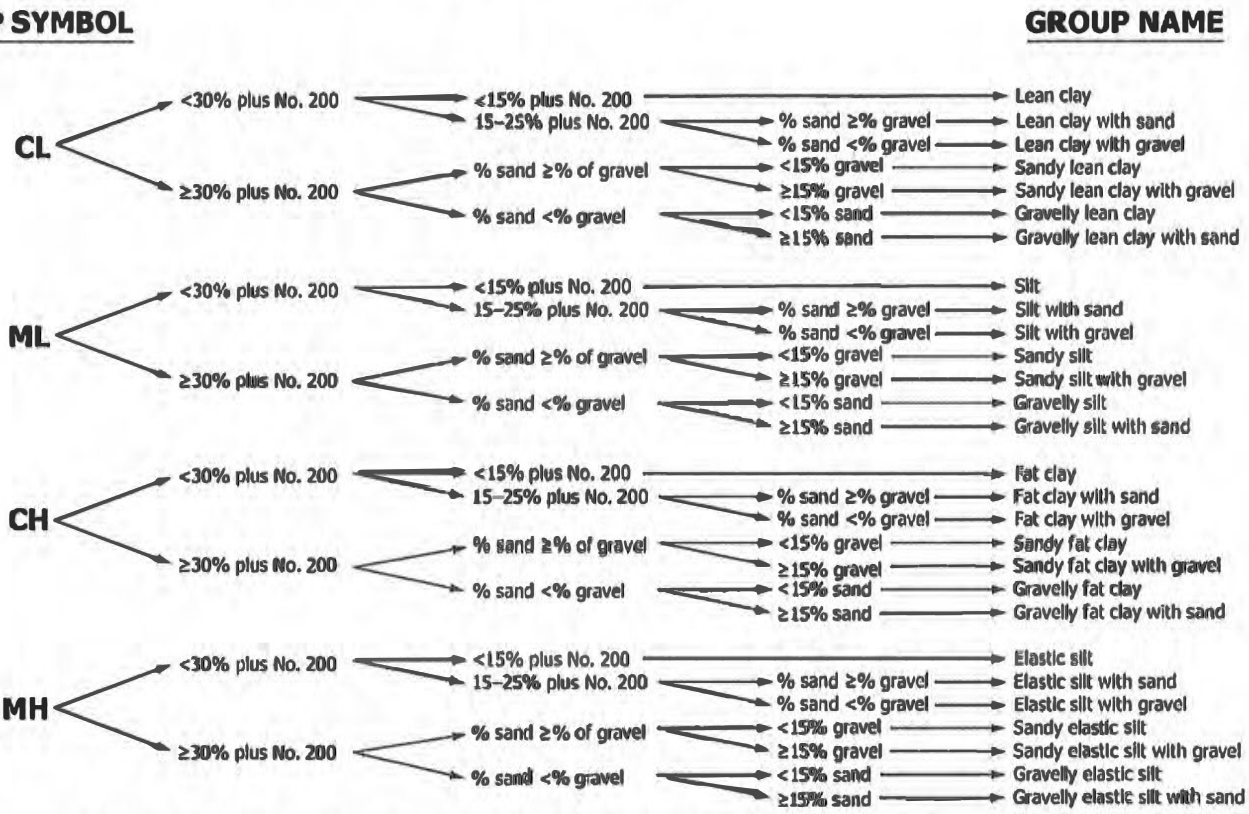
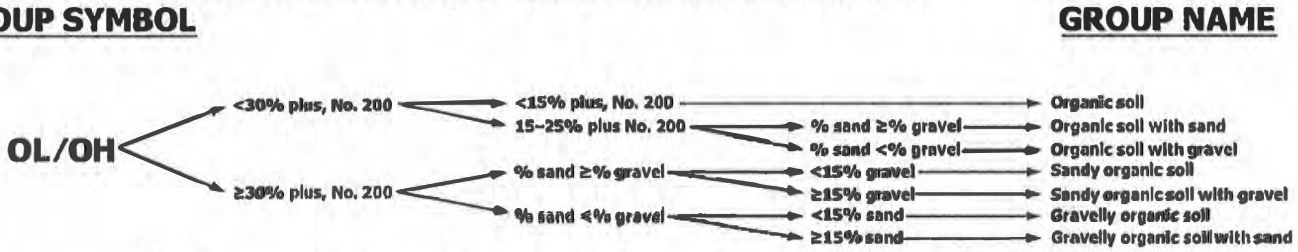


NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1 b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)

depends on several factors; Practice D3740 provides a means for evaluating some of those factors.

6. Apparatus

6.1 *Required Apparatus:*

6.1.1 *Pocket Knife or Small Spatula.*

6.2 *Useful Auxiliary Apparatus:*

6.2.1 *Test Tube and Stopper* (or jar with a lid).

6.2.2 *Hand Lens.*

7. Reagents

7.1 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean water from a city water supply or natural source, including non-potable water.

7.2 *Hydrochloric Acid*—A small bottle of dilute hydrochloric acid, HCl, one part HCl (10 *N*) to three parts water (This reagent is optional for use with this practice). See Section 8.

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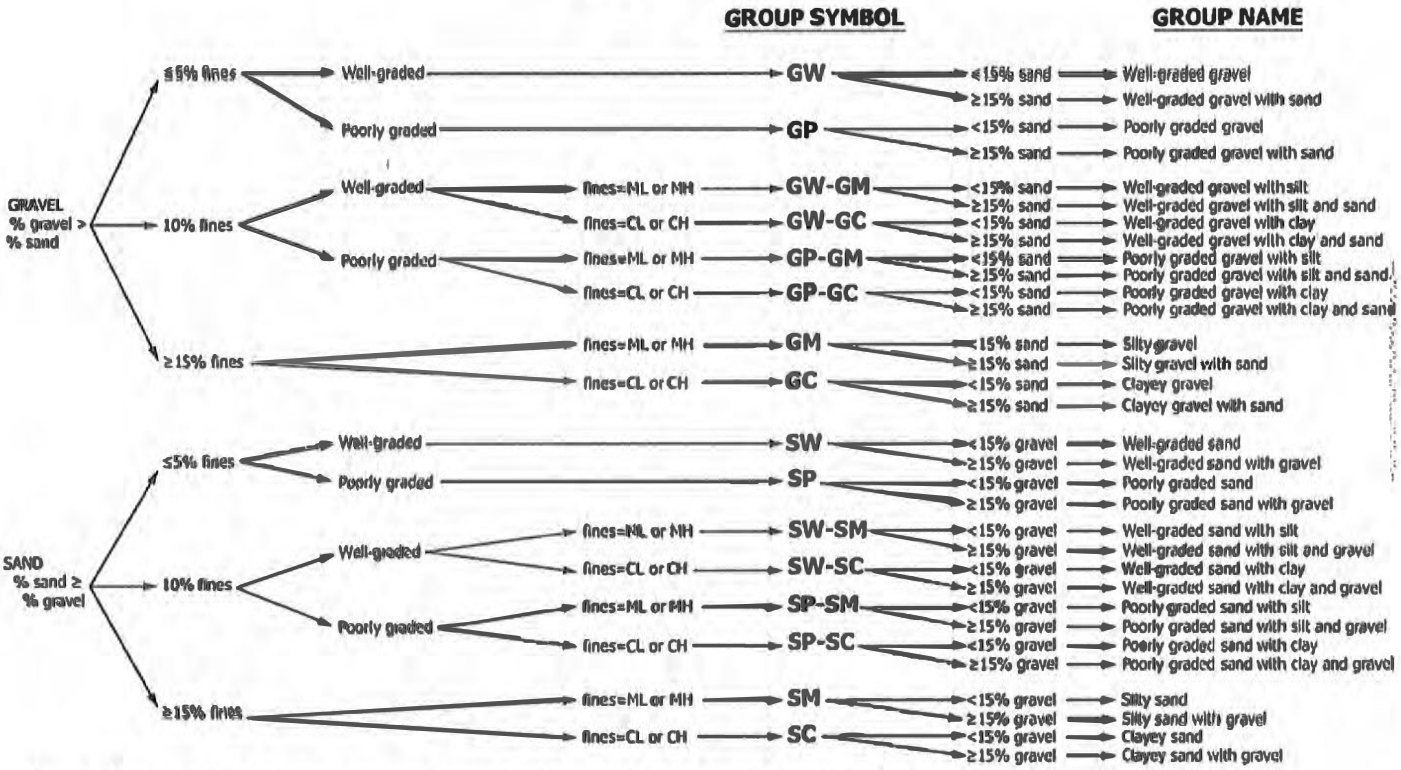

NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

8. Safety Precautions

8.1 When preparing the dilute HCl solution of one part concentrated hydrochloric acid (10 *N*) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly with water.

8.2 **Caution**—Do not add water to acid.

9. Sampling

9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

NOTE 6—Preferably, the sampling procedure should be identified as having been conducted in accordance with Practices D1452, D1587, or D2113, or Test Method D1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 7—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in accordance with the following schedule:

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (⅜ in.)	200 g (0.5 lb)
19.0 mm (¾ in.)	1.0 kg (2.2 lb)
38.1 mm (1½ in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)

NOTE 8—If random isolated particles are encountered that are significantly larger than the particles in the soil matrix, the soil matrix can be accurately described and identified in accordance with the preceeding schedule.

9.4 If the field sample or specimen being examined is smaller than the minimum recommended amount, the report shall include an appropriate remark.

10. Descriptive Information for Soils

10.1 *Angularity*—Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded in accordance with the criteria in Table 1 and Fig. 3. A range of angularity may be stated, such as: subrounded to rounded.

10.2 *Shape*—Describe the shape of the gravel, cobbles, and boulders as flat, elongated, or flat and elongated if they meet the criteria in Table 2 and Fig. 4. Otherwise, do not mention the shape. Indicate the fraction of the particles that have the shape, such as: one-third of the gravel particles are flat.

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TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

10.3 *Color*—Describe the color. Color is an important property in identifying organic soils, and within a given locality it may also be useful in identifying materials of similar geologic origin. If the sample contains layers or patches of varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

10.4 *Odor*—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 *HCl Reaction*—Describe the reaction with HCl as none, weak, or strong, in accordance with the critera in Table 4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

10.7 *Consistency*—For intact fine-grained soil, describe the consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.

10.8 *Cementation*—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

10.9 *Structure*—Describe the structure of intact soils in accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.

10.11 *Maximum Particle Size*—Describe the maximum particle size found in the sample in accordance with the following information:

10.11.1 *Sand Size*—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.6. For example: maximum particle size, medium sand.

10.11.2 *Gravel Size*—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maximum particle size, 1½ in. (will pass a 1½-in. square opening but not a ¾-in. square opening).

10.11.3 *Cobble or Boulder Size*—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

10.12 *Hardness*—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. "Hard" means particles do not crack, fracture, or crumble under a hammer blow.

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering hole, caving of trench or hole, or the presence of mica.

10.14 A local or commercial name or a geologic interpretation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

12. Preparation for Identification

12.1 The soil identification portion of this practice is based on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 9—Since the percentages of the particle-size distribution in Test Method D2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 10—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5 % of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*,

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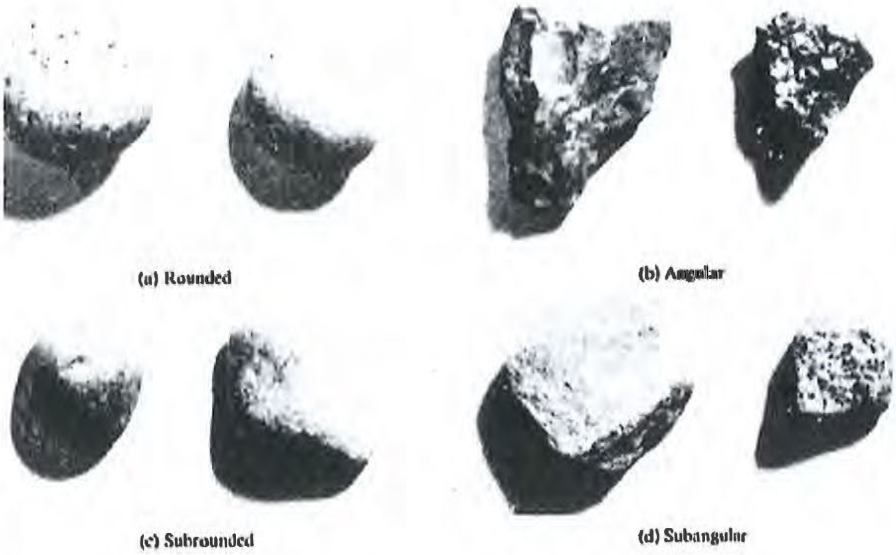

FIG. 3 Typical Angularity of Bulky Grains

TABLE 2 Criteria for Describing Particle Shape (see Fig. 4)

The particle shape shall be described as follows where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle, respectively.

Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and elongated	Particles meet criteria for both flat and elongated

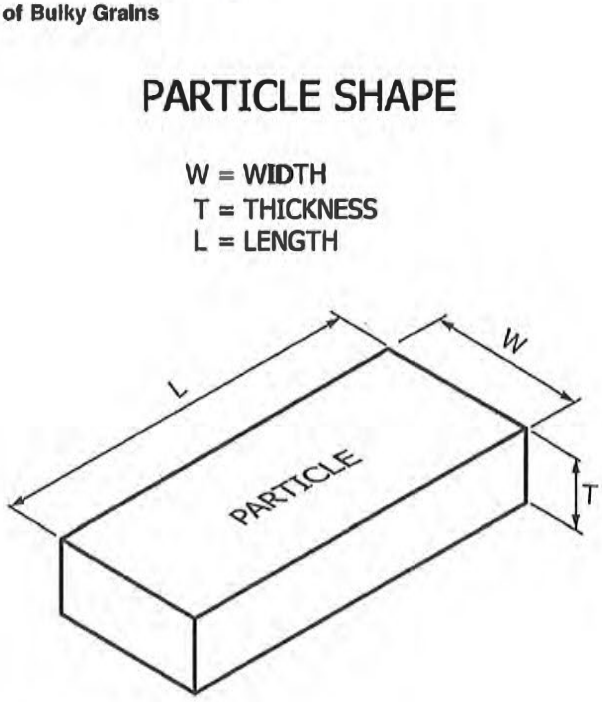

FIG. 4 Criteria for Particle Shape

for example, trace of fines. A trace is not to be considered in the total of 100 % for the components.

13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50 % fines. Follow the procedures for identifying coarse-grained soils of Section 15.

14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

14.2 *Dry Strength:*

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about ½

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TABLE 3 Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

TABLE 4 Criteria for Describing the Reaction With HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

TABLE 5 Criteria for Describing Consistency

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about ¼ in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

TABLE 6 Criteria for Describing Cementation

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

TABLE 7 Criteria for Describing Structure

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C.

14.2.3 If the test specimen contains natural dry lumps, those that are about ½ in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 11—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low, medium, high, or very high in accorance with the criteria in Table 8. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

TABLE 8 Criteria for Describing Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
Very high	The dry specimen cannot be broken between the thumb and a hard surface

14.3 *Dilatancy:*

14.3.1 From the specimen, select enough material to mold into a ball about ½ in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table 9. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

14.4 *Toughness:*

14.4.1 Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about ⅛ in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about ⅛ in. The thread will crumble at a diameter of ⅛ in. when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading.

14.4.2 Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 10.

TABLE 9 Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

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TABLE 10 Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness and Plasticity
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

14.5 *Plasticity*—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

14.7 *Identification of Inorganic Fine-Grained Soils:*

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 12—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

14.8 *Identification of Organic Fine-Grained Soils:*

14.8.1 Identify the soil as an *organic soil*, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

NOTE 13—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A ⅛-in. (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words "with sand" or "with gravel" (whichever is more predominant) shall be added to the group name. For example: "lean clay with sand, CL" or "silt with gravel, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percentage of gravel, use "with sand."

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if there appears to be more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy lean clay, CL", "gravelly fat clay, CH", or "sandy silt, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percent of gravel, use "sandy."

15. Procedure for Identifying Coarse-Grained Soils (Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

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15.5.2 The group name shall correspond to the first group symbol plus the words "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example: "well-graded gravel with clay, GW-GC" or "poorly graded sand with silt, SP-SM" (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example: "poorly graded gravel with sand, GP" or "clayey sand with gravel, SC" (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words "with cobbles" or "with cobbles and boulders" shall be added to the group name. For example: "silty gravel with cobbles, GM."

16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

NOTE 14—*Example: Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown

Geologic Interpretation—Alluvial fan

NOTE 15—Other examples of soil descriptions and identification are given in Appendix X1 and Appendix X2.

NOTE 16—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

Trace—Particles are present but estimated to be less than 5 %

Few—5 to 10 %

Little—15 to 25 %

Some—30 to 45 %

Mostly—50 to 100 %

16.2 If, in the soil description, the soil is identified using a classification group symbol and name as described in Test Method D2487, it must be distinctly and clearly stated in log forms, summary tables, reports, and the like, that the symbol and name are based on visual-manual procedures.

TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:
   Gravel—fine, coarse
   Sand—fine, medium, coarse
6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong

For intact samples:

18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
19. Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
20. Cementation: weak, moderate, strong
21. Local name
22. Geologic interpretation
23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

17. Precision and Bias

17.1 This practice provides qualitative information only, therefore, a precision and bias statement is not applicable.

18. Keywords

18.1 classification; clay; gravel; organic soils; sand; silt; soil classification; soil description; visual classification

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

X1.1 The following examples show how the information required in 16.1 can be reported. The information that is included in descriptions should be based on individual circumstances and need.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—About 75 % fine to coarse, hard, subangular gravel; about 25 % fine to coarse, hard, subangular sand; trace of fines; maximum size, 75 mm, brown, dry; no reaction with HCl.

X1.1.2 *Silty Sand with Gravel (SM)*—About 60 % predominantly fine sand; about 25 % silty fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15 % fine, hard, subrounded gravel, a few gravel-size particles fractured with hammer blow; maximum size, 25 mm; no reaction with HCl (Note—Field sample size smaller than recommended).

In-Place Conditions—Firm, stratified and contains lenses of silt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray; in-place density 106 lb/ft^3; in-place moisture 9 %.

X1.1.3 *Organic Soil (OL/OH)*—About 100 % fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry

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strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—About 75 % fine to coarse, hard, subrounded to subangular gravel; about 15 % fine, hard, subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

X2. USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE

X2.1 The identification procedure may be used as a descriptive system applied to materials that exist in-situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, and the like).

X2.2 Materials such as shells, crushed rock, slag, and the like, should be identified as such. However, the procedures used in this practice for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, an identification using a group name and symbol according to this practice may be assigned to aid in describing the material.

X2.3 The group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how group names and symbols can be incorporated into a descriptive system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. (50 to 100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h, material identified as "Sandy Lean Clay (CL)"; about 60 % fines with medium plasticity, high dry strength, no dilatancy, and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; "Poorly Graded Sand with Silt (SP-SM)"; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown.

X2.4.3 *Broken Shells*—About 60 % uniformly graded gravel-size broken shells; about 30 % sand and sand-size shell pieces; about 10 % nonplastic fines; "Poorly Graded Gravel with Silt and Sand (GP-GM)."

X2.4.4 *Crushed Rock*—Processed from gravel and cobbles in Pit No. 7; "Poorly Graded Gravel (GP)"; about 90 % fine, hard, angular gravel-size particles; about 10 % coarse, hard, angular sand-size particles; dry, tan; no reaction with HCl.

X3. SUGGESTED PROCEDURE FOR USING A BORDERLINE SYMBOL FOR SOILS WITH TWO POSSIBLE IDENTIFICATIONS.

X3.1 Since this practice is based on estimates of particle size distribution and plasticity characteristics, it may be difficult to clearly identify the soil as belonging to one category. To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.

X3.1.1 A borderline symbol may be used when the percentage of fines is estimated to be between 45 and 55 %. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.

X3.1.2 A borderline symbol may be used when the percentage of sand and the percentage of gravel are estimated to be about the same. For example: GP/SP, SC/GC, GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.

X3.1.3 A borderline symbol may be used when the soil could be either well graded or poorly graded. For example: GW/GP, SW/SP.

X3.1.4 A borderline symbol may be used when the soil could either be a silt or a clay. For example: CL/ML, CH/MH, SC/SM.

X3.1.5 A borderline symbol may be used when a fine-grained soil has properties that indicate that it is at the boundary between a soil of low compressibility and a soil of high compressibility. For example: CL/CH, MH/ML.

X3.2 The order of the borderline symbols should reflect similarity to surrounding or adjacent soils. For example: soils in a borrow area have been identified as CH. One sample is considered to have a borderline symbol of CL and CH. To show similarity, the borderline symbol should be CH/CL.

X3.3 The group name for a soil with a borderline symbol should be the group name for the first symbol, except for:

CL/CH lean to fat clay
ML/CL clayey silt
CL/ML silty clay

X3.4 The use of a borderline symbol should not be used indiscriminately. Every effort shall be made to first place the soil into a single group.

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X4. SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL, SAND, AND FINES IN A SOIL SAMPLE

X4.1 *Jar Method*—The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar, and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time; the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.

X4.2 *Visual Method*—Mentally visualize the gravel size particles placed in a sack (or other container) or sacks. Then, do the same with the sand size particles and the fines. Then, mentally compare the number of sacks to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size present. The percentages of sand and fines in the minus sieve size No. 4 material can then be estimated from the wash test (X4.3).

X4.3 *Wash Test (for relative percentages of sand and fines)*—Select and moisten enough minus No. 4 sieve size material to form a 1-in (25-mm) cube of soil. Cut the cube in half, set one-half to the side, and place the other half in a small dish. Wash and decant the fines out of the material in the dish until the wash water is clear and then compare the two samples and estimate the percentage of sand and fines. Remember that the percentage is based on weight, not volume. However, the volume comparison will provide a reasonable indication of grain size percentages.

X4.3.1 While washing, it may be necessary to break down lumps of fines with the finger to get the correct percentages.

X5. ABBREVIATED SOIL CLASSIFICATION SYMBOLS

X5.1 In some cases, because of lack of space, an abbreviated system may be useful to indicate the soil classification symbol and name. Examples of such cases would be graphical logs, databases, tables, etc.

X5.2 This abbreviated system is not a substitute for the full name and descriptive information but can be used in supplementary presentations when the complete description is referenced.

X5.3 The abbreviated system should consist of the soil classification symbol based on this standard with appropriate lower case letter prefixes and suffixes as:

Prefix:	*Suffix:*
s = sandy	s = with sand
g = gravelly	g = with gravel
	c = with cobbles
	b = with boulders

X5.4 The soil classification symbol is to be enclosed in parenthesis. Some examples would be:

Group Symbol and Full Name	Abbreviated
CL, Sandy lean clay	s(CL)
SP-SM, Poorly graded sand with silt and gravel	(SP-SM)g
GP, poorly graded gravel with sand, cobbles, and boulders	(GP)scb
ML, gravelly silt with sand and cobbles	g(ML)sc

SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this standard since the last issue (D2488 – 09) that may impact the use of this standard. (Approved June 15, 2009.)

(1) Revised Section 1.2.3.

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Designation: D 4750 – 87 (Reapproved 2001)

Standard Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)[1]

This standard is issued under the fixed designation D 4750; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method describes the procedures for measuring the level of liquid in a borehole or well and determining the stabilized level of liquid in a borehole.

1.2 The test method applies to boreholes (cased or uncased) and monitoring wells (observation wells) that are vertical or sufficiently vertical so a flexible measuring device can be lowered into the hole.

1.3 Borehole liquid-level measurements obtained using this test method will not necessarily correspond to the level of the liquid in the vicinity of the borehole unless sufficient time has been allowed for the level to reach equilibrium position.

1.4 This test method generally is not applicable for the determination of pore-pressure changes due to changes in stress conditions of the earth material.

1.5 This test method is not applicable for the concurrent determination of multiple liquid levels in a borehole.

1.6 The values stated in inch-pound units are to be regarded as the standard.

1.7 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *borehole*—a hole of circular cross-section made in soil or rock to ascertain the nature of the subsurface materials. Normally, a borehole is advanced using an auger, a drill, or casing with or without drilling fluid.

3.1.2 *earth material*—soil, bedrock, or fill.

3.1.3 *ground-water level*—the level of the water table surrounding a borehole or well. The ground-water level can be represented as an elevation or as a depth below the ground surface.

3.1.4 *liquid level*—the level of liquid in a borehole or well at a particular time. The liquid level can be reported as an elevation or as a depth below the top of the land surface. If the liquid is ground water it is known as water level.

3.1.5 *monitoring well (observation well)*—a special well drilled in a selected location for observing parameters such as liquid level or pressure changes or for collecting liquid samples. The well may be cased or uncased, but if cased the casing should have openings to allow flow of borehole liquid into or out of the casing.

3.1.6 *stabilized borehole liquid level*—the borehole liquid level which remains essentially constant with time, that is, liquid does not flow into or out of the borehole.

3.1.7 *top of borehole*—the surface of the ground surrounding the borehole.

3.1.8 *water table (ground-water table)*—the surface of a ground-water body at which the water pressure equals atmospheric pressure. Earth material below the ground-water table is saturated with water.

3.2 *Definitions:*

3.2.1 For definitions of other terms used in this test method, see Terminology D 653.

4. Significance and Use

4.1 In geotechnical, hydrologic, and waste-management investigations, it is frequently desirable, or required, to obtain information concerning the presence of ground water or other liquids and the depths to the ground-water table or other liquid surface. Such investigations typically include drilling of exploratory boreholes, performing aquifer tests, and possibly completion as a monitoring or observation well. The opportunity exists to record the level of liquid in such boreholes or wells, as the boreholes are being advanced and after their completion.

4.2 Conceptually, a stabilized borehole liquid level reflects the pressure of ground water or other liquid in the earth material exposed along the sides of the borehole or well. Under suitable conditions, the borehole liquid level and the ground-water, or other liquid, level will be the same, and the former can be used to determine the latter. However, when earth materials are not exposed to a borehole, such as material which is sealed off with casing or drilling mud, the borehole water

[1] This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.21 on Ground Water and Vadose Zone Investigations.

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[2] *Annual Book of ASTM Standards*, Vol 04.08.

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levels may not accurately reflect the ground-water level. Consequently, the user is cautioned that the liquid level in a borehole does not necessarily bear a relationship to the ground-water level at the site.

4.3 The user is cautioned that there are many factors which can influence borehole liquid levels and the interpretation of borehole liquid-level measurements. These factors are not described or discussed in this test method. The interpretation and application of borehole liquid-level information should be done by a trained specialist.

4.4 Installation of piezometers should be considered where complex ground-water conditions prevail or where changes in intergranular stress, other than those associated with fluctuation in water level, have occurred or are anticipated.

5. Apparatus

5.1 Apparatus conforming to one of the following shall be used for measuring borehole liquid levels:

5.1.1 *Weighted Measuring Tape*—A measuring tape with a weight attached to the end. The tape shall have graduations that can be read to the nearest 0.01 ft. The tape shall not stretch more than 0.05% under normal use. Steel surveying tapes in lengths of 50, 100, 200, 300, and 500 ft (20, 30, 50 or 100 m) and widths of ¼ in. (6 mm) are commonly used. A black metal tape is better than a chromium-plated tape. Tapes are mounted on hand-cranked reels up to 500 ft (100 m) lengths. Mount a slender weight, made of lead, to the end of the tape to ensure plumbness and to permit some feel for obstructions. Attach the weight to the tape with wire strong enough to hold the weight but not as strong as the tape. This permits saving the tape in the event the weight becomes lodged in the well or borehole. The size of the weight shall be such that its displacement of water causes less than a 0.05-ft (15-mm) rise in the borehole water level, or a correction shall be made for the displacement. If the weight extends beyond the end of the tape, a length correction will be needed in measurement Procedure C (see 7.2.3).

5.1.2 *Electrical Measuring Device*—A cable or tape with electrical wire encased, equipped with a weighted sensing tip on one end and an electric meter at the other end. An electric circuit is completed when the tip contacts water; this is registered on the meter. The cable may be marked with graduations similar to a measuring tape (as described in 5.1.1).

5.1.3 *Other Measuring Devices*—A number of other recording and non-recording devices may be used. See Ref. **(1)** for more details.[3]

6. Calibration and Standardization

6.1 Calibrate measuring apparatus in accordance with the manufacturers' directions.

7. Procedure

7.1 Liquid-level measurements are made relative to a reference point. Establish and identify a reference point at or near the top of the borehole or a well casing. Determine and record the distance from the reference point to the top of the borehole (land surface). If the borehole liquid level is to be reported as an elevation, determine the elevation of the reference point or the top of borehole (land surface). Three alternative measurement procedures (A, B, and C) are described.

NOTE 1—In general, Procedure A allows for greater accuracy than B or C, and B allows for greater accuracy than C; other procedures have a variety of accuracies that must be determined from the referenced literature **(2-5)**.

7.2 *Procedure A—Measuring Tape*:

7.2.1 Chalk the lower few feet of tape by drawing the tape across a piece of colored carpenter's chalk.

7.2.2 Lower a weighted measuring tape slowly into the borehole or well until the liquid surface is penetrated. Observe and record the reading on the tape at the reference point. Withdraw the tape from the borehole and observe the lower end of the tape. The demarcation between the wetted and unwetted portions of the chalked tape should be apparent. Observe and record the reading on the tape at that point. The difference between the two readings is the depth from the reference point to the liquid level.

NOTE 2—Submergence of the weight and tape may temporarily cause a liquid-level rise in wells or boreholes having very small diameters. This effect can be significant if the well is in materials of very low hydraulic conductivity.

NOTE 3—Under dry surface conditions, it may be desirable to pull the tape from the well or borehole by hand, being careful not to allow it to become kinked, and reading the liquid mark before rewinding the tape onto the reel. In this way, the liquid mark on the chalked part of the tape is rapidly brought to the surface before the wetted part of the tape dries. In cold regions, rapid withdrawal of the tape from the well is necessary before the wet part freezes and becomes difficult to read. The tape must be protected if rain is falling during measurements.

NOTE 4—In some pumped wells, or in contaminated wells, a layer of oil may float on the water. If the oil layer is only a foot or less thick, read the tape at the top of the oil mark and use this reading for the water-level measurement. The measurement will not be greatly in error because the level of the oil surface in this case will differ only slightly from the level of the water surface that would be measured if no oil was present. If several feet of oil are present in the well, or if it is necessary to know the thickness of the oil layer, a water-detector paste for detecting water in oil and gasoline storage tanks is available commercially. The paste is applied to the lower end of the tape that is submerged in the well. It will show the top of the oil as a wet line and the top of the water as a distinct color change.

7.2.3 As a standard of good practice, the observer should make two measurements. If two measurements of static liquid level made within a few minutes do not agree within about 0.01 or 0.02 ft (generally regarded as the practical limit of precision) in boreholes or wells having a depth to liquid of less than a couple of hundred feet, continue to measure until the reason for the lack of agreement is determined or until the results are shown to be reliable. Where water is dripping into the hole or covering its wall, it may be impossible to get a good water mark on the chalked tape.

7.2.4 After each well measurement, in areas where polluted liquids or ground water is suspected, decontaminate that part of the tape measure that was wetted to avoid contamination of other wells.

7.3 *Procedure B—Electrical Measuring Device*:

7.3.1 Check proper operation of the instrument by inserting the tip into water and noting if the contact between the tip and

[3] The boldface numbers in parentheses refer to the list of references at the end of this standard.

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the water surface is registered clearly.

NOTE 5—In pumped wells having a layer of oil floating on the water, the electric tape will not respond to the oil surface and, thus, the liquid level determined will be different than would be determined by a steel tape. The difference depends on how much oil is floating on the water. A miniature float-driven switch can be put on a two-conductor electric tape that permits detection of the surface of the uppermost fluid.

7.3.2 Dry the tip. Slowly lower the tip into the borehole or well until the meter indicates that the tip has contacted the surface of the liquid.

7.3.3 For devices with measurement graduations on the cable, note the reading at the reference point. This is the liquid-level depth below the reference point of the borehole or well.

7.3.4 For measuring devices without graduations on the cable, mark the cable at the reference point. Withdraw the cable from the borehole or well. Stretch out the cable and measure and record the distance between the tip and the mark on the cable by use of a tape. This distance is the liquid-level depth below the reference point.

7.3.5 A second or third check reading should be taken before withdrawing the electric tape from the borehole or well.

7.3.6 Decontaminate the submerged end of the electric tape or cable after measurements in each well.

NOTE 6—The length of the electric line should be checked by measuring with a steel tape after the line has been used for a long time or after it has been pulled hard in attempting to free the line. Some electric lines, especially the single line wire, are subject to considerable permanent stretch. In addition, because the probe is usually larger in diameter than the wire, the probe can become lodged in a well. Sometimes the probe can be attached by twisting the wires together by hand and using only enough electrical tape to support the weight of the probe. In this manner, the point of probe attachment is the weakest point of the entire line. Should the probe become "hung in the hole," the line may be pulled and breakage will occur at the probe attachment point, allowing the line to be withdrawn.

7.4 *Procedure C—Measuring Tape and Sounding Weight*:

7.4.1 Lower a weighted measuring tape into the borehole or well until the liquid surface is reached. This is indicated by an audible splash and a noticeable decrease in the downward force on the tape. Observe and note the reading on the tape at the reference point. Repeat this process until the readings are consistent to the accuracy desired. Record the result as the liquid-level depth below the reference point.

NOTE 7—The splash can be made more audible by using a "plopper," a lead weight with a concave bottom surface.

7.4.2 If the liquid level is deep, or if the measuring tape adheres to the side of the borehole, or for other reasons, it may not be possible to detect the liquid surface using this method. If so, use Procedure A or Procedure B.

8. Determination of a Stabilized Liquid Level

8.1 As liquid flows into or out of the borehole or well, the liquid level will approach, and may reach, a stabilized level. The liquid level then will remain essentially constant with time.

NOTE 8—The time required to reach equilibrium can be reduced by removing or adding liquid until the liquid level is close to the estimated stabilized level.

8.2 Use one of the following two procedures to determine the stabilized liquid level.

8.2.1 *Procedure 1*—Take a series of liquid-level measurements until the liquid level remains constant with time. As a minimum, two such constant readings are needed (more readings are preferred). The constant reading is the stabilized liquid level for the borehole or well.

NOTE 9—If desired, the time and level data could be plotted on graph paper in order to show when equilibrium is reached.

8.2.2 *Procedure 2*—Take at least three liquid-level measurements at approximately equal time intervals as the liquid level changes during the approach to a stabilized liquid level.

8.2.2.1 The approximate position of the stabilized liquid level in the well or borehole is calculated using the following equation:

$$h_o = \frac{{y_1}^2}{y_1 - y_2} \quad (1)$$

where:

h_o = distance the liquid level must change to reach the stabilized liquid level,

y_1 = distance the liquid level changed during the time interval between the first two liquid-level readings, and

y_2 = distance the liquid level changed during the time interval between the second and the third liquid level readings.

8.2.2.2 Repeat the above process using successive sets of three measurements until the h_o computed is consistent to the accuracy desired. Compute the stabilized liquid level in the well or borehole.

NOTE 10—The time span required between readings for Procedures 1 and 2 depends on the permeability of the earth material. In material with comparatively high permeability (such as sand), a few minutes may be sufficient. In materials with comparatively low permeability (such as clay), many hours or days may be needed. The user is cautioned that in clayey soils the liquid in the borehole or well may never reach a stabilized level equivalent to the liquid level in the earth materials surrounding the borehole or well.

9. Report

9.1 For borehole or well liquid-level measurements, report, as a minimum, the following information:

9.1.1 Borehole or well identification.

9.1.2 Description of reference point.

9.1.3 Distance between reference point and top of borehole or land surface.

9.1.4 Elevation of top of borehole or reference point (if the borehole or well liquid level is reported as an elevation).

9.1.5 Description of measuring device used, and graduation.

9.1.6 Procedure of measurement.

9.1.7 Date and time of reading.

9.1.8 Borehole or well liquid level.

9.1.9 Description of liquid in borehole or well.

9.1.10 State whether borehole is cased, uncased, or contains a monitoring (observation) well standpipe and give description of, and length below top of borehole of, casing or standpipe.

9.1.11 Drilled depth of borehole, if known.

9.2 For determination of stabilized liquid level, report:

9.2.1 All pertinent data and computations.

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9.2.2 Procedure of determination.

9.2.3 The stabilized liquid level.

9.3 *Report Forms*—An example of a borehole or well-schedule form is shown in Fig. 1. An example of a liquid-level measurement form, for recording continuing measurements for a borehole or well, is shown in Fig. 2. An example of a borehole or well schedule form designed to facilitate computer data storage is shown in Fig. 3.

10. Precision and Bias

10.1 Borehole liquid levels shall be measured and recorded to the accuracy desired and consistent with the accuracy of the measuring device and procedures used. Procedure A multiple measurements by wetted tape should agree within 0.02 ft (6 mm). Procedure B multiple measurements by electrical tape should agree within 0.04 ft (12 mm). Procedure C multiple measurements by tape and sounding weight should agree within 0.04 ft (12 mm). Garber and Koopman (2) describe corrections that can be made for effects of thermal expansion of tapes or cables and of stretch due to the suspended weight of tape or cable and plumb weight when measuring liquid levels at depths greater than 500 ft (150 m).

BOREHOLE OR WELL SCHEDULE FORM

Date ....., 19..... Field No. .....
Record by ..... Office No. .....
Source of data .....

1. *Location:* State ..... County .....
   Map .....
   ..... ¼ ..... ¼ sec. ..... T ..... N/S R ..... E/W
2. *Owner:* ..... Address .....
   Tenant ..... Address .....
   Driller ..... Address .....
3. *Topography* .....
4. *Elevation* ..... ft. above/below .....
5. *Type:* Dug, drilled, driven, bored, jetted ..... 19.....
6. *Depth:* Repd. ..... ft. Meas. ..... ft.
7. *Casing:* Diam. ..... in., to ..... in., Type .....
   Depth ..... ft., Finish .....
8. *Chief Aquifer* ..... From ..... ft. to ..... ft.
   Others .....
9. *Water level* ..... ft. rept./meas. ..... 19..... above/below .....
   ..... which is ..... ft. above/below surface
10. *Pump:* Type ..... Capacity ..... G. M. .....
    Power: Kind ..... Horsepower .....
11. *Yield:* Flow ..... G. M., Pump ..... G. M., Meas., Rept. Est. .....
    Drawdown ..... ft. after ..... hours pumping ..... G. M.
12. *Use:* Dom., Stock, PS., RR., Ind., Irr., Obs. .....
    Adequacy, permanence .....
13. *Quality* ..... Temp ..... °F.
    Taste, odor, color ..... Sample Yes/No .....
    Unfit for .....
14. *Remarks:* (Log, Analyses, etc.) .....

FIG. 1 Example of a Borehole or Well Schedule Form

LIQUID LEVEL MEASUREMENT FORM

Field No. .....
Owner ..... Office No. .....
Location ..... Project .....
Measuring Point .....
Elevation of Measuring Point .....

Date	Hour	Depth to Water	Elev. of Water Surface	Meas. by	Remarks (Nearby wells pumping, etc.)

FIG. 2 Example of a Liquid Level Measurement Form

11. Keywords

11.1 borehole; electrical measuring device; ground water; liquid level; measuring tape; well

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SITE NO.

BOREHOLE OR WELL SCHEDULE FORM

Recorded by _____ Date _____

Check One ____ English ____ Metric Units

GENERAL SITE DATA (0)

Site Ident No 5 _____ 19 | RG Number R=0 | Transaction T= A D M V (add, delete, modify, verified)

Site-Type 2= C D E H I M Ø P S T W X (collector, drain, excavation, sink, hole, connector multiple, outcrop, pond, spring, tunnel or shaft, well, test hole) | Data Reliability 3= C U (field checked, unchecked) | Reporting Agency 4=

Project No. 5= | District 6= | State 7= | County (or town) | 8=

Latitude 9= deg min sec | Longitude 10= deg min sec | Lat-Long Accuracy 11= S F T M (sec, 5 sec, 10 sec, Min)

Local Number 12= | Land Net Loc 13= 1/4 1/4 1/4 S section, T township, R range, meridian

Location Map 14= | Scale 15=

Altitude 16= | Method of Measurement 17= A L M (altimeter, level, map) | Accuracy 18=

Topo Setting 19= A B C D E F G H K L M Ø P S T U V W (alluvial plain, bluff, playa, stream channel, depression, dunes, flat, flood plain, hill top, sink, swamp, mangrove swamp, cliff shore, delta, ped mont, hill side, terrace, undulating flat, valley, upland draw) | Hydrologic Unit (OWDC) 20=

Use of Site 23= A C D E G H M Ø P R S T U W X Z (abandoned, standby, domestic, other supply, geothermal, seismic, heat, recharge, mine, observation, oil or gas, recharge, recreation, test, unused, withdrawal, waste, destroyed) | Secondary Site Use 301= | Tertiary Site Use 302=

Use of Water 24= A B C D E F H I J K M N P Q R S T U Y Z (air cond., bottling, E&R mercial, power, water, fire, domestic, irrigation, industrial (cooling), mining, medicinal, industrial, public supply, aquaculture, recreation, stock, institution, unused, desal, other)

Secondary Water Use 25= | Tertiary Use of Water 26= | Depth of Hole 27= | Depth of Well 28= | Source of Depth Data ① 29=

Water Level 30= | Data Measured 31= month day year | Source ① 33=

Method of Measurement 34= A B C E G H L M N R S T V Z (airline, analog, calibrated, manometer, calibrated, pressure gage, pressure gage, geophysical, manometer, non sec. gage, reported, steel tape, electric tape, calibrated, electric tape, other)

Site Status 37= D E F G H I J N Ø P R S T V W X Z (dry, recently flowing, flowing, nearby flowing, nearby recently flowing, injector site, observation site, meas. monitor discon, obstruction, pumping, recently pumped, nearby pumping, nearby recently pumped, foreign substance, well destroyed, surface water effects, other)

Source of Geohydrologic Data ① 36= | Pump Used 35= no | Date of First Construction Completion 21= month day year

OWNER IDENTIFICATION (1)

R=158 | T= A D M (add, delete, modify) | Date of Ownership 159= month day year

Name: Last 161= | First 162= | Middle Initial 163=

OTHER SITE IDENTIFICATION NUMBERS (1)

R=189 | T= A D M (add, delete, modify) | Ident 190= | Assigner 191=

New Card Same R & T | Ident 190= | Assigner 191=

SITE VISIT DATA (1)

R=186 | T= A D M (add, delete, modify) | Date of Visit 187= month day year | Name of Person 188=

FIELD WATER QUALITY MEASUREMENTS (1)

R=192 | T= A D M (add, delete, modify) | Date 193= month day year | Geohydrologic Unit 195=

New Card Same R thru 195

Temperature 196= 0,0,0,1,0 | Degrees C 197=

Conductance 196= 0,0,0,0,5 | µ Mhos 197=

Other (STORET) Parameter 196= | Value 197=

Other (STORET) Parameter 196= | Value 197=

FOOT NOTES

① Source of Data Codes

A D G L M O R S Z (other gov't, driller, geologist, logs, memory, owner, other reported, reporting agency, other)

FIG. 3 Example of a Borehole or Well Schedule Form

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REFERENCES

(1) *"National Handbook of Recommended Methods for Water Data Acquisition—Chapter 2—Ground Water"*, Office of Water Data Coordination, Washington, DC, 1980.
(2) Garber, M. S., and Koopman, F. C., "Methods of Measuring Water Levels in Deep Wells," *U.S. Geologic Survey Techniques for Water Resources Investigations*, Book 8, Chapter A-1, 1968.
(3) Hvorslev, M. J., "Ground Water Observations," in *Subsurface Exploration and Sampling of Soils for Civil Engineering Purposes*, American Society Civil Engineers, New York, NY, 1949.
(4) Zegarra, E. J., "Suggested Method for Measuring Water Level in Boreholes," *Special Procedures for Testing Soil and Rock for Engineering Purposes, ASTM STP 479*, ASTM, 1970.
(5) "Determination of Water Level in a Borehole," CSA Standard A 119.6 – 1971, Canadian Standards Association, 1971.

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Designation: D5521/D5521M – 13

Standard Guide for Development of Groundwater Monitoring Wells in Granular Aquifers[1]

This standard is issued under the fixed designation D5521/D5521M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This guide covers the development of screened wells installed for the purpose of obtaining representative groundwater information and water quality samples from granular aquifers, though the methods described herein could also be applied to wells used for other purposes. Other well-development methods that are used exclusively in open-borehole bedrock wells are not described in this guide.

1.2 The applications and limitations of the methods described in this guide are based on the assumption that the primary objective of the monitoring wells to which the methods are applied is to obtain representative water quality samples from aquifers. Screened monitoring wells developed using the methods described in this guide should yield relatively sediment-free samples from granular aquifer materials, ranging from gravels to silty sands. While many monitoring wells are considered "small-diameter" wells (that is, less than 10 cm [4 in.] inside diameter), some of the techniques described in this guide will be more easily applied to large-diameter wells (that is, 10 cm [4 in.] or greater inside diameter).

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D5088 Practice for Decontamination of Field Equipment Used at Waste Sites

D5092 Practice for Design and Installation of Groundwater Monitoring Wells

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of common terminology terms used within this guide, refer to Terminology D653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *air entrapment*—trapping of air or other gas in pore spaces of the formation or filter pack during development with compressed air.

3.2.2 *air lift pump*—a device consisting of two pipes, with one (the air line) inside the other (the eductor pipe), used to withdraw water from a well. The lower ends of the pipes are submerged, and compressed air is delivered through the inner pipe to form a mixture of air and water. This mixture rises in the outer pipe to the surface because the specific gravity of this mixture is less than that of the water column.

[1] This guide is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.21 on Groundwater and Vadose Zone Investigations.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

*A Summary of Changes section appears at the end of this standard

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3.2.3 *air line*—a small vertical air pipe used in air-lift pumping. It usually extends from the ground surface to near the submerged lower end of the eductor pipe. The length of the air line below the static water level is used in calculating the air pressure required to start air-lift pumping.

3.2.4 *annular seal*—material used to provide a seal between the borehole and the casing of a well. The annular seal should have a hydraulic conductivity less than that of the surrounding geologic materials and be resistant to chemical or physical deterioration.

3.2.5 *backwashing*—the reversal of water flow caused by the addition of water to a well that is designed to loosen bridges and facilitate the removal of fine-grained materials from the formation surrounding the borehole.

3.2.6 *bailing (development)*—a development technique using a bailer which is raised and lowered in the well to create a strong inward and outward movement of water from the formation to break sand bridges and to remove fine materials from the well.

3.2.7 *cable tool drilling*—a drilling technique in which a drill bit attached to the bottom of a weighted drill stem is raised and dropped to crush and grind formation materials. In unconsolidated formations, casing is usually driven as drilling proceeds to prevent collapse of noncohesive materials into the borehole.

3.2.8 *eductor pipe*—the vertical discharge pipe used in air-lift pumping, submerged at least one third but usually two thirds of its length below the pumping water level in the well.

3.2.9 *filter-packed well*—a well in which the natural formation materials adjacent to the well screen has been replaced by a filter pack material.

3.2.10 *formation damage*—reduction of formation hydraulic conductivity at the borehole wall caused by the drilling process. May consist of compaction, clay smearing, clogging of pores with drilling mud filtrate, or other drilling-related damage.

3.2.11 *hydraulic jetting*—a well-development method that employs a jetting tool with nozzles and a high-pressure pump to force water outwardly through the well screen, the filter pack, and sometimes into the adjacent geologic unit, for the purpose of dislodging fine sediment and correcting formation damage done during drilling.

3.2.12 *indicator parameters*—chemical parameters, including pH, specific conductance, temperature and dissolved oxygen content, which are used to determine when formation water is entering a monitoring well.

3.2.13 *jetting*—see *hydraulic jetting.*

3.2.14 *naturally developed well*—a well in which the formation materials collapse around the well screen, and fine formation materials are removed using standard development techniques.

3.2.15 *overpumping*—a well-development technique that involves pumping the well at a rate that exceeds the design capacity of the well.

3.2.16 *rawhiding*—starting and stopping a pump intermittently to produce rapid changes in the pressure head in the well.

3.2.17 *sandlocking*—refers to the accumulation of sand and other sediment on development tools while they are working in the well screen, resulting in the tools becoming lodged in the screen. Also refers to the accumulation of sand and other sediment in the impeller section of a submersible pump, resulting in the impellers binding.

3.2.18 *sloughing*—caving of formation materials into an unstabilized open borehole.

3.2.19 *spudding*—the operation, in cable-tool drilling, of drilling a collar hole and advancing a casing through overburden. Also a general term in rotary or diamond core drilling applied to drilling through overburden.

3.2.20 *sump*—a blank extension of easing beneath the well screen that provides a space for sediment brought into the well during development to accumulate.

3.2.21 *surge block*—a plunger-like tool consisting of disks of flexible material (for example, neoprene) sandwiched between rigid (for example, metal) disks that may be solid or valved, and that is used in well development. See *surging.*

3.2.22 *surging*—a well-development technique in which a surge block is alternately raised and lowered within the well casing or screen, or both, to create a strong inward and outward movement of water through the well screen.

3.2.23 *tool string*—the drill pipe or drill rod and all attached drilling or development tools used in the borehole or well.

3.2.24 *turbidity*—cloudiness in water due to suspended and colloidal material.

3.2.25 *well development*—the act of repairing damage to the borehole caused by the drilling process and removing fine-grained materials or drilling fluids, or both, from formation materials so that natural hydraulic conditions are restored and well yields are enhanced.

4. Significance and Use

4.1 A properly designed, installed, and developed groundwater monitoring well, constructed in accordance with Practice D5092 should provide the following: representative samples of groundwater that can be analyzed to determine physical properties and water-quality parameters of the sample or potentiometric levels that are representative of the total hydraulic head of that portion of the aquifer screened by the well, or both. Such a well may also be utilized for conducting aquifer tests used for the purpose of determining the hydraulic properties of the geologic materials in which the well has been completed.

4.2 Well development is an important component of monitoring well completion. Monitoring wells installed in aquifers should be sufficiently developed to ensure that they serve their intended objectives. Well development methods vary with the physical characteristics of the geologic formation in which the monitoring well is screened, the construction details of the well, the drilling method used during the construction of the borehole in which the well is installed, and the quality of the water. The development method for each individual monitoring

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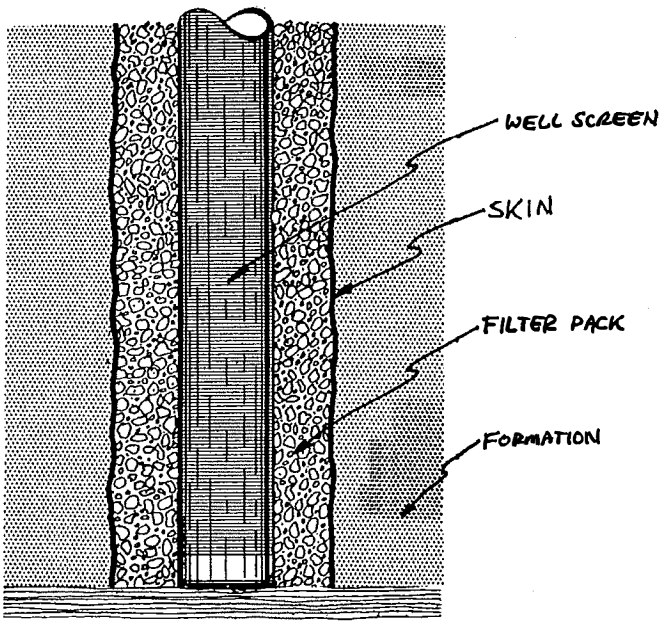
well should be selected from among the several methods described in this guide and should be employed by the well construction contractor or the person responsible for monitoring well completion.

4.3 The importance of well development in monitoring wells cannot be overestimated; all too often development is not performed or is carried out inadequately. Proper and careful well development will improve the ability of most monitoring wells to provide representative, unbiased chemical and hydraulic data. The additional time and money spent performing this important step in monitoring well completion will minimize the potential for damaging pumping equipment and in-situ sensors, and increase the probability that groundwater samples are representative of water contained in the monitored formation. Practice D3740 provides evaluation factors for the activities in this guide.

NOTE 1—The quality of the result produced by this standard is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with Practice D3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some of those factors.



NOTE 1—One of the purposes of development is to rectify the damage done to the borehole wall during drilling, such as the "skin" of fine-grained materials that accumulates on the borehole wall during mud-rotary drilling.

FIG. 1 Example of Rectifying Damage Done During Drilling

5. Purposes of Monitoring Well Development

5.1 Monitoring wells are developed primarily for the following reasons:

5.1.1 To rectify damage done during drilling to the borehole wall and the adjacent formation (that is, clogging, smearing, or compaction of formation materials) that may result in a localized reduction in hydraulic conductivity of the formation near the borehole (see Fig. 1);

5.1.2 To remove fine-grained materials from the formation and filter pack (where applicable) that may result in the acquisition of turbid, sediment-laden samples;

5.1.3 To stabilize formation and artificial filter pack materials (where applicable) adjacent to the well screen (see Fig. 2[3]);

5.1.4 To retrieve lost drilling fluid (if drilling fluid was used in the borehole installation process) that may alter the quality of water in the vicinity of the well and interfere with water quality analysis (see Fig. 3[3]); and

5.1.5 To maximize well efficiency and hydraulic communication between the well and the adjacent formation to provide for the acquisition of representative groundwater samples and formation hydraulic test data.

6. Conducting a Monitoring Well-Development Program

6.1 *Well Development Process*—The well development process consists of three phases: predevelopment, preliminary development, and final development.

6.1.1 Predevelopment refers to techniques used to mitigate formation damage during well construction. This is particularly important when using direct or reverse rotary drilling systems that depend on drilling fluid to carry cuttings to the surface and support an open borehole. Control of drilling fluid properties, during the drilling operation and immediately prior to the installation of screen, casing, and filter pack, is very important.

6.1.2 Preliminary development takes place after the screen, casing, and filter pack have been installed. Methods used to accomplish this task include surging, bailing, hydraulic jetting, and air lifting. The primary purpose of this operation is to apply sufficient energy in the well to facilitate rectification of formation damage due to drilling; removal of fine-grained materials from the screen, filter pack, and formation; stabilization and consolidation of the filter pack; retrieval of drilling fluid (if used); and creation of an effective hydraulic interface between the filter pack and the formation.

6.1.3 During this phase of well development, the preferred technique is to gradually apply the selected method, increasing intensity as long as the well responds to treatment. Response generally is indicated by increased yields of water and sediment. Intensive development of a well that appears to be plugged should not be attempted because damage and destruction of the well may result.

6.1.4 Final development refers to procedures performed with a pump, such as pumping and surging, and backwashing. These techniques are used as the final step in achieving the objectives of well development. If preliminary development methods have been effective, the time required for final development should be relatively short. However, if the preliminary methods have not been successful, or if conditions preclude the use of the preliminary techniques listed, the final development phase should be continued until the development completion criteria (described below) are satisfied.

6.2 *Factors Affecting the Selection of a Well-Development Method*—A variety of factors must be considered in selecting the method(s) used for developing any given monitoring well;

[3] Figure adapted from *Ground Water and Wells*, Second edition, 1986.

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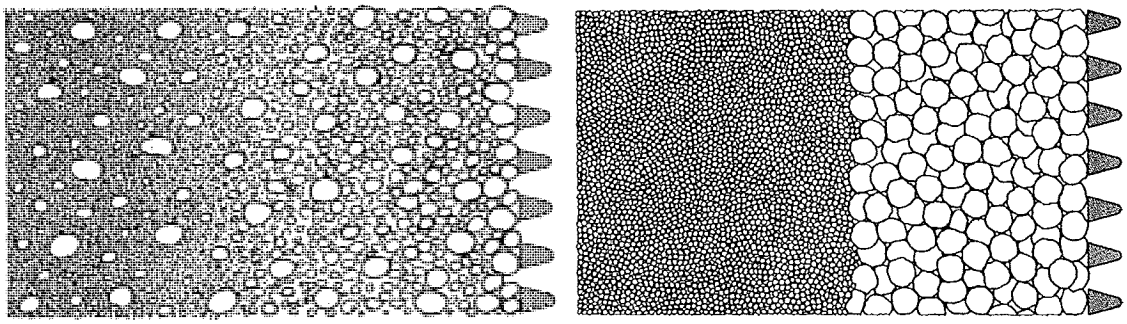
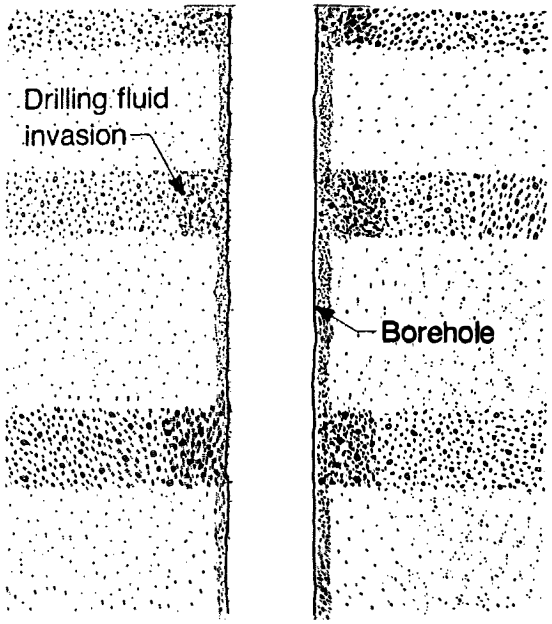


NOTE 1—After well development, formation materials in "naturally developed" wells (left) and filter packed wells (right) should be stabilized so that entry of fine-grained materials into the well is minimized and no settlement occurs.

FIG. 2 Formation Materials in Wells



NOTE 1—When drilling with water-based drilling fluids, some fluid will infiltrate beyond the borehole into the most permeable zones. One of the purposes of development is to remove lost drilling fluid from the formation adjacent to the open interval of the well.

FIG. 3 Removal of Lost Drilling Fluid

these include: the construction of the well (that is, material used for well casing and screen, type and open area of well screen, type of joint between casing sections, screen length and slot size, casing and screen diameter, whether or not a filter pack was used in the well and the thickness of the filter pack); characteristics and hydraulic conductivity of the formation materials adjacent to the well screen; water quality in the aquifer in which the well is installed (that is, whether or not it may be contaminated, requiring special safety or handling considerations, or both, such as containment or treatment upon removal from the well); consequences of introducing foreign fluids (that is, air, water, or chemical solutions) into the well and aquifer; drilling method used during borehole installation; depth to static water level and height of the water column in the well; type and portability of available equipment (that is, whether or not a drilling rig is required); time available for development; and cost effectiveness of the method.

6.3 *Timing of Well Development: When and How Long to Develop*—The point in time at which a monitoring well is developed is a decision that is generally based on design and construction of the well. For example, if the well is installed with the intent of using natural formation material as the filter pack (that is, a "naturally developed" well), development is generally performed after the screen and casing have been installed and the formation material has collapsed against the screen (to at least 1.5 m [5 ft] above the screen), but before the annular seal is installed. Because this type of well design is based on the assumption that well development will remove a significant fraction of the formation materials adjacent to the well screen (therefore causing some sloughing in the borehole), developing the well after installing the annular seal may result in portions of the annular seal collapsing into the vicinity of the well screen. On the other hand, properly designed and constructed filter-packed wells may be developed after the annular seal materials have been installed and given sufficient time to set or cure, because the well screen is designed to retain at least 90 % and preferably 99 % of filter pack materials and little or no sloughing should occur.

6.3.1 The duration of well development is based on the primary purpose(s) of the development process. For example, if the primary purpose for development is to remove drilling fluid lost to the formation during borehole installation, the time required for completion of development may be based on the time it takes to remove from the well some multiple of the estimated volume lost. If the primary purpose of development is to rectify damage done during drilling to the borehole wall and the adjacent formation, the time for development may be based on the response of the well to pumping. An improvement in recovery rate of the well indicates that the localized reduction in hydraulic conductivity has been effectively rectified by development. If the primary purpose of development is to remove fine-grained materials, development may continue until visibly clear water is discharged from the well, or until the turbidity of water removed from the well is at some specified level. These criteria may be difficult or impossible to satisfy in formations with a significant fraction of fine-grained material. Another criterion used for determining when development is complete is the stabilization of certain indicator parameters (that is, temperature, specific conductance, pH, redox potential, dissolved oxygen) that are easily measured in the field. While this criterion may be an indicator of when native formation

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water is being produced, it does not necessarily indicate that well development is complete.

6.4 *Decontamination of Well Development Equipment*—Any equipment or materials used to develop a monitoring well should be thoroughly cleaned in accordance with Practice D5088. Cleaning should take place prior to the use of any equipment in any monitoring well, and between uses in either the same well or in other wells.

7. Limitations of Well Development

7.1 Well development should be applied with great care to wells installed in predominantly fine-grained formation materials (that is, in formations dominated by fine sand, silt or clay). If vigorous development is attempted in such wells, the turbidity of water removed from the well may actually increase many times over. In some fine-grained formation materials, no amount of development will measurably improve formation hydraulic conductivity or the hydraulic efficiency of the well.

7.2 While development methods which require the addition of a foreign fluid to a well may be applied to groundwater monitoring wells, such methods should be used with an understanding of the negative effects that added fluids may have on the ability of the well to yield representative groundwater quality samples. Only in very extreme or special cases should fluids other than clean water or filtered air be considered for use in a well during development. Fluids other than water, including deflocculating or dispersing agents (that is, polyphosphates), acids (that is, hydrochloric or hydrofluoric acid), surfactants, and disinfectants (that is, sodium hypochlorite), may produce severe and persistent chemical alterations of water quality in the immediate vicinity of the well. The use of chemicals for well development is not discussed further for these reasons.

7.2.1 Any water added to a monitoring well for the purpose of development should be of known and acceptable chemistry. The impact of added water on in situ water quality should be evaluated and, to the extent possible, this water should be removed by pumping after development is complete. One possible means of reducing potential problems related to the addition of water to the well is to obtain water-quality samples from the well only after natural groundwater flow in the aquifer has had time to flush the remnants of well-development fluids beyond the well. Another means may be to use water that has been taken from the formation itself (that is, water pumped from the formation either prior to or during development) for the development process.

7.3 Development methods using compressed air (that is, air-lift pumping) should be attempted only after great care has been taken to remove any compressor oil or other foreign substances from the air stream prior to introduction into the well. Air should not be forced into the formation or allowed to be released directly into the well without the use of a containment device (that is, an eductor pipe). The injection of air into the formation may cause air entrapment and result in a dramatic reduction in formation hydraulic conductivity. An uncontrolled release of air into the well may cause significant chemical changes in the water in the well and the adjacent formation.

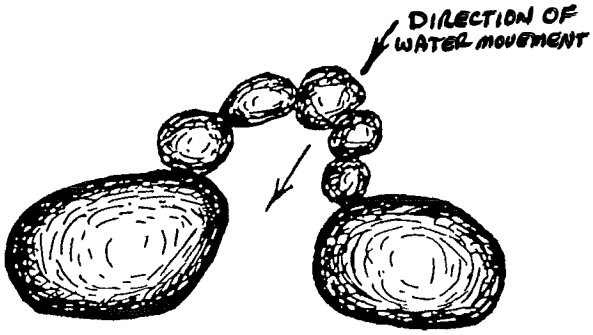
7.4 Development methods that rely only on pumping ("passive" development), especially at low-flow rates, do not sufficiently stabilize formation or filter pack materials and do not effectively remove fine-grained material or rectify formation damage done during drilling (see Fig. 4[3]). Effective development action requires movement of water in both directions through the well screen openings (see Fig. 5[3]). Although visibly clear water may eventually be discharged as a result of such pumping, any subsequent activity that agitates the water column in the well (that is, conducting a formation hydraulic test, purging prior to sampling, or sampling, especially with bailers) can cause considerable turbidity in the well.

7.5 Development should be applied very cautiously to wells that are known or suspected to be contaminated with hazardous chemical constituents, particularly constituents which pose a hazard through inhalation or dermal contact. Appropriate safety precautions should be taken to protect field personnel. It should be noted that contaminated water and sediment removed from monitoring wells during development may also have to be contained in drums, tanks, or other storage vessels until the water and sediment have been tested and evaluated to determine an appropriate disposal or treatment method. This could significantly increase the cost of development.

8. Methods and Processes Available for Monitoring Well Development

8.1 *General*—Of the various methods available for use in developing wells in general, mechanical surging, overpumping and backwashing, and high-velocity hydraulic jetting with pumping (or combinations of two or more of these methods) are best suited for use in developing groundwater monitoring wells. The method most appropriate for use in a given situation depends on a variety of factors discussed in 6.2. The user should evaluate the methods described herein and select the method that is most appropriate for the situation at hand.

8.2 *Mechanical Surging*—Mechanical surging is accomplished by using a close-fitting surge block (sometimes referred to as a surge plunger or swab) affixed to the end of a length of drill pipe, a solid rod, or a cable, operating like a piston in the well casing or screen. The up-and-down plunging action alternately forces water to flow into (on the upstroke) and out of (on the downstroke) the well, similar to a piston in a cylinder (see Fig. 6[3]). The down stroke causes a backwash action to



NOTE 1—Bridging in formation and filter pack materials is caused by movement of water in one direction only during well development.

FIG. 4 Bridging in Formation and Filter Pack Materials

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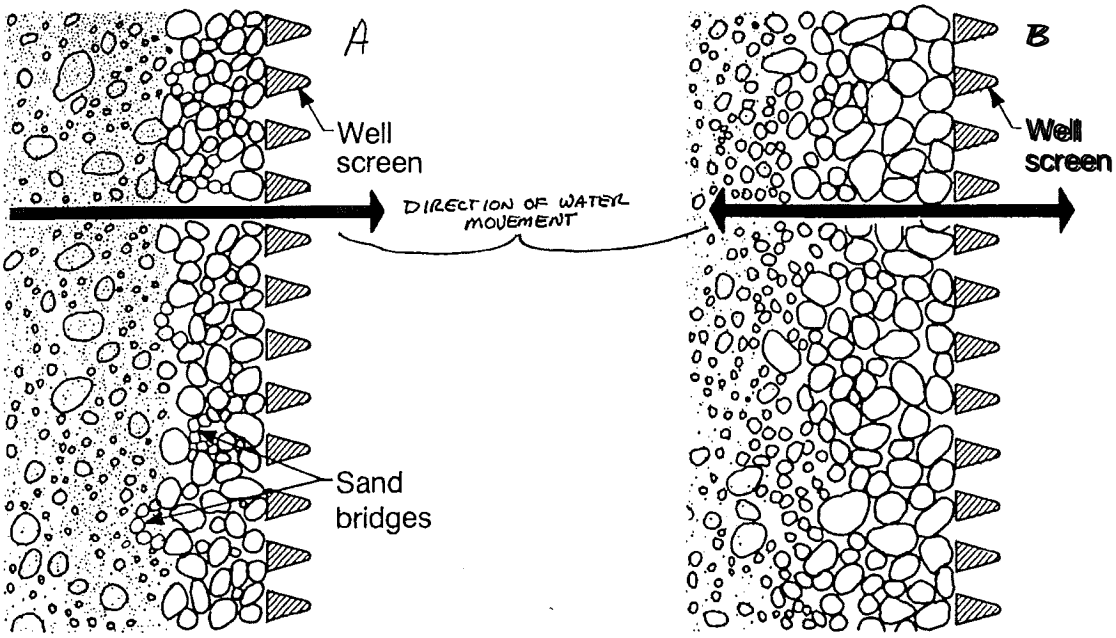

NOTE 1—Effective development action requires movement of water in both directions through the well screen openings. (*A*) Movement of water in only one direction, as when overpumping the well, does not produce the proper development effect.[3] (*B*) Reversing flow helps to minimize bridging in the aquifer and filter pack (if used).

FIG. 5 Movement of Water in Both Directions

loosen bridges in the formation or filter pack and the upstroke then pulls dislodged fine-grained material into the well. This method is equally applicable to small-diameter and large-diameter wells and is the most effective method for small-diameter wells.

8.2.1 Several designs for surge blocks, including a solid surge block, a valved or vented surge block, a spring-loaded surge block, and a multiple-flange surge block (see Fig. 7[3,4]) can be utilized. A heavy bailer or a pump (such as a gas-drive pump or an inertial lift pump) fitted with flexible disks similar to those on a surge block (see Fig. 8[5]) may also be used to produce the surging action, but these are not as effective as a close-fitting surge block.

8.2.2 The proper procedure for mechanical surging is to bail or pump the well first to make sure that the well will yield water. If the screen is completely plugged and water does not enter the well upon bailing or pumping, surging should not be attempted, as the strong negative pressure created on the upstroke of the surge block may cause the screen to collapse. When it is determined that the well will yield water, the surge block is lowered until it is below the static water level but above the screen, and a relatively slow, gentle surging action is started. This surging action should allow any material blocking the screen to break up, go into suspension, and move into the well. The surge block should be operated with particular care if the formation above the screen consists mainly of fine sand, silt or clay which may slump into the screened interval. The water column should effectively transmit the action of the surge block to the screened section of the well. As water begins to move easily in and out of the well, the surge block is lowered (in steps) farther into the well and the speed (and, therefore, the force) of the surging movement is increased. If initial development is too vigorous, particularly in fine-grained formations, surging can harm a well rather than improve it. Because significant pressure differentials can occur during mechanical surging, great care must be taken to avoid damaging (that is, collapsing) the casing or screen by overzealous development.

8.2.3 In wells with short (that is, less than 1.5 m [5 ft]) screens, it may not be necessary to operate the surge block within the screen to develop the entire screened interval; in wells with longer (that is, 3 m [10 ft] or more) screens, it may prove more effective to operate the surge block within the screened area to concentrate its action at various levels. Surging should always begin above the screen and move progressively downward to prevent the surge block from becoming sand locked and to prevent damage to the screen. The surge block should be lowered in intervals equal to the length of the stroke until the entire screen has been surged. If surging of long screened wells is done exclusively in the casing, especially in situations in which the formation adjacent to the screen is highly variable, surging may preferentially develop only the material adjacent to the top of the screen or the most permeable zones of material adjacent to the screen.

8.2.4 The force exerted on the formation depends in part on the length of the stroke and the vertical velocity of the surge block. The length of the stroke depends on the mechanism used to operate the surge block. For cable-tool rigs, that are ideally suited to the surging operation, the length of the stroke is determined by the spudding motion. For rigs using a cathead to surge, the length of the stroke can be varied by varying the length of time that the rope is tightened on the spool. For

[4] Figs. *a* and *b* adapted from *Ground Water Wells*, Second edition, 1986, and Figs. *c* and *d* adapted from *Handbook of Ground Water Development*, 1990.

[5] Figure adapted from *Handbook of Ground Water Development*, 1990.

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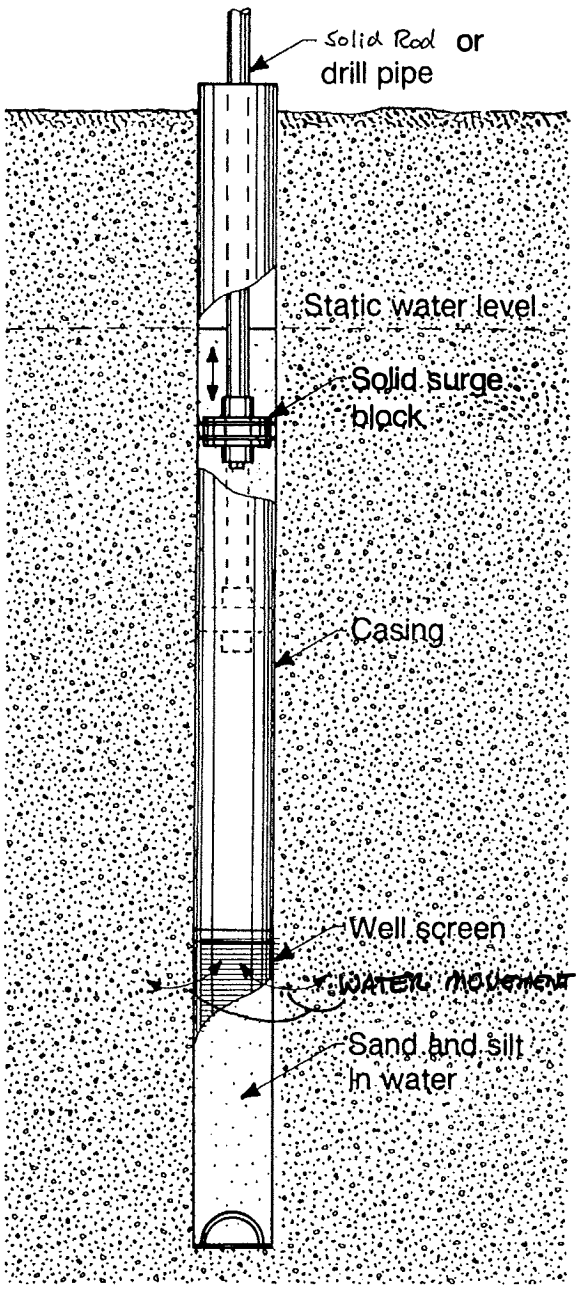

NOTE 1—For certain types of formations, a surge block is an effective tool for well development. On the downstroke, water is forced outward into the formation; water, silt, and fine sand are then pulled into the well screen during the upstroke.

FIG. 6 Mechanical Surging

manual surging, the length of the stroke is generally limited to the range of motion of the operator's arms. Generally, a 0.6 to 0.9 m [2 to 3 ft] stroke is sufficient to achieve proper well development with mechanical surging.

8.2.5 The vertical velocity of the surge block depends on the weight exerted on the block and the retraction speed. Generally, a vertical velocity of between 0.9 to 1.5 m/s [3 and 5 ft/s] is most effective. On the downward stroke, the surge block assembly must be of sufficient weight to free-fall through the water column in the well and create a vigorous outward surge. The surge block assembly should not be permitted to fall out of plumb because of the hazard of the assembly falling against and possibly damaging the screen. When used with a cable-tool rig, a surge block may be weighted using the drilling tool string so it will fall at the desired rate, with the spudding motion controlled to vary the retraction speed. If a rotary rig is used, the weight on the surge block can be provided by drill pipe, with the retraction speed controlled by the rate of response of the hydraulic system. For rigs using a cathead to assist in surging, weight must be supplied to the surge block through either drill rod or the addition of weights above or below the surge block; the speed of retraction can be varied by the tension of the rope on the spool. For manual surging, only a limited amount of weight can be added to the surge block assembly because of the difficulty of working by hand with a heavy tool string in a well. Down force may be applied more easily manually by pushing the surge block into the well. The speed of manual retraction is controlled by the rate at which the individual is capable of pulling the surge block assembly back out of the well.

NOTE 2—Manual surging is a very tiring and laborious procedure that commonly exhausts field personnel long before development is complete.

8.2.6 The effectiveness of mechanical surging is also governed in part by how tightly the surge block fits into the well casing or screen. If surging is to be performed only in the casing, the outside diameter of the surge block should be sized to be within 0.3 to 0.6 mm [⅛ to ¼ in.] of the inside diameter of the casing. (Care should be taken during casing assembly to ensure a smooth inner surface, especially at joints; shoddy assembly or irregular surfaces at casing joints could result in damage to the surge block or the casing, or both.) If surging is to be performed within the screen, care should be taken to avoid "sandlocking" the surge block. If sandlocking is a concern, the surge block can be sized to be slightly smaller. This reduction in size reduces the pressure exerted on the screen by allowing some water to flow past the surge block on both the upstroke and the downstroke, and it allows fine sediment to flow around the block rather than lodging between the block and the screen. A valved or vented surge block creates the same effect. Prior to the surging operation, the surge block or a dummy pipe of equivalent diameter and length should be tested to be certain that it will fit into the casing or screen, or both, without becoming lodged.

8.2.7 The first surging run should be very short so that the operator can judge the amount of sediment entering the screen. Surging should continue for several minutes, and the surge block should be removed from the well and the accumulation of sediment measured. Subsequent surging runs should be done over short to increasingly longer periods, keeping records of how quickly sediment enters the screen. When the sediment accumulated at the bottom of the screen begins to block off a portion of the screen, the sediment should be removed by pumping or bailing. Alternately, it may be possible to surge and pump simultaneously, using a specially designed surging tool (see Fig. 9[5]) or a surge block affixed to an open pipe with a swivel for attachment to a pump and alternating surging without pumping with surging and pumping. Because development is more effective if the amount of sediment in the

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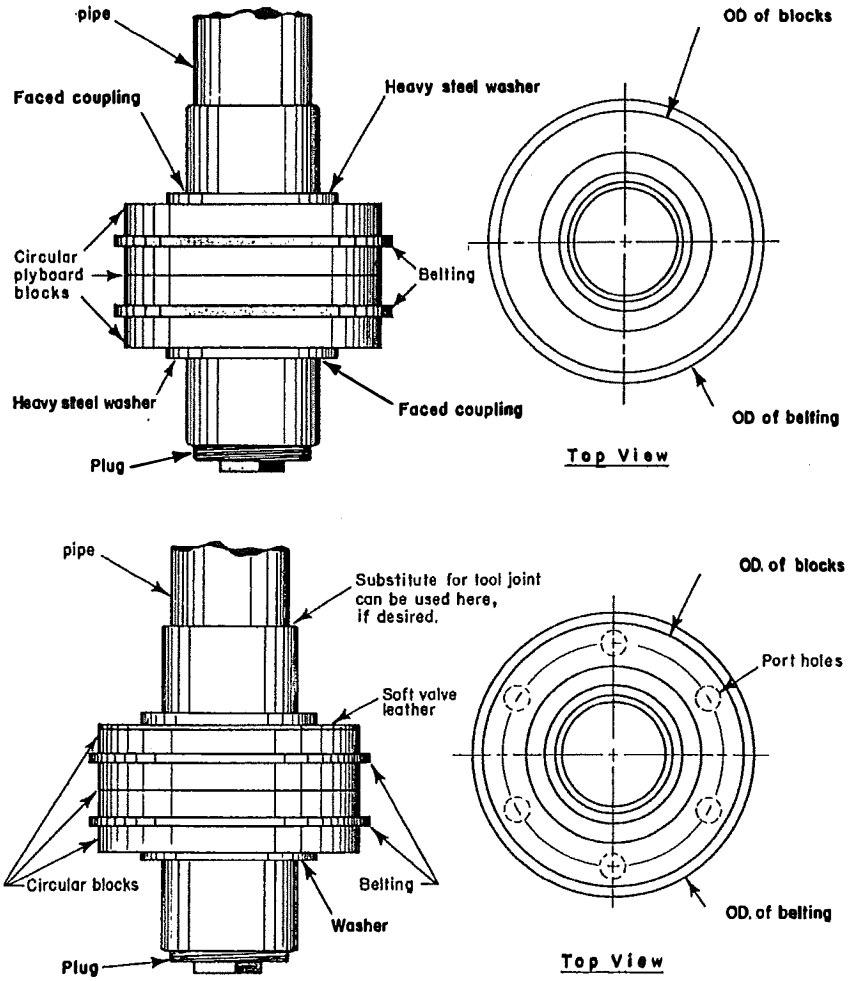

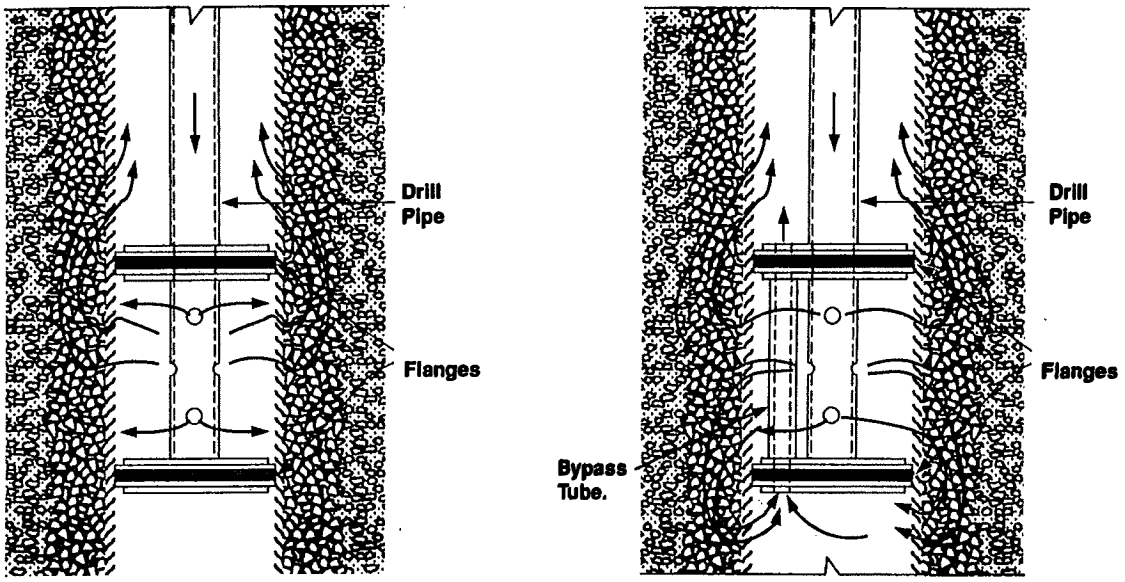

NOTE 1—Various configurations of surge blocks: (*a*) solid surge block; (*b*) valved surge block; (*c*) double-flanged surge block; and (*d*) valved double-flanged surge block.

FIG. 7 Various Configurations of Surge Blocks

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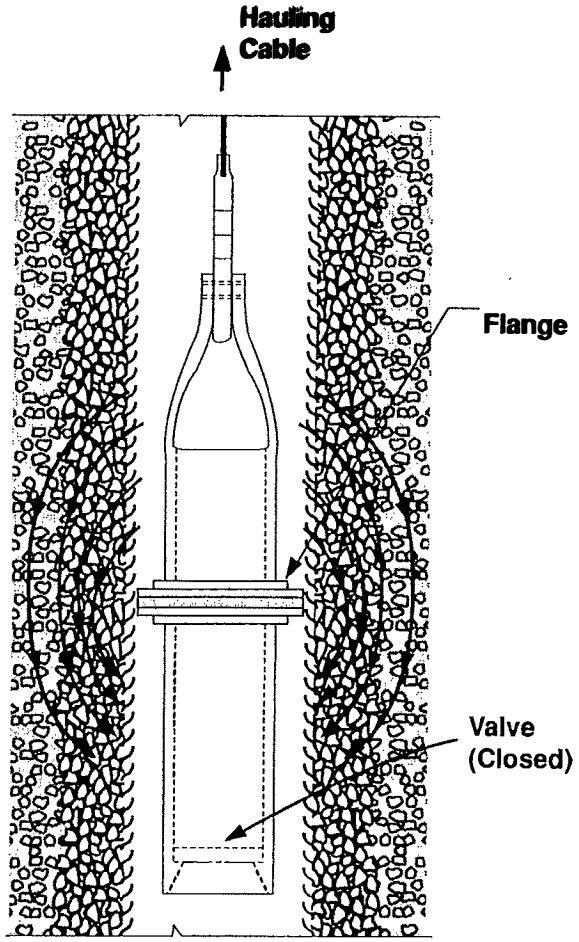
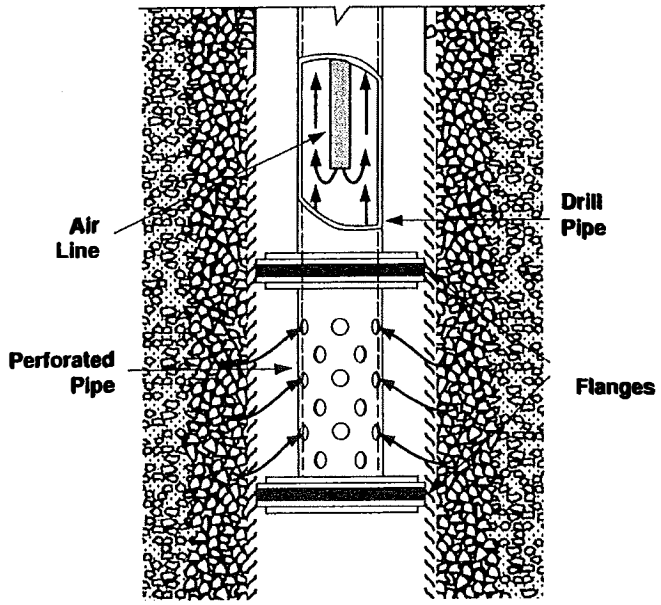


NOTE 1—A heavy (steel) bailer fitted with a flange to serve as a surging tool. Arrows indicate the direction of water movement during retraction of the bailer.

FIG. 8 Bailer

screen is kept to a minimum, accumulated sediment should be removed as often as possible. A "sump" or length of blank casing installed beneath the screen may help to keep the screen free of sediment. Surging should not be attempted when the screen is full of sediment because the force of surging may cause the casing above the screen to collapse. The rate and volume of sediment accumulation should be recorded to provide data on the progress of development. Surging and cleaning should be continued until little or no sediment is measured after surging. The time required to properly surge a well depends on the character of the aquifer material and its apparent response to development, and may vary widely from well to well.

8.2.8 Manual mechanical surging can be accomplished effectively only in relatively shallow small-diameter wells (that is, wells less than 10 cm [4 in.] in diameter that are less than 15 m [50 ft] deep). Development of larger diameter or deeper wells will require either mechanical assistance (that is, by means of a block and tackle or pulley system used with a tripod assembled atop the well) or the use of a drilling rig or pump-pulling rig.



NOTE 1—A specially designed surging tool combining a double-flanged surge block with an air-lift pumping system to allow simultaneous surging and pumping. Arrows indicate the direction of water and sediment movement during pumping.

FIG. 9 Specially Designed Surging Tool

8.3 *Overpumping and Backwashing*—The simplest of method removing formation fines is by overpumping, or pumping at a higher rate then the well will be pumped when it is purged and sampled. Theoretically, increasing the drawdown to the lowest possible level results in increased flow velocities toward the well, resulting in the movement of fine-grained materials into the well (that is, any monitoring well that can be pumped sediment-free at a high pumping rate can then be pumped sediment-free at a lower rate). However, five important limitations to overpumping include: overpumping by itself will not adequately develop a well because water flow is in only one direction; it may cause bridges to form in the formation or filter pack, or both, resulting in only partial stabilization of these materials (see Fig. 10^3); it often requires the use of larger pumping equipment than will fit into the small-diameter casings that are used in many monitoring wells; it subjects the pump used in the operation to abrasion, excessive wear, and loss of efficiency, as well as the possibility of sandlocking; and it results in the production of potentially large volumes of water that may require containment or treatment. Furthermore, because the pump is normally set above the top of the well screen, most of the development that takes place during overpumping occurs in the zones of highest hydraulic conductivity closest to the top of the screen. For a given pumping rate, the longer the screen, the less development will take place in the lower part of the screen. After fine-grained material has been removed from the high hydraulic conductivity zones near the top of the screen, water entering the screen moves preferentially through these zones, leaving the rest of the well poorly developed. Overpumping may be effective in filter-packed wells or in non-stratified sands in which flow toward the well is more or less uniform. Overpumping is also useful for removing drilling fluid lost to the

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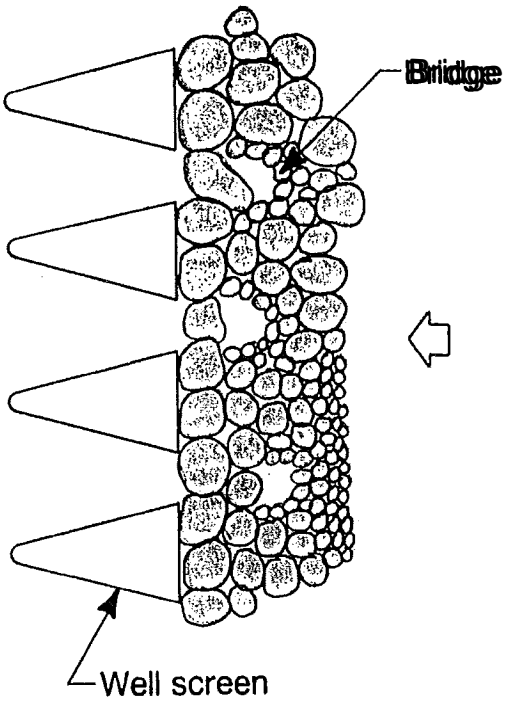

NOTE 1—During development by overpumping, sand grains can bridge openings because flow occurs in only one direction. Once the well is placed into service, agitation by normal pump cycling can break down the bridges, causing sand pumping.

FIG. 10 Overpumping

formation, but it is not an adequate development method if used alone. Overpumping is best used in combination with backwashing. Backwashing is the term applied to the method of well development in which water is added to the well to create a flow reversal.

8.3.1 A commonly used backwashing procedure is to pump water into the well in a sufficient volume to maintain a head greater than that in the formation. This requires a high-capacity water source. Water can be obtained by diverting part of the water pumped from the well during overpumping into a large tank. After the well is pumped, the stored water is pumped back down the well, either through the pump column or through a separate pipe. This method of backwashing should not be used in cases in which the water pumped from the well is potentially contaminated.

NOTE 3—There may be regulatory or legal constraints on returning potentially contaminated fluids to a monitoring well.

8.3.2 "Rawhiding" consists of starting and stopping a pump intermittently to produce rapid changes in the pressure head within the well. The alternate lifting and dropping of a column of water in the pump discharge pipe creates a surging action in the well. During a surge, the amount of water contained in the discharge pipe, combined with the well's natural recovery, may not be sufficient to cause the water level in the well to rise above the static water level. In this situation, supplemental water is generally added to the well when pumping is stopped for a surge. Judgment should be exercised concerning the duration of the backwash and the quantity of water added, because to some extent the success of this method depends on the frequency of flow reversals rather than the magnitude of water level change in the well.

8.3.3 Before beginning the rawhiding procedure, the pump should be started at reduced capacity and gradually increased to full capacity to minimize the danger of sandlocking the pump. When the pump discharge is clear of sediment, the pump is shut off and the water in the pump discharge or column pipe falls back into the well; the pump is then repeatedly started and stopped as rapidly as the power unit and starting equipment will permit. The pump used must not be equipped with a check valve or other backflow prevention device. To avoid damaging submersible pumps, the control box should be equipped with a starter lockout so the pump cannot be started when it is back spinning. During the rawhiding procedure, the well should be pumped occasionally to remove the sediment that has been brought in by the surging action.

8.3.4 Some wells respond satisfactorily to rawhiding, but in some cases the surging effect is not vigorous enough to obtain optimum results. Also, rawhiding is very hard on pumping equipment.

8.3.5 Various types of pumps can be used to rawhide a monitoring well. To be effective for development by rawhiding, a pump must be capable of pumping at a rate of at least 20 to 40 L/min [5 to 10 gal/min] . Surface centrifugal or diaphragm pumps are capable of these rates, but can only be used if the depth to static water level in the well is less than about 6 m [20 ft] below ground surface. Submersible centrifugal pumps with these pumping capacities are available for small-diameter monitoring wells, but the impellers in these pumps are relatively easily damaged by sand because of the very high speed at which they operate. Air-lift pumps can be constructed to easily fit into a small-diameter monitoring well and these pumps are capable of pumping in excess of 40 L/min [10 gpm]. However, air-lift pumping and backwashing results in mixing of aerated water with water in the well and adjacent formation, temporarily altering groundwater quality.

8.4 *High-Velocity Hydraulic Jetting*—Where conditions permit, another effective method available for use in developing monitoring wells, is high-velocity hydraulic jetting. Because of the size of the equipment required, this method is more easily applied to wells of 10 cm [4 in.] or greater diameter. Development by high-velocity hydraulic jetting employs several horizontal jets of water operated from inside the well screen so that high-velocity streams of water exit through the screen and loosen fine-grained material and drilling mud residue from the formation (Fig. 11[5]). The loosened material moves inside the well screen and can be removed from the well by concurrent pumping or by bailing. Jetting is particularly successful in developing highly stratified unconsolidated formations, consolidated bedrock wells, large-diameter wells, and naturally developed wells. Jetting can also be useful in filter-packed wells provided that filter pack material is carefully chosen to provide some, but not excessive, loss through the well screen, and that the filter pack is not too thick (that is, not greater than 50 to 70 mm [2 to 3 in.]).

8.4.1 The equipment required for jetting includes a jetting tool with two or more equally spaced nozzles; a high-pressure pump, hose, and connectors; a string of pipe; and a water tank

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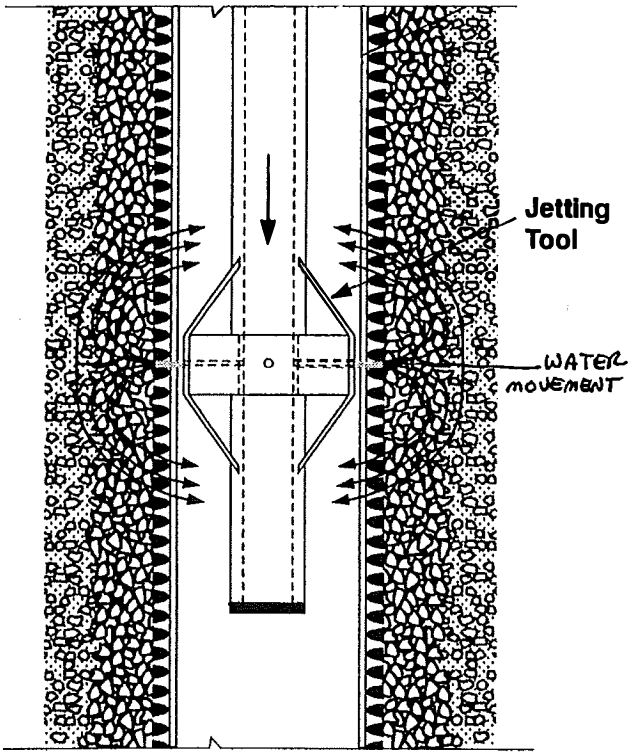
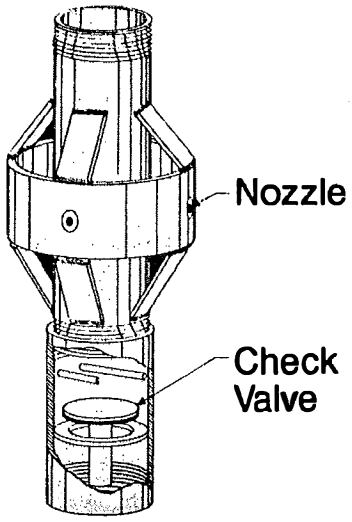


NOTE 1—Development by high-velocity hydraulic jetting employs a tool using several horizontal jets of water operated from inside the well screen. High-velocity streams of water are directed through the screen into the formation or filter pack to loosed fine-grained material and drilling mud residue and bring it into the well, where it can be pumped out.

FIG. 11 High-Velocity Hydraulic Jetting



NOTE 1—A jetting tool with four nozzles spaced 90° apart around the circumference of the tool. The check valve at the bottom of the tool closes when water pressure is introduced from the surface, and opens to allow pumping through the drop pipe after jetting is completed.

FIG. 12 Jetting Tool With Four Nozzles

or other high-volume water supply. The high-velocity jets direct water through the screen openings, and agitate and rearrange the particles of the formation materials surrounding the screen. The filter cake that is formed on the borehole wall during mud rotary drilling is broken down and dispersed, allowing easy removal by pumping. Jetting is also useful in correcting other damage done during drilling.

8.4.2 Fig. 12[3] shows a jetting tool with four nozzles. Nozzles should be equally spaced around the circumference of the jetting tool, and generally range from 4 to 9.5 mm [0.15625 to 0.375 in.]. The jetting tool should be constructed so that the nozzle outlets or holes are as close to the inside diameter of the screen as practical (generally within 12.7 mm [0.5 in.]), with the bottom end of the tool capped and the top end threaded so it can be screwed on to the lower end of the pipe string. If the outside diameter of the jetting tool is too small in relation to the inside diameter of the screen, much of the energy of the jet is dissipated by the turbulence created within the well.

8.4.3 Every effort should be made to limit sediment concentrations in the water used for jetting. Sediment-laden water that is recirculated through the jetting tool, causes erosion of the nozzle bores and may produce a pronounced pressure reduction at the nozzle face. Sediment in water used for jetting can also damage screens if the jets are directed at one area for a prolonged period of time.

8.4.4 A nozzle velocity of as low as 30 m/s [100 ft/s] can produce effective jetting results, though much better results can be expected when the nozzle velocities are between 45 and 90 m/s [150 and 300 ft/s]. Velocities greater than 90 m/s [300 ft/s] may not result in sufficient additional benefit to justify the additional cost. In general, (1400 and 2800 kPa) [200 to 400 psi] at the nozzle are the preferred operating pressures for jetting in wells constructed with metallic screens. However, great care must be exercised in jetting screens constructed of PVC or other less-abrasion-resistant materials. All jetting of PVC screens should be done only with clean, sediment-free water to minimize abrasion, and the pressure used should not exceed 700 kPa [100 psi]. In general, pressures higher than 700 kPa [100 psi] are required when working in predominantly fine-grained formations or filter-packed wells.

8.4.5 The energy that agitates formation particles outside the well screen is a function of both the velocity and the diameter of the water stream. The energy of the jetting stream will depend on the capacity of the pump (maximum pressure output and flow rate at that pressure) and the orifice size of the discharge nozzle. The nozzle size should be the largest possible diameter that will maintain a minimum line pressure of 700 kPa [100 psi] at the minimum anticipated flow rate of the pump. For a given nozzle size (water stream diameter), greater pressures will result in greater energy to penetrate formation materials. The pipe that is attached to the jetting tool should be large enough to minimize friction losses so that the velocity at the nozzle is as high as possible.

8.4.6 Although jetting can be accomplished without a drilling rig, it is usually done with a rig such as a rotary rig or another type of rig with rotating capability that is equipped with a mud pump that can supply the required down-hole pressure. When using a drilling rig, the jetting tool is attached to the lower end of the drill string and tool rotation is controlled by the rig. The jetting tool is placed near the bottom of the well screen and rotated slowly while being pulled upward at a rate of 2 to 5 m/min [5 to 15 ft/min] of screen. Material loosened

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from the formation is brought into the well by the turbulence created above and below the jets, and accumulates at the bottom of the screen (or in a sump if one is used) as the jetting tool is raised. This material must be removed concurrently or periodically. Slowly rotating and gradually raising the tool exposes the entire surface of the screen to the vigorous action of the jets. Several passes up and down the screen are made until the amount of additional material removed from the formation becomes negligible. To avoid erosion of the screen and to expedite development, the jetting tool should never be operated in a stationary position; it should always be slowly rotated and slowly raised or lowered.

8.4.7 In general, the effectiveness of the jetting process is controlled by the ratio of the filter-pack thickness to the jet radius, the velocity of the jet, the distance from the jet to its impact point on the screen, and the ratio of the hydraulic conductivity of formation materials to that of the filter pack materials.

8.4.8 Optimal removal of sediment by jetting will depend on the time allotted to the process. Because the jetting energy can focus on only a small part of the formation at a given moment, more time may be necessary for jetting than for other methods that affect a larger portion of the formation. Less satisfactory results from jetting almost inevitably occur when not enough time is allowed for a thorough job.

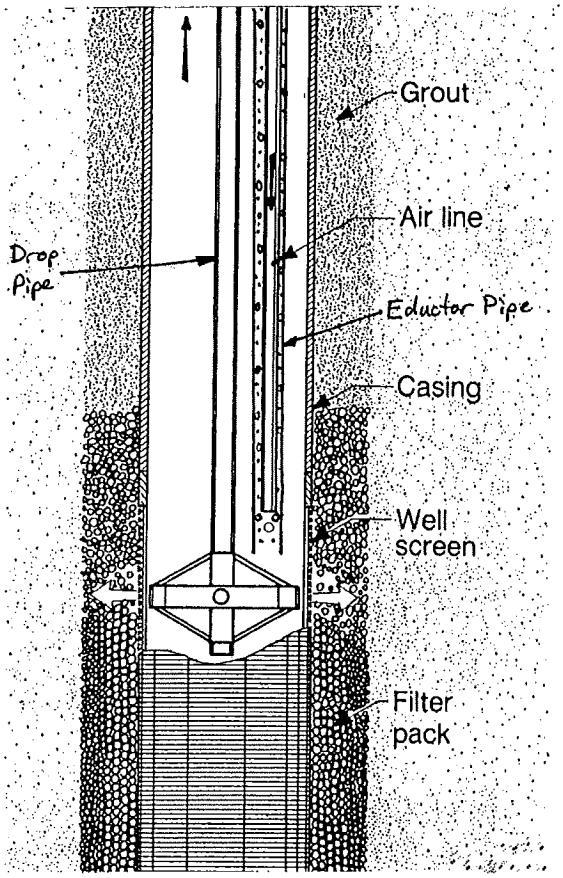
8.5 *High-Velocity Hydraulic Jetting Combined with Simultaneous Pumping*—Although jetting is effective in dislodging material from the formation, maximum development efficiency is achieved when jetting is combined with simultaneous pumping. This combination of development techniques is particularly successful for wells in unconsolidated sands and gravels. It is not always practicable, but should be considered where permitted by the size of the well, the available equipment, and the position of the static water level with respect to the screen.

8.5.1 In jetting, water is added to the well at a rate governed by the nozzle size and the pump pressure. The volume of water simultaneously pumped from the well should always exceed the volume pumped in during jetting, by as much as 1.5 to 2 times, so that a gradient is created toward the well. The movement of water into the well helps to remove some of the formation material loosened by jetting. The pump then delivers the sediment from the well before it can settle in the screen. This procedure also serves to immediately remove most of the water added to the well during jetting, which may be a concern in some monitoring wells.

8.5.2 An added advantage of pumping is that water removed from the well provides a continuous supply that can be recirculated through the pump and jetting equipment after the sediment has settled out in a tank (to avoid damaging the high-pressure pump, jetting nozzles, or screen). This partially alleviates concerns regarding the quality of water added to the well during jetting, because the water used in this situation is water from the well being pumped. This water may be altered chemically during pumping, particularly if the equipment is not cleaned prior to use. Pumping while developing also permits an appraisal of the effectiveness of the jetting, based on the size and volume of the sediment collected at the bottom of the holding tank.

8.5.3 An air-lift pump (see Fig. 13[3]) is the most common type of pump employed in this development operation, because of its small diameter and efficiency in removing sediment without damage to the pumping mechanism. Occasionally, the size of the air line and eductor pipe may have to be decreased somewhat so that the air line and eductor pipe will both fit into the annulus between the jetting pipe and the well casing. The air-lift system operates best when the air line is at least 40 % submerged (see Fig. 14[3]) and when the bottom of the eductor pipe is placed just above the jetting tool allowing more suspended sediment to be pumped out of the well.

8.5.4 Compressed air used for development must be filtered to ensure that oil from the air compressor is not introduced into the well. In theory, this could be accomplished relatively easily with high-volume carbon filters. In practice, however, the effectiveness of air/oil filters in removing entrained oil is questionable. It is difficult to ensure that the air used has a non-detectable oil content. Thus, development with compressed air may actually introduce oil into the well, albeit at very low levels. This oil may have the effect of confusing water



NOTE 1—In this configuration, the jetting tool and drop pipe are separate from an air-lift pumping system so that jetting and air-lift pumping can be done simultaneously.

FIG. 13 Air-Lift Pump

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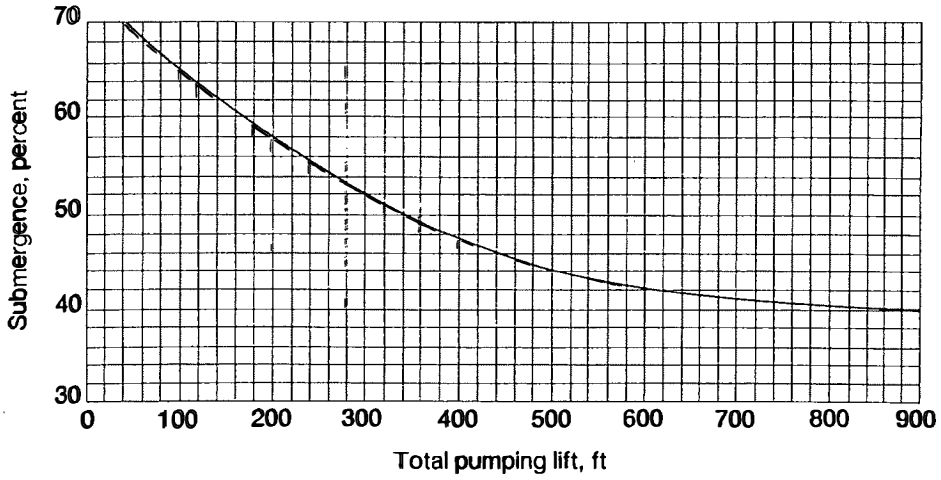

Metres	0	30	61	91	122	152	183	213	244	275
Feet	0	100	200	300	400	500	600	700	800	900

NOTE 1—Approximate percent pumping submergence for optimum air-lift efficiency. In general, development proceeds most efficiently when the discharge is maximized. Therefore, the submergence should always be as great as possible within practical limits.

FIG. 14 Submerged Air Line

quality analytical results. Alternately, oil-less or oil-free compressors may be used to obviate the problems inherent with common oil-lubricated air compressors.

8.5.5 When air-lift pumping is impractical or undesirable, a submersible pump can be used, but this is only possible in large-diameter wells. Usually, the pump must be placed above the jetting tool so that the amount of sediment passing through the pump is minimized to avoid damaging the pump. Thus, the pump causes material temporarily placed in suspension by the jetting action to move into the well, but much of the sediment falls to the bottom. This sediment must be removed periodically during the jetting and pumping operation so that the entire screen can be effectively developed.

8.6 *Developing with Air*—Developing with air is not recommended for monitoring wells. Air development may force air into contact with the formation, which may alter the oxidation-reduction potential of the formation water and change the chemistry of the water in the vicinity of the well. The effects of this type of chemical disturbance may persist for several weeks or more after well development.

8.6.1 Blowing air into the well during the process of air development may cause air to become entrapped in the narrow slots of some monitoring well screens, the pores of the filter pack or formation materials immediately adjacent to the borehole. Entrapped air is difficult to remove and it may significantly reduce formation hydraulic conductivity and effectively reduce the amount of open area of the well screen.

8.6.2 In situations in which the well is installed in an area of contaminated groundwater, development with air may potentially result in the exposure of field personnel to hazardous materials. Though precautions can be taken to minimize personnel exposure, other development methods, which may also be more effective, can be used without such exposure problems and are, therefore, generally preferable.

8.6.3 For these reasons, compressed air alone should not be used to develop monitoring wells. Air-lift pumping, in which the air stream is not released directly into the well but instead is confined within an eductor pipe (see Fig. 15), should not produce the deleterious effects of air surging, and can thus be used in conjunction with other development processes.

9. Report: Test Data Sheets/Forms

9.1 Keep records of the various operations performed during development and the progress and results of the development procedure. Report the following information: recorded:

9.1.1 Date of activities, companies and personnel involved;

9.1.2 Well identification, location coordinates;

9.1.3 Baseline turbidity (to be compared with turbidity levels obtained later in the life of the well);

9.1.4 Chemical quality, physical characteristics (that is, color, odor, etc.) volume, and sediment content of water added to the well or removed from the well;

9.1.5 Amount and particle size of sediment that accumulates in the well between phases of development;

9.1.6 Type(s) of equipment used during development;

9.1.7 Well construction details;

9.1.8 Static water level prior to, during, and after development;

9.1.9 Time spent during development; and

9.1.10 Other details pertinent to the development process and the objectives of development. A well development data form, such as that illustrated in Fig. 16, can be used for this purpose.

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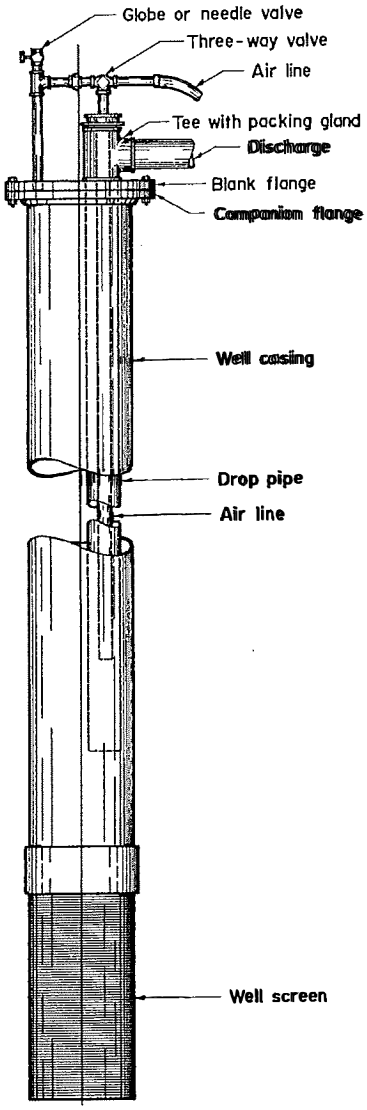

FIG. 15 A Typical Air-Lift Pumping Configuration

10. Keywords

10.1 aquifer; groundwater; high-velocity; hydraulic jetting; jetting; mechanical surging; monitoring well; over-pumping and backwashing; representative sample; well development

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WELL DEVELOPMENT DATA

SITE TYPE	SITE ID
WELL	

DEPTH TO BOTTOM (INITIAL) _____

(FINAL) _____

STATIC WATER LEVEL (INITIAL) _____

(FINAL) _____

MEASURING POINT _____

CASING I.D. _____

Responsible Professional _____

DRILLER _____

PROJECT NO. _____

DATE(S) INSTALLED _____

DATE(S) DEVELOPED _____

PUMP (TYPE) _____

(CAPACITY) _____

BAILER (TYPE) _____

(CAPACITY) _____

TIME	VOLUME OF WATER REMOVED	pH	SPECIFIC CONDUCTANCE AT 25°C	TEMP	SAND CONTENT	OTHER PHYSICAL CHARACTERISTICS (CLARITY, ODOR, PARTICULATES, COLOR)

FOPM 14 / SEPT 87

FIG. 16 Example of a Well Development Data Form

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SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this standard since the last issue (D5521 – 05) that may impact the use of this standard. (Approved Aug. 1, 2013.)

(1) Revised the standard into a dual measurement system with the units of measurement now stated in either SI units or inch-pound units.
(2) Revised Section 3 to conform to D18 policy.
(3) Added Note 1 and renumbered notes accordingly.
(4) Revised title of Section 9 to conform to D18 policy and added content.

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Designation: D6282/D6282M – 14

Standard Guide for Direct Push Soil Sampling for Environmental Site Characterizations[1]

This standard is issued under the fixed designation D6282/D6282M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide addresses direct push soil samplers, which may also be driven into the ground from the surface or through prebored holes. The samplers can be continuous or discrete interval units. Samplers are advanced by static push, or impacts from hammers, or vibratory methods, or a combination thereof, to the depth of interest. Both single tube and dual (double) tube systems may be advanced for soil sampling with direct push methods. Direct push methods are most often used to collect geo-environmental soil samples. These soil samples are used for soil classification (Practice D2488) and lithologic/hydrostratigraphic logging as well as being sub-sampled for contaminant and chemical analyses.

1.2 Other drilling and sampling methods may apply for samples needed for engineering and construction applications. This guide does not address single sampling events in the immediate base of the drill hole using rotary drilling equipment that employ cuttings removal as the sampler is advanced. Other sampling standards, such as Test Method D1586, Practices D1587 and D3550, and summarized in Guide D6169 apply to rotary drilling activities (Guide D6286). The guide does not cover open chambered samplers operated by hand such as augers, agricultural samplers operated at shallow depths, or side wall samplers.

1.2.1 While Sonic Drilling is considered a direct push method this standard may not apply to larger equipment addressed in Practice D6914.

1.3 Guidance on collection and handling of samples, are given in Practices D4220 and D6640. Samples for chemical analysis often must be subsampled and preserved for chemical analysis using special techniques such as Practice D4547, D6418, and D6640. Additional information on environmental sample preservation and transportation is available in other references (**1, 2, 3, 4, 5, 6**)[2]. Samples for soil classification may be preserved using procedures given in Practice D4220 similar to Class A. In most cases, a direct push sample is considered as Class B in Practice D4220 but is protected, representative, and suitable for chemical analysis. The samples taken with this practice do not usually produce Class C and D (with exception of thin wall samples of standard size) samples for laboratory testing for engineering properties, such as shear strength and compressibility. If sampling is for chemical evaluation in the Vadose Zone, consult Guide D4700 for any special considerations.

1.4 Insertion methods described include static push, impact, percussion, other vibratory/sonic driving, and combinations of these methods using direct push equipment adapted to drilling rigs, cone penetrometer units, and specially designed percussion/direct push combination machines. Hammers providing the force for insertion include drop style, hydraulically activated, air activated and mechanical lift devices.

1.5 Direct push soil sampling is limited to soils and unconsolidated materials that can be penetrated with the available equipment. The ability to penetrate strata is based on hammer energy, carrying vehicle weight, compactness of soil, and consistency of soil. Penetration may be limited or damage to samplers and conveying devices can occur in certain subsurface conditions, some of which are discussed in 5.6. Successful sample recovery also may be limited by the ability to retrieve tools from the borehole. Sufficient retract force must be available when attempting difficult or deep investigations.

1.6 This guide does not address the installation of any temporary or permanent soil, groundwater, vapor monitoring, or remediation devices.

1.7 The practicing of direct push techniques may be controlled by local regulations governing subsurface penetration. Certification, or licensing requirements, or both, may need to be considered in establishing criteria for field activities.

1.8 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

[1] This guide is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.21 on Groundwater and Vadose Zone Investigations.

Current edition approved May 1, 2014. Published July 2014. Originally approved in 1998. Last previous edition approved in 2005 as D6282–98(2005), which was withdrawn in January 2014 and reinstated in May 2014. DOI: 10.1520/D6282-14.

[2] The boldface numbers in parentheses refer to a list of references at the end of this standard.

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1.9 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.10 *This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a projects's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:*

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D1452 Practice for Soil Exploration and Sampling by Auger Borings

D1586 Test Method for Penetration Test (SPT) and Split-Barrel Sampling of Soils

D1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes

D2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)

D3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils

D3694 Practices for Preparation of Sample Containers and for Preservation of Organic Constituents

D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D4220 Practices for Preserving and Transporting Soil Samples

D4547 Guide for Sampling Waste and Soils for Volatile Organic Compounds

D4700 Guide for Soil Sampling from the Vadose Zone

D5088 Practice for Decontamination of Field Equipment Used at Waste Sites

D5092 Practice for Design and Installation of Groundwater Monitoring Wells

D5299 Guide for Decommissioning of Groundwater Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities

D5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock

D6001 Guide for Direct-Push Groundwater Sampling for Environmental Site Characterization

D6067 Practice for Using the Electronic Piezocone Penetrometer Tests for Environmental Site Characterization

D6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations

D6286 Guide for Selection of Drilling Methods for Environmental Site Characterization

D6418 Practice for Using the Disposable En Core Sampler for Sampling and Storing Soil for Volatile Organic Analysis

D6640 Practice for Collection and Handling of Soils Obtained in Core Barrel Samplers for Environmental Investigations

D6724 Guide for Installation of Direct Push Groundwater Monitoring Wells

D6725 Practice for Direct Push Installation of Prepacked Screen Monitoring Wells in Unconsolidated Aquifers

D6914 Practice for Sonic Drilling for Site Characterization and the Installation of Subsurface Monitoring Devices

D7242 Practice for Field Pneumatic Slug (Instantaneous Change in Head) Tests to Determine Hydraulic Properties of Aquifers with Direct Push Groundwater Samplers

D7648 Practice for Active Soil Gas Sampling for Direct Push or Manual-Driven Hand-Sampling Equipment

3. Terminology

3.1 *Definitions*—For definitions of common terminology terms used within this guide refer to Terminology D653. Definitions for additional terms related to direct push water sampling for geoenvironmental investigations are in accordance with Guide D6001.

3.1.1 *assembly length, n*—length of sampler body and riser pipes.

3.1.2 *direct push sampler, n*—sampling devices that are advanced into the soil to be sampled without drilling or borehole excavation.

3.1.3 *extension rod, n*—hollow steel rod, threaded, in various lengths, used to advance and remove samplers and other devices during direct pushing boring. Also known as drive rod. In some applications, small diameter solid extension rods are used through hollow drive rods to activate closed samples at depth.

3.1.4 *incremental drilling and sampling, n*—insertion method where rotary drilling and sampling events are alternated for incremental sampling. Incremental drilling often is needed to penetrate harder or deeper formations.

3.1.5 *push depth, n*—the depth below a ground surface datum to which the lower end, or tip, of the direct-push sampling device is inserted.

3.1.6 *sample interval, n*—defined zone within a subsurface strata from which a sample is gathered.

3.1.7 *sample recovery, n*—the length of material recovered divided by the length of sampler advancement and stated as a percentage.

3.1.8 *soil core, n*—cylindrical shaped specimen recovered from a soil sampler of soil, sediments, or other unconsolidated accumulations of solid particles produced by deposition or the physical and chemical disintegration of rocks and which may or may not contain organic matter.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *closed barrel sampler, n*—a sampling device with a piston or other secured device that is held to block the

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movement of material into the barrel until the blocking device is removed or released. Liners are required in closed barrel samplers. Also may be referred to as a protected type sampler.

3.2.2 *impact heads/drive heads, n*—pieces or assemblies that fit to top of the above ground portion of the direct push tool assembly to receive the impact of the hammering device and transfer the impact energy to sampler extensions or drive rods.

3.2.3 *open barrel sampler, n*—sampling barrel with open end allowing material to enter at any time or depth. Also may be referred to as an unprotected type sampler.

3.2.4 *piston lock, n*—device to lock the sampler piston in place to prevent any entry of a foreign substance into the sampler chamber prior to sampling.

3.2.5 *single tube system, n*—a system whereby single extension/drive rods with sampler attached are advanced into the subsurface strata to collect a soil sample.

3.2.6 *solid barrel sampler, n*—a soil sampling device consisting of a continuous or segmented tube with a wall thickness sufficient to withstand the forces necessary to penetrate the strata desired and gather a sample. A cutting shoe and a connecting head are attached to the barrel.

3.2.7 *split barrel sampler, n*—a soil sampling device consisting of the two half circle tubes manufactured to matching alignment, held together on one end by a shoe and on the other by a connecting head.

3.2.8 *dual tube systems, n*—a system whereby inner and outer tubes are advanced simultaneously into the subsurface strata to collect a soil sample. The outer tube is used for borehole stabilization. The inner tube for is used sampler recovery and insertion.

4. Summary of Guide

4.1 Direct push soil sampling consists of advancing a sampling device into subsurface soils by applying static pressure, by applying impacts, or by applying vibration, or any combination thereof, to the above ground portion of the sampler extensions until the sampler has been advanced to the desired sampling depth. The sampler is recovered from the borehole and the sample removed from the sampler. The sampler is cleaned and the procedure repeated for the next desired sampling interval. Sampling can be continuous for full depth borehole logging or incremental for specific interval sampling. Samplers used can be protected type for controlled specimen gathering or unprotected for general soil specimen collection.

5. Significance and Use

5.1 Direct Push Soil Sampling is used extensively in environmental site characterization of soils below ground surface and can also be used for subsurface geotechnical site characterization (**3, 7, 8, 9-12, 13**). Limited early studies have been done using Direct Push Soil Sampling for environmental investigations (**14, 15, 16**). These methods are preferred for environmental site characterization over rotary drilling sampling methods (D6169, D6286) because they are minimally intrusive (less disruptive to the soil column) and they do not generate soil cuttings which could be contaminated and require characterization and safe disposal. Direct Push soil samplers are grouped into two categories; Single Tube and Dual (Double) Tube systems.

5.1.1 *Dual Tube Systems*—Dual tube soil sampling systems are preferred for use because the bore hole is protected and sealed by the outer casing during operations. However, in some conditions when sampling below the groundwater, a sealed single tube sampler (5.1.2) must to be used to avoid sample cross contamination. Figure 1 shows how a Double Tube system is used. The outer tube stays in place to protect and seal the borehole and prevents potential cross contamination of the boring and the soil sample. Dual tube systems allow for rapid continuous sampling both above and below the water table. When sampling is not required, a sealed inner drive point can be locked in for driving through zones not targeted for sampling or through obstructions or difficult to sample formations.

5.1.1.1 Dual tube systems facilitate deployment of other testing and sampling systems (Test Method D1586 and Practice D1587) and sensors, groundwater sampling (D6001), water testing (D7242), and even monitoring well installations (D6724, D6725). Well installations may require use of specially designed expendable tips that facilitate well construction.

5.1.1.2 In larger Dual Tube systems with inside diameters of at least 75 mm the Standard Penetration Test (D1586) is often conducted in the bottom of the boring. Reliable SPT N values can be obtained in most soil formations that are not disturbed by the driving of the casing. Cohesionless sands and very soft clays may be disturbed during advancement of the Dual System to the test depth and should be evaluated or flagged if suspect. Reliable N values may not be obtained if there is evidence of heave or borehole instability from the base of the borehole to the inside the casing.

5.1.1.3 Dual tube systems are easily grouted and sealed for completion because the outer casing keeps an open sealed borehole for insertion of grout tubes.

5.1.1.4 As shown on Fig. 1, continuous sampling is done with an opening left at the bottom of the outer casing during the sampling process. This is fine as long as the formation is stable between sampling events. If there are heaving conditions into the outer casing the outer casing may be retracted to set the sampler barrel in position. The instability can be improved by maintaining a water level balance in the outer casing and using slower retraction of the sampler string during withdraw. If the material stability ids a problem then one must deploy a sealed single tube piston sampler (5.1.2) into the boring to retrieve samples.

5.1.1.5 A constant outer tube diameter of the Dual Tube system generally has more friction than some Single Tube rod driven samplers so may require larger equipment capable of higher more percussion and push forces. Dual Tube systems approaching 100 to 150 mm outside diameter have been developed and require larger direct push equipment.

5.1.2 *Single Tube Systems*—Sealed single tube samples assure that the soil sample is not cross contaminated by other soils or fluids inside the bore hole so they are preferred sampling method to use below groundwater. Single tube soil

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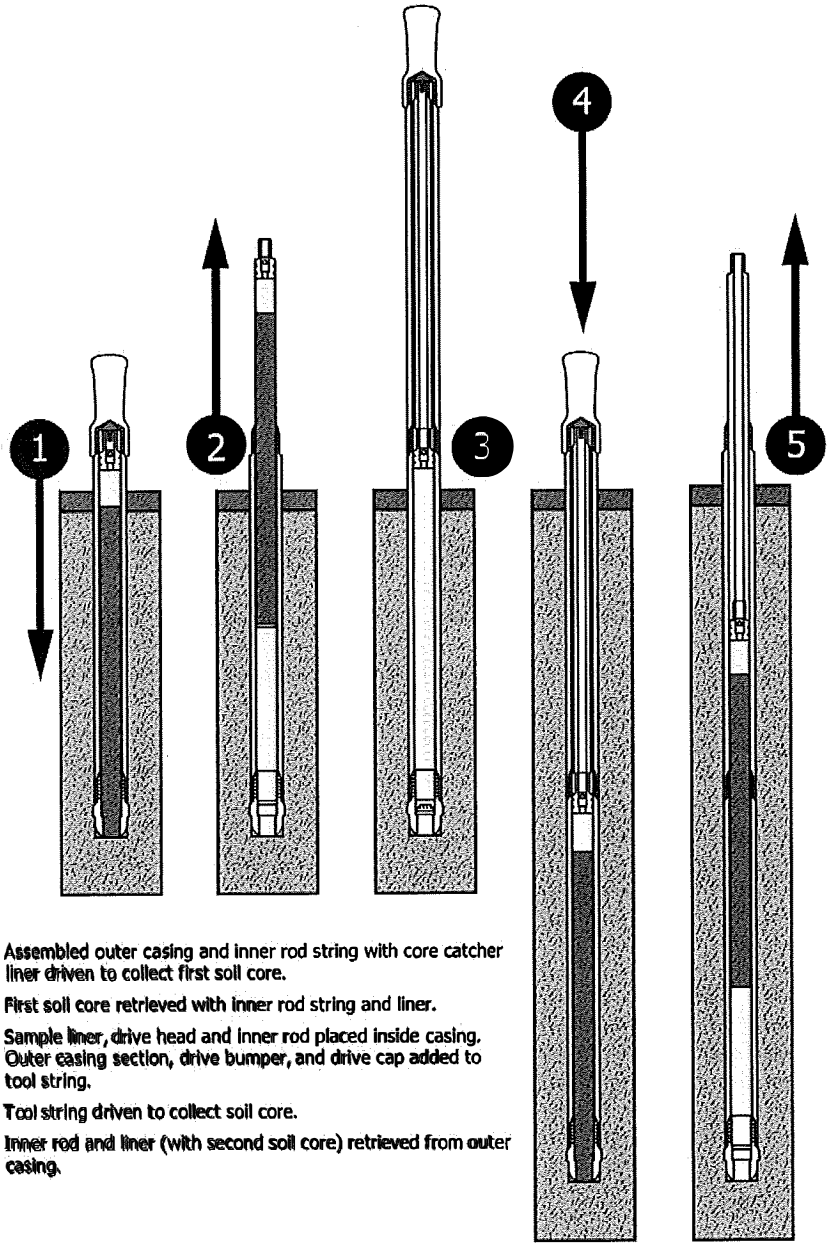

1. Assembled outer casing and inner rod string with core catcher liner driven to collect first soil core.
2. First soil core retrieved with inner rod string and liner.
3. Sample liner, drive head and inner rod placed inside casing. Outer casing section, drive bumper, and drive cap added to tool string.
4. Tool string driven to collect soil core.
5. Inner rod and liner (with second soil core) retrieved from outer casing.

FIG. 1 Dual Tube Direct Push Soil Sampler Operation

sampling systems are most often used for single incremental discrete soil sampling events but can also be used in continuous sampling modes with limitations listed below. Sealed piston type samples assure the best preservation of sample and assure no cross contamination of the soil. Figure 2 shows the basic operation of a single tube sampler. The sampler includes a sealed piston point to prevent soil intrusion during advancement to the target sample depth. The piston is then unlocked using various mechanisms and the sample is pushed to the design length. The complete sampler tube and drive rods are removed from the ground to retrieve the sample leaving an open hole after sampling.

5.1.2.1 The disadvantage to single tube sampling is that the hole left in the ground may not stay open and it would be difficult to grout if required. If positive proof of grouting is required it may be necessary to push a re-entry grout tube to the sample depth to grout the hole (D6001). Another disadvantage is possible travel of contaminants down the open hole. If cross contamination is a concern than a dual tube sampler system should be used.

5.1.2.2 Many single tube systems use drive rods of smaller diameter than the sampler body. The use of smaller diameter drive rods raises two concerns when sampling. First the soil above the sampler body may cave on the sampler and cause

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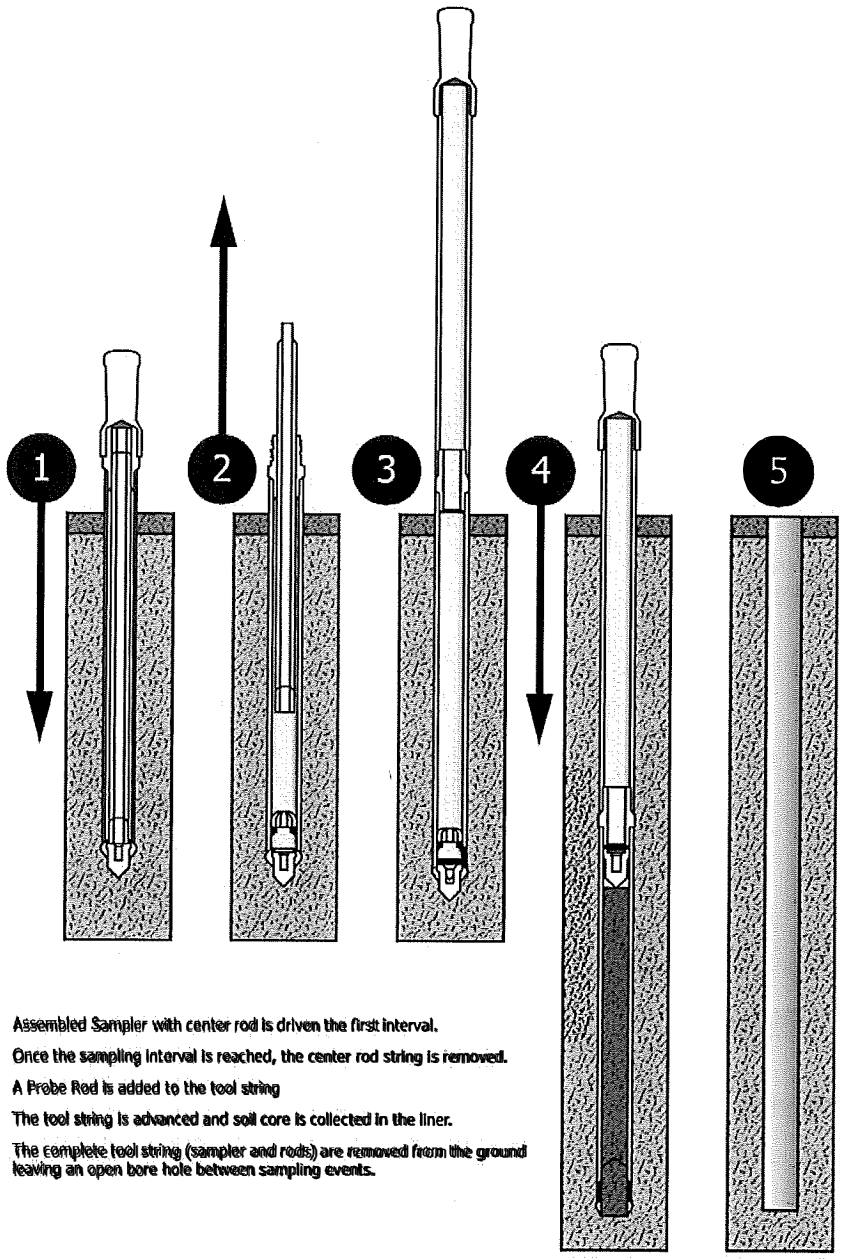

FIG. 2 Single Tube Direct Push Soil Sampler Operation

retraction problems. Second, if chemical analysis is required and the sampler will penetrate and cross contaminated zones there is concern that fluids from layers up above may run down the open annulus above the sampler causing cross contamination.

5.1.2.3 Single tube piston samplers are sometimes used in conjunction with Cone Penetrometer Testing (CPT) (D6067) and can be used in other geotechnical drilling (D6169) in the base of a drill hole.

5.1.2.4 Continuous sampling operations may be conducted in the same hole with limitations. Using the sealed piston sampler, consecutive samples can be obtained in the same hole by re-driving the sealed piston sampler to a deeper target depths.

5.1.2.5 Open tube samplers without a piston (Fig. 3) should not be used except in rare cases. Use of an unsealed open barrel sampler without a sealed piston multiple times in the same sampling hole will result in cross contamination of samples from the hole wall, cave, and heaving. Continuous soil sampling using an open barrel is sometimes performed above the water table where boreholes are very stable. This sampling mode should never be used below the water table. A sealed sample is required to assure no cross contamination.

5.2 Direct push methods of soil sampling are used for geologic investigations, subsurface soil matrix contamination studies, and water quality investigations. Examples of a few types of investigations in which direct push sampling may be

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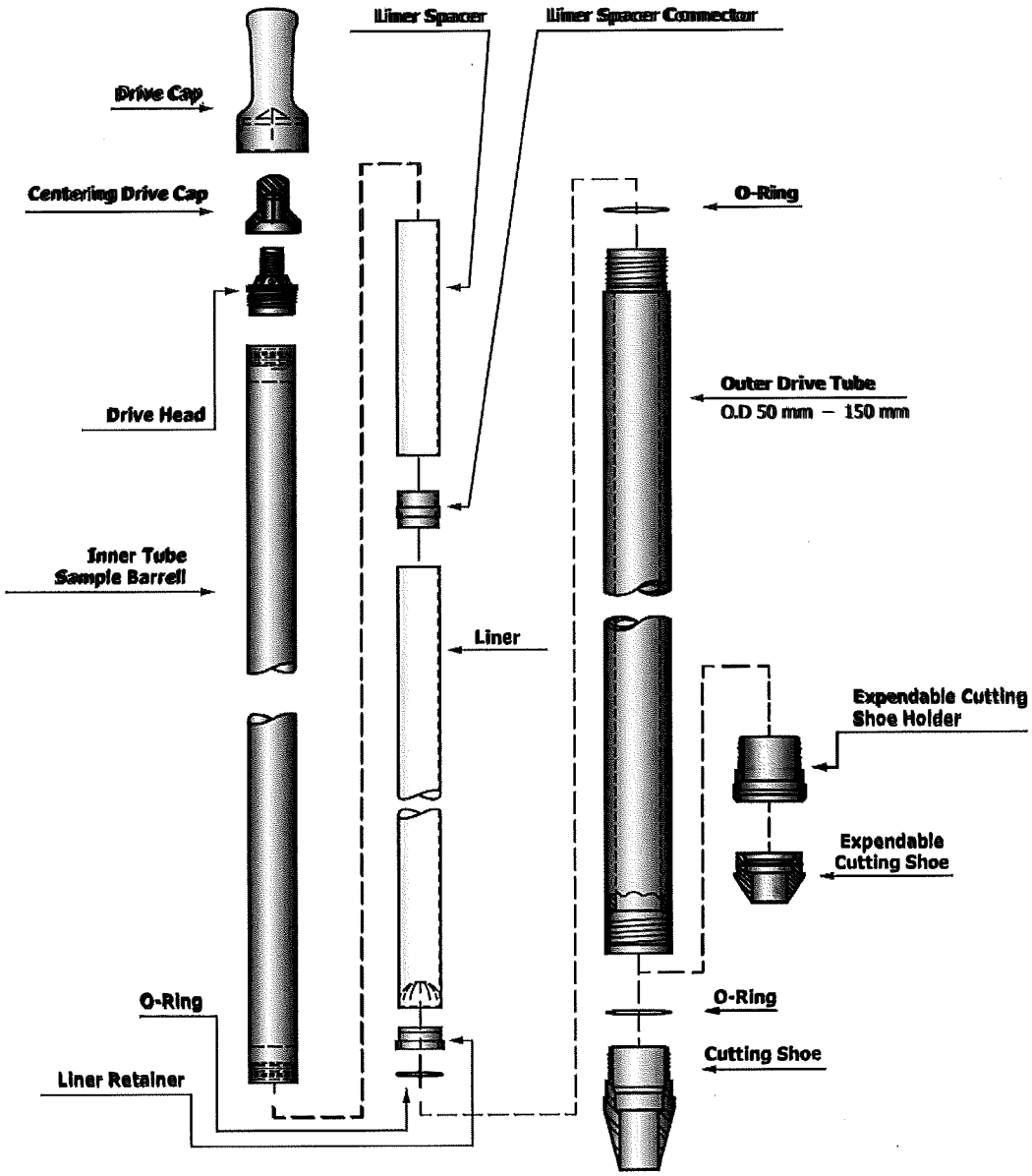

FIG. 3 Dual Tube Soil Sampler with Solid Inner Barrel and Liner

used include site assessments, underground storage tank investigations, and hazardous waste site investigations (17-19). Continuous sampling is used to provide a lithological detail of the subsurface strata and to gather samples for classification and index tests or for chemical testing. These investigations frequently are required in the characterization of hazardous waste sites. Samples, gathered by direct push methods, provide specimens necessary to determine the types and concentration of contaminants in soils and sediments, and in most circumstances, the contained pore fluids (7, 8, 9, 10, 11, 12, 13). Procedures for soil core handling for chemical testing are given standard D6640. Sampling for Volatile Organic Compounds (VOC) is addressed in Guide D4547 and often the core may be rapidly subsampled on site using other methods such as D6418 or other similar small hand core samplers. Samples for other chemical characterization generally require subsampling into glass or plastic jars or vials and preserved with refrigeration (See EPA test methods in SW-846 (4)). Verify containers and preservation requirements meet the data quality objectives as specified by the lead regulatory agency, in the project work plan, and with the selected analytical laboratory.

5.3 Direct push methods can provide accurate information on the characteristics of the soils encountered and of the chemical composition if provisions are made to ensure that discrete samples are collected, that sample recovery is maximized, and that clean decontaminated tools are used in the sample gathering procedure. For purposes of this guide, "soil" shall be defined in accordance with Terminology D653. Using sealed or protected sampling tools, cased boreholes, and proper advancement techniques can assure good representative samples. Direct push boreholes may be considered as a

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supplementary part of the overall site investigation or may be used for the full site investigation if site conditions permit. As such, they should be directed by the same procedural review and quality assurance standards that apply to other types of subsurface borings. A general knowledge of subsurface conditions at the site is beneficial.

5.4 Soil strata profiling to shallow depths may be accomplished over large areas in less time than with conventional drilling methods because of the rapid sample gathering potential of the direct push method. More site time is available for actual productive investigation as the time required for ancillary activities, such as decontamination, rig setup, tool handling, borehole backfill, and site clean-up is reduced over conventional drilling techniques. Direct push soil sampling has benefits of smaller size tooling, smaller diameter boreholes, and minimal investigative derived waste.

5.5 The direct push soil sampling method may be used as a site characterization tool for subsurface investigation and for remedial investigation and corrective action. The initial direct push investigation program can provide good soil and sediment stratigraphic information depending on the soil density and particle size, determine groundwater depth, and provide samples for field screening and for formal laboratory analysis to determine the types and concentrations of chemical contaminants in the soil or sediments and contained pore fluids. The method does not provide samples for laboratory test if engineering properties (Class C and D D4220).

5.6 This guide may not be the correct method for investigations in all cases. As with all drilling methods, subsurface conditions affect the performance of the sample gathering equipment and methods used. Direct push methods are not effective for solid rock and are marginally effective in partially weathered rock or very dense soils. These methods can be utilized to determine the rock surface depth. The presence or absence of groundwater can affect the performance of the sampling tools. Compact gravelly tills containing boulders and cobbles, stiff clay, compacted gravel, and cemented soil may cause refusal to penetration. Certain cohesive soils, depending on their water content, can create friction on the sampling tools which can exceed the static delivery force, or the impact energy applied, or both, resulting in penetration refusal. Some or all of these conditions may complicate removal of the sampling tools from the borehole as well. Sufficient retract force should be available to ensure tool recovery. As with all borehole advancement methods, precautions must be taken to prevent cross contamination of aquifers through migration of contaminants up or down the borehole. Regardless of the tool size, the moving of drilling and sampling tools through contaminated strata carries risks. Minimization of this risk should be a controlling factor in selecting sampling methods and drilling procedures. The user should take into account the possible chemical reaction between the sample and the sampling tool itself, sample liners, or other items that may come into contact with the sample (3, 4).

5.7 In some cases this guide may combine water sampling, or vapor sampling, or both, with soil sampling in the same investigation. Guides D6001 and D4700, D7648 can provide additional information on procedures to be used in such combined efforts. D3740 provides evaluation factors for the activities in this standard.

NOTE 1—The quality of the result produced by this standard is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with Practice D3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some of those factors.

6. Criteria for Selection

6.1 Important criteria to consider when selecting sampling tools include the following:

6.1.1 Size of sample.

6.1.2 Sample quality (Class A,B,C,D) for physical testing. Refer to Practice D4220.

6.1.3 Sample handling requirements, such as containers, preservation requirements. Refer to Practice D6640.

6.1.4 Soil conditions anticipated.

6.1.5 Groundwater depth anticipated and perched water tables.

6.1.6 Boring depth required.

6.1.7 Types and concentrations of contaminants in the soil or sediments and contained pore fluids.

6.1.8 Probability of cross contamination.

6.1.9 Available funds.

6.1.10 Estimated cost.

6.1.11 Time constraints.

6.1.12 History of tool performance under anticipated conditions (consult experienced users and manufacturers).

6.2 Important criteria to consider when selecting direct push equipment include the following:

6.2.1 Site accessibility.

6.2.2 Site visibility.

6.2.3 Soil conditions anticipated.

6.2.4 Boring depth required.

6.2.5 Borehole sealing requirements.

6.2.6 Equipment performance history.

6.2.7 Personnel requirements.

6.2.8 Decontamination requirements.

6.2.9 Equipment grouting capability.

6.2.10 Local regulatory requirements.

7. Apparatus

7.1 *General*—A direct push soil sampling system consists of a sample collection tool, hollow extension rods for advancement, retrieval, and transmission of energy to the sampler, and an energy source to force sampler penetration. Auxiliary tools are required to handle, assemble and disassemble, clean, and repair the sample collection tools and impact surfaces. Necessary expendable supplies are sample containers, sample container caps, sample liners, sample retainers, appropriate lubricants, and personal safety gear. The following text and subsequent figures tell and show the overall intent of this standard; however, if the exact configuration and dimensions vary in a particular tooling configuration, yet the

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intent is still met, that particular tooling configuration is acceptable to be used as a part of complying with this standard.

7.2 *Direct Push Tool Soil Sampling Systems*—Direct push soil samplers are described in two groups; Dual Tube and Single Tube Systems.

7.2.1 *Dual Tube System*—Figures 3 and 4 are examples of typical Dual Tube direct push soil samplers. The Outer Drive Tube which is generally the same diameter. Diameters range from 50 to 150 mm [2 to 6 inches]. The outer drive tube is sometimes referred to as Probe rod in the drawings. Outer drive tube friction can be reduced by using oversized cutting shoes or other friction reducers. The Outer drive tube stays in the ground and seals and protects borehole collapse as the sampling progresses to depth.

7.2.1.1 *Sampler*—Figure 3 shows a sampler with a solid inner barrel with a liner inside the barrel. Figure 4 shows just an inner liner without the solid barrel. The solid barrel may be required in situations where liner damage may occur. The length of sample ranges from 2 to 6 ft [0.5 to 1.5 m] and diameters range from 50 to 125 mm [2-5 inches]. The sampler is normally held in place with a series of inner rods that fit inside the outer tube and connect to the drive cap so both the outer rods and inner rods are advanced together. The inner rods are used to place and remove the sampler barrels during sampling events. There are other means of locking the sample barrel in place besides inner rods such as wire line latching systems.

7.2.1.2 The outer drive tube is equipped with a Cutting Shoe on the end the is designed specifically for the sampler system such that the liners, o-rings, and core catchers all fit in place correctly and the shoe cuts the core to slides into the sampler liner with minimal disturbance. There are different cutting

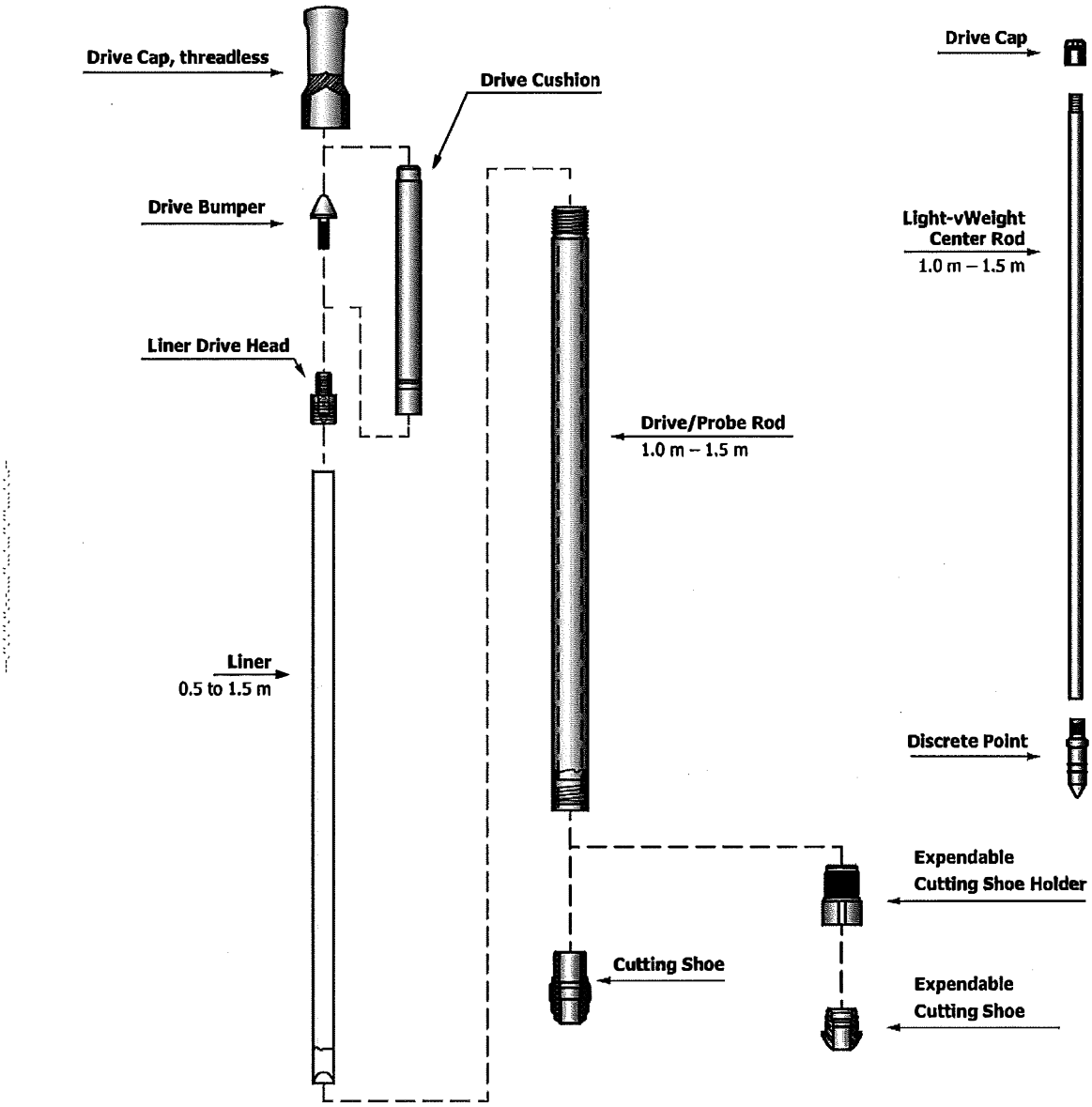

FIG. 4 Dual Tube Sampler with Inner Liner and Inner Rods

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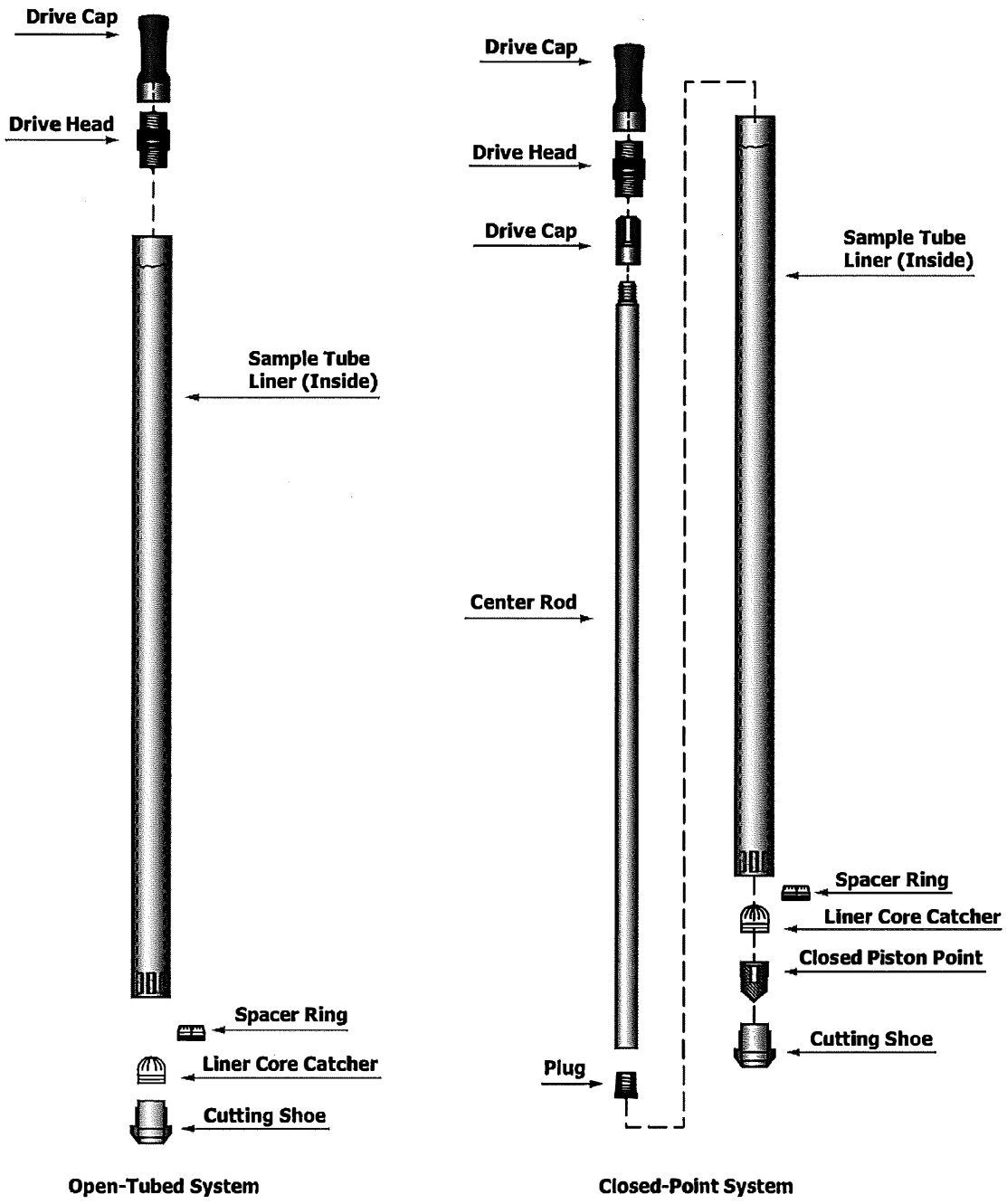

FIG. 5 Typical Single Tube Sampling System Used in Either Open Tube or Sealed (Closed) Piston Point

shoes for differing soil conditions (see Appendix X1) so the correct design must be used in the soils to be sampled. The Cutting Shoe is the most important feature that effects soil core recovery or quality. General purpose cutting shoes are successful in a wide range of soil deposits but if the recover is poor one should change the cutting shoe design for the soils to be sampled. Special expendable cutting shoes (Figs. 4 and 5) can be used when the planned investigation requires post sampling installations such as monitoring wells (D6724, D6725).

7.2.1.3 Core catchers can be used to help the soil recovery by preventing loss of core. Figure 3 shows a core catcher built into the sample liner. Core catchers should be used in most all soil conditions. The catcher does not disturb the soil except in very soft soils. The use of a catcher assures that if clean sands are encountered they can be recovered without running/falling out of the liner.

7.2.1.4 Figure 4 shows a discrete point with inner rods that can be inserted into the dual tube system in place of the sampler barrel to advance the system without sampling. It can be used to drive through difficult formations and intervals where sampling is not required.

7.2.2 *Single Tube Samplers*—Figures 5 and 6 show some single tube sampler systems. Figure 5 shows a Single Tube system used in either an open or sealed mode. Sample lengths

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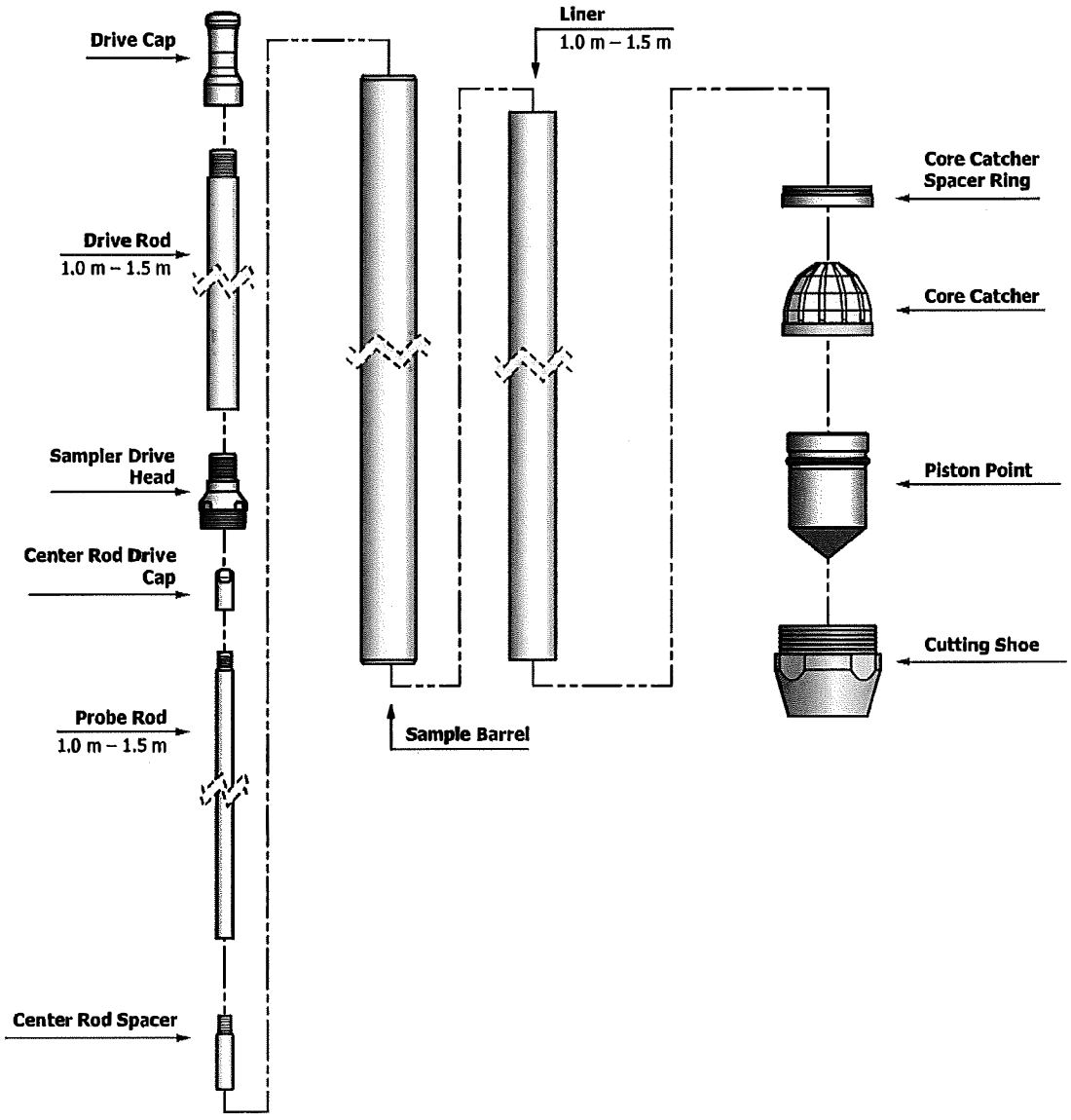

FIG. 6 Sealed Single Tube Piston Sampler

range from 0.5 to 1.5 m [2 to 5 ft]. Typical sample diameters range from 30 to 100 mm [1 to 4 inches]. Figure 6 shows the Sealed single tube sampler with solid barrel, inner liner, piston point, and cutting shoe. The sealed system includes the piston and inner rod are locked inside the liner and the sampler is advanced to the sampling depth. The piston is unlocked using rods or other methods prior to the sampling push. The sample barrel is equipped with a cutting shoe which is specifically designed to cut the core for optimal recovery.

7.2.2.1 Figure 7 shows a typical piston sampler deployed on CPT rigs (D6067) **(20)**. It uses a simple ball system to unlock the piston when the sampling depth is reached.

7.2.2.2 A Core Catcher is sometimes used to add in recovery of sands and low plasticity silts. This catcher is reusable and is not built into the liner. In many cases the catcher is not required as the piston system creates a vacuum to hold the sample in the liner.

7.2.2.3 Figure 5 shows the single tube sampler use without the piston in an open sampling mode. As discussed in section 5.1.2.5, the use of an open sampler for consecutive sampling events is extremely limited.

7.3 *Sampler Extension/Drive Rods*—Sampler extension/drive rods are lengths of rod or tube generally constructed of steel to withstand the pushing or percussion forces applied. Inner rods used with Dual Tube systems can be made with thinner walls to provide lightweight tooling to minimize manual effort in sampling. Extension drive rods lengths range from 1.0 to 1.5 m [3 to 5 ft] but are available in various lengths. Rod lengths should be mated with casing and sampling equipment used. Thread types and classes vary between equipment manufacturers. Rod joints can be sealed to prevent fluid intrusion with "O" rings. TFE-fluorocarbon washers or TFE-fluorocarbon tape. Because of the percussive effort, joint

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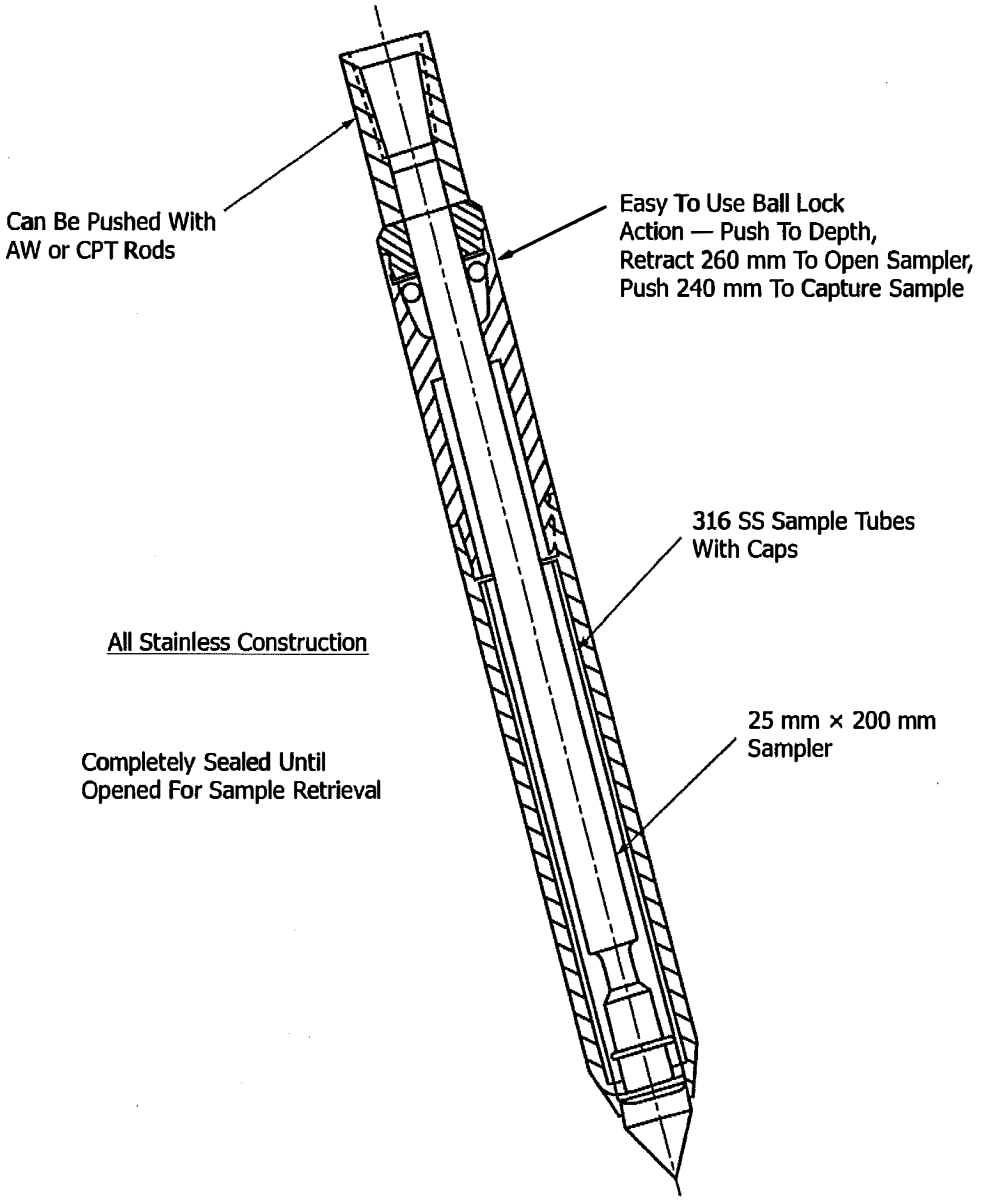

FIG. 7 Single Tube Piston Sampler Used on CPT and Drilling Operations

seals should be checked for each sampling effort. Dual Tube outer rods should have sufficient inside diameter to accommodate the equipment necessary to perform the desired action. For Direct Push monitoring well installation (D6724, D6725) research has shown (21) that the minimum nominal 100-mm [4-inches] inside diameter requirement normally specified for rotary drilled monitoring wells (D5092) is not required for the installation of smaller diameter direct push wells.

7.4 *Sampler Liners*—Sampler liners are used to collect and store samples for shipment to laboratories, for field index testing of samples and for removing samples from solid barrel type samplers. Most chemical testing of the soil core, if performed, requires rapid or immediate sub-sampling, containerization, and preservation of samples (see 5.2) for testing and therefore the material of the liner and interaction of the liner with chemicals is not a major concern. Liners are only used to retain soils for long term for classification and geotechnical index properties testing. Liners are available in lengths from 150 mm [6 in.] to 1.5 m [5.0 ft]. Liners should be sealed in accordance with Practice D4220 or sealed subsamples taken when samples are collected for moisture content physical testing. Liners generally are split in the field for subsampling. Individually split liners are available in some sizes for field use. The liner should have a slightly larger inside diameter than the soil specimen to reduce soil friction and enhance recovery (see 7.5). When a slightly oversized liner is used, the potential for air space exists around the sample. Certain chemical samples may be affected by the enclosed air. Liners having less tolerance may be required and a shortened sampled interval used to reduce friction in the liner. Metal liners can be reused after proper cleaning and decontamination. Plastic liners should be disposed of properly after use.

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7.4.1 The most predominant liner material in used is clear medical grade Polyvinyl Chloride (PVC). The clear liner has the advantage of exposing the soil core to visual examination after recovery. Smearing of soil in the liner does occur and liners should be opened and examined and required subsamples taken. Liners are available in plastics, TFE-fluorocarbon, brass, and stainless steel. Other materials can be used as testing needs dictate, however, since there is limited concern when immediate subsamples are taken on chemical test results, there may be no need for more expensive non-reactive liner materials such as TFE-fluorocarbon or brass. Verify that liner materials meet local regulatory requirements and specifications in the project sampling plan and quality assurance plan.

7.5 *Cutting Shoes*—The Cutting Shoe is one of the most important parts affecting the quality and Recovery (9.5.4) of the soil specimens. General purpose cutting shoes work well in most formations but if core recovery is poor, then one should change the cutting shoe and liner design to optimize the sample recovery and quality. The Clearance Ratio (Ratio of ID of Cutting Shoe to ID of Liner) is the most important parameter for optimizing sample recovery and quality. In general higher clearance ratios are required in dense soil formations while lower ones can be used in softer formations. The cutting angle of the shoe also influences the sample quality. Sharper cutting shoes work better in fine grained formations but they are not as durable. Appendix X1 gives additional information on Cutting Shoe design. Contact your manufacturer if you have questions regarding recovery and quality issues.

7.6 *Sample Containers*—Sample containers should be prescribed according to the anticipated use of the sample specimen. Samples taken for chemical testing may require clean containers with specific preservatives (see 5.2). Practice D3694 and EPA SW-846 (4) provides information on some of the special containers and preservation techniques required for these containers generally will be cleaned to specific criteria. Samples for geotechnical testing require certain minimum volumes and specific handling techniques. Practice D4220 offers guidance for sample handling of samples submitted for geotechnical physical testing.

7.7 *Direct Push Power Sources*—Soil probing percussion driving systems, penetrometer drive systems, and rotary drilling equipment may be used to drive casings and direct push soil sampling devices. The equipment should be capable of applying sufficient static force, or dynamic force, or both, to advance the sampler to the required depth to gather the desired sample. The system must have adequate retraction force to remove the sampler and extension/drive rods once the selected strata has been penetrated. Rotation of the drill string can be added during insertion, as well as during retraction if the drive system can impart rotation.

7.7.1 *Retraction Force*—The retraction force can be applied by direct mechanical pull back using the hydraulic system of the power source; line pull methods using mechanical or hydraulic powered winches, or cathead and rope windlass type devices. Winches used with direct push technology should have a minimum of 900 kg [2000 lb] top layer rating capacity and a line speed of 120 m/min [400 ft/min] to provide effective tool handling. Direct push sampling tools can be retracted by back pounding using weights similar to those of standard penetration testing practices. Backpounding to recover samples can affect recovery and cause disturbances to the sample. Other forms of extraction, such as jacking, that do not cause undue disturbance to the sample, are preferable.

7.7.2 *Percussion Devices*—Percussion devices for use with direct push methods are hydraulically-operated hammers, air-operated hammers, and mechanically-operated hammers. Hydraulically-operated hammers should have sufficient energy to be effective in moving the samplers through the subsurface strata. The maximum energy application is dependent on the tools used. Hammer energy that exceeds tool tolerance will result in tool damage or loss and will not achieve the goal of collecting high quality samples. Air-operated hammers should be capable of delivering sufficient energy, as well. Hammer systems utilizing hydraulic oil or air should be operated in the range specified by the manufacturer. Manually-operated hammers can be used to advance direct push tools. These hammers can be operated mechanically or manually using cathead and rope. These systems generally involve using 63.5 kg [140 lb], standard penetration (see Test Method D1586) hammers, which can work well for direct push sampling. In operation, these hammers tend to be slower than hydraulic hammers and can cause tool damage if direct push tools are not designed to take the heavy blows associated with these hammers. The hydraulic- and air-operated hammers strike up to 2000 blows/min. In addition to the energy transferred, the rapid hammer action sets up a vibratory effect, which also aids in penetration. This vibratory effect, along with the percussive effort, may disturb some soil samples.

7.7.3 *Static Push Systems*—Cone penetrometer systems are an example of static push systems. They impart energy to the sampler and extension rods by using hydraulic rams to apply pressure. The pressure applied is limited to the reactive weight of the drive vehicle. Some portable systems use screwed in augers to anchor the machine for CPT testing (D6067). The earth augers provide the reaction force to advance the CPT probe. Retraction of the sampler and extension rods is by static pull from the hydraulic rams.

7.7.4 *Vibratory/Sonic Systems*—Sonic systems (D6914) utilize a vibratory device, which is attached to the top of the sampler extension rods. Reactive pressure and vibratory action are applied to the sampler extensions moving the sampler into the formation. In certain formations, sample recovery and formation penetration is expedited; however, all formations do not react the same to vibratory penetration methods.

7.7.4.1 *Sonic or Resonance Drilling Systems*—These are high powered vibratory systems that can be effective in advancing large diameter single or dual tube systems. They generally have depth capabilities beyond the smaller direct push systems.

7.7.5 *Rotary Drilling Equipment*—Direct push systems are readily adaptable to rotary drill units (D6286). The drill units offer a ready hydraulic system to operate percussion hammers, as well as reactive weight for static push. Drill units with direct push adaptations also offer drilling techniques should obstacles be encountered while using direct push technology. Large drill units may have reactive weights that can exceed the tool

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capacity, thereby resulting in damaged tools. Typical rotary drilling equipment is larger and more massive than smaller direct push equipment which can lead to limitations with site access and slower relocation times.

8. Conditioning

8.1 *Decontamination*—Sampling equipment that will contact the soil to be sampled should be cleaned and decontaminated before and after the sampling event (D5088). Extension rods should be cleaned prior to each boring to avoid the transfer of contaminants and to ease the connecting of joints. Thread maintenance is necessary to ensure long service life of the tools. Sample liners should be kept in a sealed or clean environment prior to use. All ancillary tools used in the sampling process should be cleaned thoroughly, and if contaminants are encountered, decontaminated before leaving the site. It should not be assumed that new tools are clean. They should be cleaned and decontaminated before use. Decontamination should be performed following procedures outlined in Practice D5088 along with any site safety plans, sampling protocols, or regulatory requirements.

8.2 *Tool Selection*—Prior to dispatch to the project site an inventory of the necessary sampling tools should be made. Sample liners, containers, sampling tools, and ancillary equipment should be checked to ensure its proper operation for the work program prescribed. Sampling is expedited by having two or more samplers on site. Since samples can be recovered quite fast, a supply of samplers will allow a boring to be completed so other functions can be performed while samples are being processed. Various Cutting Shoes and Liners should be available to optimize soil sampling Recovery and quality on site. A backup tool system adaptable to and within the capabilities of the power source should be available should the original planned method prove unworkable. Materials for proper sealing of boreholes should always be available at the site (D6011 section 9 Completion)

9. Procedure

9.1 While procedures for direct push soil sampling with two common direct push methods are outlined here, other systems may be available. As long as the basic principles of practice relating to sampler construction and use are followed, other systems may be acceptable.

9.2 *General Set-Up*—Select the boring location and check for underground and overhead utilities and other site obstructions. Establish a reference point on the site for datum measurements, and set the direct push unit over the boring location. Stabilize and level the unit, raise the drill mast or frame into the drilling position, and attach the hammer assembly to the drill head if not permanently attached. Attach the anvil assembly in the prescribed manner, slide the direct push unit into position over the borehole, save a portion of the sliding distance for alignment during tool advancement, and ready the tools for insertion.

9.2.1 *Tool Preparation*—Inspect the direct push tools before using, and clean and decontaminate as necessary. Inspect drive shoes for damaged cutting edges, dents, or thread failures as these conditions can cause loss of sample recovery and slow the advancement rate. Where permissible, lubricate rod joints with appropriate safe products, but clean water only may be the best option. Many organic lubricants can result in interferences with analytical tests to be performed on the collected samples (22). Verify that any lubricants used will not cause analytical interference or result in false positives before applying to the tools. Check impact surfaces for cracks or other damage that could result in failure during operations. Assemble samples and install where required, install sample retainers where needed, and install and secure sampler pistons to ensure proper operation where needed.

9.2.2 *Sample Processing*—Sample processing should follow a standard procedure to ensure quality control requirements are met (5.2). View sample in the original sampling device, if possible. Open the sampling device with care to keep disturbance to a minimum. When using liners or thin wall tubes, protect ends to prevent samples from falling out or being disturbed by movement within the liner. Measure recovery accurately, containerize as specified in the work plan or applicable ASTM procedures, and label recovered samples with sufficient information for proper identification. When collecting samples for volatile chemical analysis, sample specimens must be contained and preserved as soon as possible to prevent loss of these components. Follow work plan instructions or other appropriate documents (see Practice D6640) when processing samples collected for chemical analysis.

9.3 *Dual Tube System*—Assemble the outer casing with the cutting/drive shoe on the bottom. Assemble the sampler and liner, if used, and attach the sampler to the extension rods. Connect the drive head to the top of the sampler extension rods, and insert the sampler assembly into the outer casing. Position the outer casing and sampler assembly under the drill head, and move the drill head downward to bring pressure on the tool string. If soil conditions allow, advance the sampler/casing assembly into the soil at a steady controlled rate slow enough to allow the soil to be cut by the shoe and move up inside the sample barrel. If advancement is too rapid, it can result in loss of recovery because of soil friction and plugging in the shoe. Occasional hammer action during the push may help recovery by agitating the sample surface. If soil conditions prevent smooth static push advancement, activate the hammer to advance the sampler. Apply a continuous pressure while hammering to expedite soil penetration. The pressure required is controlled by subsurface conditions. Applications of excessive down pressure may result in the direct push unit being shifted off the borehole causing misalignment with possible tool damage. Stop the hammer at completion of advancement of the measured sampling barrel length. Release the pressure and move the drill head off the drive head. Attach a pulling device to the extension rods or position the hammer bail and retrieve the sampler from the borehole. At the surface remove the sampler from the extension rods and process. Soil classification is accomplished easily using split barrel samplers as the specimen is available readily for viewing, physical inspection and subsampling when the barrel is opened. However, unnecessary exposure of the sample to the atmosphere will lead to loss of volatile contaminants. If Liners are used they should

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be split of sections removed for soil classification and subsampling. Clean, decontaminate, and reassemble the sampler. Reattach the sampler to the extension rod, add the necessary extension rod and outer casing to reach the next sampling interval, and sound the borehole for free water before each sample interval. If water is present, it may be necessary to change sampling tools and select a sealed Single Tube sampler . Unequal pressure inside the casing may result in blow-in of material disturbing the soil immediately below the casing. Lower the sampler to its proper position, add the drive heads, and repeat the procedure. If it is desired that the pass through certain strata without sampling, install an extension drive point in lieu of the sampler (see Fig. 5). When the sampling interval is reached, remove the point and install the sampler. Advance the sampler as described. Upon completion of the borehole, remove the outer casing after instrumentation has been set or as the borehole is sealed as described in Section 10.

9.3.1 *Dual Tube System—Other Samplers:*

9.3.1.1 *Thin Wall Tubes*—Thin wall tubes (Practice D1587) can be used with the dual tube system. Attach the tube to the tube head using removable screws. Attach the tube assembly to the extension rods and position at the base of the outer casing shoe protruding a minimum of 6.25 mm [0.25 in.] to contact the soil ahead of the outer casing. Advance the tube, with or without the outer casing, at a steady rate similar to the requirements of Practice D1587. At completion of the advancement interval, let the tube remain stationary for 1 min. Rotate the tube slowly two revolutions to shear off the sample. Remove the tube from the borehole, measure recovery, and classify soil. The thin wall tube can be field extruded for on-site analysis or sealed in accordance with Practice D4220 and sent to the laboratory for processing. Samples for environmental testing generally require the subsampling and preservation of samples in controlled containers. Soil samples generally are removed from the sampling device for storage and shipping. Thin wall tubes should be cleaned and decontaminated before and after use.

9.3.1.2 *Sealed Single Tube Piston Sampler*—A Sealed Single Tube piston sampler can be used inside the Dual Tube system. This type of sampler may be required when 1.) there is water level inside the Dual Tube and a chemical testing requires virtually no possibility of cross contamination, or 2.) when the borehole becomes unstable and the continued use of the open tube sampling system cannot assure a sample of the native soils without other slough or heave in the recovered sample. Follow the section 9.4 for operation of Single Tube samplers inside of the Dual Tube.

9.3.1.3 *Open Barrel Samplers*—Use Open Single Tube barrel samplers (Figure 5 a) in advance of the outer casing where the soil conditions could cause swelling of split barrel samplers, or where friction against the outer casing precludes its advancement and sampling must still be accomplished. The sampler requires the use of liners for removal of the sample. The sampler must be cleaned and decontaminated before use.

9.3.1.4 *Standard Penetration Test Split Barrel Sampler (D1586)*—Attach the split spoon to an extension rod or drill rod. Using a mechanical or hydraulic hammer drive the sampler into the soil the desired increment, as long as that increment does not exceed the sampler chamber length. Remove the sampler from the borehole, disassemble, and process sample. Standard split barrel samplers can be used, as long as borehole wall integrity can be maintained and the additional friction can be overcome. If caving or sloughing occurs, the sampler tip should be sealed or other sampling tools used

9.4 *Single Tube System—*

9.4.1 *Sealed Sampler (see* Figs. 3-7*)*—Insert or attach the sample liner to the shoe, and insert the assembly into the solid barrel sampler. Install sample retaining basket if desired. Attach the latch coupling or sampler head to the sampler barrel, and attach the piston assembly with point and "O" rings if free water is present, to the latching mechanism or holder. Insert the piston or packer into the liner to its proper position so the point leads the sampler shoe. Set latch, charge packer, or install locking pin, and attach assembled sampler to drive rod. Add drive head and position under the hammer anvil. Apply down pressure, hammer if needed, to penetrate soil strata above the sampling zone. When the sampling zone is reached, insert the piston latch release and recovery tool, removing the piston, or insert the locking pin removal/extension rods through the drive rods, turn counterclockwise, and remove the piston locking pin so the piston can float on top of the sample, or release any other piston holding device. Direct push or activate the hammer to advance the sampler the desired increment. Retrieve the sampler from the borehole by withdrawing the extension/drive rods. Remove the shoe, and withdraw the sample liner with sample for processing. Clean and decontaminate the sampler, reload as described, and repeat the procedure. Extreme stress is applied to the piston when driving through dense soils. If the piston releases prematurely, the sample will not be recovered from the correct interval, and a resample attempt must be made. The piston sampler can be used as a re-entry grouting tool for sealing boreholes on completion if it is equipped with a removable piston.

9.5 *Quality Control:*

9.5.1 *Quality Control*—Quality control measures are necessary to ensure that sample integrity is maintained and that project data quality objectives are accomplished. By following good engineering principles and applying common sense, reliable site characterizations can be accomplished.

9.5.2 *Water Checks*—Water seeping into the direct push casing or connecting rods from contaminated zones may influence testing results. Periodically check for groundwater before inserting samplers into borehole or into outer casings in the two tube system. If water is encountered, it may be necessary to switch to the sealed piston type samplers to protect sample integrity. Sealed piston type samples may not always be water tight. Sealing of rod or casing joints can prevent groundwater from entering through the joints.

9.5.3 *Datum Points*—Establishment of a good datum reference is essential to providing reliable sample interval depths and elevators. Select datum reference points that are sufficiently protected from the work effort, and that can be located for future reference. Field measurements should be to 0.1 ft (3.05 mm). Measure extension rods as the bore advances to locate sample depth. Mark rods before driving each sample

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interval to determine accurate measurement of sample recovery and to accurately log borehole depth.

9.5.4 *Sample Recovery*—Record and report sample recovery for every sampling event. The Recovery is defined as the recovered sample length divided by the push/drive length as a percent. Sample recovery should be monitored closely and results documented. Poor recovery could indicate a change in sampling method is needed, that improper sampling practices are being conducted, or that sampling tools are incorrect. Adjust Cutting Shoes and liners to optimize sample recovery in the field (see 7.5 and Appendix X1). Sample recovery involves both volume and condition. Poor sample recovery should cause an immediate review of the sampling program.

9.5.5 *Decontamination*—Follow established decontamination procedures. Taking shortcuts may result in erroneous or suspect data.

9.5.6 *Equipment Rinsate Samples*—Equipment rinsate samples should be collected from decontaminated samplers Periodically during the sampling program in accordance with the quality assurance plan requirements. Clean water of known quality is poured over and through the assembled or partially assembled sampler so that all surfaces having potential sample contact, including liners, are rinsed. The rinse water is collected in the appropriate clean sample containers and preserved for analysis. The rinsate samples should be analyzed for the same analytes as the soil and sediment samples or groundwater samples. The rinsate samples will provide documentation that decontamination procedures are adequate and that cross contamination is controlled. For high priority sites and large projects it may be prudent to have rinsate samples analyzed on a quick turn-around basis to verify that sample integrity is maintained during the sampling program.

9.5.7 *Replicate Borings*—It is recommended that at a minimum one in twenty borings be replicated to provide some basic quality control on the repeatability of the boring and sampling process. Spacing between replicate borings should be on the order of 3 to 5 ft [1 to 1.5 m]. The same sampling techniques and tooling should be used in the replicate boring. This practice also will provide insight into: 1) lateral variability of soil and sediment strata and 2) heterogeneity of contaminant distribution for geo-environmental investigations.

10. Completion and Sealing

10.1 *Completion*—For boreholes receiving permanent monitoring devices, completion should be in accordance with Practice D5092, Guide D6724 or Practice D6725, site work plan, and or regulatory requirements.

10.2 *Borehole Sealing*—Seal direct push boreholes to minimize preferential pathways for containment migration. State regulations will generally prescribe acceptable grout mixtures and placement techniques; refer to local regulations for the state or county where the work is conducted. Additional information and guidance on borehole sealing can be found in Guide D5299, D6001 and Practice D6725. Recent work (Lackey et al., 2009 (**23**), Ross 2010 (**24**)) have found that bentonite slurries often will dessicate and crack when emplaced in the vadose zone, especially in semi-arid to arid settings. When sealing boreholes in the vadose zone it was found that neat cement, cement-sand mixtures or bentonite chip provided the best seal to minimize fluid movement along the borehole (Lackey et al., 2009 (**23**)).Regulations generally direct bottom up borehole sealing as it is the surest and most permanent method for complete sealing. High pressure grouting is available for use with direct push technology for bottom up borehole sealing.

10.2.1 *Sealing by Slurry, Two Tube System*—Sound the borehole for free water. If water exists in the casing, place the appropriate tremie tube or extension rods, open-ended, to the bottom of the outer casing. Mix the slurry to standard specifications prescribed by regulation or work plan. Pump slurry through the tremie tube or extension/drive rod until it appears at the surface of the outer casing. Slowly retract the outer casing and tremie tube while maintaining a head of grout in the borehole. Keep the grout level inside the outer casing as the tools are retracted to prevent borehole wall collapse and poor integrity seal. If no free water exists in the borehole, the slurry can be placed by gravity. Top off the borehole as the outer casing as it is removed.

10.2.1.1 *Slurry Mixes*—Slurry mixes used for slurry grouting of direct push boreholes may be of lower viscosity when small diameter tremie pipes are required. Usable mixes are 6 to 8 gal [22.7 to 30.28 L] of water/94-lb (42.64-kg) bag of cement with 5 lb [2.27 kg] of bentonite or 24 to 36 gal [90.84 to 136.28 L] of water to 50 lb [22.68 kg] of bentonite.

10.2.2 *Sealing by Gravity—Dual Tube System*—Measure the cased hole to ensure it is open to depth. Slowly add bentonite chips or granular bentonite to fill the casing approximately 2 ft. Withdraw the casing 2 ft and recheck depth. Hydrate the bentonite by adding water. Repeat this procedure as the outer casing is withdrawn. The bentonite must be below the bottom of the casing during hydration. Wetness inside the rods may affect the flow of granular bentonite to the bottom of the casing. A tremie tube may be used to add water for hydration of dry bentonite. Fill the top foot of the borehole with material that is the same as exists in that zone.

10.2.3 *Borehole Sealing Single Tube System:*

10.2.3.1 *Gravity Sealing from Surface*—If the soil strata penetrated has sufficient wall strength to maintain an open hole, and the borings ends at or above the local water table, then it may be possible to add sealing materials from the surface. Dry bentonite chips or granular bentonite can be placed by gravity. The borehole depth and volume should be determined and the borehole sounded every 5 ft [1.5 m] to ensure bridging has not occurred. The bentonite should be hydrated by adding approximately 1 gallon [1.0 L] of clean water for each 5 ft of filled borehole. Seal the surface with native material.

10.2.3.2 *Wet Grout Mix Tremie Sealing*—Tremie sealing methods can be used with single tube systems when borehole wall strength is sufficient to maintain an open hole or when extension rods with an expendable point are used to reenter the borehole. The grout pipe should be inserted immediately after the direct push tools are withdrawn or through the annulus of the extension rods that have been reinserted down the borehole

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for grouting. Care must be taken to not plug the end of the grout pipe. Side discharge grout pipes also can be used to prevent plugging.

10.2.4 *Re-Entry Grouting*—If the borehole walls are not stable, the borehole can be re-entered by static pushing grouting tools, such as an expendable point attached to the extension/drive rods to the bottom of the original borehole. Pump a slurry through the rods as they are withdrawn. High pressure grouting equipment may be beneficial in pumping standard slurry mixes through small diameter gravity pipes. Care must be taken to ensure the original borehole is being sealed.

11. Reports: Test Data Sheets/Forms

11.1 Fields records must be kept for each soil sampling event. These records are documented on field data sheets to show the depths of drilling and sampling events to the nearest 5 cm (0.1 ft), recovery in percent to 2-3 significant digits, and records on sample processing, subsampling locations, and visual soil classification. Soil samples can be classified in accordance with Practice D2487 and/or D2488 or other methods as required for the investigation. Prepare the final report log in accordance with standards set in Guide D5434 listing the parameters required for the field investigation program. List all contaminants identified, instrument readings taken, and comments on sampler advancement. Record any special field tests performed and sample processing procedures beyond those normally used in the defined investigation. Record borehole sealing procedures, materials used, and mix formulas on the boring log. Survey or otherwise locate the boring site to provide a permanent record of its replacement.

11.2 *Backfilling Record*—Record the method of sealing, materials used, and volume of materials placed in each borehole. This information can be added to the field boring log or recorded on a separate abandonment form.

12. Keywords

12.1 decontamination; direct push; groundwater; sealing; soil and sediment sampling

APPENDIX

(Nonmandatory Information)

X1. FACTORS INFLUENCING SAMPLE RECOVERY IN DIRECT PUSH SOIL SAMPLING

X1.1 The major factors influencing sample recovery in Direct Push Soil Sampling are the Cutting Shoe inside diameter and shape, and the Liner inside diameter and length. The other major factor is to soil formation to be sampled including the soil type, particle size, cohesiveness, and stress history. The combination of Cutting Shoe and Liner should be optimized and matched to the soil formations to be sampled. It is important that prior to sampling that different equipment be available to match the soil formation in the field.

X1.2 Soil recovery (9.5.4) in direct push sampling is rarely close to the ideal 100% desired. The predominant use of long sample drive lengths of 1 to 1.5 m (3 to 5 ft) often results in less than desirable recovery. Shortening sample lengths will improve the recovery but that is rarely done. Recoveries of more than 100 % often occur in Direct Push Soil Sampling because of the large clearance ratios between the cutting shoe and liner. Extremely high recoveries can occur in heavily over consolidated clays that tend to expand. Conversely, recoveries of less than 100 % can occur in low density and low plasticity soils. Clean sands silts below groundwater may liquefy and run or fall out of the sampling tube during retraction of the sampler and as it clears water level. In cases of running sands the basket retianers should be used to help retain the soil.

X1.3 The Cutting Shoe is the most important feature that controls the sample recovery. Cutting Shoes are designed to have a smaller diameter opening than the Liner to help reduce the friction of the core inside the Liner. The ratio of inside diameter of the cutting shoe to the inside diameter of the liner is called the Clearance Ratio. If sample recovery in a soil formation is poor the operator should change the Cutting Shoe to match the formation.

X1.4 Research on intact soil sampling indicates the angle of the cutting shoe (Sharpness) should be less than 10 degrees for intact sampling. Most direct push cutting shoes are blunt with much flatter cutting angles and rounded cutting angles because they need to be very strong and durable to withstand the impact forces of Direct Push. These blunt surfaces transmit shock waves and possible bearing capacity failure in from of the cutting shoe edge and cause disturbance to the soil before it enters the shoe and barrel. In some dense plastic soils this can cause extreme expansion of the cores. If these symptoms occur in fine grained formations a sharpened cutting shoe may result in higher quality cores.

X1.5 Manufactures provide differing styles of cutting shoes that can be used in difficult soil deposits. Figures X1.1 through X1.6 show some examples of the Cutting Shoe designs for different formations. Consult your manufacturer for advice on cutting shoes for the soils to be tested.

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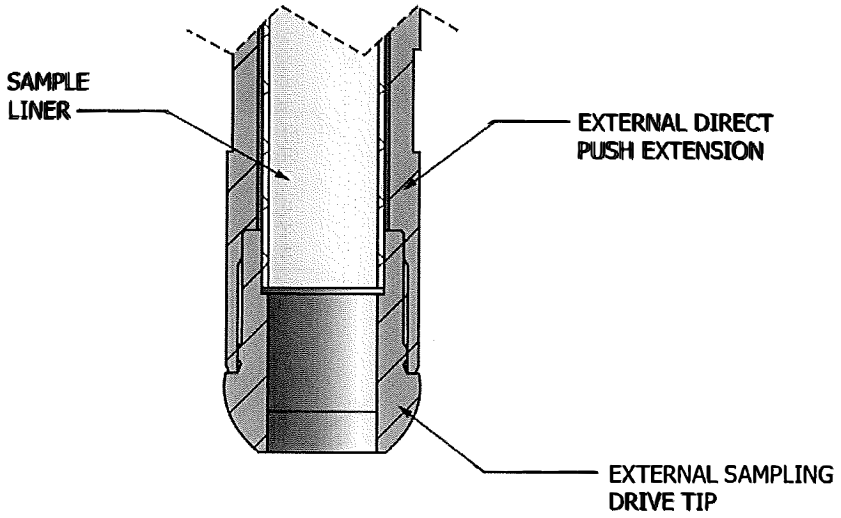

FIG. X1.1 Typical Sand and Silt Cutting Shoe

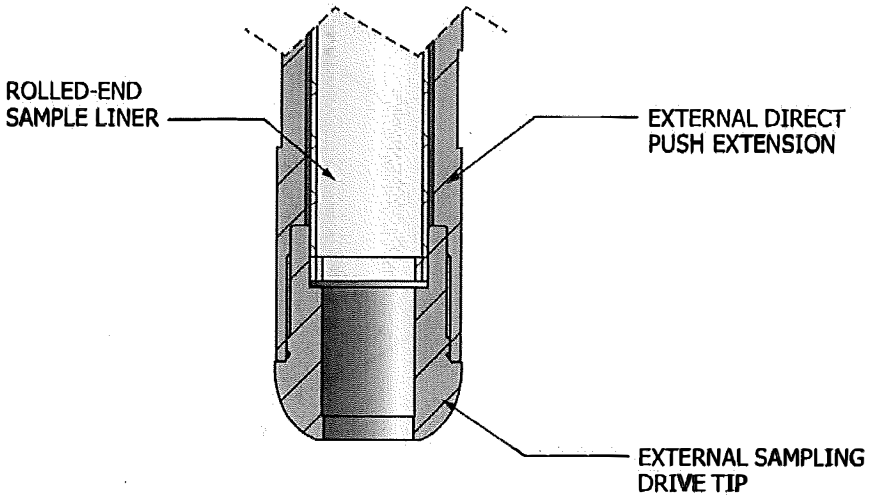

FIG. X1.2 Typical Clay Cutting Shoe

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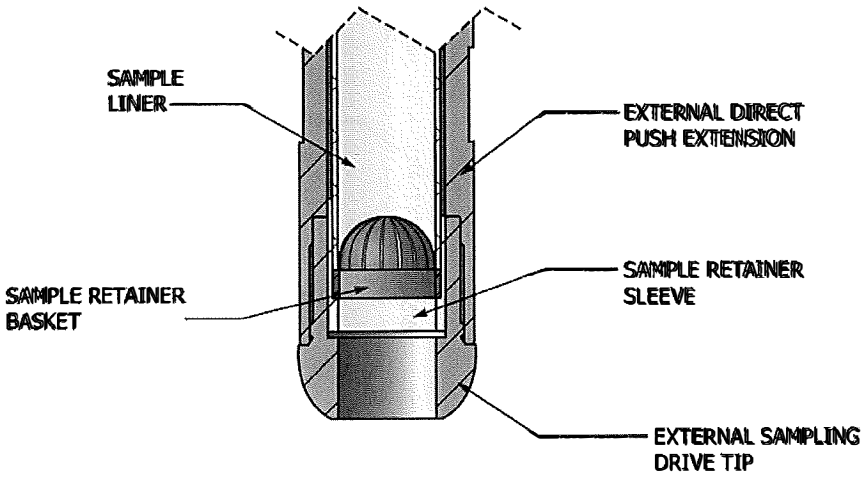

FIG. X1.3 Cutting Shoe for Loose Sand and Silts—Note Basket Retainer

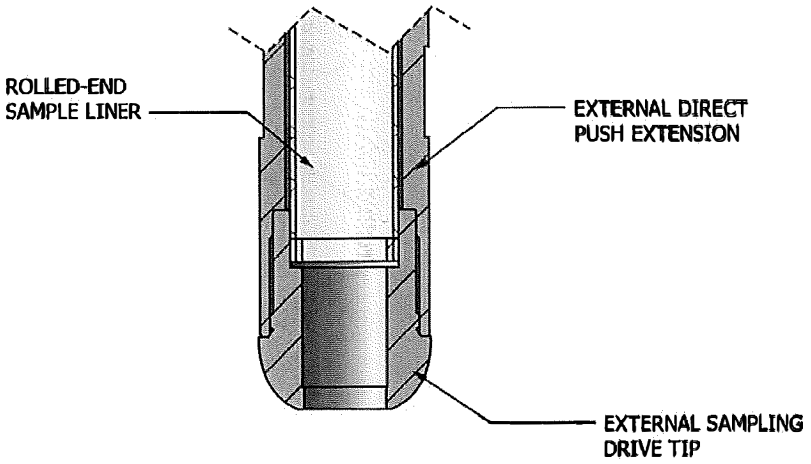

FIG. X1.4 Cutting Shoe for Very Loose Sands and Silts

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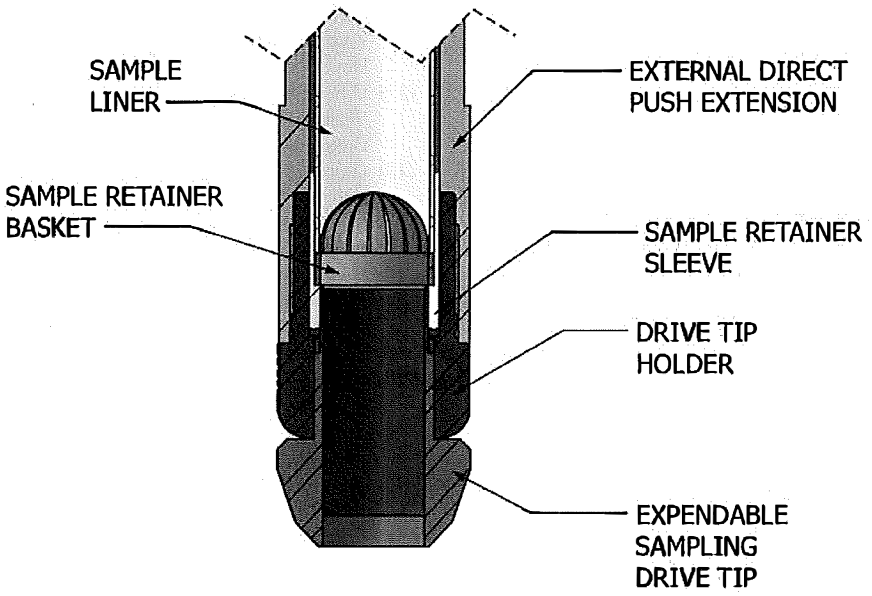

FIG. X1.5 Cutting Shoe for Stiff Over-Consolidated Clays

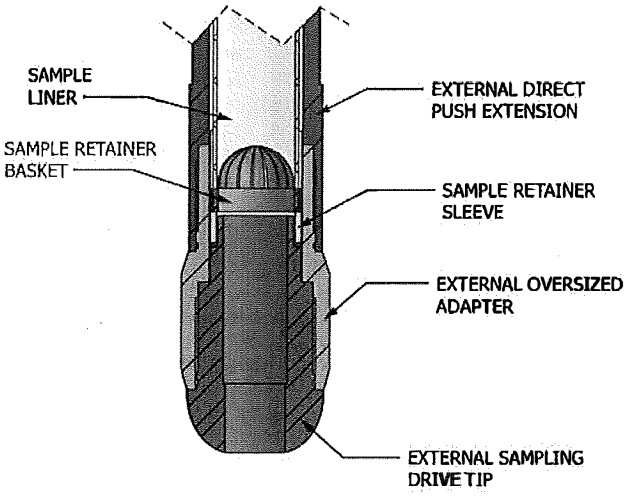

FIG. X1.6 Expendable Cutting Shoe Design for Stiff Clays

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Designation: D 6771 – 02

Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations[1]

This standard is issued under the fixed designation D 6771; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers the method for purging and sampling wells and devices used for ground-water quality investigations and monitoring programs known as low-flow purging and sampling. This method is also known by the terms minimal drawdown purging or low-stress purging. This method could be used for other types of ground-water sampling programs but these uses are not specifically addressed in this practice.

1.2 This practice applies only to wells sampled at the wellhead.

1.3 This practice does not address sampling of wells containing either light or dense non-aqueous-phase liquids (LNAPLs or DNAPLs).

1.4 This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "standard" in the title means that the document has been approved through the ASTM consensus process.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 4750 Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)[2]

D 5088 Practice for Decontamination of Field Equipment Used at Non-Radioactive Waste Sites[2]

D 5092 Practice for Design and Installation of Ground-Water Monitoring Wells in Aquifers[2]

D 5521 Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers[2]

D 5903 Guide for Planning and Preparing for a Ground-Water Sampling Event[3]

D 6026 Practice for Using Significant Digits in Geotechnical Data[3]

D 6089 Guide for Documenting a Ground-Water Sampling Event[3]

D 6452 Guide for Purging Methods for Wells Used for Ground-Water Quality Investigations[3]

D 6517 Guide for Field Preservation of Ground-Water Samples[3]

D 6564 Guide for Field Filtration of Ground-Water Samples[3]

D 6634 Guide for the Selection of Purging and Sampling Devices for Ground-Water Monitoring Wells[3]

3. Terminology

3.1 *drawdown (low-flow purging and sampling), n*—lowering of the water level in a well caused by pumping the well.

3.2 *entrance velocity, n*—the velocity with which formation pore water passes through a well screen during pumping of the well. This velocity should be controlled (held to less than 0.10 ft/s or 3.0 cm/s) to avoid turbulent flow through the screen and to minimize or eliminate deleterious effects on water chemistry and on well construction materials.

3.3 *low flow, n*—refers to the velocity that is imparted during pumping to the formation pore water adjacent to the well screen. It does not necessarily refer to the flow rate of water discharged by a pump at the surface.

4. Summary of Practice

4.1 Low-flow purging and sampling is a method of collecting samples from a well that, unlike traditional purging methods, does not require the removal of large volumes of water from the well. Low-flow purging differs from traditional methods of purging (as described in Guide D 6452) in that its use is based on the observations of many researchers that water moving through the formation also moves through the well

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.21 on Ground-Water and Vadose Zone Investigations.

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[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] *Annual Book of ASTM Standards*, Vol 04.09.

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screen. Thus, the water in the screen is representative of the formation water surrounding the screen. This assumes that the well has been properly designed, constructed, and developed as described in Practice D 5092 and Guide D 5521. In wells in which the flow through the screen or intake zone is limited by hydraulic conductivity contrasts (for example, borehole smearing, residual filter cake, filter pack grain size, or well screen open area), the head difference induced by low-flow pumping provides an exchange of water between the formation and the well. Low-flow purging involves removing water directly from the screened interval without disturbing any stagnant water above the screen. This is done by pumping the well at a low enough flow rate to maintain minimal drawdown of the water column within the well as determined through water-level measurement during pumping. The objective is to pump in a manner that minimizes stress to the ground-water system to the extent practical, taking into account site sampling objectives. Pumping at low rates, in effect, hydraulically isolates the column of stagnant water in the well and negates the need for its removal prior to sample collection. Typically, flow rates on the order of 0.1 to 0.5 L/min are used; however, this is dependent on site-specific and well-specific factors (1). Some very coarse textured formations have been successfully purged and sampled in this manner at flow rates up to 1 L/min. Pumping water levels in the well and water-quality indicator parameters (such as pH, temperature, specific conductance, dissolved oxygen and redox potential) should be monitored during pumping, with stabilization indicating that purging is completed and sampling can begin. Because the flow rate used for purging is, in most cases, the same or only slightly higher than the flow rate used for sampling, and because purging and sampling are conducted as one continuous operation in the field, the process is referred to as low-flow purging and sampling.

5. Significance and Use

5.1 The objective of most ground-water sampling programs is to obtain samples that are representative of formation-quality water. Wells used in ground-water quality investigations or monitoring programs are generally purged of some amount of water in an attempt to obtain a representative sample. For traditional methods of purging (for example, well-volume purging), purging is done to minimize bias associated with stagnant water standing in the casing of the well (above the well screen), which generally does not accurately reflect ambient ground-water chemistry. To use low-flow purging and sampling, a pump intake is set within the well screen and the pump is operated at a low flow rate (generally less than or equal to the natural recovery rate of the well), minimizing drawdown in the well and thus hydraulically isolating the water in the screened zone from the water in the casing. Water pumped in this way comes directly from the screened interval of the well. This obviates the need to purge the stagnant water in the well prior to collecting samples. Access to formation-quality water is confirmed by monitoring water quality parameters to the point at which they stabilize as described in Guide D 6452.

5.2 Low-flow purging and sampling may be used in any well that can be pumped at a constant rate of 1.0 L/min or less without continuous drawdown of the water level in the well (1). It is feasible to implement low-flow purging and sampling in wells in which the water level is always above the top of the well screen, and in wells that are constructed so that the water level is always within the well screen.

5.3 Low-flow purging and sampling can be used to collect samples for all categories of aqueous-phase contaminants and naturally occurring analytes, including volatile and semi-volatile organic compounds (VOCs and SVOCs), metals and other inorganics, pesticides, PCBs, other organic compounds, radionuclides and microbiological constituents. It is particularly well suited for use where it is desirable to sample aqueous-phase constituents that may sorb or partition to particulate matter. It is not applicable to sampling either light or dense non-aqueous-phase liquids (LNAPLs or DNAPLs).

6. Benefits and Limitations of Low-Flying Purging and Sampling

6.1 Purging and sampling at a low flow rate offers a number of benefits over traditional methods including:

6.1.1 Improved sample quality and reduced (or eliminated) need for sample filtration, through minimized disturbance of the well and the formation, which results in reduced artifactual sample turbidity and minimization of false positives for analytes associated with particulate matter;

6.1.2 Improved sample accuracy and precision and greatly reduced sample variability as a result of reduced stress on the formation, reduced mixing of the water column in the well and dilution of analytes, and reduced potential for sample agitation, aeration and degassing or volatilization;

6.1.3 Samples represent a smaller section or volume of the formation, representing a significant improvement in the ability to detect and resolve contaminant distributions, which may vary greatly over small distances in three-dimensional space;

6.1.4 Overall, improved sample reproducibility, especially when using dedicated pumps;

6.1.5 Improved ability to directly quantify the total mobile contaminant load (including mobile colloid-sized particulate matter) without the need for sample filtration;

6.1.6 Increased well life through reduced pumping stress on the well and formation, resulting in greatly reduced movement of fine sediment into the filter pack and well screen;

6.1.7 Greatly reduced purge-water volume, (often 90 to 95 %) resulting in significant savings of cost related to purge water handling and disposal or treatment, and reduced exposure of field personnel to potentially contaminated purge water; and

6.1.8 Reduced purging and sampling time (much reduced at sites using dedicated pumps), resulting in savings of labor cost, depending on the time required for water-quality indicator parameters to stabilize.

6.2 Though the application of low-flow purging and sampling will improve sampling results and produce significant technical and cost benefits at most sites, not all sites, and not all individual wells within a site, are well suited to this approach. Limitations of the method include the following:

6.2.1 On a practical basis, low-flow purging and sampling is generally not suitable for use in very low-yield wells (those that will not yield sufficient water without continued drawdown

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with pumping over time). This limitation is largely a function of the limitations of discharge rates of available pumps and the volume of the flow cell (if used) for indicator parameter measurement;

6.2.2 The need to use a variable flow-rate pump capable of pumping within the desired flow-rate range. Low-flow purging cannot be performed using grab sampling devices, such as bailers, or inertial lift devices, which severely agitate the water column in the well, resulting in significant mixing of the water column and release of considerable sediment, which shows up as increased turbidity in samples.

6.2.3 For some applications, the need to use a flow-through cell, which may increase capital costs, lead to slightly greater set-up time in the field, and add one piece of field equipment.

7. Equipment Requirements for Low-Flow Purging and Sampling

7.1 A variety of pumps capable of pumping at low flow rates may be used for low-flow purging and sampling. Continuous discharge and cyclic discharge pumps work equally well as long as the pump has adjustable flow rate controls and is capable of being run at a low enough flow rate to avoid causing continuous drawdown in the well. Because the purging and sampling processes are joined together into one continuous operation, the pump selected (see Guide D 6634) should be appropriate for use both in purging and sampling the analytes of interest. For example, if VOCs or other pressure-sensitive parameters (for example, dissolved oxygen, carbon dioxide, trace metals) are analytes of interest, peristaltic and other suction-lift pumps should be avoided because they may cause loss of VOCs, degassing and redox and pH changes (2-5).

7.2 Dedicated pumps (those that are permanently installed in the well) are preferred over portable pumps because they eliminate disturbance to the water column in the well resulting in lower turbidity values, shorter purge times and lower purge volumes to achieve stabilized indicator parameter measurements. However, portable pumps can be used if care is taken to minimize disturbance to the water column during pump installation and some time is allowed prior to pump operation for any fines agitated in the water column to settle.

7.3 Grab sampling devices, such as bailers and kemmerer samplers, and inertial-lift devices, cannot be used for low-flow purging and sampling because of the disturbance they cause to the water column in the well and the attendant effects of mixing and increased sample turbidity.

7.4 A volume measuring device (for example, graduated cylinder) and a time piece capable of measuring in seconds will be necessary to calculate the flow rate from the discharge tube from the pump.

7.5 Low-flow purging and sampling requires continuous or periodic water-level measurements (see Test Method D 4750). Any water-level measurement equipment that does not disturb the water column in the well may be used, as long as it provides the accuracy required by the sampling program (generally ±0.01 ft [3 mm]).

7.6 Low-flow purging and sampling requires continuous or periodic measurement of selected water-quality indicator parameters (and, possibly, turbidity) to determine when purging is complete and sampling can commence. Continuous monitoring in a closed flow-through cell of known volume generally provides the most consistent and reliable results, especially for dissolved oxygen and redox potential, and is the preferred method of measuring indicator parameters. However, individual instruments designed to measure the most common water-quality indicator parameters (temperature, pH, and conductivity or specific conductance) may also be used. Dissolved oxygen and redox potential measurements made after the purged water is exposed to atmospheric conditions, however, will not accurately reflect in-situ conditions. All instruments used to measure indicator parameters should be properly calibrated and maintained in accordance with manufacturers' instructions at the well head at the start of each day of sampling and calibration should be checked periodically throughout the sampling event.

7.7 Other equipment and supplies that may be used in low-flow purging and sampling include those items specified by the site-specific sampling and analysis plan (for example, decontamination supplies, sample bottles, filtration media and equipment, preservation supplies, wellhead screening instruments [PID, FID, OVA, combustible gas indicators], sample shipping containers, and field documentation materials [for example, field notebook, field data sheets, chain-of-custody forms, sample bottle labels, shipping documents]).

8. Description of the Procedure

8.1 *General*:

8.1.1 "Low flow" refers to the velocity with which water enters the pump intake and that is imparted during pumping to the formation pore water adjacent to the well screen. This velocity must be minimized to preclude the entrainment of artifactual particulate matter in the water to be collected as a sample. Low-flow does not necessarily refer to the flow rate of water discharged by a pump at the surface, which can be affected by valves, restrictions in the discharge tubing or flow regulators. Some researchers refer to the method as "low-stress" purging, where "low-stress" refers to the impact of pumping the well on the formation. Water-level drawdown provides a measurable indicator of the stress on a given formation imparted by a pumping device operated at a given flow rate. The objective of low-flow purging is to pump in a manner that minimizes stress (drawdown) or disturbance to the ground-water flow system to the extent practical.

8.2 *Preparation for Low-Flow Purging and Sampling*:

8.2.1 Prior to conducting the initial sampling event, the sampling team should prepare themselves and any equipment and materials to be used in the event in accordance with Practice D 5903. Any equipment used in the sampling program that could contact the water in the well, the water collected during field parameter measurement, or the water collected as a sample should be properly cleaned before each use (see Practice D 5088). The clean equipment should not be allowed to contact the ground or other surfaces that could impart contaminants. An effort should be made to closely match the length of the tubing used for portable pumps with the depth at which the pump will be set in the well. Excess tubing can affect the temperature of the water sampled, which could affect sample chemistry (see Guide D 6634). All instrumentation used during low-flow purging and sampling must be properly

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calibrated. Instructions for calibration are specific to the individual instrument and manufacturers' instructions should be followed. The frequency and timing of calibration should be in accordance with the site-specific sampling and analysis plan.

8.3 *Pump Placement:*

8.3.1 In situations where a well is screened or open across a single zone of interest, and that zone is comprised of nearly homogeneous geologic materials, the pump intake should be positioned at or near the mid-point of the well screen. In this type of situation, the water that is withdrawn will likely represent the water quality of the entire screened zone, even at low-flow pumping rates. In situations in which the geology of the screened zone consists of heterogeneous materials with layers of contrasting hydraulic conductivity, the pump intake should be positioned adjacent to the zone of highest hydraulic conductivity (as defined by geologic samples). This provides the preferred flow pathway for ground water, and samples will be drawn primarily from this zone. In situations in which dissolved-phase contaminants of interest are known to concentrate near the top or bottom of the screened zone, it may be desirable to position the pump intake to target this zone.

8.3.2 Care should be taken not to position the pump intake too near the top of the screen in wells in which the water level is above the top of the screen (to avoid drawing in water from storage in the casing), or too near the bottom of the screen (to avoid mobilization and entrainment of settled solids from the bottom of the well). If screen length allows, the pump intake should be at least two feet from the top and two feet from the bottom of the screen.

8.3.3 Portable pumps can be used for low-flow purging and sampling, but the pump must be installed carefully and lowered slowly into the screened zone to minimize disturbance of the water column. Even if done with the utmost care, the installation of a portable pump will result in some mixing of the water column above the well screen with that within the screened interval, and the release of some suspended material. This usually requires pumping for a longer period of time to achieve stabilization of indicator parameters and turbidity. Ideally the pump should remain in place prior to operation until any turbidity resulting from pump installation has settled out and until horizontal flow through the well screen has been reestablished. Carefully lowering the pump intake to the appropriate position in the well screen, then completing preparation of other equipment and materials to be used in the sampling event often allows sufficient time for reduction of initial turbidity to acceptable levels. If, after the pump is started, initial turbidity readings are high (for example, >100 NTU) and reducing the pumping rate does not result in lower readings after a few minutes, it may be necessary to stop the pump and allow turbidity to settle for an hour or more. The time required for turbidity to settle is well-specific and should be determined on a well-by-well basis.

8.4 *Pumping Rate:*

8.4.1 In general, the pumping rate used during low-flow purging and sampling must be low enough to minimize mobilization and entrainment of particulate matter that is not naturally mobile (for example, artifactual particles) under ambient, non-pumping conditions and to minimize hydraulic stress on the well and the formation (for example, to minimize drawdown and to eliminate inclusion of stagnant water from the casing in the sample).

8.4.2 Because each well screen is installed in a hydraulically unique position, and because of differences in the effects that drilling and well development may have had on the borehole and adjacent formation, the hydraulic performance of each well will be different. This means that the pumping rate used for low-flow purging and sampling should be determined on a well-specific basis. It is not appropriate to assess one well in a network of wells and apply the low-flow purging and sampling techniques and rates from that one well to all of the wells in the network. If possible, the optimum pumping rate for each well should be established in advance of the initial sampling event. For newly installed wells, this can be done immediately following well development by running a short-term single well pilot test ideally using the same pump that will be used for low-flow purging and sampling. Once the optimum pumping rate is established for a given well, the same pumping rate can be used for that well for each sampling event, provided well performance does not vary over the life of the well.

8.4.3 To determine the appropriate pumping rate for any given well, the following procedure is recommended. After the pump intake is properly set in the well, the pump should be started at a low pumping rate, generally 100 mL/min or less. For pumps that cannot achieve a flow rate this low, start the pump at the lowest flow rate possible. From the time the pump is started, the water level in the well should be measured (see 8.5) to determine the amount of drawdown caused by pumping. If drawdown is rapid and continuous, the pumping rate should be lowered until drawdown decreases and stabilizes. If drawdown is very slow or imperceptible, the pumping rate may be raised slowly and adjusted to the point at which drawdown stabilizes. The maximum pumping rate used for sampling should not exceed the rate used for purging. Increases in pumping rates may induce increases in turbidity (6-9).

8.5 *Drawdown and Water-Level Measurement:*

8.5.1 Prior to installing a portable pump in the well or prior to the commencement of pumping in wells in which dedicated pumps are installed, an initial water level measurement should be obtained.

8.5.2 Measurement of the water level in the well during purging, on either a continuous or periodic basis, is critical to establishing the optimum flow rate for purging and to determining the stress placed on the well by pumping. The goal is to achieve a stabilized pumping water level as quickly as possible with minimal drawdown. Continuous water-level measurements may be made using devices such as downhole pressure transducers, bubblers or acoustic tools; periodic measurements may be made with electric tapes, poppers or ploppers or other devices as described in Test Method D 4750. Measurement accuracy of the device used should be in accordance with that specified in the sampling and analysis plan (generally ±0.01 ft [3 mm]). Water-level measurements should be taken every one to two minutes to the point at which the water level in the well has stabilized, or at which drawdown ceases. Pumping rate (see 8.4) may need to be adjusted to allow the water level to stabilize.

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8.5.3 After the water level in the well has stabilized, water-level measurements can be discontinued. Once the optimum pumping rate is established for the well, it may be necessary to periodically monitor the water level during subsequent purging and sampling events, more frequently iff a significant difference in well performance (generally signified by an increase in drawdown over time) is noted in subsequent sampling events.

8.5.4 Several researchers have proposed limits on the amount of drawdown that should be allowed before water-level stabilization occurs, but none have provided any scientific rationale for the proposed limits. For example, Puls and Barcelona suggest a limit of less than 0.1 m (0.33 ft or about 4 in.) drawdown for all wells, conceding that this goal may be difficult to achieve under some conditions due to geologic heterogeneities within the screened interval, and may require adjustment based on site-specific conditions and personal experience (1). In practical terms, allowable drawdown should never exceed the distance between the top of the well screen and the pump intake, which is normally positioned near the mid-point of the screen. To provide a safety factor, drawdown should generally not exceed 25 % of this distance to ensure that no water stored in the casing prior to purging is drawn down into the pump intake and collected as part of the sample.

8.6 *Measurement of Water Quality Indicator Parameters and Turbidity*:

8.6.1 Water-quality indicator parameters should be measured to determine when purging is complete and sampling can commence. In wells in which the pump intake is set in the screen and operated at a rate less than the natural recovery rate of the well, stabilized water chemistry indicates that formation-quality water is being pumped and, therefore, that conditions are suitable for sampling (1). The water quality parameters that are most easily measured in the field and that provide evidence that formation-quality water is being provided include: pH, conductivity (or specific conductance), dissolved oxygen and oxidation-reduction potential (redox or ORP, also measured as Eh).

8.6.2 Water-quality indicator parameters can be monitored on either a continuous or periodic basis, though continuous monitoring in a closed flow-through cell provides the most consistent and reliable results, particularly for dissolved oxygen and redox potential. Indicator parameters are considered stable when three consecutive readings made several minutes apart fall within the ranges presented in Table 1.

8.6.3 While the criteria in Table 1 are reasonable criteria for many hydrogeochemical situations, it should be recognized that firm criteria may not be appropriate for other situations because of factors including variability in aquifer properties, monitoring well hydraulics, and natural spatial and temporal variation in ground-water chemistry and contaminant distribution. Therefore, the criteria in Table 1 should be compared to well-specific measurements to determine iff the site-specific criteria need to be adjusted. Additionally, these criteria should be evaluated to select those that are most important and relevant to meeting the sampling objectives for the specific site. Not alll criteria need to be met for alll sites. Stabilization criteria that are too stringent may unnecessarily lead to the generation of large amounts of contaminated purge water without providing the benefit of ensuring that the samples are any more representative.

TABLE 1 Example Criteria for Defining Stabilization of Water-Quality Indicator Parameters

Parameter	Stabilization Criterion
pH	±0.2 pH units[A]
Conductivity	±3 % of reading
Dissolved Oxygen	±10 % of reading or ±0.2 mg/L, whichever is greater[A]
Eh or ORP	±20 mV[A]

[A] Related to the measurement accuracy of commonly available field instruments.

8.6.4 For in-line flow-through cells, the frequency of the measurements should be based on the time required to completely evacuate one volume of the cell, to ensure that independent measurements are made. For example, a 500 mL cell in a system pumped at a rate of 250 mL/min will be evacuated in 2 min so measurements should be made at least 2 min apart. It is important, therefore, that the sampling team establish the following volumes and rates in the field prior to the sampling event: (*1*) Volume of the pump and discharge tubing; (*2*) Optimum pump discharge rate; and (*3*) Volume of the flow-through cell corrected for displacement volume of the field parameter measurement instrumentation installed inside the flow-through cell. It is also important to know the manufacturer's recommendations for the amount of time to allow individual sensors being used to measure field parameters (for example, dissolved oxygen) to stabilize to ensure that representative data are being collected.

8.6.5 For wells in which dedicated pumps are used, chemical indicator parameters tend to stabilize more readily because there is minimal disturbance of the water column in the well. For wells in which portable pumps are used, the effects of pump installation on the water column usually result in the need to remove significantly more water before chemical indicator parameters (and, as noted below, turbidity) reach stabilization.

8.6.6 Though not a chemical parameter, and not indicative of when formation-quality water is being pumped, turbidity may also be a useful parameter to monitor. Turbidity is a physical parameter that provides a measure of the suspended particulate matter in the water being pumped. Turbidity may be most indicative of pumping stress on the formation. Sources of turbidity in monitoring wells can include: (*1*) Naturally occurring colloid-sized or larger solids that may be in transit through the formation; (*2*) Naturally occurring solids or artifactual solids from well drilling and installation (for example, drilling fluids, filter pack, grout) that have not been effectively removed by well development and are mobilized by agitation of the water column (that is, by bailing, by installation of a portable pump, or by overpumping the well); (*3*) Microbial growth that often occurs within monitoring wells in the presence of certain types of contaminants (that is, petroleum hydrocarbons); and (*4*) Precipitation caused by different redox conditions in the well than in the aquifer. Turbidity levels elevated above the natural formation condition can result in biased analytical results for many chemical parameters. Naturally occurring turbidity in some ground water can exceed 10 NTU (1) and

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may be unavoidable. Turbidity in a properly designed, constructed and developed well is most often a result of significant disturbance of the water column or excessive stress placed on the formation by overpumping.

8.6.7 To avoid artifacts in sample analysis, turbidity should be as low as possible when samples are collected.[4] Turbidity measurements should be taken at the same time that chemical parameter measurements are made, or, at a minimum, once when pumping is initiated and again just prior to sample collection, after indicator parameters have stabilized. The stabilization criterion for turbidity is ±10 % of the prior reading or ±1.0 NTU, whichever is greater. If turbidity values are persistently high, the pumping rate should be lowered until turbidity decreases. If high turbidity persists even after lowering the pumping rate, the pump may have to be stopped for a period of time until turbidity settles, and the purging process restarted. If this fails to solve the problem, well maintenance or redevelopment may be necessary. Difficulties with high turbidity should be identified during pilot tests prior to implementing low-flow purging or during the initial low-flow sampling event, and contingencies should be established to minimize the problem of elevated turbidity.

8.7 *Sample Collection Following Purging:*

8.7.1 After drawdown and chemical indicator parameters stabilize, sampling can begin per the site's approved sampling and analysis plan. If an in-line flow-through cell is used to continuously monitor chemical indicator parameters, it should be disconnected or bypassed during sample collection. The pumping rate may remain at the established purging rate or it may be adjusted downward to minimize aeration, bubble formation, or turbulent filling of sample bottles. For most parameters, sampling rates of less than 500 mL/min are appropriate (1). Sampling rates for the most sensitive parameters (for example, VOCs) should be lower (generally less than 250 mL/min). Generallly, the most sensitive parameters, or those that are of greatest interest at the site, should be sampled first; analyses that require filtration should be sampled last (1). Sample filtration (see Guide D 6564), preservation (see Guide D 6517), handling, shipping and documentation (see Guide D 6089) should be consistent with procedures documented in the approved site-specific sampling and analysis plan.

[4] The primary reason for minimizing turbidity during purging and sampling is that turbidity can affect the aqueous phase concentration of the analytes of interest for both organic and inorganic analytes. The accurate analysis of aqueous-phase inorganic analytes can be affected by stripping of cations, particularly metal species, from the surface of suspended inorganic particulate matter (for example, clays) by the sample preservation process (acidification). The accurate analysis of hydrophobic organic compounds can be affected by the presence of both organic and inorganic particulate matter. In addition, analysis of aqueous-phase organic analytes can be hampered by the physical presence of suspended solids (that is, causing clogging of the nebulizer on the analytical equipment).

9. Reporting

9.1 The procedures and equipment used during low-flow purging and sampling must be documented in the field. Specific guidance on documenting a ground-water sampling event is provided in Guide D 6089. Field data specific to low-flow purging and sampling that should be recorded includes:

9.1.1 Equipment calibration;
9.1.2 Equipment decontamination;
9.1.3 Equipment configuration for purging and sampling;
9.1.4 Pump placement (relative to well screen position and static water level);
9.1.5 Initial static water level;
9.1.6 Initial pumping rate;
9.1.7 Drawdown measurements;
9.1.8 Stabilized pumping water level;
9.1.9 Final pumping rate;
9.1.10 Water quality indicator and turbidity measurements;
9.1.11 Times for all measurements; and
9.1.12 Sampling flow rate.

10. Keywords

10.1 ground water; ground-water monitoring; ground-water quality; ground-water sampling; indicator parameters; low-flow purging; low-stress purging; micropurging; minimal drawdown purging; purging; water quality monitoring

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Designation: D6911 – 15

Standard Guide for Packaging and Shipping Environmental Samples for Laboratory Analysis[1]

This standard is issued under the fixed designation D6911; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This standard provides guidance on the selection of procedures for proper packaging and shipment of environmental samples to the laboratory for analysis to ensure compliance with appropriate regulatory programs and protection of sample integrity during shipment.

1.2 This standard does not address transport of hazardous wastes for disposal purposes.

1.3 This standard does not address the selection of parameter-specific sample bottles or containers.

1.4 This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This guide cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances. This guide is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this guide be applied without consideration of the many unique aspects of a project. The word "standard" in the title of this guide means only that the guide has been approved through the ASTM consensus process.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory requirements prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D4220 Practices for Preserving and Transporting Soil Samples

D4840 Guide for Sample Chain-of-Custody Procedures

D5079 Practices for Preserving and Transporting Rock Core Samples

D5903 Guide for Planning and Preparing for a Groundwater Sampling Event

D6089 Guide for Documenting a Groundwater Sampling Event

D6517 Guide for Field Preservation of Groundwater Samples

2.2 *Shipping Regulations:*

International Air Transport Association (IATA) Dangerous Goods Regulations, 56th Edition, January 2015, or current edition

International Atomic Energy Agency (IAEA) Regulations for the Safe Transport of Radioactive Material, Section 10, Publication IAEA TS-R-1 (2005), or current edition

International Civil Aviation Organization (ICAO) Technical Instructions for the Safe Transport of Dangerous Goods by Air, Document #9284-AN/905 (2013-2014 edition), or current edition

United States Government Printing Office, Title 40 Code of Federal Regulations Resource Conservation and Recovery Act (RCRA), Part 261

United States Government Printing Office, Title 49 Code of Federal Regulations Transportation (DOT), Parts 170-174

United States Postal Service, Hazardous, Restricted and Perishable Mail USPS Publication 52 (Updated May 15, 2014), or current edition

3. Terminology

3.1 For definitions of common terminology terms used within this guide, refer to Terminology D653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *carrier*—a commercial company that is responsible for the actual shipment of environmental samples from the point of sample receipt from the shipper to the sample's final destination.

3.2.2 *dangerous goods*—those goods that meet the criteria of one or more of nine United Nations (UN) hazard classes

[1] This guide is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.21 on Groundwater and Vadose Zone Investigations.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

*A Summary of Changes section appears at the end of this standard

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and, where applicable, one of three UN packaging groups according to the provisions of shipping regulations.

3.2.3 *environmental sample*—containerized liquids, solids or gases that are collected for the purpose of laboratory analysis.

3.2.4 *inner packaging*—packaging for which an outer package is required for transport (for example, a sample bottle or container).

3.2.5 *outer packaging*—the outer protection of a composite or combination packaging together with any absorbent materials, cushioning and any other components necessary to contain and protect sample bottles or inner packaging.

3.2.6 *shipper*—the person who actually packages and presents environmental samples to a commercial carrier for shipment or who personally transports samples. The shipper is commonly the person who collected the environmental samples.

3.2.7 *shipping*—the commercial or private transport of environmental samples via highway, rail, vessel or aircraft.

4. Significance and Use

4.1 This standard provides guidance in determining the most appropriate procedures for packaging and shipping environmental samples. Use of this guide by personnel involved in packaging and shipping environmental samples will facilitate safe, effective and compliant procedures.

4.2 Due to the changing nature of regulations and other information, users are advised to thoroughly research requirements related to packaging and shipping prior to initiating a sampling event that will require shipment of the samples.

5. Regulatory Requirements

5.1 The shipment of many environmental samples falls under the jurisdiction of national and standardized international regulations whenever samples exhibit one or more properties that classify the samples as being dangerous or hazardous. Not all environmental samples, however, satisfy the criteria for being classified as dangerous or hazardous substances. These samples can be packaged and shipped as non-regulated or non-hazardous environmental samples.

5.2 It is the shipper's responsibility to determine which regulations apply to the environmental samples requiring shipment. This determination must be made prior to sample collection to ensure compliance with shipping regulations at the conclusion of sample collection. The primary sources of shipping regulations that can apply to environmental samples in the United States include the U.S. Department of Transportation (DOT), the International Air Transport Association (IATA), and the U.S. Postal Service (USPS). DOT regulations govern transport of samples by water, rail, roadway and air; IATA regulations govern air transport of samples; USPS regulates both ground and air delivery of samples through the U.S. Postal System. Other agencies such as the U.S. Department of Agriculture (USDA) (restrictions on interstate shipment of soil samples to prevent the spread of biological contaminants), The International Atomic Energy Agency (IAEA) (transport of radioactive materials by air), the International Civil Aviation Organization (ICAO) (shipment of the dangerous goods by air). The International Maritime Dangerous Goods Code (shipment by vessel) may also need to be considered. Sample shippers must also be aware of the potential for restrictions on shipping samples at both the state and local levels. Shippers should contact state and local agencies to determine any shipping restrictions. Other countries may have additional or equivalent agencies and regulations.

5.3 Should dangerous or hazardous samples be shipped using methods not in full compliance with applicable regulatory requirements, the following penalties can be assessed to the shipper:

5.3.1 Refusal to deliver the environmental samples to their intended destination, which can result in sample integrity being compromised, chain-of-custody being broken, or sample holding times being exceeded;

5.3.2 Assessment of financial penalties which can be severe; and/or

5.3.3 Imprisonment for blatant illegal shipment of dangerous or hazardous substances.

6. Procedures for Packaging and Shipping Environmental Samples

6.1 *Planning*—As indicated in Guide D5903, the Sampling and Analysis Plan (SAP) for a project will specify the number of samples to be collected for each medium being sampled (for example, soil, groundwater, surface water, soil gas, sediment and corresponding quality control samples). This SAP will also include a discussion on the need to plan for the appropriate number, size(s), and type(s) of outer packaging based on the number and sizes of sample containers to be filled and to plan for adequate space in outer packaging to accommodate inner packing materials and temperature controls. The SAP will specify the analyses to be performed on each sample and should also indicate the type of sample bottle or container and volume required for each analyte. The SAP should also provide guidance on selection of the methods for sample packaging and shipment of samples to the laboratory for analysis when dangerous or hazardous samples are anticipated.

6.2 *Regulatory Responsibilities of the Shipper*—The sample shipper is responsible for ensuring that all environmental samples are packaged, labeled, and marked in a manner that is consistent with applicable shipping regulations. Failure to do so puts the shipper at risk of the penalties discussed in 5.3.

6.3 *Determination of Dangerous or Hazardous Properties of Environmental Samples:*

6.3.1 Prior to collection of environmental samples, it is necessary to determine the hazard class of a sample. If this is unknown, the shipper must use best professional judgment to determine the potential for samples to exhibit one or more hazardous characteristics (for example, through background research review, interviews and review of purchasing and disposal records) and to determine the appropriate degree of danger associated with those hazardous properties as defined by applicable shipping regulations (see Note 1). Table 1 summarizes the nine United Nations (UN) hazard classes that are defined within shipping regulations and provides three

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TABLE 1 Summary of United Nations Hazard Classes

Class 1	Explosives
Class 2	Gases
Class 3	Flammable Liquids
Class 4	Flammable Solids; Substances Liable to Spontaneous Combustion; Substances Which, in Contact with Water, Emit Flammable Gases (for example, soil sample contaminated with high concentrations of gasoline released from an underground storage tank)
Class 5	Oxidizing Substances and Organic Peroxide
Class 6	Toxic and Infectious Substances (for example, samples of refuse collected from a solid waste landfill)
Class 7	Radioactive Material
Class 8	Corrosives (for example, nitric acid used for preservation of some groundwater samples) (see Note 2)
Class 9	Miscellaneous Dangerous Goods

examples of environmental samples that might meet the criteria of a given hazard class. Table 2 summarizes the degree of hazard associated with dangerous goods being shipped as defined by applicable shipping regulations.

NOTE 1—Dangerous or hazardous properties of environmental samples are as defined specifically by shipping regulations. Definitions developed for use under other regulatory programs may be substantially different and are not applicable. For example, a corrosive liquid under IATA definition is "a substance which, in the event of leakage, can cause severe damage by chemical action when in contact with living tissue or can materially damage other freight or the means of transportation." This is determined through a series of intact skin tissue exposure tests and/or corrosive tests on steel or aluminum for defined exposure periods. Under the Resource Conservation and Recovery Act (RCRA), a corrosive liquid is defined as a liquid with a pH less than or equal to 2 or greater than or equal to 12.5, as determined by a pH meter using EPA Method 9090.

NOTE 2—In a letter dated April 11, 1979, the Associate Director for Hazardous Materials Regulation of the Research and Special Programs Administration granted exception to the DOT hazardous materials regulations for water samples containing the corrosives: hydrochloric acid, mercuric chloride, nitric acid, sulfuric acid, sodium hydroxide and phosphoric acid. The listed corrosives include the preservatives commonly used in water samples. This exception was revalidated in a letter first issued on April 11, 1979, reconfirmed on December 13, 1993 and again in a letter dated February 14, 1997, and February 2003 and in Interpretation #08–0222 dated October 2, 2008. This exception may not apply in other shipping regulations. When in doubt, consult the regulations, interpretations, and exemptions in place for the materials and quantities in question.

6.3.1.1 When the actual hazard class of a sample is unknown, the most conservative packaging group possible for the chosen shipping name must be used. Refer to 6.4.1 for guidance on choosing the appropriate shipping name.

6.3.2 It is possible that environmental samples may not exhibit a dangerous or hazardous property and, as such, may be packaged and shipped as a non-regulated sample using methods described in 6.5 and 6.6. Other packaging and shipping guidance is provided in Practices D4220, D5079, and D6517.

6.3.3 The shipper must make the determination of sample hazard prior to collection to ensure that an appropriate carrier has been selected to transport samples to the laboratory and to ensure that appropriate packaging materials are available in the field at the time of sample preparation for shipping.

TABLE 2 Summary of Packing Groups By Hazard Level

Packing Group I—High (Great) Danger
Packing Group II—Medium Danger
Packing Group III—Low (Minor) Danger

6.4 *Determination of Proper Shipping Name and UN Number for Dangerous or Hazardous Samples:*

6.4.1 Once the shipper has determined that an environmental sample does or will likely exhibit one or more hazardous characteristics, the shipper must select the "proper shipping name" for the sample as defined by the regulations under which the sample is to be shipped (see Table 3). These shipping names are standard names used in the shipping industry to identify the dangerous article or substance on the outside of the package and on the "Shipper's Declaration for Dangerous Goods" and are not names created at random by the shipper. To determine the proper shipping name for each environmental sample, the shipper must refer to the shipping regulations that will be followed directly. It is possible for there to be more than one shipping name. The selected shipping name must accurately reflect the chemical, physical or biological characteristics of the sample being shipped and must not include a Trade name.

6.4.2 When selecting the proper shipping name, the shipper must consider:

6.4.2.1 The dangerous or hazardous property of the sample,

6.4.2.2 If the sample is classified as a solid (for example, soil or sediment), liquid (for example, groundwater or surface water) or gas (for example, soil gas or atmospheric air),

6.4.2.3 The anticipated or known contaminant(s) contained in the sample,

6.4.2.4 Whether the contaminant is present in a pure form or a mixture, and

6.4.2.5 The preferred method of sample shipment (for example, ground transportation versus overnight air transportation).

6.4.3 Once selected, the proper shipping name is used by the shipper to obtain the following information from the appropriate shipping regulations:

6.4.3.1 The corresponding UN number,

6.4.3.2 Correct sample packaging (inner and outer packaging),

6.4.3.3 Required package labels and markings,

6.4.3.4 Restrictions on sample volumes per package,

6.4.3.5 Applicable exceptions for small quantity shipments (see Note 3), and

6.4.3.6 Available shipping options (for example, passenger versus cargo aircraft).

TABLE 3 Examples of Proper Shipping Names and Associated UN Numbers

Proper Shipping Name/ Description	UN Number	Example of Environmental Sample
Flammable solid, organic, n.o.s.	1325	Soil sample saturated with gasoline
Nitric acid	2031	Sample preservative that is other than red fuming, with 70 % or less, but more than 20 % nitric acid
Refrigerant gas, n.o.s. (Tetrafluoromethane, Trifluoromethane)	1078	Surface water sample containing mixture of Freon 14™ and Freon 23™

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NOTE 3—In some cases, very small quantities of dangerous goods may be transported in such a manner that they may be excepted from the marking, labeling and documentation requirements of dangerous or hazardous materials. Actual definitions of excepted small quantities vary by hazard class, carrier and, in some circumstances, by state. Typically, shipments under these exceptions do require accepted packaging, and the package must be appropriately marked and labeled as specified by the regulations being followed. For example, small quantity exceptions exist for corrosive liquids (Class 8, Packing Groups II and III) which can be applied when shipping vials, ampoules or pre-preserved bottles containing nitric acid preservatives to the field.

6.5 *Selection of Shipping Method:*

6.5.1 Once the hazardous or dangerous nature of an environmental sample has been determined by the shipper, and the shipping name has been selected, the method of shipment must be determined. For both non-regulated and hazardous or dangerous environmental samples, the following sample options must be evaluated by the shipper for applicability and compliance with shipping regulations:

6.5.1.1 Direct sample delivery by the sampling team to the laboratory,

6.5.1.2 Sample pickup and subsequent delivery by a laboratory-provided courier,

6.5.1.3 Commercial overnight carriers,

6.5.1.4 Public transportation systems (for example, public buses, ferries, passenger aircraft),

6.5.1.5 Commercial ground transportation carriers, and

6.5.1.6 Delivery options (for example, overnight, three-day etc.).

6.5.2 Each method presented in 6.5.1 must be evaluated with regard to the:

6.5.2.1 Potential for sample breakage and loss due to carrier handling practices,

6.5.2.2 Potential for sample tampering during shipment,

6.5.2.3 Sample delivery time versus sample holding time,

6.5.2.4 Ability to maintain sample chain-of-custody procedures,

6.5.2.5 Compliance with regulatory requirements for dangerous or hazardous samples,

6.5.2.6 Existence of any regulatory restrictions, limitations or exceptions

6.5.2.7 Carrier-specific variances on shipping regulations (see Note 4), and

6.5.2.8 Locations of drop-off stations accepting dangerous or hazardous samples for shipment.

6.6 *Selection of Proper Sample Packaging and Packing Procedures:*

6.6.1 *Packaging Non-Regulated or Non-Hazardous Samples for Shipment*—The shipper is responsible for all aspects of the packaging of samples for shipment to the laboratory. In cases where samples have been determined to be non-hazardous or unregulated, samples should be packaged in a manner that will protect both the physical and chemical integrity of the samples during transport to the laboratory as described in Practices D4220, D5079, D6517, and Guide D5903. Sample packaging should be selected with the following considerations in mind:

6.6.1.1 *Total Weight of the Final Package Once Filled With Samples*—The weight of the empty package should be such that, once filled with samples, the final package weight will not be so great that it will be too difficult to move and may exceed standard per-package weight limits for shipping.

NOTE 4—The shipper must be aware that commercial sample carriers must comply with all shipping regulations, but that carriers are permitted to develop and enforce company-wide variations that are more restrictive than regulations. The shipper must know what these carrier-specific variances are because they can affect whether a sample can be accepted for shipping, and if, accepted, in what quantity.

6.6.1.2 *Package Volume*—The package should be sufficiently large to hold a reasonable number of sample containers or bottles without exceeding weight limitations.

6.6.1.3 *Ability to Securely Seal the Package*—For some projects, it is necessary to implement a program of sample tamper-proofing which involves the use of security seals and tags on both the sample container or bottle as well as the outer packaging materials.

6.6.1.4 *Leak-proof Package*—When shipping liquid samples or samples packed on wet ice, it is necessary to prevent the release of any liquids in the event of sample container breakage or melting of wet ice. Leakage can be prevented by lining the inside of the outer package with plastic, placing individual sample containers or bottles inside sealed plastic bags, ensuring that outer drain plugs are sealed shut, and placing wet ice inside two bags, at least one of which can be tied closed.

6.6.1.5 *Insulation*—For parameters that require shipment below a specific temperature, it is essential that the outer package be sufficiently insulated to minimize changes in sample temperature during shipment. This is especially true when the shipping period is longer than overnight.

6.6.1.6 *Ease of Handling*—Outer packages may become heavy and awkward once filled, making them difficult to maneuver. It may be preferable to use containers with handles on larger packages, although some carriers assess additional fees if packages have handles.

6.6.1.7 *Materials of Construction*—Package materials should be durable, easy to clean, should not introduce either positive or negative sample bias to the samples, and should be able to hold the weight of the samples being shipped. Materials of construction should be non-absorbent.

6.6.1.8 *Durability and Reusability*—When shipping non-regulated or non-hazardous samples, it is acceptable to reuse shipping packages, such as coolers. Selected packages must be strong enough to retain all structural integrity.

6.6.1.9 *Ease of Cleaning*—The shipping package should be designed so it is easy to access the interior for cleaning.

6.6.2 *Packing Non-Regulated or Non-Hazardous Samples for Shipment*—Once collected, labeled and ready to ship to the laboratory, the shipper must pack the sample containers in a manner to ensure that the physical and chemical integrity of the samples are protected. The shipper must take the following into account when packing these samples for shipment:

6.6.2.1 *Sample Container Breakage*—There are many different materials that can be used to pack sample containers to prevent breakage during shipment. Examples include: bubble wrap, protective sleeves or foam blocks over individual containers, and expanded polystyrene peanuts. Containers

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should be packed with enough packing material to ensure that containers do not bang against each other or move freely during shipment.

6.6.2.2 *Protection of Sample Labels*—When shipping samples that are liquid or that are being shipped on wet ice, it is important to prevent sample labels from getting wet. Wetting the labels can cause the ink to run or fade, disintegration of the label, or the label to come off the container. It is a common practice to use waterproof labels and indelible ink. Various measures can be taken to prevent or reduce water contact with the labels such as placing a single layer of clear packing tape over the labels.

6.6.2.3 *Preventing Leakage from Outer Packaging*—No liquids should leak from the outer packaging as the result of sample container breakage, condensation on containers or release of melted wet ice. It is recommended that absorbent materials be placed on the bottom of the outer packaging, between sample containers, and on the top of all containers within the outer packaging once filled. This will help secure sample containers within the outer packaging and will absorb any free liquids. It is also recommended that any outside drain plugs be secured shut. It may also be appropriate to place individual sample containers in a zipper-seal bag within the outer packaging to act as secondary containment for the sample in the event of container breakage. Some containers are coated with a plastic film to prevent leakage of sample in the event the container is broken.

6.6.2.4 *Temperature Control*—For some samples, it is necessary to ship samples below 4.0°C. As discussed in Practice D6517, it is recommended that wet ice be used for this purpose. Sufficient ice should be used to cool and maintain samples at the desired temperature until receipt by the laboratory. It is recommended that all wet ice be double-bagged to contain melt water and that at least one bag should be sealed with a knot which will not fail under pressure changes when being shipped by aircraft.

6.6.2.5 *Labeling the Outer Packaging*—Regulations do not specify any particular requirements for the outer packaging of non-regulated samples. It is necessary to include the complete ship to and return addresses including telephone numbers. Optional, but recommended labeling includes: "Fragile," "This Side Up," and "Packed in Wet Ice," especially when a commercial carrier is shipping samples. It is also recommended by some carriers that a Shipper's Declaration be placed on the outside of the outer packaging that indicates why samples are being shipped as a non-regulated substances. This can prevent unnecessary opening of the outer packaging by shipping officials that could compromise any security tags or seals in use. This Shipper's Declaration must be signed and dated by the shipper. (see Note 5).

6.6.3 *Packaging Dangerous or Hazardous Samples for Shipment*—Environmental samples that are dangerous or hazardous in nature must be packaged according to the specifications of the selected shipping regulations (Federal, International, state or local) and in compliance with carrier variance requirements. Packaging of environmental samples includes not only the sample bottle or container that is specified by the laboratory's analytical method, but also includes inner and outer packaging materials. It is the shipper's responsibility to ensure that the packaging complies with Packing Group requirements, as specified by the shipping regulations, for the hazard associated with the samples being shipped. Only those packaging materials permitted by regulation are to be used and inner and outer packaging materials cannot be reused. Shippers need to be aware that there are restrictions on the number and weight of samples permitted per package and that these limits cannot be exceeded under any circumstance. The shipper must ensure that all packaging materials are assembled correctly and that all required labels and markings are presented on the outer packaging. When shipping materials under the small quantities exception rule, a Dangerous Goods in Small Quantities Label must be used as illustrated in Fig. 1.

NOTE 5—A Shipper's Declaration is a statement made in writing by the shipper that explains what the contents of the package being shipped are and why the shipment is considered unregulated or non-hazardous. The statement is dated and signed by the shipper and includes a telephone number for the shipper.

7. Timing of Sample Packaging and Shipment

7.1 *Timing of Sample Packaging*—All environmental samples should be packaged in the field after sample collection and labeling. It may be necessary to cool some water samples to 4.0°C prior to final packaging as discussed in Practice D6517.

7.2 *Timing of Sample Shipment*—Environmental samples should be shipped in time to assure the arrival of the samples at the laboratory prior to the expiration of the holding time for the analytical parameters of interest The holding time is specified by the analytical method being used in the laboratory and can vary from hours to months depending upon the parameter. Scheduling of sample shipments should be coordinated with the laboratory as discussed in Guide D5903.

8. Documentation

8.1 *Chain-of-Custody*—In many circumstances, a Chain-of-Custody form should accompany environmental samples being submitted to a laboratory regardless of the hazard classification of the samples. Chain-of-Custody forms should be completed as described in Guide D6089. The original Chain-of-Custody form should be included in the outer packaging of samples and contained within a water-proof package to prevent it from becoming wet during sample shipment. A copy of the Chain-of-Custody should be retained by the shipper. Guide D4840 provides a standardized Chain-of-Custody form.

8.2 *Laboratory-Specific Forms*—In some programs, individual laboratories may have special forms that must accompany samples. These can include project contact information forms and analytical request forms.

8.3 *Shipping Manifests:*

8.3.1 If samples are being shipped as non-regulated or non-hazardous samples, standard shipping labels, forms and air bills can be used on outer packages. Although not required, it is recommended that outer packages be marked with "This Side Up" arrows to help minimize sample breakage due to mishandling of the package and that a Shipper's Declaration be placed on the exterior of the outer packaging to indicate why

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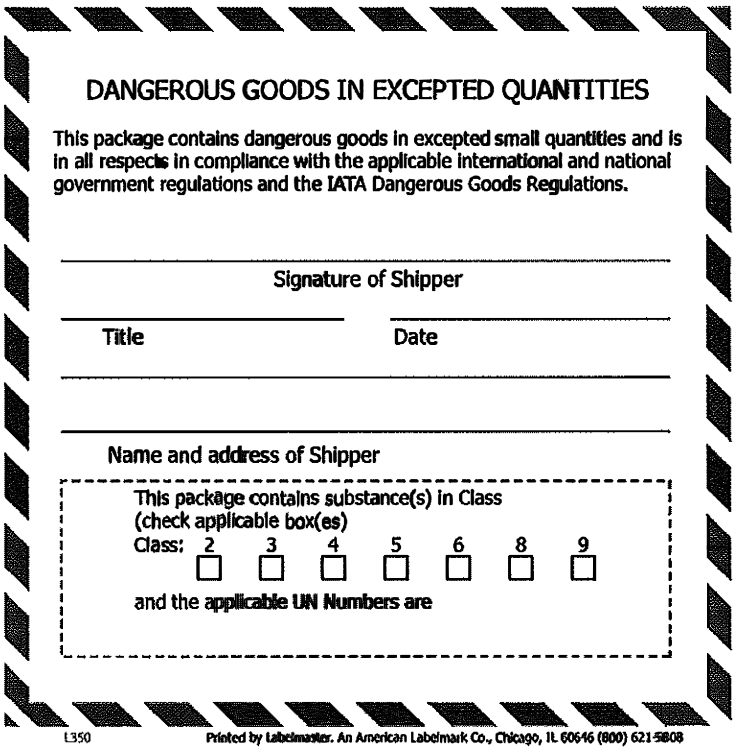

FIG. 1 Example of Small Quantities Exception Label

samples are being shipped as non-regulated substances. The shipper should retain the shipper's copy of any manifest and should have a copy of any tracking, delivery confirmation or air bill numbers.

8.3.2 When shipping dangerous or hazardous samples, the shipper must complete the appropriate dangerous goods/hazardous materials manifests. The shipper should retain the shipper's copy of any manifest and should have a copy of any tracking, delivery confirmation or air bill numbers.

8.4 *Verification of Sample Delivery*—The laboratory should be contacted the day samples are expected to be delivered to verify that samples were received and that samples were in good condition. If samples have not been received, the shipper should use air bill or tracking numbers to determine the location of the samples and anticipated delivery times. In the event that improper packaging of hazardous or dangerous materials causes refusal of sample delivery by the carrier, the shipper will need to contact the carrier to determine what must be done to facilitate sample shipment to the laboratory.

9. Keywords

9.1 carrier; dangerous goods; environmental samples; hazard classifications; packaging; shipper; shipping; transport

SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this standard since the last issue (D6911–93(2010)) that may impact the use of this standard. (January 15, 2015)

(1) Revised Section 3 on Terminology to comply with Committee D18 requirements.
(2) Added 4.2.
(3) Updated information on small quantities exemptions.
(4) Updated editions on international regulations.

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APPENDIX C

Additional Guidance Manuals

DoD Environmental Field Sampling Handbook

EM 1110-1-4000

EM 1110-35-1

EP 200-1-2

DoD Environmental Field Sampling Handbook

DoD Environmental Field Sampling Handbook

Revision 1.0

April 2013

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Preface

This handbook provides basic guidance for working-level environmental field sampling personnel to ensure the integrity of monitoring activities tied to regulatory reporting requirements. The handbook was developed as a tool for Department of Defense (DoD) personnel. In cases where a contractor provides environmental sampling and field testing services, the contractor is responsible for ensuring self-compliance with all environmental and occupational safety and health laws and regulations. In certain instances, special requirements may dictate a more rigorous detail, depending on federal, state, and local regulations. Local field sampling procedures should be compatible with the contents of this handbook. However, there is no intent for guidance herein to replace standard operating procedures, which may exist at the local level.

Issues regarding the contents of this handbook should be brought to the attention of the DoD Environmental Data Quality Workgroup, Field Sampling and Testing Subgroup.

The DoD Environmental Data Quality Workgroup (EDQW) developed this handbook to provide guidance for environmental field sampling personnel and laboratories performing services for the DoD. It is based on the *Navy Environmental Compliance Sampling and Field Testing Procedures Manual* (August 2009), and is expanded to incorporate DoD-wide field sampling and testing guidance. Nothing in this document relieves any field or laboratory personnel from complying with more stringent contract specifications, host-nation final governing standards, or federal, state, and local regulations. This handbook can and should be supplemented by project-specific requirements. The DoD EDQW strongly encourages project teams to involve laboratories, project chemists, and field personnel during project-planning activities. The involvement of the laboratories, field personnel, and project chemists is critical to the development of project-specific measurement performance criteria (MPC) and to the selection of methods capable of satisfying the MPC.

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TABLE OF CONTENTS

Preface i

Chapter 1. Introduction 1-1

1.1. Purpose 1-1
1.2. Scope 1-1
1.3. Background 1-1
1.4. Requirements for Laboratory Testing 1-1
1.4.1. Compliance Testing 1-2
1.4.2. Restoration Testing 1-2
1.5. Handbook Overview 1-2

Chapter 2. Sampling and Field Testing Program Overview 2-1

2.1. Purpose 2-1
2.2. Need for Proper Planning 2-1
2.2.1. Systematic Planning and the Conceptual Site Model (CSM) 2-1
2.2.2. Data Quality Objectives (DQO) Process 2-3
2.2.3. Sampling Strategy 2-4
2.2.4. Selecting a Sampling Design 2-5
2.2.5. Background Samples 2-7
2.2.6. Collecting Effective Data 2-9
2.2.7. Selecting the Project Team 2-9
2.3. Developing a SAP 2-10
2.4. Health and Safety Plan 2-11
2.4.1. Service-Specific Safety and Occupational (SOH) Health Program 2-11

Chapter 3. Common Sampling Procedures 3-1

3.1. Purpose 3-1
3.2. Preparations for Field Sampling 3-1
3.2.1. Preparing for a Sampling Event 3-2
3.2.2. Preliminary On-Site Evaluation 3-3
3.2.3. Preliminary Site Safety Evaluation 3-3
3.2.4. Explosive Safety Evaluation 3-4
3.2.5. Preliminary Sampling Evaluation 3-4
3.3. The Sampling Event 3-4
3.4. Sampling Procedures 3-4
3.4.1. Sampling Strategies 3-5
3.4.2. Sampling Procedure Checklist 3-5
3.5. Sample Documentation and COC Procedures 3-6
3.5.1. Pre-Assigned Sample Numbers 3-6
3.5.2. Sample Container Labeling 3-7
3.5.3. FLB/FN 3-7
3.5.4. Field Notes/Field Sampling Forms 3-9
3.5.5. Chain of Custody (COC) 3-10
3.5.6. Request for Analysis 3-16
3.6. Sample Packaging, Handling, and Transportation 3-16
3.6.1. Sample Packaging Requirements 3-17
3.6.2. Marking and Labeling 3-23
3.6.3. Shipping Papers 3-23
3.7. QA/QC Protocol 3-23
3.7.1. Decontamination of Sampling Equipment 3-24

3.7.2. Sample Container Cleanliness Requirements 3-24
3.7.3. Sample Container Type and Size Requirements 3-24
3.7.4. Sample Preservation and Storage Requirements 3-25
3.7.5. Sample Holding Time Limits 3-25
3.7.6. Laboratory and Field Analytical Procedures 3-25
3.7.7. QC Samples 3-25
3.7.8. Field Audits 3-27
3.8. Generic Sampling Equipment List 3-28

Chapter 4. Soil Sampling 4-1

4.1. Purpose 4-1
4.2. Scope 4-1
4.3. Project Planning 4-1
4.3.1. Sampling Strategy 4-1
4.3.2. Site-Specific SAP 4-3
4.3.3. QA 4-4
4.4. Hazards and Safety Precautions 4-5
4.4.1. General Safety 4-5
4.4.2. Subsurface Hazards 4-6
4.4.3. Explosive Hazards 4-7
4.5. Principles of Sample Collection 4-7
4.5.1. Preparation of Site Map 4-9
4.5.2. Preliminary Tests and Observations 4-10
4.6. Methods of Accessing Soils 4-14
4.6.1. Surface Samples 4-14
4.6.2. Subsurface Samples 4-14
4.6.3. Subsurface Geological/Geotechnical Characterization 4-18
4.6.4. Use of Soil Sampling Equipment 4-19
4.7. Soil Sampling Procedures 4-23
4.7.1. Preparation 4-23
4.7.2. Sample Collection 4-24
4.7.3. Composite Sampling 4-26
4.7.4. Sample Handling and Preparation 4-27
4.8. Restoration of Sample Locations 4-29
4.8.1. Backfill Sample Holes 4-29
4.8.2. Grouting Boreholes 4-29
4.8.3. Replace Sod 4-29
4.8.4. Replace Pavement 4-29
4.9. Decontamination 4-29
4.9.1. Decontamination Solutions and Supplies 4-30
4.9.2. Procedure 4-30
4.9.3. Preparation of Equipment Rinsate Blanks 4-33
4.10. Waste Material Storage and Disposal 4-33
4.10.1. Soil Cuttings 4-33
4.10.2. Used Disposable PPE 4-33
4.11. Sampling Equipment List 4-33
4.12. References 4-34

Chapter 5. Aquatic Sediment Sampling 5-1

5.1. Purpose 5-1
5.2. Scope 5-1
5.3. Project Planning for Sediment-Related Sampling 5-1
5.3.1. Identify Project Goals 5-1

5.3.2. Determine Data Needs 5-2
5.3.3. Develop Data Collection Options 5-3
5.4. Developing a Sampling Strategy 5-6
5.5. Methods for Bulk Sediment Sampling 5-7
5.5.1. Sediment Grab Sampling Methods 5-7
5.5.2. Sediment Core Sampling Methods 5-8
5.6. Bulk Sediment Handling and Analysis 5-10
5.7. Methods for Collection of Pore Water 5-11
5.8. Benthic Macroinvertebrate Investigations 5-16
5.8.1. Benthic Habitat Mapping 5-23
5.8.2. Toxicity Testing in Microcosms or Mesocosms 5-23
5.9. References 5-26

Chapter 6. Surface Water Sampling 6-1

6.1. Purpose 6-1
6.2. Scope 6-1
6.3. Project Planning 6-1
6.3.1. Sampling Strategy 6-1
6.3.2. Site-Specific SAP 6-1
6.3.3. QA 6-2
6.4. Hazards and Safety Precautions 6-2
6.5. Field Preparation 6-3
6.5.1. Representative Sampling Considerations 6-3
6.5.2. Point Source Investigations 6-4
6.5.3. Nonpoint Source Investigations 6-4
6.5.4. Leachate 6-5
6.5.5. Wetland Sampling 6-6
6.6. Sampling Procedures 6-6
6.6.1. Operation of Sample Collection Devices 6-7
6.6.2. Sample Collection Procedures 6-12
6.7. Sampling Equipment List 6-13

Chapter 7. Storm Water Sampling 7-1

7.1. Purpose 7-1
7.2. Storm Water Program Overview 7-1
7.2.1. Regulatory Summary 7-1
7.2.2. Permitting Requirements 7-3
7.3. Storm Water Compliance 7-4
7.3.1. Development of a SWPPP 7-5
7.3.2. Compliance Monitoring at Industrial Sites 7-6
7.4. Visual Monitoring of Storm Water from Industrial Facilities 7-8
7.5. Collection of Storm Water Samples 7-8
7.5.1. Sampling Locations 7-9
7.5.2. Staffing Considerations 7-10
7.5.3. Sample Type: Grab and Composite Storm Water Samples 7-12
7.5.4. Storm Water Sampling from Retention Ponds 7-13
7.6. Obtaining Flow Data 7-15
7.6.1. Measuring Flow Rates 7-15
7.7. Compliance Monitoring at Construction Sites 7-17
7.7.1. "Known or Should Be Known Pollutants" at Construction Sites 7-17
7.7.2. Deciding When Sampling Is Required at Construction Sites 7-17
7.7.3. When Sampling and Analysis May Not Be Required at Construction Sites 7-18
7.7.4. When Sampling and Analysis May Be Required at the Construction Site 7-18

7.7.5. Deciding Where to Sample at a Construction Site 7-19
7.7.6. Collection of Construction Storm Water Samples 7-22
7.7.7. Coupling Visual Observations with Sampling Results 7-22
7.7.8. Retention of Data 7-23
7.8. Storm Water Sampling Equipment 7-23
7.9. Hazards and Safety Pre-Warnings 7-23
7.10. QA/QC 7-23
7.11. Sampling Equipment List 7-24

Chapter 8. Groundwater Sampling 8-1

8.1. Purpose 8-1
8.2. Scope 8-1
8.3. Project Planning 8-1
8.3.1. Sampling Strategy 8-1
8.3.2. Site-Specific SAP 8-1
8.3.3. QA 8-2
8.4. Hazards and Safety Precautions 8-4
8.4.1. General Safety 8-4
8.4.2. Subsurface Hazards 8-4
8.5. Field Preparation 8-5
8.5.1. Access and Identification 8-5
8.5.2. Sampling Equipment Selection 8-5
8.5.3. Equipment Cleaning and Decontamination 8-6
8.6. Sampling Monitoring Wells 8-7
8.6.1. Field Measurements 8-7
8.6.2. Well Development and Purging 8-8
8.6.3. Pumps 8-12
8.6.4. Groundwater Sampling Procedures Using Monitoring Wells 8-15
8.6.5. Overview of Passive Groundwater Sampling in Monitor Wells 8-16
8.7. In Situ Groundwater Sampling Using Probes 8-20
8.7.1. In situ Well Installation 8-21
8.7.2. Point-in-Time Sampling 8-21
8.7.3. DPT Monitoring Well Installation 8-22
8.8. Sample Handling and Collection 8-23
8.8.1. Sampling for Metals 8-23
8.8.2. Sampling for VOCs 8-24
8.8.3. Sampling for Extractable Organics 8-24
8.8.4. Sampling for Cyanide 8-24
8.8.5. Sampling for Conventional Parameters and Nutrients 8-25
8.8.6. Sampling for Radioactive Elements 8-25
8.8.7. Sampling for Light, Non-aqueous Phase Liquids 8-26
8.8.8. Sampling for Dense, Non-aqueous Phase Liquids (DNAPLs) 8-27
8.9. Sampling Industrial Wells 8-27
8.10. Aquifer Testing 8-27
8.11. Well Decommissioning or Abandonment 8-28
8.12. Sampling Equipment List 8-28

Chapter 9. Drinking Water Sampling 9-1

9.1. Purpose 9-1
9.2. Background 9-1
9.3. Scope 9-2
9.4. Project Planning 9-3
9.4.1. Sampling Strategy 9-3

9.4.2. Site-Specific SAP 9-3
9.4.3. Certification 9-3
9.4.4. Analytical Methods 9-4
9.4.5. Quality Assurance 9-4
9.5. Hazards and Safety Precautions 9-4
9.6. General Sampling Procedures 9-5
9.6.1. General Tap Sampling 9-5
9.6.2. Service Line Sampling 9-6
9.6.3. First-Draw Sampling 9-7
9.6.4. Source Water Sampling (Surface Water) 9-7
9.6.5. Source Water Sampling From a Well 9-8
9.7. Parameter-Specific Sampling Procedures 9-9
9.7.1. Field Data 9-9
9.7.2. Microbiological 9-10
9.7.3. Metals 9-14
9.7.4. Nitrates/Nitrites 9-16
9.7.5. Pesticides and Synthetic Organic Chemicals 9-17
9.7.6. DBPs 9-18
9.7.7. Radionuclides 9-19
9.8. Sampling Equipment List 9-21

Chapter 10. Waste Sampling 10-1

10.1. Purpose 10-1
10.2. Scope 10-1
10.2.1. USTs 10-1
10.2.2. PCBs 10-2
10.2.3. Containers and Drums 10-2
10.2.4. Oil Spills 10-3
10.2.5. Solid and Hazardous Waste Characterization 10-3
10.2.6. Sewage Sludge 10-5
10.2.7. IDW 10-5
10.3. Hazard and Safety Precautions 10-5
10.3.1. Container Hazards 10-5
10.3.2. USTs and Other Confined Spaces 10-5
10.3.3. Explosive Hazards 10-6
10.4. Preparation 10-6
10.4.1. Preparation for UST Sampling 10-6
10.4.2. Preparation for PCB Sampling 10-6
10.4.3. Preparation for Drum Sampling 10-6
10.4.4. Preparation for Cylinder Sampling 10-8
10.4.5. Preparation for Storage Tank, Vacuum Truck, Process Vessel, and Similar Large Container Sampling 10-8
10.5. Sample Collection Procedures 10-9
10.5.1. Large Tanks 10-9
10.5.2. Secondary Containment Sampling 10-9
10.5.3. Surficial Sampling 10-9
10.5.4. Transformers 10-12
10.5.5. Containerized Liquids 10-12
10.5.6. Waste Pile Sampling 10-16
10.5.7. Containerized Solids 10-18
10.5.8. Sampling for Lead in Paint 10-19
10.5.9. Ashore Oil Spill Sampling 10-20
10.6. QA/QC 10-21

10.7. Sampling Equipment List 10-21

Chapter 11. Air Sampling 11-1

11.1. Purpose 11-1
11.2. Scope 11-1
11.3. Background 11-1
11.3.1. Air Matrices 11-1
11.3.2. Objectives of Air Sampling and Monitoring 11-1
11.4. General Classification of Air Pollutants 11-2
11.5. Factors Affecting Ambient Air Sampling and Monitoring 11-4
11.5.1. Meteorological 11-4
11.5.2. Topographical Factors 11-5
11.5.3. Extraneous Contaminant Sources 11-5
11.5.4. Response Time of Sensors 11-5
11.5.5. Placement of Samplers and Monitors 11-5
11.6. General Terms 11-6
11.6.1. Whole Air versus Component Samplers 11-6
11.6.2. Real Time versus Integrated or Composite Samplers 11-6
11.6.3. Active Versus Passive Samplers 11-6
11.7. Strategies for Assessment of Air Pollution Emissions 11-6
11.7.1. Direct Assessment 11-6
11.7.2. Indirect Assessment 11-6
11.7.3. Air Monitoring and Dispersion Modeling 11-7
11.7.4. Predictive Modeling 11-7
11.8. Field Measurement Instruments 11-7
11.8.1. Detection of Volatile Organic Chemicals (VOCs) 11-8
11.8.2. Explosimeter 11-10
11.8.3. Detection of Hydrogen Sulfide (H_2S) 11-11
11.8.4. Detection of Carbon Monoxide (CO) 11-11
11.8.5. Particulates 11-11
11.8.6. Mercury Vapor 11-11
11.9. Collecting Samples for Laboratory Analysis 11-11
11.9.1. Whole Air Samples 11-11
11.9.2. Air Component Samples 11-13
11.10. Particulates 11-17
11.10.1. Filtration 11-17
11.10.2. Centrifugal Collection and Impaction 11-17
11.11. Stationary Source Emission Samples 11-18
11.11.1. Special Problems with Stack Vent and Duct Sampling 11-18
11.11.2. Specified Procedures 11-19
11.12. Measurement of Air Volume Sampled 11-19
11.12.1. Low Flow Rate Samples 11-20
11.12.2. High Flow Rate Samples 11-20
11.13. Hazard and Safety Precautions 11-20
11.13.1. Environmental Hazards 11-20
11.13.2. Stack, Vent, and Duct Sampling Safety 11-20
11.13.3. Instrument Hazards 11-20
11.14. Preparation for Sampling 11-21
11.14.1. Role of the Sampler 11-21
11.14.2. Guidelines for Air Sampling 11-21

Chapter 12. Process Sampling 12-1

12.1. Purpose 12-1

12.2. Scope 12-1
12.3. Ex situ Groundwater Treatment 12-1
12.3.1. Liquid-Phase Granular Activated Carbon 12-1
12.3.2. Air Stripping 12-1
12.4. In situ Groundwater Treatment 12-2
12.4.1. Monitored Natural Attenuation (MNA) 12-2
12.4.2. Enhanced Anaerobic Bioremediation (EAB) 12-3
12.4.3. Aerobic Biodegradation via Oxygen-Releasing Chemicals 12-4
12.4.4. Air Sparging 12-5
12.4.5. In situ Thermal Remediation 12-5
12.5. Ex situ Soil Treatment 12-5
12.5.1. Off-Site Disposal 12-5
12.5.2. Landfarming 12-6
12.5.3. Solidification/Stabilization 12-6
12.5.4. Low-Temperature Thermal Desorption 12-6
12.6. In situ Soil Treatment 12-7
12.6.1. Soil Vapor Extraction (SVE) 12-7
12.6.2. Bioventing 12-7
12.6.3. In situ Thermal Remediation. 12-7
12.7. Chemical and Physical Parameters for Remediation Processes 12-7
12.8. References 12-8

Chapter 13. Field Testing 13-1

13.1. Purpose 13-1
13.2. Scope 13-1
13.3. Background 13-1
13.4. Training 13-1
13.5. Field Screening 13-1
13.6. Field Operations 13-2
13.7. Sample SOPs 13-2

Chapter 14. Guidelines for Requesting Laboratory Testing 14-1

14.1. Purpose 14-1
14.2. Scope 14-1
14.3. Responsibilities 14-1
14.4. Hazards and Safety Precautions 14-2
14.5. Planning 14-2
14.6. Parameters and Analytical Methods 14-3
14.7. Laboratory Selection 14-4
14.8. QA/QC 14-5
14.9. Reporting 14-5
14.10. Project Schedule Considerations 14-7

Appendix A. Sampler/Sampling Recommendations and Strategies A-1

Appendix B. Requirements for Sample Containers, Preservation, and Holding Times B-1

Appendix C. Requirements for Collection of Quality Control Samples C-1

Acronyms i

Glossary of Terms i

Chapter 1. Introduction

1.1. Purpose

The purpose of the *DoD Environmental Sampling Handbook* is to provide general sampling guidance and promote consistency in how environmental samples are collected and analyzed. The handbook discusses strategies and techniques that can be employed to sample and analyze various media, including but not limited to water, soils, gas, and tissues. Applications and limitations of each sampling strategy and technique are briefly described. This handbook is not intended to be all inclusive, but it does provide guidance and discussion of basic sampling techniques. Many of the techniques discussed in this handbook have been derived from approved and accepted regulatory programs. When appropriate, references to standardized methods are provided.

1.2. Scope

This handbook describes techniques that can be used for environmental sampling and analysis at Department of Defense (DoD) compliance, restoration, or other sites. Handbook users are cautioned on possible differences between material presented here and requirements contained in control documents such as permits, licenses, state, local, and other countries' program regulations. These control documents have legal precedence and may prescribe sampling practices unique to a specific program or site. When sampling to document compliance with a control document (regulation, permit, etc.), the control document takes precedence over this handbook, and this handbook should be used as a guidance document only.

1.3. Background

Accurate, defensible, environmental sampling and field-testing results are imperative for regulatory compliance monitoring. There is great opportunity for error considering the variable conditions within the environment and the great variety of sampling equipment available. There is little tolerance for error since the validity of associated laboratory test results depends on sample integrity. Sampling personnel are key to the success of environmental sampling and testing programs upon which decisions are based.

At times, sampling personnel interface directly with federal, state, and local oversight personnel while sampling. They play sensitive roles in representing their commands and activities in this manner. At all times, success requires that sampling personnel be familiar with governing directives and their roles in relation to them, that they be properly trained and qualified, and specifically, that they have a strong appreciation for:

- The environmental sampling organization
- The importance of sampling plans
- Sampling and laboratory personnel interface
- Sampling equipment usage and maintenance requirements
- Sampling and field testing procedures
- Record and log keeping requirements
- Chain-of-custody (COC) requirements
- Personnel and equipment safety precautions
- Labeling, preservation, packaging, and shipping requirements
- Training and qualification requirements.

This handbook responds to the above concerns by providing clear, concise, and consistent guidance to sampling personnel. It provides the framework to identify generic requirements pertaining to sampling, to the extent possible, given the diverse missions and sites of the DoD, and is designed to augment and improve internal management of DoD environmental sampling programs. It is not intended to create any right or benefit, substantive or procedural, enforceable at law by any party against the DoD, its officers, employees, or any person.

1.4. Requirements for Laboratory Testing

An important element of the DoD's mission is to prevent environmental pollution, protect human

health and the environment, and comply with regulations established by federal, state, local, and tribal governments. To document the results of the DoD's efforts in protecting human health and the environment, and to substantiate compliance with environmental regulations, the DoD procures environmental laboratory testing services. These services consist of two significant components:

- Assessing regulatory compliance of materials, systems, and processes
- Evaluating effectiveness of environmental restoration efforts.

1.4.1. Compliance Testing

The DoD has a continual need for laboratory testing services to evaluate compliance with regulatory limits defined for environmental pollutants. The DoD requires compliance testing to conform with the following environmental laws:

RCRA Resource Conservation and Recovery Act

CWA Clean Water Act

TSCA Toxic Substances Control Act

SDWA Safe Drinking Water Act

FIFRA Federal Insecticide, Fungicide, and Rodenticide Act

CAA Clean Air Act

Note: The Emergency Planning and Community Right-to-Know Act (EPCRA) and Executive Order 12856 may place some additional demands on the laboratories.

These laws prescribe analyses of potable and non-potable water systems, hazardous and toxic materials, and air emissions. To comply with these regulations, the DoD operates its facilities pursuant to regulatory requirements that address process discharges. Permits may be required for base support systems (dry docks, sewer, water, industrial waste treatment) and production processes (painting, degreasing, abrasive blasting, flushing). The DoD accomplishes environmental analysis through both in-house and commercial laboratories.

1.4.2. Restoration Testing

Restoration testing is conducted pursuant to requirements in the following laws:

CERCLA Comprehensive Environmental Response, Compensation, and Liability Act

SARA Superfund Amendments and Reauthorization Act of 1986

RCRA Resource Conservation and Recovery Act

Restoration testing is performed almost exclusively by commercial laboratories. Restoration work is accomplished by using prime contractors that sub-contract analytical work to commercial laboratories. The laboratories are nominated by the prime contractor and approved by the DoD. Laboratories performing testing in support of the DoD environmental restoration programs must be accredited in accordance with the DoD Environmental Laboratory Accreditation Program (ELAP). DoD ELAP ensures laboratories performing analyses for the environmental restoration program meet a minimum quality standard. A project-specific audit of the laboratory's ability to meet project-specific requirements may also be performed. Additionally, unannounced data package audits may be completed to ensure quality data is being submitted after the laboratory has been approved.

1.5. Handbook Overview

Chapter 1 – Summarizes the handbook and gives direction for its use.

Chapter 2 – Provides an overview of the sampling program in general. This chapter is intended to provide sampling personnel with guidance concerning a sampling program, responsibilities of all personnel in the sampling program, as well as the documentation required by the United States (U.S.) Environmental Protection Agency (EPA) for each sampling event.

To sampling personnel, Chapters 3 through 12 represent the "core" of the handbook by providing the procedures and requirements of field sampling. A single sampling run will involve the following sections; see Figure 1-1:

Chapter 3 – Common Sampling Procedures

Chapter 4 –12 – Soil, Sediment, Surface Water, Storm Water, Groundwater, Drinking Water, Waste, and Process Sampling

Chapter 13 – Field Testing

Chapter 14 – Guidelines for Requesting Laboratory Testing

Appendix A – Sampler/Sampling Recommendations and Strategies

Appendix B – Requirements for Sample Containers, Preservation, and Holding Times

Appendix C – Requirements for Collection of Quality Control Samples

Of major importance with any material, is the ability to quickly locate certain information such as chapters, key words, subjects, figures, tables, etc. This handbook accomplishes this task with the following guides:

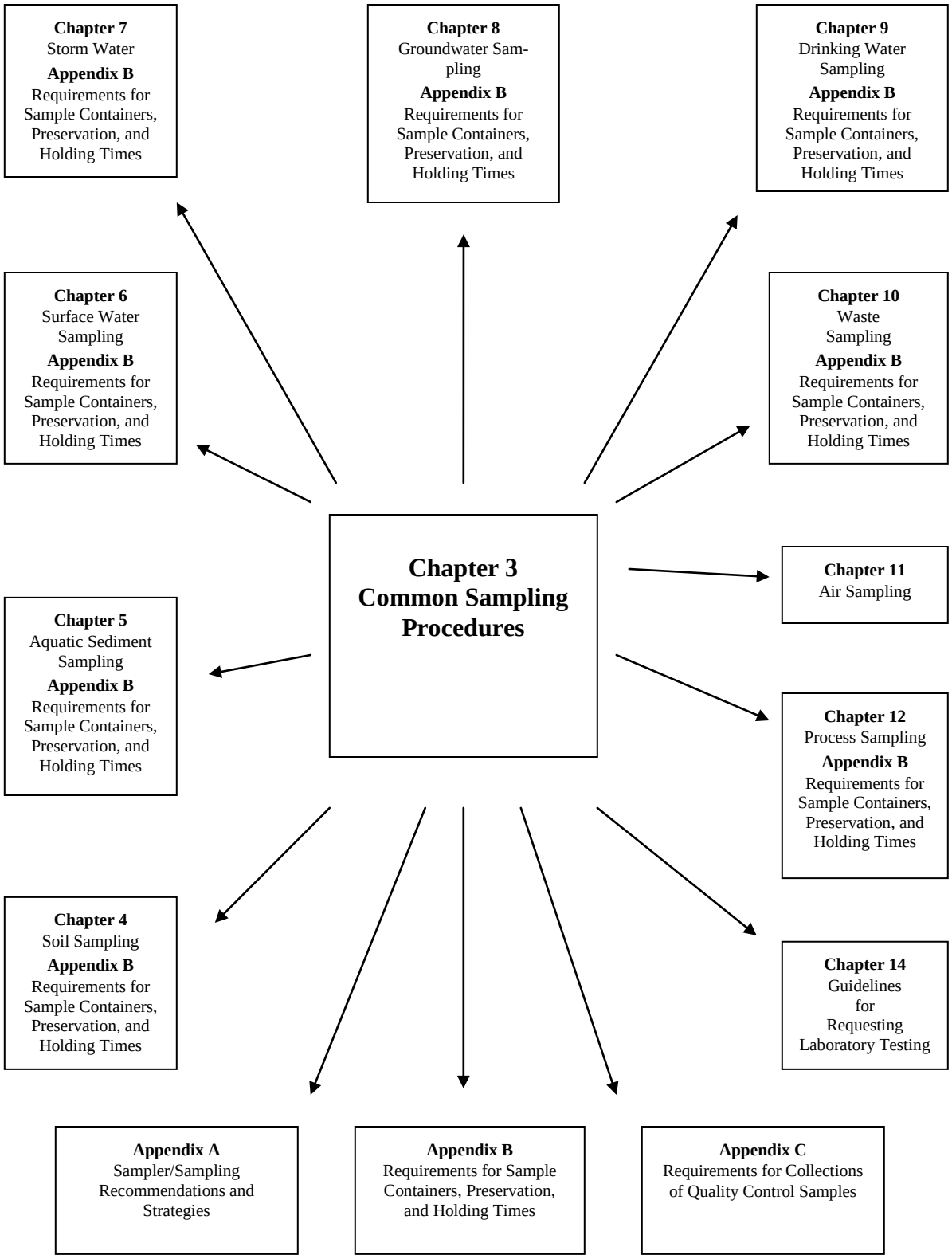
Table of Contents provides page numbers for all major sections and subsections.

List of Figures and **List of Tables** provide page numbers for all figures and tables.

Glossary of Terms and **Acronyms** define technical words and abbreviations.

Reference Sections provide sources of information used throughout the handook, including additional sources of information.

Figure 1-1. Chapter / Appendix Relationships



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Chapter 2. Sampling and Field Testing Program Overview

2.1. Purpose

This chapter presents the fundamental components of planning a sampling and analysis program and discusses methods for selecting a sampling design and strategy for collecting environmental data. In addition, guidance is provided on developing a Sampling and Analysis Plan (SAP). A well-developed SAP plays a critical role in ensuring the collection of data that have sufficient quality from which to make defensible decisions.

Planning is a necessary component of any environmental data collection program. The SAP should clearly state the purpose of the project, identify the type, quality, and quantity of data needed to accomplish project goals, and openly acknowledge any underlying assumptions or sources of uncertainty that could significantly impact the quality of the data.

2.2. Need for Proper Planning

Environmental sampling projects require careful planning and consideration by the project team to ensure that resources are effectively used to collect acceptable data for accomplishing project goals. The level of detail and amount of time spent on planning should reflect the importance and intended use of the data and the resources available to the project (sometimes referred to as the "graded approach"). In any environmental program, the three following questions need to be answered before a project is started:

- What are the objectives of the project?
- How will the data generated ultimately be used?
- What type, quality, and quantity of data are needed to accomplish the objectives of the project?

The answers to these questions provide the foundation for determining the proper sampling methodology for the project.

2.2.1. Systematic Planning and the Conceptual Site Model (CSM)

The Systematic Planning Process is a methodical approach recommended by the U.S. EPA to:

- Identify the technical goals of a project and site conditions
- State the expected outcome of data collection
- Outline the cost and schedule of the project
- State the acceptance criteria for the final result.

The essence of systematic planning is accurately stating the objectives related to an environmental issue and then strategizing how best to address those objectives. Successful systematic planning identifies the key decision makers and allows all participants in the environmental project to be aware of the reasoning behind their decisions. Communication between organizations and individuals involved in an environmental project is encouraged early in the planning process. This will ensure that all participants understand the needs and expectations of the data collection effort and the questions the project is trying to answer. Early communication also provides an efficient use of program resources by requiring a thorough discussion among the entire project team of the type, quality, and quantity of data required to address project goals prior to the start of the data collection process.

A key tool used in the systematic planning process is a CSM. A CSM can be defined as a written and/or pictorial representation of an environmental system and the biological, physical and chemical processes that determine the fate and transport of contaminants through environmental media to environmental receptors and their most likely exposure models. A CSM promotes project transparency among the project team by summarizing all the available information about a site and identifying what additional information must be known to achieve project objectives. The format of a project's CSM may vary.

A good CSM addresses the following elements as applicable to the objectives of the project:

- Nature and extent of contamination
- Geology
- Hydrogeology
- Fate and transport
- Biological and geochemical conditions
- Potential transport pathways of contamination and exposure scenarios
- Potential monitoring points
- Potential receptors
- Potential exposure scenarios and pathways
- Potential areas of unacceptable risk
- Potential target treatment zones
- Site history and intended future site use
- Other factors relevant to the understanding of contamination and related risk to human health and the environment.

During the systematic planning process, project goals are linked to the individual activities necessary to reach these goals by identifying data gaps in the CSM. The CSM then serves as the foundation for evaluating all proposed and implemented project activities.

The CSM is the basis for defining the Remedial Action Objectives (RAOs). It also should be used to expose data gaps and aid in development of the SAP.

The CSM is used onsite to focus fieldwork efforts on obtaining the information needed to remove important unknowns from the model and developing an exit strategy. As site work progresses and data gaps are filled, the CSM is updated to reflect the new information. This process allows the CSM to evolve as the project progresses. The CSM ultimately serves as a planning tool as well as a modeling and data interpretation tool. It also provides a line of communication between field personnel and the rest of the project team, which keeps all parties focused on the data collection process and achieving project objectives.

2.2.1.1. Aerial Photo and Map Analysis

As part of the project planning process, current and historical aerial photos, satellite imagery, and present-day maps can provide valuable insight into past and present suspected source areas. Historical photos may be used to identify past disposal pits, ground disturbance indicative of landfills, or stained soil locations that may indicate past spills. Current aerial photos or satellite imagery may be used to identify potential seeps for sampling by locating vegetation concentrations in an otherwise dry area. Similarly, the presence of stressed vegetation may indicate potential groundwater contamination. In coastline areas, comparing past and present aerial photos can identify areas of significant shoreline erosion or aggradation. Source areas that were located hundreds of feet inland in the 1940's may now be coastline features. Current aerial photos and satellite imagery can also be used to infer soil type and relative permeability of soils present at the ground surface. Coarse drainage patterns or broad, shallow valleys may indicate higher permeability soils. Conversely, streams with steep slopes indicate low permeability soils. Current aerial photos and satellite imagery can provide information on the degree of development and industrialization in the vicinity of source areas, and can be used to determine potential receptors and identify potential sample locations.

Guidance for aerial photo analysis may be found in *Aerial Photographs in Geologic Interpretation and Mapping*, U.S. Geological Survey Professional Paper 373.

U.S. EPA's EnviroMapper for Envirofacts website (http://www.epa.gov/emefdata/em4ef.home) maps potential waste generators in the project vicinity and provides information on the types of waste being generated.

Free imagery can be found at a number of sources. The Environmental Systems Research Institute (ESRI) offers two online imagery maps (World Imagery and Bing Maps Aerial) for inclusion into ArcGIS mapping projects at http://www.esri.com/data/free-data/index.html

Military installations usually have imagery available also. Army Installation imagery can often be accessed through the geographic information system (GIS) or the Department of Public Works shops. This imagery can be georeferenced and provide the basis for site sample maps.

2.2.1.2. Fate and Transport

Understanding contaminant fate and transport is an important element of the CSM. In many cases, the sampling effort or remedial action to address contamination in soil is based on the potential to impact groundwater quality or surface water quality due to the leaching potential. The transport of contaminants via leaching and migration through groundwater can be a very complex process. In order to develop a quantitative predictive tool (e.g., a model), geological, geochemical, and hydrogeological data must be available, including an understanding of seasonal and historical fluctuations in hydrogeological conditions. Similarly, an understanding of the fate and transport behavior of site contaminants and related degradation products, particularly in groundwater, is critical to understanding the potential for contaminant migration and attenuation. This information is useful in understanding the nature and extent of any remediation or treatment processes that may be required to supplement natural attenuation. These data are used for a risk assessment and developing risk-based remedial action objectives for restoration projects and useful in determining impact for compliance efforts.

Additional information on CSMs can be found in the American Society for Testing and Materials E1689-95 (2008): Standard Guide for Developing Conceptual Site Models for Contaminated Sites (ASTM, 2008).

2.2.1.3. Geophysical Exploration

The use of surface geophysics can be valuable in planning a sampling program particularly for choosing sampling locations at suspected source areas. Geophysical techniques include magnetic and electromagnetic surveys, ground-penetrating radar, and seismic surveys. These methods can help identify buried objects that may represent sources or sampling hazards, can help define limits of past excavations or landfills, and can clarify subsurface hydrogeology that can affect contaminant transport.

Guidance for the application of geophysics for contaminated sites is available in United States Army Corps of Engineers (USACE) Engineer Manual 1110-1-1802 Geophysical Exploration for Engineering and Environmental Investigations (http://synectics.net/public/file/searchresults.aspx?dsn=pub&category=USACE&subcategory=Engineer%20Manuals&title=USACE%20Engineer%20Manuals&idMenu=37839&ddlDSN=SYSTM) and U.S. EPA documents such as *Geophysical Techniques for Sensing Buried Wastes and Waste Migration* EPA-600/7-84/064 and *Subsurface Characterization and Monitoring Techniques, A Desk Reference Guide, Volume 1, Chapter 1, Remote Sensing and Geophysical Methods* EPA/625/R-93/003a, and ASTM Standard D6429 *Standard Guide for Selecting Surface Geophysical Methods*.

2.2.2. Data Quality Objectives (DQO) Process

The DQO process is a systematic planning tool recommended by the U.S. EPA to develop sampling designs for data collection activities that support decision making. The DQO process is a method used to structure the project planning processes in order to manage uncertainty. The DQO process is best applied when critical environmental decisions need to be made (e.g., final decision-making or compliance with a standard). The DQO process integrates the work of a multidisciplinary team for planning action-oriented environmental data collection activities. It encourages thoughtful consideration of the following: what decisions need to be made; what data type, quality, and quantity are needed to support the decisions; what portion of the environment (and/or what time frame) shall be represented by data; how data will be used to support the decision; and what level of decision certainty (and therefore data quality) is desired. The DQO

process is iterative and the final outcome is a design for collecting data (e.g., the number of samples to collect, their locations, and the procedure for sampling). Additionally, acceptable limits on the probabilities of making decision errors can be determined if a statistically based sampling design is used. The full DQO process is described in the U.S. EPA's *Guidance for the Data Quality Objectives Process* (QA/G-4, EPA/240/B-06/001, http://www.epa.gov/quality/qs-docs/g4-final.pdf). The DQO process is a seven-step planning approach based on the scientific method. It involves the entire planning cycle for an environmental project and encompasses all the activities necessary for project completion. The seven steps of the DQO process are:

Step 1: State the Problem. Define the problem clearly, identify the primary decision maker and planning team members, and determine the available budget, personnel, and deadlines.

Step 2: Identify the Goal of the Study. Develop an appropriate decision statement, identify the principal study question, define alternative actions that could result from resolving the principal study question, link the principal study question to possible actions, and organize multiple decisions.

Step 3: Identify Information Inputs. Identify the type and sources of information needed to resolve the decision statement, identify information needed to establish the action level, and confirm that suitable methods exist.

Step 4: Define the Boundaries of the Study. Specify the characteristics that define the population of interest, define the spatial and temporal boundaries, define the scale of decision making, and identify any practical constraints on data collection.

Step 5: Develop the Analytic Approach. Construct the theoretical "If...then...else..." decision rule by combining the possible results from the study, the Action Level, the scale of decision making (Step 4), and the alternative actions (Step 2).

Step 6: Specify Performance or Acceptance Criteria. Determine the decision maker's tolerable limits on potential decision errors by identifying the decision errors and base-level assumptions. Specify a range of possible parameter values where the consequences of decision errors are relatively minor, and assign probability values for the occurrence of potential decision errors.

Step 7: Develop the Detailed Plan for Obtaining Data. Identify a resource-effective sampling design for data collection that will then satisfy the DQOs documented in the previous steps. Meeting or exceeding the DQOs is the goal of the selected sampling design. The DQO process is flexible and allows the planning team to incorporate new information into the sampling plan as it becomes available. The final outcomes of the DQO process are qualitative and quantitative statements that:

- Clarify the study objective
- Define the type, quality, and quantity of required data
- Determine the most appropriate conditions under which to collect the samples
- Specify how the data will be used to address the project objectives.

For more additional information on the DQO process, see EPA QA/G-4.

2.2.3. Sampling Strategy

Selecting the correct sampling strategy for the SAP requires consideration of project resources and an understanding of the data quality required for the project. When evaluating which sampling strategy is most appropriate for a given environmental program, project teams should assess the amount of time available to complete the project, the availability of technical experts for on-site review, the type of data and quality level required for decision making, and the amount of information already known about the site. Knowing these key pieces of information will assist project teams

in determining the most appropriate sampling strategy for the project.

Sampling strategies may be categorized as "static" or "dynamic." Static sampling strategy represents a phased approach to environmental data collection. During static sampling, data are collected and analyzed and then typically documented in an interim report. After the report is reviewed, the direction of the next phase in the project is decided. The phased process generally continues until the project objectives are resolved. In contrast, dynamic sampling strategy streamlines field sampling activities by providing the data needed to make decisions on site without multiple iterations of project work plans and interim reports. The term dynamic is used because field activities are designed to incorporate changes as new information is obtained, thus accommodating the iterative nature of fieldwork at many environmental sampling sites. The "Triad Approach" incorporates dynamic work strategies, real-time measurements, and systematic planning. More information on the Triad Approach can be found at http://www.triadcentral.org/.

A primary advantage of a dynamic sampling strategy is that it allows an adaptive sampling approach by encouraging decision makers and regulators to take an active role in understanding site problems and resolving sampling issues quickly. A thorough planning process that clearly outlines how decisions will be made in the field is crucial to effectively executing a dynamic sampling program. Dynamic sampling plans are living documents that provide a roadmap for decisions that a field team can follow, and outline how subsequent site activities will progress as new information is acquired.

Although the benefits of using a dynamic sampling strategy are substantial, they are not applicable for all situations. Dynamic sampling activities often need more extensive planning up front than traditional staged or static field activities. Successful dynamic sampling plans should prepare not only for what is known about a site, but also for possible conditions that could affect the completion of the fieldwork. Quick turnaround analysis is typically needed to facilitate dynamic field activities. If on-site or rapid off-site analysis is not economically or technically feasible, a static sampling strategy may be more appropriate.

Dynamic field activities also need more field oversight, because the regulator should be involved in evaluating key technical decisions as they occur. In addition, dynamic sampling routinely requires the presence of one or more experienced technical staff in the field. Experienced staff plays a key role in the decision-making process, and their recommendations can greatly influence the direction field activities take. If an experienced technical team leader is not available to oversee the fieldwork, dynamic sampling will often be an ineffective method for data collection. In this case, a static sampling strategy, which allows time for review and careful consideration by technical experts not available for on-site activities, may be more appropriate.

For additional information on the dynamic sampling process refer to EPA/540/R-03/002 (http://www.epa.gov/superfund/programs/dfa/download/guidance/40r03002.pdf).

2.2.4. Selecting a Sampling Design

One of the primary objectives of systematic planning and the DQO process is to determine the data quality and quantity needed to address project objectives. Once the data requirements are identified, the next step in the process is to develop a sampling design or methodology that specifies the number, type, and location (spatial or temporal) of the samples to be selected for measurement.

There are two main categories of sampling designs: statistical and non-statistical. Statistical sampling designs apply sampling theory and involve random selection of sampling locations. When a statistical sampling design is used, statistical inferences may be made about the sampled population from the data obtained from the sampling locations. Non-statistical sampling designs involve the selection of sampling units based on

expert knowledge or professional judgment. Data derived from non-statistical sample designs cannot be assigned a quantitative level of confidence and are limited by the degree of professional knowledge available to the project team.

2.2.4.1. Statistical Sampling Designs

The most commonly used statistical sampling designs in environmental data collection are:

- **Simple random sampling.** Sample locations are selected randomly. Locations are assumed to be independent and have an equal probability of being selected. Simple random sampling is most useful when the population of interest is known or assumed to be homogeneous. A main advantage of the simple random sampling design is that it provides statistically unbiased estimates of the mean, proportions, and variability.
- **Stratified random sampling.** The target population is separated into non-overlapping strata, or subpopulations that are known or thought to be more homogeneous (relative to the environmental medium or the contaminant), so that there tends to be less variation among the areas sampled in the same stratum than among sampling areas in different strata. Strata may be chosen based on spatial or temporal proximity of the units, or based on preexisting information or professional judgment about the site or process. This design is useful for estimating a parameter when the target population is heterogeneous and the area can be subdivided based on expected contamination levels.
- **Systematic grid sampling.** Samples are taken at regularly spaced intervals over space or time. An initial location or time is chosen at random, and then the remaining sampling locations are defined so that all locations are at regular intervals over an area (grid) or time (systematic). This design provides a practical and easy method for designating sample locations and ensures uniform coverage of a site, unit, or process.
- **"Hot-spot" sampling or adaptive cluster sampling.** Samples are taken using simple random sampling, and additional samples are taken at locations where measurements exceed some threshold value. Several additional rounds of sampling and analysis may be needed. Adaptive sampling is useful for estimating or searching for rare characteristics in a population and is appropriate for inexpensive, rapid measurements. It enables delineating the boundaries of hot spots, while also using all data collected with appropriate weighting to give unbiased estimates of the population mean.
- **Ranked set sampling.** Multiple sets of field locations are identified using simple random sampling. The locations are ranked independently within each set using professional judgment, or an inexpensive, fast surrogate measurement that is correlated to the final measurement of interest. One sampling unit from each set is then selected (based on the observed ranks) for subsequent measurement using a more accurate and reliable method for the contaminant of interest. Relative to simple random sampling, this design results in more representative samples and so leads to more precise estimates of the population parameters. Ranked set sampling is useful when the cost of locating and ranking locations in the field is low compared to laboratory measurements. To use a ranked set sampling design effectively, the ranking method and analytical method should be strongly correlated.
- **Incremental Sampling Methodology (ISM).** ISM is based on particulate sampling theory. It incorporates the relationship that exists among variability of the soil, particle sizes in the soil, the distribution of the contaminant, and the size of the sample taken.

  An incremental sample is similar to but different from a composite sample. A composite sample is a combination of discrete samples. An incremental sample is a

representative sample for a given area to be sampled (i.e., a decision unit (DU)). An incremental sample is collected within a DU, whereas a composite may be collected without regard to a specific DU. Although the physical process of collection is similar, the information derived from each process is different.

A DU identifies the spatial and temporal characteristics that define the decision's domain. Populations are broken into one or more discrete DUs. The identification and delineation of the DU is one of the most important factors when using ISM.

Several benefits of using ISM include improving the confidence in the mean concentration in the DU, enabling fewer samples for shipping and laboratory analysis (which would result in cost savings), and providing improved site coverage.

When using ISM, establishing a DU is critical. In addition, this method can be difficult to use for volatile contaminants, and improper selection of a DU may "dilute" contamination that could result in underestimating the need for cleanup. To ensure achieving the proper results, consulting a statistician prior to using ISM is recommended.

For more information regarding ISM, see *Incremental Sampling Methodology*, Interstate Technology & Regulatory Council (ITRC), 2011.

2.2.4.2. Non-Statistical Sampling Designs

Non-statistical sampling designs are based on professional judgment, and are usually selected with the intent of obtaining biased data. For example, selecting specific locations where a known spill occurred will provide estimates of the "worst case" or those of the highest concentrations. Sampling locations are selected based on visual signs of contamination or previous knowledge about the site. Using a biased sampling design is most appropriate when dealing with a known contamination source. The disadvantage of biased sampling is that contaminated areas may be overlooked due to inadequate knowledge of the site or a lack of visual signs of contamination.

For additional information on sampling designs for environmental data collection, see EPA/240/R-02/005 QA/G-5S: http://www.epa.gov/quality1/qs-docs/g5s-final.pdf).

Visual Sample Plan (VSP) is a software tool that can be used to employ several of the sampling strategies previously discussed. VSP supports the implementation of the DQO process by displaying different sampling plans, linking them to the DQO process, and then determining the optimal sampling specifications to protect against potential decision errors.

This easy-to-use program is highly visual, very graphic, and intended for use by non-statisticians. The VSP software program may be downloaded from http://vsp.pnnl.gov/.

2.2.5. Background Samples

In accordance with U.S. EPA guidance, background (reference area) sampling is conducted to distinguish site-related contamination from naturally occurring or other non-site-related anthropogenic chemicals (EPA, 1989). Background chemicals can be either localized or widespread and should be evaluated during site investigations in order to differentiate between Defense Environmental Restoration Program cleanup responsibilities for site-related releases and background conditions and/or non-site-related anthropogenic sources. Both naturally occurring and non-site-related anthropogenic background levels of chemicals should be established and considered as early as the Preliminary Assessment/Site Inspection (PA/SI) phase of the CERCLA process or the Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA) of the RCRA process.

Establishing scientifically defensible background levels early in the process can provide evidence of whether a release has occurred. This technical

position requires a scientifically defensible characterization of background levels of chemicals in all relevant media that are potentially present at the site due to background conditions (naturally occurring and/or non-site-related anthropogenic). The approach is consistent with the U.S. EPA's Role of Background in the CERCLA Cleanup Program (EPA, 2002a), the EPA's Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites (EPA, 2002b), and the U.S. Navy's Policy on the Use of Background Chemical Levels (Navy, 2004).

Background is represented by the ambient concentrations of chemicals that are not site-related or attributable to site releases or activities. This includes both naturally occurring, and non-site-related anthropogenic substances present in the environment. Ideally, background samples should be geochemically similar to the impacted portions of the site being evaluated. Soil characteristics such as soil horizon and type, pH, redox conditions, cation exchange capacity, density, total organic carbon (TOC), grain size, and moisture are lines of evidence that can be used as indicators of similarity. Also, background locations should be selected that represent similar conditions of ambient, anthropogenic contaminants. Sources of anthropogenic background chemicals that may not be specifically site related include agricultural runoff, septic systems, application of pesticides, air pollution, industrial discharges, and urban pollution. Background samples are typically taken at upstream locations or areas not thought to be impacted by the primary site being investigated.

These non-impacted background or reference areas identified for sampling may be off-site or within the designated site boundaries. In order to reduce the chance of introducing potential sampling bias, background samples should be taken using the same depth and methodologies as those used for the site investigation. This includes using the same sample equipment and procedures. It is also advisable to use the same sampling personnel and laboratory to perform the analyses. It is recommended that project teams ensure that a sufficient number of study areas and background samples be collected to perform proper statistical tests for the background evaluation. (Appropriate sample sizes can be determined using software programs like VSP or ProUCL). The sampling strategy for background should be discussed and documented during the early phases of project planning.

A variety of descriptive statistics may be developed to evaluate the background data set (e.g., mean, median, range, etc.). Various statistical tests to compare the mean and/or upper bound between the site and reference areas require a sufficient number of reference samples. Geochemical association analysis can also be a valuable tool for background investigations (Navy, 2010). Elemental association relationships can augment statistical comparisons. It is advisable that the project team consult a geochemist, chemist, geologist, and/or statistician very early during project planning to ensure the appropriate chemicals are evaluated as well as the number and location of selected background samples. These should be documented in the sampling and analysis plan, which should also specify the project DQOs and procedures that will be used to collect the data.

References:

- EPA, 2002a. U.S. Environmental Protection Agency, Role of Background in the CERCLA Cleanup Program, Office of Solid Waste and Emergency Response, Washington, D.C., OSWER 9285.6-07P, May. This is also included as Appendix B in EPA, 2002b.
- EPA, 2002b. U.S. Environmental Protection Agency, Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites, Office of Emergency and Remedial Response, Washington, D.C., EPA 540-R-01-003, OSWER 9285.7-41, September.
- Navy, 2001. Navy Facilities Engineering Command (NAVFAC), Guidance for Environmental Background Analysis, Volume I: Soil, May 3, 2001.

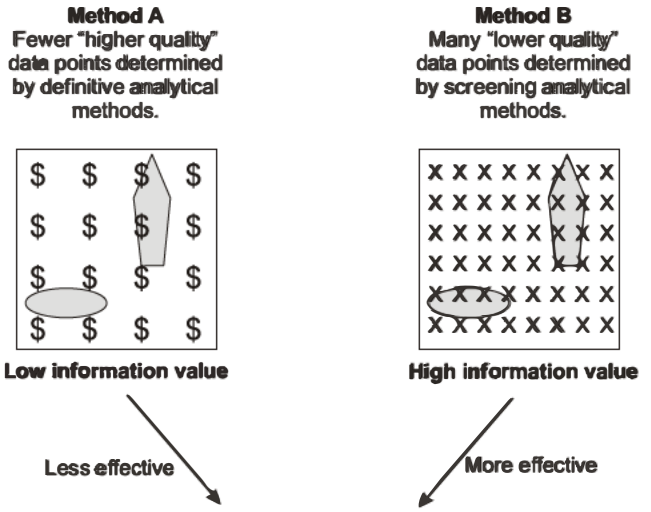
- Navy, 2004. Department of the Navy, Navy Policy on the Use of Background Chemical Levels, Washington, D.C., 5090, Ser N45C/N4U732212, 30 January.

2.2.6. Collecting Effective Data

The primary objective when selecting a sampling design for an environmental program is to determine which design represents the most efficient methodology for collecting data that are scientifically valid and legally defensible. Data are acceptable when both sampling and analytical uncertainties have been managed to the degree necessary to meet accurately defined project objectives.

While the ability to document the quality of the data is significant in determining the value of a data set, the importance of the relationship between data generation and the intended use of the data cannot be overstated. For example, in a hypothetical environmental contamination problem (see Figure 2-1) a site contains two hot spot locations with significantly higher contamination concentrations than the surrounding area. The project objective is to identify where the hot spots are located. Method A analyzes a few samples using a highly accurate definitive analytical method that must be sent off site for processing. Method B surveys the area by analyzing several samples using a lower quality analytical screening method that can be performed on site. The additional data points generated using Method B represents a more effective data set than the data generated using Method A despite the fact that Method B data is determined using a lower quality analytical method. Inexpensive or faster screening methods that meet project DQOs can be a cost-effective strategy for achieving project objectives.

Figure 2-1. Data Quality vs. Information Value



Goal: A defensible site decision that reflects the "true site" condition.

Effective data reinforce a more productive conceptual framework for data generation by encouraging critical thinking about the anticipated role of data. Focusing on achieving effective data forces the systematic planning process to answer the following questions:

- What is the intended use of the data?
- What are the strengths and limitations of the proposed methods?
- What are the site-specific considerations that could adversely impact analytical performance?
- What are the site-specific considerations that will influence representative sampling?
- What are the site-specific considerations that will govern what statistical measure should be determined?

2.2.7. Selecting the Project Team

Systematic planning is a multidisciplinary process that requires the participation of the entire project team early in the planning stages and at key review points to ensure project resources are used efficiently. Team members should include the primary decision makers on the project as well as the end users of the data to encourage clear communication of data requirements and limitations

for achieving project goals. Systematic planning evolves as new information becomes available. The involvement of the appropriate project team members at each stage in the process is necessary to keep the focus on collecting the most effective data for accomplishing project objectives. Ultimately the planning process is a collaborative effort that involves the regulator, program managers, field sampling personnel, laboratory personnel, facility health and safety officers, and any additional individuals involved in the data collection process. Encouraging active participation of the entire project team is the key to successful environmental sampling programs.

2.3. Developing a SAP

A SAP is an integral part of the systematic planning process. In general, a site-specific SAP shall be completed, reviewed, and approved prior to any data collection. In many cases, the SAP is not completed before sampling begins and results in the production of data that may not be usable for their intended purpose, thus wasting valuable project resources. It is imperative that project teams invest the time to complete the DQO process and prepare a SAP prior to data collection to increase the likelihood that "effective data" will be generated for the project.

At a minimum, each SAP should include the following sections:

- **Introduction.** Explains the objectives of the sampling program at the site
- **Objective.** Presents the project objectives, including the decision criteria applicable to each parameter analyzed, and describes how the work will meet these objectives. Explains the sampling operation in terms of the number of personnel, education, training, technical knowledge, and experience needed to meet assigned functions
- **Site Description.** Provides a description of the site, including location, current and historical uses, potential sources of contamination, and site maps showing the existing features
- **Conceptual Site Model**. Provides information on both the geology and hydrology at the site, information on existing water quality and pollutant information, and any known or potential data gaps
- **Sample Collection**. Explains the types of samples to be collected, intended methods for collection, sample handling procedures (including bottle types, preservation, filtration, and chain of custody (COC)), analytical methods, and analytical laboratories
- **QA/QC.** Includes DQOs, field QA/QC procedures (including sampling equipment construction, duplicate samples, field blanks, trip blanks), and requirements for precision, accuracy, and completeness
- **Documentation of Field Activities**. Includes field observations and procedures, sample labeling, and photographic documentation (if available)
- **References.** Individuals responsible for preparing the SAP should conduct a site walk over to familiarize themselves with the field conditions and, if necessary, consult with experienced field personnel to obtain input on appropriate sampling procedures that may be unique to the site. In addition, the SAP should incorporate any local regulatory agency requirements for surface water sampling and sampling waste management.

SAPs should be prepared based on the regulatory requirements, the information required for making decisions, and qualifying factors of the sampling and laboratory operations. SAPs describe the quality system requirements appropriate to meet the type, range, and scope of the sampling and testing being performed. Defense Environmental Restoration Program (DERP) projects must create a SAP following the UFP-QAPP. The UFP-QAPP format contains all technical and quality aspects for the life cycle of the project, including planning, implementation, and assessment. Although only mandatory for DERP projects, the UFP-QAPP format can also be used for other environmental sampling projects. Addi-

tional information and guidance on the UFP-QAPP can be found at http://www.epa.gov/fedfac/documents/qualityassurance.htm.

2.4. Health and Safety Plan

The Health and Safety Plan (HASP) is a separate deliverable sometimes included with the SAP. A site-specific HASP meeting the requirements of 29 CFR 1910.120(a)(1)(ii) or (iii) will be included when the scope of work requires it. A much less extensive site-specific safety plan will be included for the usual compliance type sampling that does not fall under 29 CFR 1910.120.

2.4.1. Service-Specific Safety and Occupational (SOH) Health Program

Navy: OPNAVINST 5100.23G, *Navy Safety and Occupational Program Manual*, is the primary reference document describing the Navy SOH Program. All elements of this handbook apply to protecting the health and safety of Navy DoD environmental compliance personnel. The relationship between OSHA standards and the Navy SOH Program is detailed in Chapter 16 of OPNAVINST 5100.23G.

Army: Army Regulation (AR) 385-10, *The Army Safety Program*, implements requirements of the OSH Act of 1970 as implemented in EO 12196, 29 CFR 1960, DODI 6055.1, DODI 6055.4, and DODI 6055.7. It provides the policy on Army safety management procedures with special emphasis on responsibilities and organizational concepts. This AR applies to the Active Army, the Army National Guard/Army National Guard of the U.S., and the U.S. Army Reserve, unless otherwise stated. It also applies to Army civilian employees and the U.S. Army Corps of Engineers and Civil Works activities and tenants and volunteers in accordance with Section 1588, Title 10, U.S. Code and AR 608-1.

Army Corps of Engineers: EM 385-1-1, *Safety and Health Requirements Manual*, prescribes the safety and health requirements for all Corps of Engineers activities and operations and applies to occupational exposure for missions under the command of the Chief of Engineers, whether accomplished by military, civilian, or contractor personnel.

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Chapter 3. Common Sampling Procedures

3.1. Purpose

This chapter presents specific sampling procedures and items common to the sampling events covered in Chapters 4 – 12. Section 1.5 and Figure 1-1 of this handbook illustrate the relationships among these chapters. Additional references include facility standard operating procedures (SOPs) and special requirements contained in regulatory programs and site permits.

3.2. Preparations for Field Sampling

The success of a field sampling program depends on the level of preparation prior to entering the field. Implementation of the SAP begins with preparing for the field sampling operation. The following preliminary steps are vital to the success of the project:

- **Preliminary Off-Site Evaluation.** Prior to implementing the SAP, the Program Manager and Health and Safety Supervisor should review any Historical Overview and Site Description sections of the SAP. This review may result in the decision for an on-site evaluation to assess the sampling procedures, relevant safety equipment, and PPE.
- **Equipment Verification.** The SAP should specify an equipment list, including sampling equipment, sample containers, and PPE. This list should be reviewed in detail by the entire sampling team and the Health and Safety Supervisor to verify that necessary items are included and appropriate for the site being sampled.
- **Inventory.** The Equipment Technician (however named) shall gather all the specified equipment and containers into one place and verify that it is on hand. Reagents, supplies, and quality control materials shall be checked and verified as appropriate. The designated technician shall notify the Program Manager that equipment preparations are complete.
- **Sign-Over of Materials.** The designated individual shall check the equipment inventory, and sign for custody if required.
- **Staffing and Scheduling.** The Program Manager shall consider the impact of specified sampling requirements on staff and schedule.
- **Screening or Field Measurements**. Sample screening or field testing for pH, dissolved oxygen (DO), sulfite, conductivity, disinfection chemicals, and temperature require additional field time. The need for additional personnel is based on time demands, training requirements and degree of difficulty. Significant field testing requirements may justify the procurement of a field laboratory and a trained field chemist to relieve other team members of this responsibility.
- **Preservation.** Preservation, either chemical or thermal, is required for most water samples. Thermal preservation usually requires icing the samples after collection and storing samples at $\leq 6°$ Celsius (C). For chemical preservation, two practices exist for adding preservative: 1) addition of the chemicals to the samples in the field, and 2) addition of the chemicals to the sampling containers prior to sending the containers to the field. Adding the reagents to the sample containers at the time the samples are collected requires the sampler to maintain records of addition and quality of the reagents and to follow proper chemical handling techniques. In some cases it may be advisable to have the laboratory add the reagents to specially labeled sample containers before they are sent to the field. This may reduce the fieldwork required and the possibility of field error resulting from contaminating the preservatives. Addition of the correct amount of preservative can be estimated for samples collected on a routine basis having little to no outside environmental or process effects.

WARNING: When using containers filled with preservative, use caution when filling the bottles to ensure the preservative is not released to the environment and the correct amount of preservative has been added to adequately fix the sample.

- **Time.** Many samples have short holding times prior to analysis. Review the holding time requirements and coordinate the schedule with the laboratory so the samples are analyzed within the required holding times. Holding times are dictated by the regulatory program and data may be invalidated if holding times are not met.

Note: Refer to Appendix B of this handbook for specific information on hold times, preservation, and containers.

3.2.1. Preparing for a Sampling Event

Preparing for a sampling event requires planning and a thorough knowledge of the regulatory program. The key elements for such preparation include:

- **Objectives.** The objectives should be thoroughly understood by all sampling personnel prior to sample collection. Knowledge of the compliance scope, boundaries, geography, and area roads and bridges will facilitate sampling.
- **Map of Study Area.** A map of the study area is essential for sampling. The map should be detailed enough so that sample locations and landmarks are clearly identifiable.
- **Permits and Regulations.** The person collecting samples should have a working knowledge of applicable permits, required monitoring, and other specified conditions. Regulations that potentially impact the sampling area, such as right of entry, should be reviewed by the sample collector.
- **Waste Sources.** When the objective of a project is to determine the nature, extent, or impact of a waste source upon an environmental medium, knowledge of waste source(s) within the area, as well as those sources upstream or upgradient that may impact the area, is essential. This knowledge entails knowing waste source discharge points or areas, type of waste, volume of discharge, and constituent concentration. When this information is not readily available, it may be necessary to collect background information.
- **Environmental Medium Characteristics.** If the study is of a waterway, the physical characteristics of the waterway should be known prior to sample collection. These important physical characteristics include whether the receiving waterway resembles a lake, reservoir, pond, small stream, or a river. Average and maximum recorded flow, width and depth, type of benthic substrate, and type of predominant aquatic vegetation also should be noted.
- If the study area is limited to land, it is important to have knowledge of the terrain, soils classification, geology, terrestrial vegetation, industrial and residential development, predominant land use, and wildlife.
- **Sampling Information.** A sampler must know the types of samples to be collected, (e.g., water, wastewater, soil, or solid waste). The sampler also must know whether the samples are to be collected nocturnally or during the daytime, and where within the environmental medium the samples are to be collected (including both horizontal and vertical collections) as well as the preferred method of collection.
- **Laboratory Arrangements.** Arrangements must be made with the analytical laboratory to ensure that the laboratory is expecting the samples when they arrive and has a description of the types of samples (e.g., liquid, semi-solid, solid, or biological), an approximation of the number of samples for each sample type, and the analyses requested on each sample type. Arrangements must be made for the appropriate number of sample containers and preservatives where required. Regulations on transportation of samples from the point of collection to the laboratory must be considered, and the COC record must be traceable, as detailed in the SAP.

- **Equipment.** Prior to going to the sampling location, the sampling gear should be examined to ensure that it is appropriate for the task and in good working order. Verify that any preventative maintenance has been completed according to the SOPs. Label, mark, and otherwise identify all equipment, instruments, reference materials, and associated supplies for measurement processes to indicate calibration or standardization status. Expiration dates of reagents and solutions should be checked and verified as to usability. If a boat is required, an appropriate boat, motor, and life jackets must be available, and preliminary boat launch locations should be known before going to the sampling site. All equipment should be examined prior to starting the sampling event.

Note: When in use, sampling equipment should be anchored to prevent loss in the event the rope or equipment slips through the hands of the sample collector.

- **Safety.** The safety of sampling personnel is paramount. During wading operations, a rope should be attached to the sampler and extended to an anchored person on shore. In boating operations, at least two people should be present, one to collect the samples and another to operate the boat motor. Boat personnel are required to wear life preservers and take care to avoid overloading the craft. When collecting samples, beware of snakes, stinging insects, ticks, or other animals that may cause injury to the sample collectors.
- **Personnel Transportation and Lodging.** The Program Manager must consider arrangements for transporting sampling personnel and equipment to the sampling site, and for lodging when the sampling extends beyond a working day.

3.2.2. Preliminary On-Site Evaluation

When sampling for the first time at a new location, a preliminary on-site evaluation should be conducted prior to the sampling event to ensure that all aspects of the sampling process are addressed.

Upon arrival at the site, the Program Manager (or designee) and the Health and Safety Supervisor shall check with facility personnel to determine whether there have been any recent changes at the sampling locations that would influence the SAP or modify the expected hazards.

3.2.3. Preliminary Site Safety Evaluation

After a preliminary hazard analysis, sampling locations should be inspected to develop the Safety Plan or HASP as appropriate to the scope of the project. PPE information specified may not be completely reliable, and additional air monitoring may be required. When air monitoring activities are needed, focus first on identifying conditions that present an acute health hazard, and then evaluate exposure to chemicals such as carcinogens that could create long-term health problems.

If samples are to be collected in a confined spot, testing the air within the space for oxygen content should be a priority. Tests for explosive levels of flammable vapors should be conducted next, followed by testing for the presence of hazardous concentrations of specific toxic agents (depending upon the nature of the space and its contents or previous contents).

Note: Real-time instrumentation is available for making these measurements. Air samples should be collected to evaluate the levels of other chemicals in the air that may require respiratory protection. Some organic chemicals such as gasoline vapors can be monitored with standard field instruments. However, monitoring for carcinogens will normally require the use of a field gas chromatograph or the collection of test samples for laboratory analysis.

In general, the air monitoring program to evaluate worker exposures to toxic chemicals should be designed by an industrial hygienist familiar with the facility and potential hazards to which the field sampling team will be exposed.

Review physical hazards that may be present at the site, such as unstable footing near river embankments, water safety practices, first aid supplies, equipment safety practices, and other physical hazards.

3.2.4. Explosive Safety Evaluation

The possibility of encountering explosive hazards must be considered in all sampling plans. When the presence of energetic materials is suspected from the history of a site, appropriate precautions can be incorporated during the planning stages.

Consideration should also be given to situations that can lead to the formation of unstable materials from constituents that are not originally energetic compounds. Formation of peroxides in ethers and metal picrates are two examples that have been known to create safety hazards.

3.2.5. Preliminary Sampling Evaluation

Sampling locations should be inspected to ensure the information in the SAP is correct. All equipment should be checked prior to mobilization and the day before the sampling event to ensure proper equipment operation, parts, and records are available for the sampling operation. If needed, preventative maintenance should be performed.

Reagents, supplies, reference materials, and consumable materials should be verified as to expiration dates, quality, and applicability to the assigned equipment.

Locate all the sample locations during the on-site evaluation to determine site accessibility with the designated equipment, sample location, and possible background contamination for the contaminants of interest. Electromagnetic interferences, volatile air pollutants from locations off site, weather, and climate may affect the sampling event and should be planned for, as much as practical, to avoid delays in sampling.

3.3. The Sampling Event

A typical sampling event should include the following sequential activities:

- Complete all preparation and preliminary evaluation activities as needed
- Arrive at the sampling site with appropriate equipment, supplies, materials, and sample containers
- Set up equipment, work areas, and safety areas, as described in the SAP
- Collect samples at the locations specified in the SAP or reference procedure
- Immediately following sample collection, ensure that each sample container is labeled as described in the SAP. The sample label must be traceable to the sample number, date/time sampled, sampler's name, preservative, and site name, location or unique project identifier.
- Document the exact location of the collected sample(s) in the field logbook or field notebook (FLB/FN). Also, record in the FLB/FN other observations of environmental conditions that could affect or contribute to knowledge of the sampling area and the environment where the sample is collected. Prevailing weather conditions at the time of sampling should also be recorded.
- Preserve or ice samples as appropriate and record preservation method
- Perform field tests or field screening measurements and record all observations in the FLB/FN
- Complete the COC record and other field records
- Pack and seal the shipping container with collected samples, and transport the shipping container with the COC record and any laboratory required forms to the laboratory. Retain copies of all transmitted forms.
- Return all forms and copies of relevant FLB/FN pages to the Program Manager or designee
- Clean sampling equipment for the next sampling event or storage
- Breakdown all work area and safety areas as required and return the site to the condition found at the start of the sampling event
- Dispose of all waste materials using appropriate procedures.

3.4. Sampling Procedures

The SAP refers to detailed sampling procedures or includes the details of the sampling operation. A standard SOP format should be used to incor-

porate the following items for each type of sampling operation:

- Sampling locations, sample numbers or identifiers
- Type, volume, and number of sample containers to be filled at each sampling location and the records to be maintained
- Contaminants to be measured and special handling procedures to ensure proper collection
- Safety, health, and hazard cautions
- Sampling equipment (construction material, type, etc.) and records to be maintained for status, maintenance, and corrective action
- Step-by-step sample collection procedures (grab, composite, continuous for specified period, etc.)
- Sampling frequency for repeated sampling at the same sample location
- Special sampling requirements (e.g., the collection of initial runoff samples after a rain for contamination)
- Sample handling procedures for each sample container (e.g., screened, filtered, sequence for filling groundwater sample containers, etc.)
- Preservatives required for each sample container and contaminant
- Reagents, supplies and support services quality, verification and validation criteria to ensure materials are used properly
- Equipment decontamination procedures to be used between sample locations and between sampling events
- Recordkeeping requirements, documentation handling, and retention requirements
- Sample, equipment, and materials storage requirements
- Provisions for storage or disposal of wastes generated during field sampling.

3.4.1. Sampling Strategies

See Appendix A for sampler and sampling recommendations and strategies for waste materials. Sampling strategies for drinking water, wastewater, groundwater and TSCA materials are permit or compliance dependent. The Scope or Purpose section of the sampling procedures should describe the rationale for the sampling strategy to ensure that all personnel involved with the project have an understanding of the sampling event.

3.4.2. Sampling Procedure Checklist

Following is a checklist of the minimum steps to address in SOP format.

- **Sampling Approach**
  - Objective
  - Design of sampling plan
  - Statistics
- **Material to be Sampled**
  - Physical state
  - Volume
  - Hazardous properties
  - Composition
- **Site**
  - Accessibility
  - Waste generation and handling
  - Transitory events, startup, shutdown
  - Maintenance
  - Climate
  - Hazards
- **Equipment**
  - Maintenance
  - Preparation and cleaning
  - Operation
  - Calibration and standardization
- **Sample Handling, Transportation, Storage and Preservation**
  - COC
  - Seals
  - Forms
  - Containers
  - Preservatives, reagents, and supplies
- **QA/QC**
  - Controls on process
  - Audits
  - Training
  - Samples, blanks, duplicates, and spikes
- **Health and Safety**
  - Personnel protection

  - Safety procedures
  - Emergency procedures
- **Laboratory**
  - Document transfer
  - Sample arrival schedule, transfer
  - Sample preservation, handling and storage
  - Analytical methods and QC
  - Reporting format and schedule.

3.5. Sample Documentation and COC Procedures

Thorough documentation of a sample's custody is required to support sample validity. The documentation must verify that the samples are representative, were collected in accordance with the requirements of the SAP, and are not vulnerable to tampering before being received by the laboratory. The COC begins when the sample is taken and ends when the sample is disposed of. Sample documentation and COC procedures include the following.

- A completed sample collection label attached to all sample containers
- Records of sampling operations written in FLB/FN or related forms as designated for the operation in the SAP. Records include sample type, sample matrix, sampling method, field test methods, and QC procedures. A table may be used to present this information.
- Identification of every sample container on a COC record and all custody transfers documented
- Custody of the samples with all discrepancies in the field operations resolved or duly recorded.

The following should be used to generate the required sample documentation.

Note: EPA's "Field Operations and Records Management System II Lite (FORMS II Lite™)" software is an electronic COC and may also be used to simplify and accelerate the sample documentation process.

3.5.1. Pre-Assigned Sample Numbers

Each sample consists of all of the material collected for analysis at one place, at one time, and of one matrix, except for composite samples, which may contain components collected at different locations or time.

The Program Manager shall establish a system for assigning a unique sample number to each sample collected in the field. The numbering system will be defined in the SAP, in case additional samples are generated in the field. The number for each sample will be used to identify the sample in the FLB/FN, on the sample container, and on the COC record. The number may be used on other forms and reports presenting measurements, test data, or evaluations.

The sample numbers of field QC samples like a field duplicate should be transparent to the laboratory. The sample numbers should not reveal whether a sample is a blank sample or two field samples are duplicate/split pairs to avoid potential biasing of analytical results.

The sample number provides a common identifying code for all of the analytical results for a single sample. This is particularly useful when the results are entered into a computer database, which should include:

- Sample number
- Sample container number
- COC record number
- Matrix
- Location
- Sample type
- Sample date and time
- Sampler's name
- Parameter
- Analytical result
- QC data
- Compliance limit and
- Data qualifier code (optional).

Results from analysis of trip blanks, field blanks, equipment decontamination blanks, split samples and MS/matrix spike duplicate (MSD) samples may be entered into a computer database. In some testing programs, these results are used to

generate the data qualifier code for the analytical results from test and duplicate samples.

It is recommended that the information associated with each sample number consists of elements describing the sample type, matrix, location, and the time and date of sample collection as required.

Note: If the sampling and analytical data are to be added to an existing database, sample numbers should be consistent with database requirements.

3.5.2. Sample Container Labeling

Sample labels are an important part of proper documentation to reduce the possibility of confusing sample containers, and to provide the necessary handling information. Sample containers should be pre-labeled as much as practical before sample collection. The labels may be protected from the sample matrix with a clear tape covering. For volatile samples, check with the laboratory to ensure that any labels being used do not interfere with their auto-samplers. Sample labels should include sample number, date and time sampled, location, sample type, preservative and the sampler's initials or signature.

Sample numbers may be unique to the sample location, to the sample type or to the container. In some labeling processes, a unique sample number is written on the container label, and all information recorded on the accompanying form(s) is traceable to the unique sample number.

Some number schemes uniquely number each sample container. All data reported for the sample includes the sample container number for traceability to the container measured. This is useful when sample containers are cleaned and lot controlled, and traceability from container preparation, preservation, sampling, and testing is required.

A designated Field Sample Custodian or sampler should label the sample containers when they are filled. Preprinted, adhesive, multiple part labels formatted as shown in Figure 3-1 may be used. Each part includes the unique sample container number that may be pre-numbered to avoid duplication.

Note: Because 40-mL volatile organic analysis (VOA) vials may be stuck in an autosampler, the field sampling team leader needs to contact the laboratory to make sure if applying a clear tape over a sample label of 40-mL VOA vials is acceptable. Use waterproof ink to make label entries. FLB/FN notations should provide an explanation if a pencil was used to fill out the sample container label due to field weather conditions. Because waterproof ink may contain target VOAs such as xylene, toluene, or alcohols as a solvent, great care is needed to prevent VOA samples from contamination by the solvent of waterproof ink or permanent marker.

Figure 3-1. Multiple Part Container Label

PROJECT NAME
Sample #: XXXXX
Container #: XXXXX Sample #: _____ Date: _____ Time: _____ Location: _____ Cont. Size: _____ Cont. Type: _____ Matrix: _____ Type of Sample: _____ Preservative: _____ Signature: _____

3.5.3. FLB/FN

The FLB/FN is the written record of all field data, observations, field equipment calibrations, and sample collection activities. Potential for future legal actions dictates that the FLB/FN be site-specific and that they be hardbound (e.g., ledger, composition book, diary, etc.). All pages (front and back) shall be serially numbered so removal will be apparent. Samplers shall adhere to the following guidelines when using FLB/FN.

- The FLB/FN shall be assigned to the QA/QC Coordinator or designee. Additional log books may be assigned by the Program Manager or designee to the Field Chemist and the Health and Safety Supervisor. The QA/QC Coordinator or designee shall note in each FLB the individual to whom it was assigned. The FLBs may be controlled by the QA/QC Coordinator or the Program Manager.

- Each FLB shall be annotated with the sampling program name or number.
- Key personnel and telephone numbers shall be listed on the first page.
- Entries shall be written in waterproof blue or black ballpoint pen. Avoid felt tip pens. *Do not use pencil.*
- Start a new page at the beginning of each day.
- Entries should be chronological – a time notation should introduce each entry.
- Sketch or obtain a map of the area or facility. Include sketches of layout, structural features, and points of interest or contamination. Include a north arrow and a rough scale. If possible, obtain a site map (reduced if necessary) and permanently place it in the FLB/FN.
- Language should be objective, factual, and free of personal feelings or other inappropriate terminology. Speculation or personal observations may be included if they are clearly identified as such.
- Do not erase or scratch out errors. Draw a single line through the error, then insert corrected material. The person who made the error shall initial and date the correction as well as clearly state the reason for the error.
- Entries or corrections made by individuals other than the person to whom the FLB/FN was assigned shall be signed and dated by the individual making the entry or correction. An explanation for the correction should be noted.
- The last entry for each day should include a short summary of the day's activities, weather conditions and the time the site was left. As appropriate, the last entry for each week should be a summary of the week's activities. Weekly summaries should be thorough and descriptive.
- The FLB/FN shall be signed at the end of each day. Signatures shall be written on a single diagonal line drawn across the blank portion of the page following the day's last entry.
- All FLBs/FNs shall be returned to the individual designated for review and final storage when sampling is completed as described in the SAP.
- FLB/FN entries will contain a variety of information. Information to be entered at the start of each day of sampling includes the following:
    - Date of the sampling event
    - Time sampling started and approximate time for set up of equipment
    - Weather conditions
    - Level of PPE being used
    - Names of field sampling team members and others present during the sampling.
- Fully document all deviations from the SAP or changes in sampling procedures. Problems, delays, or any unusual occurrences such as improper equipment or breakdowns should be included, along with resolutions and recommendations. Summarize the content and conclusions of all relevant meetings, discussions, and telephone conversations in which you are involved. Include the names and affiliations of all personnel involved. Thoroughly document all directives and/or guidance from EPA or other government personnel. Directives that give personnel specific authority to make critical decisions must be documented in the FLB/FN.
- Whenever a sample is collected or a measurement is made, a detailed description of the location must be recorded. The source from which the sample is collected should be clearly identified to maintain traceability and allow another person to locate the exact sampling location. The ability to relocate the sample site ensures duplication of future sampling events. Measurements from permanent features (e.g., center line of road, numbered utility pole, etc.) to the sample point must be made and entered into the FLB/FN. Coordinates on a map, or an accurate site sketch with distance measurements to known locations are other options to ensure the exact location of each sample is recorded.

- Describe the site thoroughly so another person will be able to locate the exact sample location. Note signs of contamination such as oily discharges, discolored surfaces, unusual odors, dead or distressed vegetation including types of plants, if possible. Photographs may be taken to provide evidence of visual observations, record site conditions, and assist with locating the sample site in the future. Photographs taken of sample locations should be noted along with the picture number. Log the record in the FLB/FN to identify which sampling site is depicted in the photograph.

Note: A series of photographs can be identified by taking the first photograph of an informational sign with the sampling program name, number, and the project number on it.

- Each time a sample container is filled and labeled, a copy from the multiple part form of the sample container label or reference number label with all information recorded shall be put into the FLB/FN.
- All equipment used to make measurements must be identified by type, manufacturer, and serial number, along with the date of calibration. Details of field calibration procedures and results shall also be included in the FLB/FN.
- Note decontamination or disposal procedures for all equipment, samples, protective clothing, and personnel decontamination procedures.
- For each delivery or shipment of samples to a laboratory, record the following information in the FLB/FN:
    - Custody procedures and serial numbers
    - Packing and shipping procedures (record air bill numbers)
    - Name, address, telephone number, and contact of the laboratory performing the analysis.

Note: The laboratory address should be the sample receipt address, which may not be the same as the mail receipt address.

3.5.4. Field Notes/Field Sampling Forms

Field notes or field sampling forms are used in addition to or in lieu of field log notes. When field notes are used in lieu of an FLB, the record keeping practices presented in Section 3.5.3 should be followed. The field form provides a place for the sampler to record the information required for the project. Field forms are specially designed for any given project and may be completed one per sample or one per sampling event. The forms include blank lines for recording the information necessary for the project to ensure the proper information is recorded. All blanks must be completed on a field form to ensure proper documentation. The sampler completes the field form for all samples collected including QC samples. An example of a field form for a well sampling activity is presented in Figure 3-2 below.

Note: A review of the regulatory program's specific requirements must be conducted to ensure that all documentation requirements are met. Some programs do not allow the use of loose field forms as the sole documentation vehicle and require hardbound logbooks.

The field form lists the sample number, location, matrix, the type and number of sample containers filled (including QC samples), any chemical preservatives added and checked for each sample container, sampling procedure reference, deviations to the procedures and all field measurements and observations.

The Field Sample Custodian indicates acceptance of the information on the field form by signing and dating the form. In cases where multiple part forms are used for the sample label, for each sample container filled, one part of the multiple part adhesive sample container label is placed on the field form at the appropriate location. The completed field forms are returned to the Program Manager as soon as possible and by the means indicated in the SAP. Deviations or problems encountered during the sampling event must be communicated promptly in writing to the Program Manager or designee. This may be completed by sending the field form by facsimile or other means to communicate the deviations, as

well as allow for continuation of the project and ensure sample holding times are not jeopardized.

Note: The field form becomes part of the permanent project records, but is not usually sent to the laboratory.

3.5.5. Chain of Custody (COC)

An overriding consideration for environmental measurement data is the ability to demonstrate that samples have been obtained from the locations stated and that they have reached the laboratory without alteration. Documentation of security, field handling criteria, shipment, laboratory receipt, and laboratory custody until disposal, provides evidence of proper processing. The degree of custody documentation is dependent on the regulatory program, data use, and needs. Many state programs for sampling wastewater and drinking water do not require "legal custody," but recommend legal custody whenever data is known to be used for evidence. A review of data use and risk of legal proceedings will dictate the type of custody procedure to be employed. Documentation consists of a COC record that is completed by the Sample Custodian.

3.5.5.1. Field Custody Procedures

The Field Sample Custodian or sampler is personally responsible for the care and custody of the samples until they are transferred or properly dispatched. As few people as possible should handle the samples. A sample is considered to be "in custody" for legal proceedings if it is:

- In a person's actual possession
- In view after being in physical possession
- Locked up so that no one can tamper with it after having been in physical custody
- In a secured area, restricted to authorized personnel only.

If any one of these is not in place at all times, the COC is broken.

The Program Manager or designee shall review all field activities to determine whether proper custody procedures were followed during the fieldwork and whether additional samples are required. The sampler or Sample Custodian shall notify the Program Manager of any breach or irregularity of COC procedures described in the SAP.

Figure 3-2. Field Form

Sheet _1__ of __1_

MICROPURGE/LOW-FLOW SAMPLING LOG

PROJECT:		**WELL ID:**	
EPA ID NO:			
Proj./Task No.		Well Condition:	
Date:		Well Riser Dia. (ID):	
Weather:		Screened Interval:	
Samplers:		S.W.L. Measuring Pnt:	
		Well Bottom Depth:	
Purge Method: Micropurge			
Sample Collection Method:			
Sampling Device:		**STATIC WATER LEVEL:**	
Tubing:	**Pump Intake Depth:**	Initial Purge Volume:	
Total Recovered Purge Water This Well:		Approximate Pump Throttle Setting:	

Groundwater Sample Data:

Sample ID	Analysis	Primary	QC	MS/MSD	Blank	Sample ID	Analysis	Primary	QC	MS/MSD

Instrumentation/Equipment Data:	**Calibration Date:**

Field Test Results:

Hach Kit Tests:

D.O.		mg/L			
Total Iron:		mg/L			
Ferr. Iron:		mg/L			
CO2:		mg/L			

Comments:

Observations: Clarity: Odor: Floating Product: Sheen:

PURGE WATER DATA TABLES

Stabilization Parameters	Units	Minutes	Minutes	Minutes	Minutes	Minutes	Minutes	Minutes	Minutes
Temperature	C								
Sp. Cond.	ms/cm								
D.O.	ppm								
pH									
ORP (Eh)	mV								
Turbidity	NTU								
Clock Time									
Static W.L.									
Flow Rate	ml/min.								

Stabilization Parameters	Units	____ Minutes	____ Minutes	____ Minutes	____ Minutes	____ Minutes	____ Minutes	____ Minutes	____ Minutes
Temperature	C								
Sp. Cond.	ms/cm								
D.O.	ppm								
pH									
ORP (Eh)	mV								
Turbidity	NTU								
Clock Time									
Static W.L.									
Flow Rate									

3.5.5.2. COC Records

From time of collection through final sample disposal, there are many transfers of custody during the course of a sampling program. All sample containers must be accompanied by a COC record to document these transfers. A separate COC record shall be prepared by the Field Sample Custodian or sampler for each sampling event. In some programs, a COC record accompanies each shipping container and includes a pre-numbered COC record. This record lists the sample containers that are in the shipping container, and serves as the packing list for the container. The serial number on the form becomes the identifying number for the shipping package.

Figures 4-3 provides an examples of a sample COC record. The example has been used for a wide variety of regulatory programs and meets legal COC requirements. It tracks the samples from sample collection to disposal. All sampling, preservative, and test information is included. The SAP will indicate the individual responsible for completing each section. The following information relates to the numbered blocks:

COC Record–Figure 3-3.

(1) The **company/command** name and **code** for the source of the funding.

(2) The **contact name** for the Program Manager or designee indicated in the SAP.

(3) The **job order number** (**J.O. #**) is entered to trace the information to the specific job.

(4) The **signature** of the Program Manager or designee authorizing the funds.

(5) The **permit number** (**No.**), if applicable, for the samples collected. The number is issued by the regulatory agency for specific compliance reporting.

(6) The **sample ID/location** based on permit designations or actual site location name.

(7) The **sample taken date and time** are recorded for grabs on the start line only and for composites on the start date and time and stop date and time.

(8) The code for **sample type** such as grab, composite flowing and composite time (see Section 18).

(9) The initials for the **person sampled by**.

(10) The code for **sample matrix** such as liquid, solid, and gas (see Section 18).

(11) The code for **preservative** (see Section 18).

(12) The **# of samples** and **container** type are entered as “4-P” for four plastic containers (See Section 18).

(13) The **analysis** to be performed - may reference descriptions in the SAP.

(14) The field reading for **pH** for the sample containers indicated.

(15) The field reading for **temperature** with the unit of measure for the sample containers indicated. The SAP may indicate the temperature to be recorded in the outfall temperature and not the sample temperature.

(16) The field reading for **other** required measurements may be entered with the unit of measure. The SOP and name of the test must be indicated on the custody form.

(17) After the samples are preserved, the **preservation is verified**. The verification is noted per the SAP. This verification may be temperature, pH, or if all is correct an indication is made as “OK.”

(18) This section of the custody form contains **common codes** to be used by the sampler when completing the custody record. When situations arise that do not match the code designations, alternates may be added for the one time use on the custody form.

(19) The expected **turnaround** for sample request is placed in this area. The reason is presented to determine if the turnaround time is regulatory, project specific, or based on holding time requirements.

(20) **Special instructions** or comments may be entered in this space.

(21) The **regulation applied** to the project is checked.

(22) The **sample collection/charge**, **possible sample hazard** and other **comments** relate to the command in charge of sampling, special sample hazards, or to other sample comments. Reference may be made to code or specific sections of the SAP.

(23) The **delivery order number** is entered.

(24) The **contract lab** and **contract number** (**No.**) are entered for testing work performed by a designated contract laboratory.

(25) The **sample disposal** method and the date completed.

(26) The signature and **company/command** of the person relinquishing custody (**relinquished by**).

(27) The signature of the person custody is **received** (**rec'd**) **by**.

(28) The **date/time** custody is transferred.

Figure 3-3. COC Record

CHAIN-OF-CUSTODY RECORD
& ANALYSIS REQUEST FORM

PWC ENVIRONMENTAL LABORATORY
CODE 930 BLDG Z-140
9142 MARYLAND AVENUE
NORFOLK, VA 23511-3095
PH: (004)4450851 FAX: (004)4450892

ENVIRONMENTAL

CLIENT INFORMATION

COMPANY/COMMAND: 1 CODE:
CONTACT: 2
PHONE: EXT: FAX:
J.O. #: 3
SIGNATURE: 4
PERMIT NO.: 5

LAB USE ONLY LINE ITEM #	LAB USE ONLY SAMPLE NO	SAMPLE ID/LOCATION	SAMPLE TAKEN	ON DATE	AT TIME	TYPE	SAMPLED BY	MATRIX	PRESERVATIVE	# OF SAMPLES CONTAINERS	ANALYSIS	FIELD READINGS pH	FIELD READINGS TEMPERATURE	FIELD READINGS OTHER	PRESERVATION VERIFIED BY
		6	START	7		8	9	10	11	12	13	14	15	16	17
			STOP												
			START												
			STOP												
			START												
			STOP												
			START												
			STOP												
			START												
			STOP												
			START												
			STOP												
			START												
			STOP												
			START												
			STOP												

TYPE	MATRIX	CONTAINER	PRESERVATIVE
G - GRAB	L - LIQUID SW - SWIPE	P - PLASTIC B - BAG A - AMBER(glass)	1 - COOL TO 4C 5 - HCL, pH<2
CF - COMPOSITE, FLOW 18	S - SOLID	GL - GLASS C - CARTRIDGE	2 - HNO3, pH<2 6 - 0.008% Na2S2O3, 4C
CT - COMPOSITE, TIME	GS - GAS	T - TEFLON TL - TEFLON LINED LID	3 - H2SO4, pH<2 7 - FIELD FILTER
	SS - SEMI SOLID	V - VOA H - HEXANE RINSED	4 - NaOH, pH>12 8 - NONE

TURNAROUND: 19 *(FOR RUSH TURNAROUND STATE REASON BELOW)*
SPECIAL INSTRUCTIONS: 20

REGULATION APPLIED: 21

RCRA	( )	HRSD	( )
SDWA	( )	TSCA	( )
CWA	( )	PHOTO	( )
CAA	( )	OTHER	( )

SAMPLING/COLLECTION CHARGE:
POSSIBLE SAMPLE HAZARDS: 22
COMMENTS:

SAMPLE DISPOSAL: ( )RETURN TO CLIENT ( )DISPOSAL BY LAB 25

D.O. NUMBER: 23
CONTRACT LAB: 24
CONTRACT NO.(S)

*1. CUSTOMER IS RESPONSIBLE FOR ALL CHARGES NECESSARY FOR THE PROCESSING AND ANALYSIS OF SAMPLE(S).**
**ALL RUSH SAMPLES ARE SUBJECT TO SURCHARGE*
2. SAMPLES RECEIVED AFTER 3:00PM MON. – THURS. AND 2:00PM ON FRIDAY WILL REPROCESSED THE NEXT BUSINESS DAY(7:30 AM– 4:00 PM).

RELINQUISHED BY:	COMPANY/COMMAND:	REC'D BY:	DATE/TIME:
26		27	28
RELINQUISHED BY:	COMPANY/COMMAND:	REC'D BY:	DATE/TIME:
RELINQUISHED BY:	COMPANY/COMMAND:	REC'D BY:	DATE/TIME:
RELINQUISHED BY:	COMPANY/COMMAND:	REC'D BY:	DATE/TIME:

The COC record identifies which pairs of sample containers were collected for the same analysis, and identifies the sample containers that were filled with sample for use as the MS/MSD QC samples. Based on the needs and data use, the COC record may not list any information as to the exact sample location or whether a sample is a field duplicate, field blank, trip blank or an equipment decontamination blank. This information is kept as blind information from the laboratory to ensure objective reporting. When this process is used, records must be maintained that trace the sample collected in the field with the sample as identified to the laboratory. Compliance data for drinking water or wastewater testing do not require blind submissions. The QC sample information is provided to the laboratory to ensure prompt notification when the QC data does not meet the SAP specifications.

Whenever samples are split with a second laboratory or government agency, a separate COC record may be prepared for the second set of samples. The additional set of COC records must be noted. Copies of the original may be sent with the split samples noted, or a separate form may be prepared by copying the appropriate information for the samples onto the additional form. In all cases, the use and need of the additional form should be noted.

Upon completion of the packing of each shipping container, the Field Sample Custodian shall confirm the completeness of the COC record by signing the COC record. If a multiple-part form is used:

- The original copy is put into the shipping container
- The first copy is sent immediately (preferably by fax) to the Program Manager or designee
- The second copy is kept with the FLB/FN or copy of the field form.

If a single part form is used, photo copies should be made for the Program Manager and the FLB.

After the COC record is completed and all samples are packaged and shipped to the appropriate locations, the person relinquishing the samples to the laboratory or agency shall request the representative's signature acknowledging sample receipt. If the representative is unavailable or refuses to sign, this is noted in the "received by" space.

Field COC terminates upon laboratory receipt of the samples. The laboratory should complete the "received by" sections and if appropriate, the "preservative checks" sections on the COC record and return the original signed record to the Program Manager. If there are any discrepancies between the COC record, the contents of the shipping container, and the SAP or contract requirements provided to the laboratory, the samples in question shall be segregated from normal sample storage, and the laboratory shall immediately notify the Program Manager. In some cases, the laboratory checks the sample submittal and recordkeeping to ensure adherence to the SAP. This added check is often used in drinking water and wastewater testing programs for compliance monitoring. Recordkeeping and information checks should be performed by the laboratory to ensure the samples received meet the requirements of the SAP.

3.5.5.3. Custody Seals (Optional)

Custody seals are narrow strips of adhesive paper used to indicate whether a shipping container has been opened during shipment. The seals are placed along the edges of the most exterior container in which samples are enclosed. It is not always necessary to place seals on individual sample containers in the shipping container.

Paper custody seals should be signed and applied before the shipping container is shipped to the laboratory. The preferred procedure includes use of a custody seal attached to the front-right and back-left of the container. Custody seals are covered with clear plastic tape. Another way to use custody seals, is to put all sample containers with packing and ice in a large garbage bag and seal the garbage bag with a signed custody seal.

3.5.5.4. Custody Transfer

Transfer of custody and shipment procedures are as follows.

- Each sample shipping container shall be accompanied by a properly completed COC record. The original of the record shall be included in the container. The Field Sample Custodian shall keep a copy of the completed form as part of permanent documentation and will send a copy of the COC record to the Program Manager.
- When transferring possession of samples, individuals relinquishing and receiving shall sign, date, and note the time of the transfer. This record documents custody transfer from the Field Sample Custodian to another person, to a mobile laboratory, to the permanent laboratory, or to a secure storage area.
- If the sample container is sent by common carrier, a bill of lading shall be used. Bill of lading receipts shall be sent to the Program Manager for permanent retention. If sent by mail, the package shall be registered with return receipt requested. Commercial carriers and the U.S Postal Service are not required to sign off on the COC record as long as it is sealed inside the package with the sample container and the custody seals remain intact (if used).

3.5.6. Request for Analysis

The Request for Analysis form is often incorporated into the COC record since the chain must accompany the samples. In more complex sampling programs, an additional form may be used to request testing.

When contracting for laboratory services and prior to submitting the samples, the laboratory should be contacted and the following information presented. The Request for Analysis form can be used as a preliminary contact mechanism to ensure that the scope of work is understood. This form:

- Specifies the analyses, procedures, and QC data to be performed on each sample container and the compliance protocols to be followed
- Specifies the laboratory accreditation/ certification required to be maintained during the period of the contract
- Authorizes the payment for the analyses
- Alerts the laboratory to any anticipated hazards associated with the samples and custody procedures to be followed while the samples are in the possession of the laboratory
- Specifies the reporting requirements and content for the final report from the laboratory
- Instructs the laboratory as to the disposition of the samples after the completion of the analyses.

3.6. Sample Packaging, Handling, and Transportation

The Field Sample Custodian is responsible for the proper field storage, security, packing, and shipping of the samples from the field to the laboratory or designated holding location. The packaging, labeling, and shipment of samples by common carrier are regulated by the DOT and the International Civil Aviation Organization (ICAO)/International Air Transport Association (IATA), when appropriate. Instructions for classification, labeling, and packaging of hazardous materials are contained in DOT regulations (49 CFR 172 and 173, and subsequent Parts). Overnight couriers generally accept materials shipped under these regulations. However, some couriers have additional restrictions for hazardous shipments. EPA also regulates the shipment of hazardous waste and hazardous material by requiring labeling on certain packages.

The procedure for determining whether a sample is hazardous under DOT regulations is complex, as is the determination of the proper shipping name, packaging requirements, and labeling requirements for DOT hazardous materials. A summary of specific requirements are addressed below. Should questions arise, assistance is available from the DOT (1-202-366-4000) and Federal Aviation Administration (FAA) (1-866-835-5322) hotlines.

Samples obtained at sites are classified for shipping purposes as either environmental (non-hazardous) samples or hazardous samples. If a material is being shipped for testing to determine its hazards, a tentative hazard class assignment

should be made based on knowledge of the material. Samples requiring special packaging or labeling are those containing chemicals that are listed as hazardous materials in:

- 49 CFR 172.101
- CERCLA RQ Hazardous Substances
- DOT CLASS 9 listed in 49 CFR 172.101 Appendix A, Poison DOT Class 6.1 and Flammable Liquids.

Environmental (non-hazardous) samples are those that are not classified as Hazardous Materials under DOT regulations, are packaged in quantities less than the CERCLA RQ, *and* for which a Hazardous Waste Manifest is not required by EPA. These samples require careful packing, but no special shipping procedures. In general, samples of groundwater, surface water (other than leachate or lagoons), and soil may be shipped as environmental samples (non-hazardous) to an analytical laboratory for testing if each of the sample containers contains less than 1 pound of soil or 1 gallon of water, and the entire shipping package weighs less than 66 pounds. Eventual analysis for a hazardous constituent does not necessarily classify a sample as a DOT hazardous material, nor does the classification of a material as a hazardous waste under EPA regulations. DOT regulations forbid the shipping of non-hazardous materials as hazardous. However, if any doubt exists as to whether the sample might be classified as a hazardous material, the sample should be treated as hazardous.

Note: For details on the shipping of non-hazardous waste, refer to *ASTM D6911-03: Standard Guide for Packaging and Shipping Environmental Samples for Laboratory Analysis*. This standard provides guidance in determining the most appropriate procedures for packaging and shipping environmental samples.

The storage and disposal of hazardous waste is regulated by the EPA. Hazardous waste, as specified in 40 CFR 262, is not exempted from EPA manifesting requirements. However, EPA RCRA regulations exempt samples collected for analysis or treatability testing from the RCRA requirements that otherwise apply to hazardous waste (including the requirement for a Hazardous Waste Manifest). The definitions for these exemptions are:

- **Samples for Analysis**. 40 CFR 261.4(d): Samples of solid waste, water, soil, or air, which are collected for the sole purpose of testing to determine their characteristics or composition, when samples are being sent to the laboratory for testing or are being returned to the collector after testing.
- **Samples for Treatability Testing**. 40 CFR 261.4(e): Samples collected for the purpose of conducting treatability studies when they are being transported to the testing facility provided they meet criteria for the quantity of material, packaging, and permit status of the receiving facility.

3.6.1. Sample Packaging Requirements

The Field Sample Custodian is responsible for the packing and shipping of the samples from the field to the laboratory. Samples shall be properly packaged for shipment and dispatched to the laboratory for analysis with a signed custody record enclosed in the shipping container box or cooler. Shipping containers shall be locked or secured with strapping tape in at least two locations. Shipments that are sent to an on-site laboratory or one in close proximity that does not require the use of a common carrier shall be transferred in accordance with local regulations. Table 3-1 below lists sample packaging procedures that will ensure samples arrive at the laboratory with the COC record intact.

The following major issues must be addressed in preparing environmental samples for shipment to the laboratory by common carrier:

- Compliance with EPA regulations, so the samples are not classified as hazardous waste
- Compliance with transportation regulations, including use of the proper shipping containers, use of warning labels, and completion of the required paper work
- Packing, to assure that the samples do not break or leak during shipping. This includes:

- Using approved containers meeting DOT drop test specification
- Lining coolers or containers with plastic bags
- For glass containers, wrapping each in bubble wrap and placing in a clear plastic resealable food bag
- For plastic containers, placing each in a clear plastic resealable food bag
- Never stacking glass containers or laying glass on its side.

3.6.1.1. Samples Classified as Flammable Liquid

Table 3-2 Column 1 lists packaging procedures that apply to those flammable and combustible liquids that do not meet the definitions of another hazard class except DOT Class 9, and for which exceptions under 49 CFR 173.150 are allowed. This includes Flammable Liquids Not Otherwise Specified (NOS), toluene, gasoline, and many of the other flammable liquids that are commonly encountered on hazardous waste sites.

Note: The DOT definition of "liquid" is different from that used by EPA. For purposes of transportation, liquid means a material that has a vertical flow of over 2 inches (50 mm) within a 3-minute period, or a material having 1 gram or more liquid separation, when determined in accordance with the procedures specified in *ASTM D4359-90, Standard Test Procedure for Determining whether a Material is a Liquid or Solid*, (49 CFR 171.8).

3.6.1.2. Samples Classified as Poison — DOT Class 6

Table 3-2 Column 2 lists packaging procedures that apply to those poisonous liquids and solids for which exceptions under 49 CFR 173.153 are allowed. This includes 1,1,1-trichloroethane, trichloroethylene, trichlorobenzene, PCB transformer oil, and many of the other poisonous materials commonly encountered.

3.6.1.3. CERCLA Reportable Quantities — DOT Class 9

Table 3-2 Column 3 lists packaging procedures for substances (liquids and solids) where the waste material is not otherwise classified as a DOT Hazardous Material because of hazardous properties *and* for which the entry in Column 8a of 49 CFR 172.101 Table is 155. For the shipment of larger quantities of EPA hazardous waste and DOT Class 9 hazardous substances where the quantity of material in each container *exceeds* the CERCLA RQ and no other DOT Hazardous Material classification applies, the following packaging requirements apply:

- Label each container with a separate container number
- Seal each drum or pail with a Security Seal
- Prepare one COC record for each group of containers that is being shipped at the same time to the same destination. List the container numbers on the COC record.

These shipments may include EPA Hazardous Waste in 5-gallon cans and 55-gallon drums. Most DOT containers are approved. The list of approved containers for packing Groups II and III Class 9 Hazardous Substances are listed in §173.203 for liquids and §173.213 for solids. These lists include steel, aluminum, plastic and fiber drums (solids only). Quantity limitations are shown in 49 CFR 172.101, Column 9.

Table 3-1. Packaging by Common Carrier

	By Common Carrier	
Instructions	**Non-hazardous Samples**	**Hazardous Samples**
Secure sample container lids with strapping tape.	1*	1*
Mark the level of material in each sample container with a grease pencil.	2	2
Place each container in a clear plastic resealable food bag so that the sample container label can be read.		3
Place about ½ inch of inorganic cushioning material such as vermiculite in the bottom of a metal can.		4
Place each container in a separate can and fill the remaining volume of the can with an inorganic cushioning material such as vermiculite (do not use plastic foam cushioning material as it could dissolve if the sample container were to leak).		5
Close the can using three clips to secure the lid.		6
Write the sample number on the can lid. Indicate "This Side Up" by drawing an arrow on the can.		7
Put about 1 inch of cushioning material (e.g., vermiculite or plastic foam) in the bottom of a watertight metal or equivalent strength plastic shipping container. If the container is a cooler, seal the drain plug on the inside of the cooler with tape. Also line the inside of the container with a plastic bag.	3	8
Wrap glass bottles and jars in plastic bubble wrap.	4	
Place cans in the container and fill the remaining volume of the shipping container with packing material. Add ice bags if required.		9
Place the sample containers top-up in the shipping container. Arrange the sample containers so that glass containers are surrounded by plastic containers.	5	
Fill the void space around and on top of the sample containers with plastic bags filled with ice cubes or ice chips.	6	
Seal the COC record in a clear plastic resealable food bag and tape it securely to the inside of the shipping container lid.	7	10
Close and lock or latch the shipping container.	8	11

	By Common Carrier	
Instructions	**Non-hazardous Samples**	**Hazardous Samples**
If the shipping container used is a picnic cooler, use tape to seal the drain plug.	9	12
After acceptance by the shipper, tape the shipping container completely around with strapping tape at two locations. Secure the lid with tape. Do not cover any labels.		13
Place the laboratory address on the top of the shipping container.		14
For all hazardous shipments, complete shipper's hazardous material certification form.		15
Place a "This End Up" label on the lid and on all four sides of the shipping container.	10	16
Affix the signed and dated custody seals on the front right and back left of the shipping container. Cover the seals with wide, clear tape.	11	17

*Numbers indicate the instructions that must be followed.

Table 3-2. Packaging Not by Common Carrier

Instructions	Flammable Liquid	Poison DOT Class 6.1	DOT Class 9
Quantity limitations shipped by cargo aircraft Gross weight of package: Total quantity of flammable liquid: Maximum sample container size:	66 pounds 49 CFR 172.101 Table, Column 6b 49 CFR 172.101 Table, Column 5 *or* The flash point of the liquid	66 pounds *Liquids* – 4 liters (1 gallon) *Solids* – 5 kilograms (11 pounds)	66 pounds *Liquids* – 4 liters (1 gallon) *Solids* – 5 kilograms (11 pounds)
Check the caps of all sample containers to assure that they are secure. Tape caps.	1*	1*	1*
Place each sample container in an individual 6-mL plastic bag and secure with a twist tie. The sample identification tag should be positioned to enable it to be read through the bag.	2	2	2
Place sample containers in paint cans in a manner that will prevent bottle breakage.	3	*Liquids:* 3	
Place vermiculite in the paint can around the samples. The amount of vermiculite used should be sufficient to absorb the sample if a sample container should break.	4		
Secure the lid to the paint can with can clips and label the outside of the can with the sample ID numbers and quantity.	5		
Wrap bubble wrap around each glass sample container and fix with tape.		*Solids:* 4	3
Package the paint cans in DOT boxes or cooler. Use additional packaging to secure cans.	6		
Seal the drain plug with tape on the inside and outside of the cooler and line		5	4

Instructions	Flammable Liquid	Poison DOT Class 6.1	DOT Class 9
the cooler with a plastic bag. Place the canned or bagged sample containers in the cooler. If plastic bottles are being used, alternate them with any glass container.			
Fill any voids in the cooler with additional packing material.	7	6	5
Place ice contained in bags on top of all sample containers within the cooler. Use as much ice as space will allow.	8	7	6
Place the COC record in a clear plastic resealable food bag and tape to the inside of the cooler lid. Label the outside of the cooler as containing the COC record.	9	8	7
Seal the cooler lid with clear tape or strapping tape. Affix security seals.	10	9	8

*Numbers indicate the instructions that must be followed.

3.6.2. Marking and Labeling

All samples *must be labeled* to prevent misidentification and should include the following information:

- Sample # or ID
- Date of collection
- Collector
- Analysis requested
- Preservative
- Sample location.

Sample labels must clearly link the sample to the field sheet or the COC record and must be written legibly and in permanent ink. In addition, all containers must be labeled and listed on the COC record.

Note: If a three-bottle set is used for VOAs, all three bottles must be labeled and listed on the COC record.

EPA TSCA regulations [40 CFR 761.40(e)] require that a PCB label be put on all containers whose surfaces are in direct contact with material that is over 50 parts per million (ppm) PCBs. This requirement applies to sample containers as well as pails, drums, and other containers that are in direct contact with the PCB material. The labeling requirement does not apply to containers in which PCB sample containers are shipped. Although the sample containers must be individually labeled, this requirement is not affected by the quantity of sample or whether the sample is classified as hazardous under RCRA or DOT regulations. For DOT Class 9 and EPA Hazardous Waste the following labeling requirements apply:

- If EPA Hazardous Waste Manifest is required:
  - Hazardous waste
    - liquid, NOS, NA3082
    - solid, NOS, NA3077

- If EPA Hazardous Waste Manifest *is not* required:
  - Environmentally hazardous substances
    - liquid, NOS, UN3082
    - solid, NOS, UN3077

OSHA's Hazard Communication Standard requires all containers of hazardous materials coming in or out of a workplace to be labeled with the contents, appropriate hazard warnings, and the name and address of the manufacturer. OSHA does not specify a standard labeling method, but some commonly used ones are provided by National Fire Protection Association (NFPA), Hazardous Materials Identification System (HMIS), ANSI, and DOT.

3.6.3. Shipping Papers

Ship high hazard samples via overnight courier following the courier's documentation requirements. A special airbill must be completed for each shipment. An EPA manifest must be prepared if the shipping container contains hazardous waste *unless* the samples are exempt. The Hazardous Waste Manifest must bear the handwritten signatures of the generator, transporter, and designated facility. A copy of the manifest must be kept for 3 years by the shipper. The shipping papers must contain the name, address, and handwritten signature of the shipper.

The shipping papers (and Hazardous Waste Manifest if used) must contain a 24-hour emergency response telephone number. This phone number must be monitored at all times while the hazardous material is in transportation, including storage incidental to transportation. The phone must be monitored by a person who is either knowledgeable of the hazards and characteristics of the hazardous material being shipped and has comprehensive emergency response and incident mitigation information for that material, or who has immediate access to a person who possesses such knowledge and information. The emergency response phone number must be entered on the shipping paper immediately following the description of the hazardous material or entered once on a shipping paper if the number applies to all of the hazardous materials and is indicated for emergency response information.

3.7. QA/QC Protocol

QC is a normal part of good field and laboratory practice. QC includes all of the procedures ap-

plied to data collection and generation activities to achieve and maintain the level of pre-established data quality. The desired level of data quality should be based on the intended use of the data. Therefore, the QC protocol should include all technical controls (e.g., sampling and analytical methods, use of field blanks, field duplicate samples, inclusion of performance testing or reference samples, statistical analysis, etc.). The controls start with the regulatory requirements of the data acquisition project and carry through to the ultimate data reporting and completion of all of the documentation of the use of these controls.

QA refers to the procedures used by management to assure that the QC is what is required and that it is being adhered to at any point in the project. QA constitutes the overview and monitoring processes designed to ensure that the quality of the data generated meets the desired levels as established by management. These controls include establishing DQOs based on the intended use of the data, the institution of procedures for formalizing planning documents prior to the initiation of data collection activities, and the use of audits to identify problems in both QC and QA.

The QA/QC protocol is specified in the SAP for each job that involves field sampling. QA/QC requirements are based on the level of data quality required for the project, and may address specific regulatory requirements. The purpose of a QA/QC protocol is to ensure the following:

- The laboratory receives samples that accurately represent the conditions existing at the sample site
- The results of the analysis are traceable to the specific sample location
- Compliance requirements are met.

The methods used to attain this protocol include training of personnel, providing detailed procedures for preparation, collection, marking and handling, packaging, packing, transfer of samples, and validation and verification of the administrative process and sampling techniques.

3.7.1. Decontamination of Sampling Equipment

The SAP should address the extent of decontamination and specify the procedures to prevent sample contamination. Sampling may be performed using separate laboratory cleaned equipment for each sample location. Procedure effectiveness should be checked for each matrix by submitting equipment decontamination blank samples to the laboratory for analysis.

Note: For specific information regarding the decontamination of field equipment, refer to *ASTM D5088-02, Standard Practices for Decontamination of Field Equipment Used at Waste Sites*. This standard describes the decontamination process for field equipment used in the sampling of soils, soil gas, sludges, surface water, and groundwater at waste sites. According to this standard, these practices are applicable only at sites where chemical (organic and inorganic) wastes are a concern, *not* for radiological, mixed (chemical and radiological), or biohazard sites.

3.7.2. Sample Container Cleanliness Requirements

Sample containers are a possible source of sample contamination. The SAP should specify the level of QC for sample containers. Pre-cleaned containers meeting EPA CERCLA cleanliness endurance criteria are available from several suppliers. If these containers are used, the serial number and QA batch number of each one should be recorded in the FLB/FN or on the field form. A review of the cleanliness should be made to ensure all parameters are checked to be below the detection limit of the contaminants to be tested for compliance. Some SDWA and CWA parameters may require laboratory cleaned containers proven to be below the limit of detection for the method.

Note: In no case should an effort be made in the field to decontaminate a sample container. If a container becomes contaminated, it should be replaced, with a note to that effect recorded in the FLB/FN.

3.7.3. Sample Container Type and Size Requirements

The types and sizes of sample containers to be filled for each sample will depend on method requirements and on QC requirements of the SAP. General sample container requirements are shown in Appendix B for different matrices and

analytical parameters. Compliance with specific instructions in the SAP is mandatory. If specified sample containers are not available, permission must be obtained from the Program Manager in writing for the use of other sizes and types of sample containers.

3.7.4. Sample Preservation and Storage Requirements

Special preservation and storage requirements should be specified in the SAP to ensure that samples do not undergo chemical changes from the time they were collected until their analysis by the laboratory. General requirements are specified in Appendix B. The specific requirements of the SAP will govern.

The quality of the reagents, water and materials used for preservation should be verified to ensure these items do not invalidate the reported results. Chemicals used as preservatives may be traced by lot number and quality by maintaining a reagent record keeping system. The water and acid preservatives used for trip and field blanks may be checked prior to use in the field and lot controlled to ensure no contamination is present prior to the material leaving the laboratory.

3.7.5. Sample Holding Time Limits

Even with preservation and special storage procedures, the composition of samples can change over time. The holding time for samples is the time from collection to laboratory preparation or analysis. Holding time limits summarized in Appendix B are method and program requirements. Site-specific holding times specified in the SAP take precedence.

3.7.6. Laboratory and Field Analytical Procedures

Laboratory analytical procedures for each parameter are specified based on the compliance limits, permit limits and data needs stated in the SAP. The SAP or COC record indicates to the laboratory which sample containers are to be analyzed for what parameters and specifies the analytical methods. Based on the DQOs, field testing may require the same level of QC as laboratory testing, and the procedures specified in the field sampling or test plan must be followed exactly. Any deviations from established test procedures must be entered in the FLB/FN or on the field form and the Program Manager must be informed immediately of sample numbers affected.

3.7.7. QC Samples

Field QC samples are prepared and analyzed to determine whether test samples have become accidentally contaminated, check on the repeatability of the method, and ensure the samples are representative of the site or matrix sampled. A number of different QC samples may be specified. Each of the QC samples checks for a potential problem that can affect data reliability. The recommended frequency for each type of QC sample is summarized in Appendix C.

3.7.7.1. Test Sample

The test sample consists of one or more sample containers filled with material collected at one sampling point within a stated time. Several sampling containers may be required if material collected for analysis for different parameters must be preserved differently or sent to different laboratories. For a specific test sample, all containers are designated by the same sample location number, but may have different sample container numbers or designations to indicate variations made to the samples.

3.7.7.2. Field Duplicates and Split Samples

Field duplicate samples are two separate samples taken from the same source and are used to determine data repeatability based on field sampling and laboratory analysis procedures. Field duplicate samples are as follows:

- Assigned different container numbers
- Specified in the FLB/FN or on the field form
- Distinguished from the test samples on the COC record or field records
- Often submitted blind as to designation so the laboratory data assures objectivity.

Exception: Each test sample collected for a specific organic analysis may consist of two or more containers filled with the same material; these may be given different

container numbers but are designated as the same sample on the COC record. Only one sample container will be analyzed; the other being saved as a backup in case the laboratory must repeat the extraction and/or analysis. Duplicate samples for analysis consist of sets of two containers, with each pair of containers being designated on the COC record.

Field duplicate samples may be submitted to one laboratory for analysis for the same parameters. The comparability of the results provides information on the repeatability of the field sampling and laboratory analysis procedures.

The containers may be submitted to different laboratories for identical analyses to obtain information on inter-laboratory repeatability of field sampling and laboratory analysis procedures. This is a split sample.

Sample heterogeneity may cause major problems with the representativeness of field duplicate or split samples of soil/sediment matrices. Proper sample homogenization in the field will significantly improve the repeatability of the field sampling procedure. (Gy P. 1993, *Sampling for Analytical Purposes*, Wiley, West Sussex. Pitard F. F. 1993, *Pierre Gy's Sampling Theory and Sampling Practice: Heterogeneity, Sample Correctness and Statistical Process Control*, Books Britain, London.)

Typically, both field duplicates and split samples will be collected at a rate of 10% of field samples or at a minimum of one, per analyte, matrix, and sampling technique. More duplicates and split samples may be collected depending on the data quality needs.

3.7.7.3. Equipment Decontamination Blanks

Equipment decontamination blanks, or rinsate blanks, provide information on the levels of cross-contamination resulting from field or laboratory sample preparation actions. These blanks are specified in the SAP and on field sampling forms, and are prepared in the field. An equipment decontamination blank is usually reagent or deionized water that is free of the analyte of interest and is transported to the site, opened in the field, and poured over or through the sample collection device, collected in a sample container, and returned to the laboratory and analyzed. This serves as a check on sampling device cleanliness. For example:

- **Field Groundwater Equipment Decontamination Blank for Metals Analysis.** Handled by the bailer, use ASTM Type II water, or better. Filter, place in a sample container, and preserve using the same procedures as for the test and duplicate samples.
- **Soil Sampling Equipment Decontamination Blank for Semivolatile Organics.** Rinse the field equipment prior to its use and collect the rinsate for analysis.
- **PCB Wipe Sample Equipment Decontamination Blank.** Use a wipe pad to wipe the sampling template in the same way the pad is handled during the actual wipe sampling of a surface.

One equipment decontamination blank is collected for each type of equipment used during the day or sampling event. Equipment decontamination blanks are assigned container numbers from the same sequence as the test samples, and may not be distinguished from the test samples on the COC record. More blanks may be collected depending on the data quality needs.

3.7.7.4. Field Blanks

Field blanks are prepared and analyzed to check cleanliness of sample containers, environmental contamination, and purity of reagents or solvents used in the field. A sample container is filled with laboratory ASTM Type I or II water, preserved, shipped to the field with clean sample containers, opened in the field to exposure to ambient field air for a time compatible to field sampling process, and is closed and submitted for analysis using the same parameters as the test sample. The reported results will indicate the presence of contamination. Field blanks are most often used when measuring for volatile analytes.

3.7.7.5. Trip Blanks

A trip blank is used with VOA analysis of water. A blank may consist of two 40-milliliter VOA vials filled at the laboratory with laboratory ASTM Type I or II water, transported to the

sampling site and returned to the laboratory without being opened. This serves as a check on sample contamination during sample transport and shipping.

Note: The caps used on VOA vials have Teflon®-lined septa. The Teflon® side of the silicone septum should face the sample. Prior to closing a vial, make sure there is no soil particle or dirt on the sealing surface of the VOA vial to prevent leaks. If a high concentration of volatile chemicals is present in the air in a shipping container, these chemicals can pass through the septum and contaminate the sample.

A trip blank is included in each shipping container used to ship VOA water samples. One VOA trip blank (two vials) is submitted to the laboratory in each cooler or per sampling event. The frequency of collection for trip blanks is specified in the SAP and is based on the data quality needs. Trip blanks are assigned container numbers from the same sequence used for the test samples, and are not designated as blanks on the COC record.

3.7.7.6. Matrix Spike (MS)/Matrix Spike Duplicate (MSD)

Project or compliance QC procedures require that the laboratory spike a portion of the matrix with a predetermined quantity of analyte(s) prior to sample extraction/digestion and analysis. The frequency of performing an MS is dependent on the data quality needs and method requirements.

A spiked sample is processed and analyzed in the same manner as the sample. The result of the analysis of the spike compared with the non-spike sample indicates the ability of the test procedures to recover the analyte from the matrix, and provides a measure of the performance of the analytical method executed by the laboratory.

For an MSD, a second portion of the matrix is spiked, and the recovery of the MSD can be compared with the recovery of the MS.

Depending on the matrix and analysis, additional sample containers may be specified to provide enough material for this laboratory procedure. These sample containers are assigned container numbers from the same sequence as the test samples and are designated MS/MSD materials on the COC record.

The MS/MSD samples are commonly used in CERCLA testing, but are not commonly used in CWA or SDWA testing. MSs are routinely performed by the laboratory as part of its internal QC on randomly chosen samples. If MS data is required for SDWA or CWA reporting requirements, a request must be made to the laboratory to ensure the MS is performed and reported on the appropriate sample. The sample selected for MSs should have the same or similar matrix as the field samples' but without high levels of target analytes.

3.7.8. Field Audits

The SAP will specify who will conduct field audits, along with their frequency and procedures. QA/QC procedures of the sample collection effort must identify and determine the magnitude of error associated with the contamination introduced through the sample collection effort. Audits are perhaps the most effective tool to ensure that the sampling is done correctly. The two factors most likely to influence the magnitude of the sample collection error are collection methods and frequency of sampling.

In general, a field sampling audit provides an independent outside check on the following:

- **Field Records**
  - COC records
  - Sample container labels
  - FLBs or field forms
  - Personnel training records
- **Sampling Procedures**
  - Equipment
  - Sample containers
  - Accuracy of sample location descriptions
  - Comparability of field sampling techniques
  - Collection and preparation of QC samples
  - Sample preservation
  - Equipment decontamination
  - Contaminated waste storage and disposal

- Sample packing, storage, security, and transportation
- Shipping containers, including use of custody seals (if applicable).

3.8. Generic Sampling Equipment List

Equipment specific to each type of media is found at the end of the related chapters. The following is a generic sampling equipment list:

- Map of sampling location(s)
- Sampling SOP
- FLB or field form
- Pens
- Containers
- Preservatives
- Labels
- Markers
- Coolers
- Ice
- Packing material
- Packaging tape
- COC form
- Custody seals (if required)
- Decontamination storage containers, equipment, and materials
- Personal safety equipment, safety test equipment
- Field screening or testing equipment, standards, reagents, and SOP
- Testing field forms or logbooks
- Laboratory instructions (if different from custody form).

Chapter 4. Soil Sampling

4.1. Purpose

This chapter identifies the major steps that are required and technical areas that will be encountered when soil sampling. The scope of the sampling program is defined, as well as procedures that will guide the sampler in conducting soil sampling.

4.2. Scope

The characterization of soil and soil contamination requires a collection of samples from identifiable locations. Soil sampling programs can accomplish the following:

- Determine site soil characteristics (presence and location of different types of soil, subsoil, and bedrock)
- Define the extent, depth, type, and severity of soil contamination
- Determine soil "cleanliness" during procedures such as UST removal, or PCB transformer operation
- Soil sampling programs also can provide for background monitoring at treatment, storage, and disposal facility (TSDF) or hazardous waste handling areas.

4.3. Project Planning

This section provides an overview of the planning process for conducting soil sampling. Included is a discussion of sampling strategy, development of a site-specific SAP, and QA considerations.

Before soil sampling can begin, clear and concise objectives regarding the intent of the sampling program need to be developed. The objectives provide the framework for developing a sampling strategy for the site and preparing the SAP. Once the objectives are established, a sampling strategy can be developed.

4.3.1. Sampling Strategy

The sampling strategy is designed around the objectives of the project and should begin with a review of the conceptual site model. The model takes into consideration historical site use, known or suspected pollutant releases, and the geology of the area. The conceptual site model is dynamic and is constantly revised as new information is collected and processed. The model focuses on contaminant fate and transport processes, the control of geologic materials on the contaminant pathways (e.g., depositional environments, geologic structure), the types of contaminants present (e.g., hydrophobic versus hydrophilic), and the processes that influence the concentrations of contaminants present (e.g., dilution, biodegradation, dispersion).

The detail of the conceptual site model will depend greatly on the availability of information including historical site uses, native soil type, areas where fill materials may be present (e.g., utility trenches), and the direction of surface water flow. Specifically, the conceptual site model should describe:

- Physical characteristics of the site, including locations of buildings, paved areas, subsurface utilities, overhead utilities, significant topographical changes (e.g., steep banks), exposed bedrock, standing water, stained soils, areas of depressed vegetation, equipment maintenance and storage areas, manufacturing locations, waste disposal areas, and expected depth to groundwater
- Types of contaminants to be sampled (e.g., volatile organic chemicals (VOCs), semi-VOCs, metals) and factors that could bias sampling results (e.g., organic contaminants that are tightly bound to soil particles)
- Lateral and vertical distribution of contamination (e.g., contaminants distributed throughout an entire unit being monitored versus localized distribution controlled by small-scale features).

The sampling strategy and the information gathered from the conceptual site model will become the framework for development of the site-specific SAP. Key issues related to the concep-

tual site model are presented in more detail in the following subsections.

4.3.1.1. Types of Contaminants

The sampler or Site Manager may be able to predict the types of soil contaminants present and the duration of contamination by consulting site historical records and information on previous manufacturing practices, fuel or chemical usage, and any reported spills. This information can be used to determine sample collection locations. For instance, heavy metals such as oxidized lead or organic chemicals such as pesticides which are relatively insoluble in water may be limited to the top few inches of soil and will not have spread far from their source in undisturbed sites. However, if sites are affected by soil erosion or construction activities, the contaminants may have moved from their source, and sampling program planners should account for these changes in site conditions. The extent to which the underlying groundwater is contaminated also would be a function of the solubility of the organic liquid in the water. Dense non-aqueous liquids, such as chlorinated solvents (e.g., trichloroethylene, tetrachloroethylene, carbon tetrachloride) or heavier chlorinated organic liquids (e.g., chlorinated benzenes, PCBs), can permeate the subsurface until they reach a confining layer, such as clay or bedrock.

For soil contaminants such as soluble metals found in metal plating wastes or from spills of concentrated organic chemicals (e.g., gasoline, aviation fuel, solvents, and transformer oil), the presence and extent of contamination may not be easily predictable due to a number of factors. Soluble metals and organic liquids often are carried through soil by percolating rain water. The extent of contaminant movement is affected by a number of factors, including:

- **Density of Organic Liquids.** Light organic liquids (e.g., gasoline, diesel fuel, and waste oils) will settle through soils that are not saturated with water until they reach a confining surface such as clay, bedrock, or groundwater. It is not unusual to find a concentrated layer of organic liquid moving along the surface of a tilted clay layer or forming a pool or lens on the groundwater. Therefore, the extent to which the underlying groundwater is contaminated, is a function of the solubility of the organic liquid in the water. Dense, non-aqueous liquids, such as chlorinated solvents (e.g., trichloroethylene, tetrachloroethylene, carbon tetrachloride) or heavier chlorinated organic liquids (e.g., chlorinated benzenes, PCBs) can continue to sink through groundwater until they reach a confining layer, such as clay or bedrock. These chemicals can flow along tilted surfaces or pool in the cracks in bedrock and then slowly leach into groundwater.
- **Susceptibility to Biodegradation.** Microorganisms in the soil can degrade many contaminants. However, for contaminants like fuels or other petroleum distillate products, the microorganisms require oxygen and generally are not active at depths of more than 1 foot. Therefore, the surface soils may be relatively uncontaminated by these organic chemicals due to biodegradation, while deeper soils may be contaminated due to the lack of oxygen needed for biodegradation.

4.3.1.2. Type of Soil

Soil type can have a significant impact on the mobility of pollutants. For example, clay layers create relatively impermeable barriers, retarding groundwater flow and in some instances preventing surface contaminants from affecting groundwater. However, clay particles also can absorb certain types of hazardous chemicals, resulting in increased pollutant concentrations in localized areas. Organic liquids can form pools in the low reaches of clay layers, or can flow down the surface of tilted clay layers.

Soils that contain large amounts of organic material, such as peat, can absorb and concentrate hazardous chemicals. A layer of organic soil, therefore, may be more contaminated than the soil layers above and below it.

Porous non-organic soils, such as sand or gravel, do not absorb pollutants and allow for rapid surface and groundwater movement. In such soils, PCBs from spilled transformer fluid and from buried electrical capacitors have been found several hundred feet from the source of the contamination. Gasoline from leaking USTs can be carried hundreds of feet by moving groundwater.

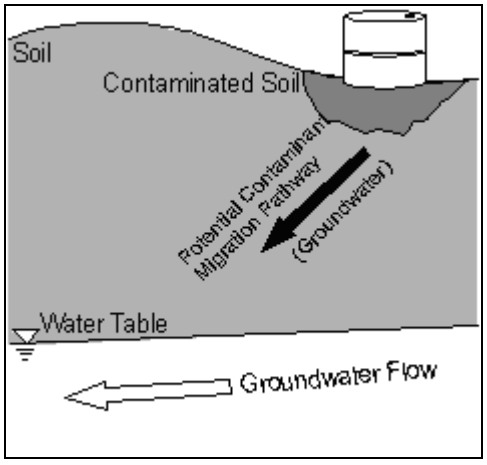
Bedrock may provide a confining layer beneath groundwater. Fractured bedrock, however, may provide channels for the movement of groundwater and heavy organics or low spots for the accumulation of pools of heavy organic liquids.

Soil characteristics such as pH, can change the chemistry of the surrounding water, which in turn can affect the solubility of some pollutants, including heavy metals. For instance, acidic stormwater can dissolve metals on the ground surface. However, as the dissolved metals pass through the soil column, they may encounter areas with elevated soil pH (e.g., limestone) that cause the metals to become insoluble precipitates again.

4.3.1.3. Presence of Groundwater

Moving groundwater can carry hazardous contaminants for considerable distances; see Figure 4-1.

Figure 4-1. Contaminated Groundwater



The rate at which groundwater will cause contaminants to spread is affected by both the speed at which the groundwater moves through the soil and the extent to which the soil absorbs the contaminants. One of the most serious effects of accidental spills and improper disposal of hazardous chemicals is contamination that precludes the use of a groundwater source for drinking water.

4.3.2. Site-Specific SAP

A soil sampling program should collect soil samples at a specific locations and depths that are representative of the site. Procedures that result in the collection of an undisturbed soil column will yield the most representative soil samples. The development of a site-specific SAP is the first step toward collecting a representative soil sample (see Chapter 2 for a detailed discussion of SAP development applicable to all sampling programs). Each SAP is an instruction manual for field personnel, and should be built around the objectives and sampling strategy. The discussion below focuses specifically on SAP development for soil sampling programs.

Ideally, the SAP should be based on knowledge of which contaminants are likely to be present and how the distribution of the contaminants may be affected by the soil characteristics of the site. The purpose of the fieldwork also may be to define the soil characteristics and obtain chemical data for determining compliance with federal, state, or local requirements. It is possible for soil sampling to be conducted in a number of phases, with the field observations and field test results providing data to guide subsequent work. If knowledge of contaminants and site soil characteristics is limited, then dynamic sampling techniques and field measurements can be used to locate sampling points.

Dynamic sampling relies on individuals in the field to interpret field data as it becomes available and revise the sampling strategy accordingly. Dynamic sampling can quickly provide significant amounts of information needed to develop the conceptual model for the site. Dynamic sampling in many instances, however, is considered a first step toward developing a more focused soil sampling program for a particular area within the site.

The SAP should consider a variety of factors, including, but not limited to, the physical features of the site (e.g., locations of buildings, tanks, buried utilities, roadways), the types of contaminants and their potential mobility and biodegradability, soil types, the accessibility of potential sampling locations, the size of equipment needed to collect samples at depth, suspected pollutants, field screening requirements, DQOs, analytical methods and detection limits, soil collection methods, sample handling procedures (e.g., preservation requirements, COC), containment and disposal procedures for contaminated soils generated during sampling activities, and safety.

The SAP cannot be implemented effectively if field personnel do not understand its contents. Many times the primary reason that sampling events are problematic is that the person who prepared the SAP is not the person in the field. One method that alleviates this problem is assigning a Sampling Team Leader who is responsible for all activities in the field. The Sampling Team Leader will work closely with those individuals preparing the SAP to understand fully the objectives of the program. The Sampling Team Leader then will be responsible for all individuals in the field. He or she also is responsible for providing additional training to field personnel, if required, before fieldwork begins.

4.3.3. QA

Soil sampling programs encompass a variety of information sources and include both primary and secondary data collection. These data sources are used to continuously update the conceptual site model and allow site managers to make decisions regarding further investigation, additional monitoring, remediation alternatives, or site closure.

The level of data quality for each soil sampling program, and for each specific sampling event, depends on the intended use of the data. For example, the level of QA/QC needed to estimate the volume of soil that may need to be removed for a corrective action might be different than for samples needed for site closure. It is important to remember, regardless of the level of QA/QC for any soil sampling event, that sample integrity must be maintained during sample collection. Laboratory analysis, no matter how sophisticated, is defensible only if the sample supplied to the analyst has retained its integrity.

To ensure quality data, site managers and those responsible for data integrity should begin with a systematic planning process that helps define the DQOs. The DQOs clarify the study objective, define the most appropriate type of data to collect, determine the most appropriate conditions for data collection, and specify tolerable error limits that will be used as the basis for program decision making. Detailed information on QA/QC, including the systematic planning process, development of DQOs, and preparation of SAPs, is available in Chapter 2 of this handbook.

Some specific QA/QC issues related to soil sampling programs include equipment specifications, equipment decontamination, and QC samples. Each of these is discussed briefly in the following sections.

4.3.3.1. Secondary Data

Secondary data are those data collected in addition to sampling data. For a soil sampling program, secondary data may include items such as historical records regarding site use, spills, and corrective actions on neighboring properties, current and historical subsurface utility maps, locations of previous above-ground and below-ground structures as well as possible disposal areas and areas containing fill materials or other antidotal agents. These data aid the Site Manager in selecting soil sampling locations or determining possible pollutants.

For secondary data, acceptance criteria are used instead of the measurement performance criteria typically used for laboratory data. In general, acceptance criteria are used to assess secondary data adequacy and evaluate uncertainty in the results derived from the use of secondary data sources. For example, the Project Manager for the soil sampling program may require interviews of former employees to validate the location of

disposal areas found on historical site maps. In this case, the acceptance criteria are the verbal confirmation of the disposal areas by the former employees. The SAP for each soil sampling program will explain the acceptance criteria for determining which sources of data are sufficient to support the project objectives. See Chapter 2 for more information.

4.3.3.2. Equipment Specifications for Quality Control

The selection of appropriate materials for soil sampling equipment is critical to ensuring data quality. The materials that come into contact with the sample are as critical as the composition of the laboratory sample containers. Selecting the appropriate materials for sampling equipment should be based on the type of expected pollutants. It is important that the sample equipment not add or remove target pollutants. For example, if collecting samples for analysis of low-level metals, carbon steel sampling equipment should not be used. If samples are being collected for low-level organic constituents, plastic sampling equipment should be avoided because plastics have the potential to absorb organic pollutants.

The recommended materials for hand augers, split spoons, trowels, and other sampling devices are as follows: polytetrafluoroethylene (PTFE) (Teflon®), stainless steel, polypropylene, linear polyethylene, polyvinyl chloride (PVC), Viton®, and conventional polyethylene. Because soil sampling typically requires more rugged equipment compared with other types of sampling, stainless steel equipment is typically the material of choice.

4.3.3.3. Equipment Decontamination

Decontamination of existing and new equipment is required prior to use in the field. Section 4.9 describes decontamination procedures for various types of soil sampling equipment. Decontamination procedures must be followed and documented to prevent cross-contamination between sites and within the site. Rinsate blanks may be collected at the start and end of the sampling event to determine the cleanliness of the sampling devices and evaluate the cleaning techniques used in the field. Decontamination procedures for all equipment that contacts soils must be included in the SAP.

4.3.3.4. Quality Control Samples

Field duplicates or splits are collected in the field in double the number of bottles required for the regular sample. A duplicate sample is a sample collected concurrently, under comparable conditions, with a first sample. Duplicate samples are QC samples that are used to assess data repeatability based on field conditions. Duplicate samples provide a total precision of field sampling precision and lab analysis. Duplicate samples should not be identified as duplicates to the laboratory. Split samples are two or more representative portions taken from one sample in the field or in the laboratory and analyzed by different laboratories. Split samples are QC samples that are used to assess analytical variability and comparability. Samples sent to the same laboratory are duplicates, and samples sent to a different laboratory are splits. Split samples shall be field homogenized. To ensure that split samples are representative, the soil sample collection must follow Pierre Gy's *Sampling Theory and Sampling Practices*. However, for VOC samples, split samples shall be collected as field duplicates to minimize loss of volatile components.

Procedures for obtaining split soil samples are included in Section 4.7.4.3.

4.4. Hazards and Safety Precautions

The HASP should address all anticipated hazards for each task. The following discussion contains common (and commonly overlooked) hazards associated with soil sampling activities. Refer to Chapter 2 for references to specific hazard identification techniques and detailed control measures.

4.4.1. General Safety

Some of the general safety hazards associated with soil sampling programs include the following:

- Moving sampling equipment and containers across rough terrain either by hand or by driving off road
- Use of heavy equipment such as drill rigs and power augers
- Conflicts with other uses of the area (e.g., traffic conflicts when sampling on or next to roads)
- Contact with overhead power lines when using a drill rig or a backhoe to gain access to subsurface soil.

4.4.2. Subsurface Hazards

Soil sampling is an intrusive activity that could expose sampling personnel to unidentified subsurface hazards, as discussed below.

4.4.2.1. Buried Munitions

If the probability of encountering buried munitions during the sampling program is moderate to high, a Required Explosives Safety Submission (RESS) waiver from the relevant explosives safety authority may be required prior to disturbing the site. In addition, a qualified explosives safety expert will be required to accompany the investigation team. See DoD TP18 for the minimum qualifications for unexploded ordnance technicians and personnel. The site should be checked by qualified personnel with ground-penetrating radar and/or metal detectors before any samples are collected. Only trained and certified personnel should handle or sample explosive or suspected explosive materials.

4.4.2.2. Buried Utilities

The use of augers and drill rigs to gain access to subsurface soil can damage buried utilities, including electrical and telephone lines and gas, steam, water, and industrial pipelines. Facility records should be reviewed carefully to identify any buried utilities in the sampling area. The site should be checked with ground-penetrating radar and/or metal detectors if there is any question as to the presence of subsurface utilities.

4.4.2.3. Toxic Chemicals

Collecting soil samples poses the risk of exposure to hazardous chemicals. The following major exposure scenarios should be evaluated:

- **Skin Contact with Contaminated Soil.** Field sampling personnel should wear disposable boot covers and surgical gloves as a minimum, and should consider the use of disposable Tyvek® coveralls to prevent contamination of clothing. The sample custodian should wear appropriate PPE when handling samples.
- **Skin Contact with Contaminated Water.** Deep soil samples usually result in the requirement to handle wet soil that can drip and splash. Decontamination of sampling equipment also can result in splashes of contaminated water. Field sampling and decontamination personnel should wear waterproof rain gear or coated Tyvek® coveralls if there is a possibility of contact with contaminated water.
- **Ingestion of Contaminated Soil.** Ingestion can occur when food or drink is exposed to contaminated dust or is picked up with contaminated gloves. Field personnel should not eat, smoke, or chew gum or tobacco when working with contaminated soil. Drinking water should be kept in closed squirt bottles or should be stored outside the contaminated area.
- **Inhalation of Contaminated Dust.** Inhalation of contaminated dust may be a problem on dry windy days at sites where the surface soil is contaminated. Digging and drilling activities also may generate contaminated dust. Personnel should remain upwind of any source of dust. If the site is generally contaminated, then full-face, air-purifying respirators equipped with particulate filters should be worn.
- **Inhalation of Toxic Vapors.** The exposure of contaminated soil to ambient air may generate toxic vapors from the evaporation of VOCs. The HASP should establish air monitoring requirements for intrusive work and specify

the type of air monitoring equipment to be used as well as the criteria for the use of respirators. Either air-purifying respirators or supplied-air respirators may be required, depending on the toxicity of the chemicals present, the capabilities of the monitoring equipment, and the warning properties of the vapors.

- **Confined Space Hazards.** In general, pits more than 4 feet deep are considered to be confined spaces. However, any pit dug in contaminated soil could have the same hazards associated with confined spaces because flammable vapors or toxic gases, including hydrogen cyanide and hydrogen sulfide, could accumulate. All applicable confined space entry requirements should be imposed and detailed in the HASP.

WARNING: Personnel who enter into a confined space should be accompanied by an on-site standby unit at all times.

The following steps should be detailed in the HASP prior to entry into a confined space:

1. Ventilate the area thoroughly prior to entry.
2. Disconnect connecting pipelines.
3. Take air samples to verify the absence of flammable or other hazardous vapors and demonstrate the presence of adequate oxygen levels.
4. Provide entry and standby teams with proper training, respiratory protection, protective clothing, safety harnesses, and ropes.
5. Establish lifeline signals (e.g., tugging on a rope) prior to entry so that Field Sampling Personnel can communicate.
6. Maintain ladder(s) and other equipment in accordance with OSHA regulations.

4.4.3. Explosive Hazards

Due to the inherent dangers involved in sampling explosives and potential or suspected explosives, only those individuals who have been trained and certified in the proper handling of these materials should participate in sampling activities. Special considerations are required when sampling explosive wastes that are susceptible to shock, friction, electromagnetic radiation, electrostatic discharge, sparks, flames, elevated or freezing temperatures, moisture, or sunlight. Failure to handle explosives correctly could result in damage to property, injury, or loss of life. For explosives safety and handling requirements, refer to DoD 6055.09-M, *DoD Ammunition and Explosives Safety Standards*. For Navy projects, also refer to NAVSEA OP5, *Volume 1, Ammunition and Explosives, Ashore Safety Regulations for Handling, Storing, Production, Renovation, and Shipping*.

General explosives safety considerations include wearing PPE such as flameproof clothing, caps, safety goggles or face shields, conductive shoes, and respirators, where appropriate. Only non-sparking tools should be used. Electrical grounding may be necessary in some cases. Sampling of the smallest amount necessary to perform testing is recommended. Specific precautions are material-dependent. It is imperative that sampling personnel have a thorough knowledge of the characteristic dangers and safety requirements for individual explosives materials.

4.5. Principles of Sample Collection

The collection of quality soil sampling data requires documentation of site surface conditions (e.g., locations of buildings, pavement, standing water, seeps, sediment runoff, discolored soil) and subsurface conditions such as depth of various layers of soil, depth to groundwater and bedrock at different locations. The chemical data obtained from the analysis of soil samples is useful only within the context of these site conditions, so it is imperative that the exact location of each sample be documented and the soil samples accurately represent the conditions at the site.

Soil samples must represent field conditions and address the data needs of the program. For instance:

- In determining whether the contamination of surface soil presents a hazard by skin contact or ingestion, the samples should consist of soil

from the surface to a depth of only 2 inches, and the soil should be sieved to eliminate stones larger than 2 mm in diameter.

- EPA cleanup requirements for soil contaminated with PCBs are based on the concentration of PCBs in the soil, including rocks. The samples taken to define the location of PCB-contaminated soil and the appropriate remediation criteria should not eliminate rocks, because the cleanup standards are based on the maximum allowable average concentration of PCBs in the remaining soil.
- To determine whether excavated soil is classified as a hazardous material under RCRA, soil samples should be representative and include rocks and hard chunks. The extraction procedure specified by EPA may require that the lab screen the soil to eliminate rocks larger than 3/8 inch in diameter, but the criteria are too complicated to allow a decision to be made in the field as to whether the soil should be screened when it is collected.
- Special sampling procedures must be used when collecting soil samples that will be analyzed for VOCs because these chemicals rapidly evaporate from soil once exposed to the air. Unless precautions are taken to minimize this evaporation, the samples will not be representative of the actual level of contamination of the soil.

Another important data requirement from any field sample is the documentation of the exact location where the sample was collected. Stakes or flags should be installed to indicate the locations of soil samples. However, because sites probably will be disturbed by subsequent construction work, it also is important that the location of each sample be measured with reference to permanent features such as survey monuments, measurements to a reference point, or latitude and longitude location. For soil sampling programs, it is generally acceptable for the survey to define each sample location to an accuracy of 1 foot horizontally and a few inches vertically. Unless the area to be sampled is flat, an initial survey should be made to define the surface contour. Measuring the depth from the surface at which a sample is taken and at which different soil layers and groundwater are encountered is insufficient, unless the elevation of the surface at that point is known and will remain undisturbed.

The final important data requirement is the physical characteristics of the site, including the surface soils, subsurface geology and soil characteristics. The physical characteristics of surface soils help define the initial locations for soil borings and aid in selecting the appropriate laboratory analyses for future soil samples. The following locations and physical characteristics should be noted and included on a site map:

- Erosion patterns and accumulated runoff sediments
- Equipment or activities, including above-ground and underground storage tanks, chemical storage buildings, outdoor areas where servicing of automotive or mechanical equipment has occurred, raw material storage areas, locations of lagoons, waste pits and fire pits, and locations where trash is either disposed or stored temporarily, such as in dumpster areas
- Discolored soil
- Areas covered by impermeable material, such as pavement and buildings
- Areas of distressed vegetation
- Exposed bedrock
- Standing water
- Groundwater seeps.

Subsurface geology and soil characteristics are typically determined during the site investigation phase of a soil sampling program and are used to predict pollutant movement and develop alternatives for any potential remedial actions that may be required. Subsurface geology and soil characteristics data include the following:

- Type of soil as a function of depth at each sample location (e.g., layers of clay, peat, sand, silt, shale, layers having different colors or the presence of large stones)

- Soil moisture at different depths, and the depth at which the soil becomes saturated with water (i.e., depth to groundwater)
- Presence of organic vapors in soils at various depths.

Field sampling personnel often are in the best position to detect areas of suspicion and, therefore, are critical to the success of the sampling program. Though sampling techniques may be sophisticated, they should not be relied upon to replace the good judgment and common sense of sampling personnel in discerning the difference between routine and extreme case scenarios. Sampling personnel must be alert to their surroundings (e.g., unusual circumstances, odors, presence of dead animal or plant life in the area) while conducting the following sampling tasks:

- Collecting and recording visual and physical data
- Collecting soil samples, both surface and subsurface
- Adhering to field sampling and safety procedures
- Maintaining the COC record
- Preserving program integrity.

Techniques for preparing a site map and documenting field data and observations are discussed below.

4.5.1. Preparation of Site Map

Documentation of site conditions and sample locations requires a site map. The site map should be included with the SAP. The site map may be based on facility drawings but should be verified in the field and augmented with additional information on the drainage of rainwater and other surface conditions that affect the movement of contaminated soil. If the SAP does not include a site map, one should be prepared by Field Sampling Personnel based on the availability of facility drawings and field measurements.

Integrating a geographic information system (GIS) into a sampling program allows for creating maps in significantly less time compared with traditional computer aided design (CAD) procedures. GIS-based data analysis is quicker, easier, and more accurate compared with traditional CAD methods. GIS can be used to analyze site conditions such as depth to groundwater, saturated thickness, hydraulic conductivity, and soil type for selection of suitable sampling points as well as for analyzing relationships between sample locations, tracking sampling points, and relocating sampling points under changing site conditions.

The basic tools necessary for incorporating a GIS into a sampling program include a global positioning system (GPS) unit/receiver and a computer program such as the ESRI's ArcGIS. The GPS receiver is used to locate predetermined sampling points in the field and/or record the location of sampling points as samples are collected. The GIS program can be used to analyze site conditions prior to the sampling event or map and analyze the collected data. Creating a GIS database at the early stages of the sampling process provides for an effective method for data management, analysis, and presentation. The use of a GIS can significantly streamline many aspects of a soil sampling program and facilitate the exchange of resultant data among stakeholders.

Site maps, whether prepared using GIS- or CAD-based systems, should include surface contour, surface information, and sampling locations, as discussed below.

4.5.1.1. Surface Contour

Unless the site is completely flat, it is important that the surface contour be indicated on the site map. The depth of soil samples is measured from the surface, but the surface reference can be lost due to excavation or filling activities at the site. If a contour map of the site is not available, it may be necessary to have one prepared by a survey team prior to sampling.

4.5.1.2. Surface Information

Sampling personnel should validate the site map before beginning any sampling activities, noting

any discrepancies. The following surface information should be recorded if not already shown:

- Buildings or structures
- Paved areas
- Unpaved roads and parking areas
- Surface areas with different types of soils, including fill areas (e.g., gravel roads, clay, sand, peat)
- Standing water, both permanent (e.g., ponds and streams) and temporary (e.g., persistent puddles)
- Water seeps
- Water runoff patterns and accumulations of runoff sediments
- Exposed bedrock
- Discolored soil
- Stored materials, debris, and soil piles
- Vegetation, including distressed vegetation.

Photographs should be taken to document site surface features. Photography requirements should be established by the Program Manager to ensure compliance with the policy and regulations of the facility.

4.5.1.3. Documentation of Sampling Locations

The location of each sample and the designated sample numbers should be shown on the site map. Samples should be collected at the designated sampling points. Depth of samples from the surface should be recorded. If it becomes necessary to sample more than 1 foot from the required location due to interferences from trees, pavement, subsurface rocks, or buried utilities, the new sample location should be noted on the map, and the reason for moving the sampling location should be explained in the FLB/FN.

4.5.2. Preliminary Tests and Observations

A number of field tests and observations may be required to document sampling and subsurface conditions. Such tests may include weather conditions at the time of sampling, a description of the subsurface geology, and the presence of VOCs in soil vapor. Each of these preliminary tests and observations is described below.

4.5.2.1. Weather Conditions

The weather conditions at the time of sample collection should be noted in the FLB/FN. Weather data should include temperature, relative wind speed and direction, relative humidity, and the presence of rain or snow. Recent weather conditions at the site should be summarized, including recent rain events (how much and how recently) and freezing conditions (how cold and how deeply is the soil frozen).

4.5.2.2. Description of Soil Types and Soil Characteristics

The movement of groundwater and the transport of hazardous chemicals are strongly influenced by the presence and depths of different types of soil. Knowledge of subsurface soil characteristics is necessary to understand the dynamics of soil contamination.

The soil should be described by a professional geologist if this information will be used to support the computer modeling of groundwater flow. If this level of detail is not required, the soil layers and the soil samples should be described by Sampling Personnel.

Chapter 3 of EPA's *Description and Sampling of Contaminated Soils — A Field Pocket Guide* is a good source for the field description of soils. As necessary, the following soil features should be described as a function of the depth from the surface:

- **Color.** Soil colors should be determined with the use of a color chart, such as a Munsell chart
- **Mottles.** Blotches or spots of contrasting color interspersed with the dominant soil color
- **Soil Texture.** This is the amount of sand, silts, and clays in a soil
- **Particle Shape.** Shape of individual soil particles
- **Structure.** Shape of the natural soil aggregates

- **Consistency.** Degree of resistance to breaking or crushing (descriptions will vary with moisture condition)
- **Presence of Visible Organic Liquids.** Such as oil, gasoline, solvents or other
- **Horizon Thickness**. Layers of soil with distinct changes of the above features.

4.5.2.3. Soil Gas

Soil gas monitoring is primarily used to measure characteristics of the soil atmosphere as an indirect indicator of VOC contamination in soil or groundwater. The resulting information may be used to:

- Detect and monitor migration of volatile contamination of soils within the vadose zone
- Support the design of a soil vapor extraction system
- Assess the extent of groundwater volatile organics contamination
- Verify UST integrity
- Monitor for any subsurface discharges
- Target soil borings
- Aid in placing groundwater monitoring wells, extraction wells, or recovery trenches, etc.

The information also can be used for general reconnaissance, and as a screening technique when large areas are being evaluated that have little or no information available on past waste disposal practices. For information on soil gas sampling as it relates to the evaluation of vapor intrusion, see the *DoD Vapor Intrusion Handbook*.

In many circumstances, soil gas sampling alone may not be adequate to determine the source and extent of contamination, and sampling of other environmental media may be necessary. Soil gas sampling should be designed to obtain all necessary information with a minimal expenditure of time and resources. Sampling strategies are developed by the project team to address project-specific data needs that are identified during the systematic planning process. Sampling strategies will vary based on the intended purpose of the soil gas survey. The overall effectiveness of a soil gas sampling method to depict subsurface conditions accurately is dependent on several factors. These factors include soil permeability and the presence of any underground obstacles or other features affecting sampling pathways, the nature and concentration of contamination and the presence of interfering chemical compounds, and infiltration moisture and barometric pressure changes.

Sampling considerations include site physical constraints, soil types and stratigraphy, and background information available. Multiple depth sampling should be considered when complex geologic settings are encountered. Sample locations also must account for a variety of physical properties of the soil, including grain size, cohesiveness, organic matter, moisture content, geographic fractures, and overall soil permeability. Not all of these properties may be known in advance, but a review of any background information such as past sampling or well installation should be accomplished prior to soil gas sampling. If this information is not available, it may be beneficial to install a continuously cored boring to the proposed greatest depth of the soil gas investigation and examine the soil lithology. Low permeability materials may result in a lower flow rate for active sampling and passive sampling may be a better choice. It may also be necessary to install an increased number of sampling points in low permeability soil to achieve sufficient coverage, or reevaluate the need for that particular sampling location.

In addition, the properties of the chemical contaminants must also be considered, including volatility, solubility or immiscibility in water, and degradation potential. Soil gas sampling technology is most effective in mapping low-molecular-weight, halogenated, or aromatic hydrocarbons that possess high vapor pressures and low aqueous solubilities (e.g., benzene, toluene, trichloroethylene, vinyl chloride, etc.). Rainfall or wet soil conditions decrease the porosity of the soil and limit diffusion of contaminants. Soil gas sampling should not be performed after a rainfall

event. Barometric pressure changes can introduce atmospheric air into the shallow vadose zone, so soil gas should not be sampled during the passing of a weather front. All of the factors listed above can affect the ability of contaminants to be properly sampled. In most cases, adjustments to the sampling strategy can be made to increase sampling effectiveness.

When soil gas sampling is used to optimize monitoring wells or soil boring locations or monitor the integrity of USTs, a sampling strategy based on a judgmental or biased approach is recommended. However, when soil gas sampling is used for general site reconnaissance, the use of a statistical sampling method (i.e., a systematic grid approach) is typically used. Many projects use a combination of these sampling strategies. For instance, an initial sampling may be done by a predetermined regularly spaced grid pattern to identify the presence of contamination, followed by a judgmental or close, irregularly spaced grid pattern approach to refine the delineation of the contamination detected. Grid spacing shape and size should be based on the project objectives and allowable uncertainty in the decision-making process, but be flexible enough to allow modifications in the field to account for site characteristics, or generated results.

Soil gas samples may be generated in conjunction with an active or passive sampling system. An active soil gas sampling system involves the forced movement of bulk soil gas from the vadose zone to a collection device through a probe or similar apparatus by the influence of a vacuum source. The air within the system may be monitored real-time through a sample port with an appropriate detector (e.g., photoionization detector (PID) or flame ionization detector (FID)). Active soil gas systems may also be sampled with a gas-tight syringe, Tedlar® bags, glass bulbs, Summa® canisters, or other containment devices for subsequent onsite or off-site analyses.

The active soil gas sampling system may also be configured to collect a sorbent sample. In this type of system, the probe is connected to a collection device designed to extract and trap chemical contaminants from the soil gas stream by adsorption. The collection medium is dependent on the contaminant being collected and is typically activated charcoal, silica gel, activated alumina, various porous polymers, or molecular sieve adsorbents that have been prepared by thermal (or solvent) desorption treatment. Using sorbent media is especially useful when contamination is present that is below the instrument sensitivity capabilities for whole air samples, and preconcentration of the contaminants onto the adsorbent can be accomplished by passing a large volume of air past the sorbent and trapping the contaminants of interest. Some sorbent media can also be used to segregate interfering compounds (e.g., reactive or oxygenated organic compounds) by treating or designing the medium so the interferences will not be adsorbed, or easily desorbed, from the collection medium.

Sorbent samples are also beneficial when the chemical contaminants are more amenable or more efficiently removed and detected by extraction techniques. Limitations in the collection of sorbent samples include interactions between the contaminants and the sorption medium, the release of artifacts during the desorption process, and susceptibility to high humidity, which can significantly impact the adsorption efficiency of the sorption medium. Advantages in using an active soil gas sampling system include the quick turnaround for data (a larger amount of soil gas is sampled more rapidly), the generation of concentration-based data (mass of contaminant per volume of air sampled) that can be used in a contaminant transport model or risk assessment, and the ability to tailor the survey as it progresses. Limitations of an active soil gas system include its increased cost compared with that of passive techniques because of the need for a vacuum source and additional collection equipment. Driven probes associated with active soil gas sampling also tend to degrade the natural soil permeability around the body of the probe due to soil compaction during probe insertion.

This may severely impede the active soil gas flow in moist, heavy clay soils.

A passive soil gas sampling system entails placing a collection device in the subsurface or on the surface of the ground. Most commonly, passive soil gas sampling techniques are used in conjunction with a sorbent medium. Several varieties of these collection devices exist, with slightly different configurations. However, the basis for sampling is the same, in that it is the passive movement of contaminants in soil gas to a sorbent medium contained in a collection device over a specified period of time. Several types of sorption media are available, which, due to their adsorption properties, will reduce the contaminant concentration directly adjacent to the device. This induced concentration sink helps maintain continuous migration of contaminants from the vadose zone toward the collection device by diffusion and mass transfer. The rate of contaminant migration is limited by many of the same factors affecting the active soil gas sampling techniques. These include soil physical characteristics and the physical and chemical properties of the contaminants. In addition, caution must be exercised during installation or backfilling to avoid cross-contamination of the sorbent media. Typical residence times for the collection devices range from several days to weeks to complete. Advantages to the use of a passive soil gas sampling system include its nominal cost, its lower susceptibility to meteorological changes, and the increased ability to detect less volatile compounds when compared with active soil gas sampling. Limitations include an extended turnaround time for data, the need for more samples for thorough coverage because passive samplers generally sample a smaller volume of soil gas, the lack of concentration-based data, and it the inappropriateness for use with soil vapor extraction system design.

Soil gas samples may be analyzed onsite, or samples may be containerized and shipped to a laboratory for off-site chemical analyses. Methods for preservation of whole air and sorbent samples are relatively limited and are generally intended to retard thermal and photodegradation. Preservation methods for whole and sorbent samples are typically avoidance of heat or light. This may be as simple as placing samples potentially exposed to light (e.g., Tedlar® bags) in dark plastic garbage sacks, and keeping them out of direct sunlight. Sorbent samples preservation will vary based on the sorbent medium used. Therefore, follow any procedures identified by the vendor or manufacturer.

The ASTM D5314 standard provides a guideline for setting up an active soil gas sampling system. The California Environmental Protection Agency's Department of Toxic Substance Control also has comprehensive guidance on active soil gas sampling. Additional procedures may be necessary based on the manufacturer's specifications.

Typically, the active soil gas sampling system involves sampling devices that are directly inserted into the soil to be sampled without drilling/excavation using static pressure, impacts, or vibration, or the sampling device is inserted into the soil ahead of an auger or drill bit if performing deep sampling or vertical profiling. The equipment generally used to drive the sample probe is small and relatively compact allowing for mobility around the site and access to confined areas. The probe is then retracted slightly to remove the expendable drive point or open a sample port and create a void where soil gas may enter the sample probe. A vacuum is drawn on the system with a pump to induce the flow of soil gas through the sample probe to the surface where whole air or sorbent samples may be acquired. There must be a good seal between the probe and the earth's surface to minimize pulling atmospheric air into the collector. A drop in vacuum or too low a vacuum may indicate system problems. Sample containers may include, gastight syringes, Tedlar® bags, Summa® canisters, etc., for a whole air sample. If using Summa® canisters to collect samples, ensure that the valves have remained closed during shipping from the laboratory and are fully functional. In some instances the laboratory will pre-set the flow rate into the canister, and sample volumes are calcu-

lated by the amount of time the valve is open, rather than by monitoring the gauge on the flow controller. Similarly, when collecting field replicate soil gas samples, proper flow splitters and controllers must be used to maintain the same flow rates to individual Summa® canisters. Additionally, the soil gas may be collected on an appropriate sorbent media and cartridge at a location between the probe and the vacuum pump, or analyzed by a real-time monitor such as a photo-ionization detector or FID. Appropriate decontamination procedures should be followed between each soil gas sample collected.

4.6. Methods of Accessing Soils

It is important that soil samples consist of reasonably undisturbed soil from the specified sampling depths. Access to the soil often requires drilling or excavation down to the specified depth. In some cases, it may be necessary to use a jackhammer to remove either concrete or pavement from the sampling locations. In instances where areas are grass-covered and no surface sample is required, several square feet of sod should be carefully cut away. A decontaminated stainless steel shovel should be used to carefully remove the turf so that it may be replaced when sampling is complete. The stainless steel shovel should be decontaminated between sampling locations. Turf also can be removed by hand from sample locations, provided that personnel wear clean nitrile or PVC gloves.

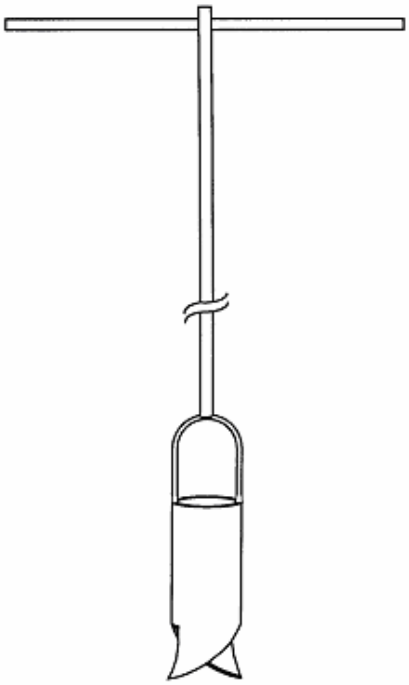
4.6.1. Surface Samples

Soil samples should be taken from undisturbed soil, not from material that is temporarily lying on the ground. Unless the SAP specifically requires the sampling of surface debris, remove organic debris such as leaves, and accumulated trash or demolition rubble, to expose the soil. The SAP should define the depth of surface samples. Specific state and local compliance programs may define surface samples as the first 3, 6, or 12 inches below the vegetation layer. Note in the FLB/FN how much and what kind of material is removed. Surface samples can be collected using stainless steel trowels, spoons, or bucket augers. A diagram of a typical bucket auger is provided in Figure 4-2.

4.6.2. Subsurface Samples

Subsurface samples should consist of undisturbed soil starting at the depth below the surface specified in the SAP. Subsurface samples should not contain material from different layers of soil. Collection of subsurface soil samples requires that the overlying soil be removed. The SAP should detail material separation and depths of subsurface sampling, including sample mixing, splitting, and representativeness.

Figure 4-2. Bucket Auger



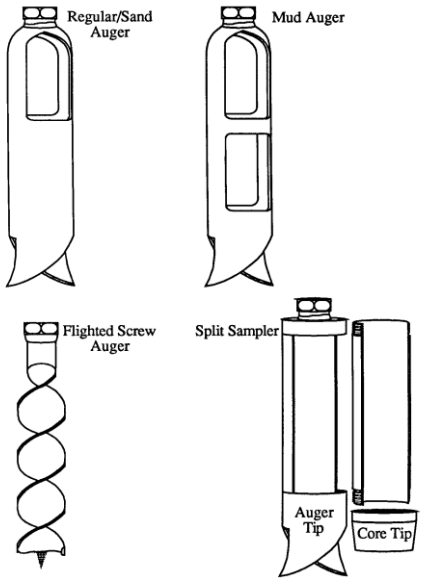
A variety of tools, ranging from handheld methods to larger fuel-powered methods, can be used to access unconsolidated soils. Consolidated soils can be difficult to sample because they are difficult to penetrate. Different drilling methods can be used to access consolidated soils. Truck-mounted drill rigs can gain access to soil at any reasonable depth and can penetrate hard layers. When used with a hollow-stem auger, a drill rig can retrieve reasonably undisturbed cores for classification purposes. The following subsections describe the various techniques used to

access both unconsolidated and consolidated subsurface soils.

4.6.2.1. Augers

An auger is a hole-making tool that is screwed into the soil; see Figure 4-3. The auger is used to bore a hole to a desired sampling depth and is then withdrawn. In general, augers should be used only to gain access to the soil that is to be sampled. Augers churn the soil and destroy its structure, making soil classification more difficult and causing rapid release of volatile contaminants. Also, when augers are lowered into boreholes, they can scrape soil off the sides of the hole so samples collected from the bottom of the hole may be contaminated with soil from shallower levels.

Figure 4-3. Augers



Various types of augers are available. The major types of augers, their advantages, and their limitations are summarized in Table 4-1.

Table 4-1. Types of Augers

Sampling Device	Applications	Limitations
Screw Auger	Cohesive, soft or hard soils, or residues	Will not retain dry, loose, or granular material
Standard Bucket Auger	General soil or residue	May not retain dry, loose, or granular material
Sand Bucket Auger	Bit designed to retain dry, loose, or granular material, silt, sand, and gravel	Difficult to advance boring in cohesive soils
Mud Bucket Auger	Bit and bucket designed to wet silt and clay soil or residue	Will not retain dry, loose, or granular material
Dutch Auger	Designed specifically for wet, fibrous, or rooted soils (marshes)	
In situ Soil Recovery Auger	Collection of soil sample in re-usable liners; closed top reduces contamination from caving sidewalls	Similar to standard bucket auger
Eijkelcamp Stony Soil Auger	Stony soils and asphalt	
Planer Auger	Clean out and flatten the bottom of predrilled holes	

A hand auger can be used to expose soil as deep as 4 feet. Gasoline-powered portable augers may be able to reach up to 12 feet depending on soil conditions, but are heavy, require two people to operate, and may contaminate samples when volatile organics are to be sampled.

The hollow-stem auger is commonly used in unconsolidated soils. The hollow-stem auger column rotates as it drills into the ground and is designed to push soil up and out of the borehole along the outside of the auger. The auger itself is driven either mechanically or by a hydraulically-

powered drill rig. A plug is placed through the auger to prevent soil from rising through the hollow portion of the stem. Samples are retrieved by retracting the plug and lowering the sample collection tube through the auger. Casings and screens for access holes can be placed in the hollow stem to prevent the borehole wall from collapsing and to ensure discrete interval samples. Casings also can be used to isolate near-surface contamination while drilling continues using a smaller diameter auger.

Auger Procedures

1. Clear the area to be sampled of any surface debris, such as twigs, rocks, or litter. It may be advisable to remove the first 3 – 6 inches of surface soil from an area 1 foot in diameter to prevent loose near-surface soil particles from falling down the hole.
2. Attach the auger bit to a drill rod extension, and then attach the drill rod to the T handle or the power unit.
3. Begin drilling, periodically removing, and depositing accumulated soils onto a plastic sheet spread near the hole. This practice prevents accidental brushing of loose material back down the borehole when removing the auger or adding drill rods, facilitates refilling of the hole, and avoids possible contamination of the surrounding area.
4. After reaching the desired depth, slowly and carefully remove the auger from the hole.

4.6.2.2. Direct-Push Techniques

Direct-push methods involve pushing a small-diameter hollow steel rod into the ground to a selected depth and can be used in most materials that can be augered or sampled with a split spoon. Direct-push techniques typically rely on a truck-mounted hydraulic ram to gain access to subsurface soils. The hydraulic ram pushes a closed-end ¾ – 2-inch diameter sampler into the soil, down to the sampling depth. The sampler contains a removable sampling tube and is capped with a retractable penetrating point. After the sampler is pushed to the desired depth, the penetrating point is retracted and the sampler is advanced to collect the soil sample inside the removable tube. This sampler can reach depths of 30 – 60 feet or more in sand or fairly loose soil, but has trouble penetrating clay and hard materials. As with any sampling device, hydraulic rams have both advantages and disadvantages.

The advantages of direct-push technology include the following:

- Retrieves relatively undisturbed soil cores up to 18 inches long. By collecting cores from different depths at closely adjacent locations, it is possible to develop a continuous core for soil classification purposes.
- Collects samples rapidly- one core sample can be collected every 10 minutes
- Minimizes the release of organic vapors, reducing personnel exposure hazards
- Generates little to no waste soil as compared to other drilling methods.

The primary disadvantages of direct-push technology include the following:

- Requires the rental of special equipment and trained operators
- Soil cores are only ½ inch in diameter, so several core samples may have to be obtained from a single sampling location to meet the laboratory sample quantity requirements.

Direct-push technology has rapidly become the method of choice for collection of subsurface soil samples due to its speed and low cost. There are currently numerous commercial environmental drilling companies located throughout the country that can provide direct-push soil sampling services.

4.6.2.3. Sonic Drilling

Sonic drilling is used for continuous sampling in unconsolidated and soft/fractured bedrock. The primary benefit of this technology is that very rapid drilling rates, combined with reduced volumes of secondary waste, are possible. Recent improvements in equipment design could lead to increased use in the future. A sonic rig uses an

oscillator or head with eccentric weights driven by hydraulic motors to generate significant sinusoidal force in a rotating pipe drill. The frequency of vibration (generally between 50 and 120 cycles per second) of the drill bit or core barrel can be varied to allow for the optimum penetration of subsurface materials. A dual-string assembly allows for the advancement of casing along with the inner casing used to collect samples. Small amounts of air and water can be used to remove the material between the inner and outer casings. When a drill bit is used, most of the cuttings are forced into the borehole wall. A thin-wall or split-spoon sampler can be used to obtain continuous samples. Sonic drilling also is referred to as vibratory drilling and rotosonic drilling.

4.6.2.4. Cable Tool

Cable tool drilling is well suited for areas contaminated by hazardous substances because it does not use any circulation fluids that could potentially spread contamination. Auger drilling and sonic drilling are the only other drilling methods that do not use circulation fluids. Of these two, only sonic drilling has demonstrated the ability to contain contaminants as effectively as the cable tool.

There are two types of cable tool drilling methods used in the field.

- **Hard Tooling (Percussion Drilling)**. Best used below the water table in areas where unsaturated zone soils become consolidated.
- **Drive Barrel (Dry Drilling).** This technique is appropriate for relatively dry, unconsolidated soils, such as sand and gravel, often found in the unsaturated zone (i.e., the soil above the water table).

Cable tool drilling rigs operate by repeatedly lifting and dropping a heavy string of drilling tools attached to a cable into the borehole. The drilling string of a cable tool consists of five components:

1. Consolidated rock is broken or crushed into small fragments, and unconsolidated material is loosened by the drill bit or shoe.
2. The drilling stem connects the drill bit to the drilling jars.
3. The drilling jars are used to vibrate the drill bit free of the formation.
4. The swivel or rope socket connects the remaining drill tools to the cable.
5. The cable is strung over a pulley on the mast to the drill motor.

Hard tooling is the most common form of cable tool drilling and can be used in any formation, including basalt. The percussive action (producing a noise level of 53 – 115 decibels) of the drill bit crushes the formation. The cable is attached to an eccentric walking or spudding beam that also serves to mix the crushed or loosened particles with water (generally 10 – 20 gallons if no water is present in the formation) to form slurry at the bottom of the borehole. Periodically, the drilling string is removed, and the slurry is pulled from the borehole using a sand pump or bailer. The drive barrel method uses the cable tool rig to drive the drill casing into the soil. The soil is pushed inside of the casing and then collected in a split-spoon sampler or core barrel.

4.6.2.5. Test Pits

Under unusual circumstances, the excavation of a test pit may be useful in determining the depth and thickness of different types of soil or any apparent band of soil contamination. A backhoe can be used to remove sections of soil. This method probably is the most expensive method of accessing soils for sampling due to the relatively high cost of backhoe operation.

Samples should be collected from undisturbed portions of the walls or bottom of the pit, not from soil that is excavated from the pit. Before digging a test pit, four stakes should be driven into the ground far enough from the sample location that they will not be disturbed by the backhoe or other activities. The stakes should be located

such that strings attached to opposite posts will intersect directly above the sampling location.

The following procedures are used for excavating test pits or trenches for soil sampling:

- Prior to any excavation with a backhoe, it is important to ensure that all sampling locations are clear of overhead and buried utilities
- Review the site-specific HASP and ensure that all safety precautions, including installation of appropriate monitoring equipment, are taken as required
- Using the backhoe, excavate a trench approximately 3 feet wide and 1 foot deep below the cleared sampling location. Place excavated soils on plastic sheets. Trenches greater than 5 feet deep must be sloped or protected by a shoring system, as required by OSHA regulations.
- A shovel is used to remove a 1- to 2-inch layer of soil from the vertical face of the pit where sampling is to be done
- Samples are taken using a trowel, scoop, or coring device at the desired intervals. Be sure to scrape the vertical face at the point of sampling to remove any soil that may have fallen from above and expose fresh soil for sampling. In many instances, samples can be collected directly from the backhoe bucket if the soils in the bucket are representative of the target sampling location.
- Abandon the pit or excavation according to applicable state regulations. Generally, shallow excavations can be backfilled with the removed soil material.

The advantages of excavating test pits include the following:

- **Visibility.** Provides the best information on the location of soil layers.
- **Versatility.** May be the only way to access subsurface soil where large rocks are present.

The disadvantages of excavating test pits include the following:

- **Safety**
  - The backhoe may have to be decontaminated before removing it from the site
  - Trench walls deeper than 3 feet may be unstable. Shoring may be required prior to having anyone enter the test pit to collect samples
  - Toxic or flammable vapors may accumulate in the test pit. Any entry into a test pit that is at least 4 feet deep should be considered a confined space entry, and all applicable requirements should be imposed and detailed in the HASP. See Section 4.4.2.3 for a brief discussion of confined space entry requirements.

Note: Excavation of contaminated soil can lead to the vaporization of toxic chemicals or the generation of contaminated dust, posing an inhalation hazard to sampling personnel. The SAP and HASP should address these potential hazards.

- **Environmental**
  - If soil contamination is suspected, large quantities of soil may have to be put into containers such as drums and stored or disposed of as hazardous waste
  - If the pit is refilled with excavated soil, contaminated surface material may be buried to a greater depth, or contaminated soil from subsurface layers may be exposed on the surface.

4.6.3. Subsurface Geological/Geotechnical Characterization

There are several drilling techniques that can be utilized to characterize the subsurface geology of a site. These drilling techniques do not provide undisturbed soil samples and should not be used in place of sonic drilling or cable tool methods.

4.6.3.1. Direct Mud Rotary

The direct mud rotary technique provides a flexible and rapid drilling method for a wide range of borehole diameters in consolidated and unconsolidated materials. Direct mud rotary drilling uses a rotating drill pipe with a hard-tooled drill bit

attached at the bottom. Fluid is forced down through the drill pipe and then back up the borehole. The fluid is then discharged at the surface through a pipe or ditch into a sedimentation tank, pond, or pit. As the cuttings settle in the pond, the fluid overflows into a suction pit, where a pump recirculates the fluid back through the drill rods. The drilling fluid serves to accomplish the following:

- Cool and lubricate the bit
- Stabilize the borehole wall
- Prevent the inflow of formation fluids, thus minimizing cross-contamination of aquifers.

Casing is not required during drilling. When unconsolidated materials overlie a bedrock aquifer, mud rotary can be used to drill the bedrock. The hole can then be cased and a less intrusive drilling method, such as air rotary, can be used to complete the borehole. Reverse-circulation rotary drilling is a variant of the mud rotary method in which drilling fluid flows from the mud pit down the borehole outside of the drill rods and passes upward through the bit. Cuttings are carried into the drill rods and discharged back into the mud pit. Reverse-circulation rotary drilling equipment is similar to direct mud rotary drilling equipment except that most pieces are larger.

4.6.3.2. Directional Drilling

Directional drilling technology has the potential to offer borehole access to subsurface areas beneath buildings, tanks, landfills, and impoundments, where vertical drill rigs cannot reach. Directional drilling involves the use of equipment located at the surface to drill slanted or horizontal holes into the subsurface. Test applications have focused primarily on remedial activities, but the potential exists for use during characterization and monitoring activities. All directional drilling systems require the following:

- A steerable drill stem
- The capability to detect the location of the drill head or trajectory of the borehole.

Directional drilling equipment ranges in size from scaled-down rigs developed for the oil industry to relatively compact, simple equipment used to install utilities.

4.6.3.3. Direct Air Rotary with Rotary Bit/Down-Hole Hammer

Direct air rotary drilling should be considered for all situations involving consolidated rock. Air rotary drilling relies on a sharp bit to drill through earth and rock layers. A system of cables, engines, support mechanisms, lubricating devices, and pulleys control the rotation of the bit below the surface, keep the bit lubricated, and bring debris out of the borehole. The basic rig setup for air rotary with a tri-cone or roller-cone bit is similar to the setup for direct mud rotary drilling, except the circulation medium is air instead of water or drilling mud. Compressed air circulates down through the drill rods to cool the bit and then carries cuttings back up the borehole (a minimum 6-inch diameter hole required) to the surface. A cyclone separator is used to slow the air velocity and allow the cuttings to fall into a container. Several different bits might be used on a single borehole when drilling deep through different layers of rock. A larger diameter bit is generally used at the start of the drilling process with progressively smaller bits used to finish the hole. Use of a down-hole hammer in place of a roller-cone bit provides better penetration in hard geologic formations.

4.6.3.4. Rotary Diamond Drilling

Rotary diamond drilling is used for borehole drilling and coring in consolidated rock. This method uses a rotating bit consisting of a tube that is 10 – 26 feet long, with a diamond-studded ring fitted to the end of the core barrel. Water is circulated through the bit to cool the cutting surface. The diamond bit cuts through rock, with a solid core remaining in the tube.

4.6.4. Use of Soil Sampling Equipment

Soil sampling equipment should be selected according to the objectives of the sampling program. It is important to determine the depth at which samples will be collected prior to the start

of a sampling program because sample depth will determine the types of equipment required. All sampling equipment should be decontaminated prior to use at each sampling location. Decontamination should be conducted in a controlled area before entering the site. Equipment should be decontaminated in the field between sampling locations as described in Section 4.9.

Note: Sampling equipment suppliers listed in EPA's manual *Description and Sampling of Contaminated Soils - A Field Pocket Guide* can be contacted to obtain pictures and information on soil sampling equipment.

4.6.4.1. Trowels, Scoops, and Spoons

Small hand tools can be used to collect surface samples and samples of undisturbed soil from the sides and bottoms of sampling pits. These small tools also are used to mix and handle soil obtained from deeper locations.

A trowel is a small shovel. A laboratory scoop is similar to a trowel, but the blade is usually more curved and has a closed upper end to contain the soil. Scoops come in different sizes and makes. Many are chrome plated, but these are unacceptable, since the plating can peel off and contaminate the soil sample. Stainless steel scoops are preferred. However, scoops made from other materials may be acceptable in certain instances. Stainless steel trowels and scoops can be purchased from scientific or forestry equipment supply houses. Stainless steel spoons can be purchased from housewares departments.

Hand tools should be decontaminated and wrapped in aluminum foil prior to use. If the equipment is not pre-wrapped in aluminum foil or another clean wrap material, sampling personnel should assume that it is not clean and should not use it.

4.6.4.2. Tube Samplers

Tube samplers are hollow tubes that are driven or screwed into the soil. The soil fills the tube and is retained when the sampler is withdrawn. Various types of tube samplers are available. The applications and limitations of the various types are summarized in Table 4-2. The split-spoon sampler and Veihmeyer sampler are discussed in Sections 4.6.4.3 and 4.6.4.4.

4.6.4.3. Split-Spoon Sampler

A split-spoon sampler is a length of carbon or stainless steel tubing split along its length and equipped with a drive shoe and drive head. Split-spoon samplers are available in a variety of lengths and diameters and generally are used to collect undisturbed soil cores of 18 or 24 inches in length. A series of consecutive cores may be extracted with a split-spoon sampler to give a complete soil column profile, or an auger may be used to drill down to the desired depth for sampling. If an auger is used, the split spoon is then driven to its sampling depth through the bottom of the augured hole and the core extracted. A standard 2-foot split spoon is advanced ahead of the auger with a 140-pound hammer. Due to its weight, the split-spoon sampler is generally used with a drill rig. The advantages of split-spoon samplers include the ability to be driven into hard soils and the ease of extraction of the soil sample. When split-spoon sampling is performed to gain geologic information, all work should be performed in accordance with *ASTM D1586, Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils.*

Split-spoon samplers are available typically in diameters of 2 – 3½ inches. A larger barrel may be necessary to obtain the required sample volume.

Split-Spoon Sampler Use Procedures:

1. Use an auger or drill rig to open a borehole down to the depth to be sampled.
2. Assemble the split-spoon sampler by aligning both sides of the barrel, and then screw the drive shoe with retainer onto the bottom and the heavier head piece onto the top.
3. Place the sampler in a perpendicular position to the sample material.
4. Using a well ring, drive the tube. Do not drive past the bottom of the head piece, or compression of the sample will result.

5. Record the length of the tube used to penetrate the material being sampled and the number of blows required to obtain this depth.
6. Withdraw the sampler, and open it by unscrewing the bit and head and splitting the barrel. The amount of recovery and the soil type should be recorded.

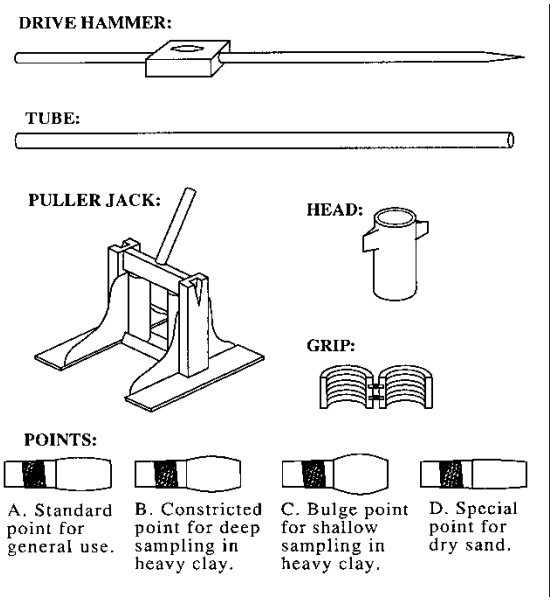
Table 4-2. Types of Tube Samplers

Sampling Device	Applications	Limitations
Split-spoon Sampler	Disturbed samples from cohesive soil	Ineffective in cohesionless sands; not suitable for collection of samples for laboratory tests requiring undisturbed soil
Soil Probe	Cohesive, soft soils or residue; representative sample in soft to medium cohesive soils and silts	Sampling depth generally limited to less than one meter
Shelby Tubes	Cohesive, soft soils or residue; special tips for wet or dry soils are available	Similar to Veihmeyer tube
Soil Recovery Probe	Similar to thin-walled tube; cores are collected in reusable liners, minimizing contact with the air	Similar to Veihmeyer tube
Veihmeyer	Cohesive soils or residue to depth of 3 meters	Difficult to drive into dense or hard material; will not retain dry, loose or granular material; may be difficult to pull from the ground
Peat Sampler	Wet, fibrous organic soils	

4.6.4.4. Veihmeyer Sampler

The Veihmeyer sampler was developed by Professor F. J. Veihmeyer of the University of California at Davis. The Veihmeyer sampler is recommended for core sampling of most types of soil; however, it may not be applicable to sampling stony, rocky, or very wet soil. A basic Veihmeyer sampler is shown in Figure 4-4 and contains the following components.

Figure 4-4. Veihmeyer Sampler



- Tube, 1.5 meters (5 feet)
- Tube, 3 meters (10 feet)
- Drive head
- Tip
- Drop hammer, 6.8 kilograms (15 pounds)
- Puller jack and grip, recommended for deep soil sampling.

The Veihmeyer sampler can achieve substantial depths with appropriate lengths of tubing, and various heads are available for different soil types. However, the Veihmeyer sampler can be difficult to clean, and some sampler components are constructed of materials that are not approved for the collection of certain types of analytes.

Veihmeyer Sampler Use Procedures

1. Assemble the sampler by screwing the tip and the drive head onto the sampling tube.
2. Insert the tapered handle (drive guide) of the drive hammer through the drive head.

3. Place the sampler in a perpendicular position to the material to be sampled.
4. With one hand holding the tube, drive the sampler into the material to the desired sampling depth by pounding the drive head with the drive hammer. Do not drive the tube further than the top of the hammer's guide.
5. Record the length of the tube that penetrated the material being sampled and the number of blows required to obtain this depth.
6. Remove the drive hammer, and fit the keyhole-like opening on the flat side of the hammer onto the drive head. In this position, the hammer serves as a handle for the sampler.
7. Rotate the sampler at least two revolutions to shear off the sample at the bottom.
8. Lower the sampler handle (hammer) until it just clears the two ear-like protrusions on the drive head, and rotate about 90 degrees.
9. Withdraw the sampler by pulling the handle (hammer) upwards. When the sampler cannot be withdrawn by hand, as in deep sampling, use the puller jack and grip.
10. Dislodge the hammer from the sampler, turn the sampler tube upside down, tap the head gently against the hammer, and carefully recover the sample from the tube.

4.6.4.5. Thin-Wall Open Tube Samplers

Thin-walled core samplers are most commonly used for collection of undisturbed core samples in cohesive soils, silt, and sand above the water table. Sample collection procedures are similar to those for split-spoon sampling except that the tube is pushed into the soil using the weight of the drill rig, rather than driven. Some common thin-wall open tube samplers are discussed below.

4.6.4.5.1. Shelby Tube

Shelby tube samplers are used to obtain undisturbed samples in cohesive soils, silt, and sand above the water table. A Shelby tube consists of a thin-walled tube with a tapered cutting head. The device allows the sampler to penetrate the soil and aids in retaining the sample in the tube after the tube is advanced (without excessive force) to the desired depth. A Shelby tube is used mainly for collecting geologic information but may be used to obtain samples for chemical analysis.

Shelby tube samplers are easily cleaned, and VOC samples can be sent to the laboratory within the tube, thus minimizing air exposure. However, Shelby tube samplers can be difficult to drive into hard soils and are not durable in rocky soils. Further, certain types of soils can be difficult to extract from the tube.

Shelby Tube Sampler Use Procedures

1. Use an auger or drill rig to open a borehole down to the depth to be sampled.
2. Place the sampler over the borehole in a perpendicular position.
3. Push the tube into the soil by a continuous and rapid motion, without impact or twisting. In no instance should the tube be pushed further than the length provided for the soil sample.
4. Let the tube sit for a few minutes to allow soils to expand in the tube.
5. Before pulling out the tube, rotate it at least two revolutions to shear off the sample at the bottom.
6. If the sample is to be shipped for geologic analysis, the ends of the tube should be sealed with wax to preserve the moisture content. In such instances, the procedures and preparation for shipment should be in accordance with *ASTM D1586-83*.

4.6.4.5.2. Continuous Tube

Continuous tubes are similar to Shelby tubes, except that the longer barrel is designed to operate inside the column of a hollow-stem auger.

Continuous Tube Sampling Procedures

1. Use an auger or drill rig to open a borehole down to the depth to be sampled.

2. Remove the auger from the drill rods, and insert a pre-cleaned thin-wall tube sampler. Install the proper cutting tip (an optional step is to first replace the auger tip with a planer auger to clean out and flatten the bottom of the hole before using the tube sampler).
3. Carefully lower the tube sampler down the borehole. Gradually force the tube sampler into the soil. Do not scrape the borehole sides. Avoid hammering the rods, because the vibrations may cause the boring walls to collapse.
4. Remove the tube sampler, and unscrew the drill rods.
5. Remove the cutting tip and the core from the device.
6. Discard the top of the core (approximately 1 inch) because it possibly represents material collected before penetration of the layer of concern. Place the remaining core into the sample container(s).
7. If another sample is to be collected from a greater depth in the same hole, reattach the auger bit to the drill and assembly, and follow steps 2 through 7, making sure to decontaminate the auger and tube sampler between samples.
8. Abandon the hole according to applicable state regulations. Generally, shallow holes can be backfilled with the removed soil material.

4.6.4.5.3. Thin-Wall Piston/Specialized Thin-Wall Tube

Thin-wall piston samplers usually are used when soil conditions are unfavorable for conventional thin-wall samplers. Piston samplers are similar to conventional thin-wall samplers except they are equipped with internal pistons to generate a vacuum within the sampler as it is withdrawn from the soil. Many specialized thin-wall piston samplers have been developed for collecting undisturbed samples of a wide variety of soil types, as exemplified below:

- **Internal Sleeve Piston.** Heaving sands (used with a hollow-stem auger)
- **Wireline Piston.** Cohesive soils and non-cohesive sands (used with a hollow-stem auger)
- **Fixed-Piston.** Cohesive soils, silts, and sand above or below the water table
- **Stationary Piston, Free Piston, and Open Drive.** Undisturbed samples in stiff cohesive soils. Representative samples in medium to soft cohesive soils, silts, and sands.

The various types of specialized thin-wall tube samplers (and the soil types they are designed to collect) are listed below:

- **Pitcher.** Undisturbed samples in hard cohesive soils and cemented sands. Representative samples in soft to medium cohesive soils, silts, and sands. Frequently ineffective on loose soils
- **Denison.** Undisturbed samples in hard cohesive soils, cemented sands, and soft rocks. Not suitable for undisturbed sampling of loose or soft cohesive soils
- **Vicksburg.** Similar to Shelby tube but able to sample denser, coarser material.

4.7. Soil Sampling Procedures

The procedures described here generally apply to any type of soil sampling. Any departures from the procedures contained in the SAP should be documented and justified.

4.7.1. Preparation

Thorough preparation is the key to a successful project. Before beginning any sampling program, personnel should complete the following:

- Review the SAP and HASP to identify special equipment and procedures
- Obtain the required equipment. A sample list of soil sampling equipment is provided at the end of this chapter
- Inspect the site to ensure that present conditions are the same as indicated in the

SAP and that all designated sample locations are accessible

- Prepare decontamination facilities for personnel and equipment as required by the HASP.

Refer to Chapter 3 for a complete discussion of sampling preparation requirements applicable to all types of sampling programs.

4.7.2. Sample Collection

Field sampling personnel should be familiar with all of the technical issues and documentation provided in the SAP. The following sampling procedures can be used when there are no special conditions present or special requirements specified by the SAP. Refer to Chapter 3 for a complete discussion of sample collection requirements applicable to all types of sampling programs.

4.7.2.1. Surface Samples

The simplest and most direct method for collecting surface soil samples is with a spade and scoop. The accuracy and representative nature of these samples depends on the care and precision demonstrated by the sampler. A flat, pointed trowel can be used to cut a block of soil 2 inches deep. Chrome plated tools, common with garden implements such as potting trowels, should be avoided.

Sampling Procedures

1. Clear the area to be sampled of any surface debris such as twigs, rocks, and litter. Cut grass down to the level of the soil and remove.
2. Define a sample area such that a 2-inch deep soil sample will provide enough material for all required sample containers.
3. Dig a trench at least 2 inches deep around the sample block using a clean spade.
4. Cut the sample loose from the ground using a pre-cleaned stainless steel trowel. Place the soil in a clean stainless steel bowl.
5. Remove all roots and other debris. Describe the amount and kind of material removed in the FLB/FN.
6. If instructed by the SAP, sieve the sample as described in Section 4.7.4.2.
7. Fill the sample container(s).

4.7.2.2. Subsurface Samples

Handheld augers and thin-walled tube samplers can be used separately or in combination to collect subsurface samples. Where rocky soils do not limit the use of tube samplers, a combination of augers to remove soil material to the depth of interest and tube samplers for actual sample collection allows the most precise control of sample collection. Depths of up to 2 meters can be readily sampled, and depths of up to 6 meters can be achieved where conditions are favorable. A drill rig should be used to gain access where deeper samples are required or where soil conditions preclude the use of augers. Tables 5-1 and 5-2 summarize the applications and limitations of different types of augers and tube samplers for sampling under different soil conditions. Section 4.6.2.1 describes procedures for using augers. Section 4.6.4.5 discusses the selection and use of various types of thin-walled tube samplers.

4.7.2.3. VOCs

EnCore™ samplers can be used to collect soil samples for VOC testing. Separate procedures are provided below for collecting samples with high and low concentrations of VOCs.

Note: The EnCore™ sampler has not been thoroughly evaluated by EPA as a sample storage device. While preliminary results indicate that storage in the EnCore™ device may be appropriate for up to 48 hours, samples collected in this device should be transferred to the soil sample vials as soon as possible, or analyzed within 48 hours.

When sampling for VOCs, soil samples should be taken from auger cuttings only if soil conditions make collection of undisturbed cores impossible. New techniques, such as direct-push technologies with the ability to continuously measure vadose zone VOC concentrations in the soil gas, are

useful for defining the boring depth where discrete soil samples should be collected for laboratory analysis. Soil recovery probes with dedicated or reusable liners (see Table 4-2) will minimize contact of the sample with the atmosphere.

Sampling Procedures

Low-Concentration VOC Soil Samples

Steps 1 – 5 are performed prior to transporting VOC vials to the field for sample collection.

1. Add approximately 1 gram of sodium bisulfate to each vial. If samples that are markedly smaller or larger than 5 grams are to be collected, adjust the amount of preservative to correspond to approximately 0.2 grams of preservative for each gram of sample. Enough sodium bisulfate should be present to ensure a sample pH of 2.
2. Add 5 milliliters of organic-free reagent water to each vial. The water and the preservative will form an acid solution that will reduce or eliminate the majority of the biological activity in the sample, thereby preventing biodegradation of the VOAs.
3. Seal the vial with the screw cap and septum seal. If double-ended, fritted vials are used, seal both ends as recommended by the manufacturer.
4. Affix a label to each vial to eliminate the need to label the vials in the field. This will ensure that the tare weight of the vial includes the label. The weight of markings added to the label in the field is negligible.
5. Weigh the prepared vial to the nearest 0.01 gram, record the tare weight, and write it on the label.
6. Using an EnCore™ Sampler, collect approximately 5 grams of sample as soon as possible after the surface of the soil or other solid material has been exposed to the atmosphere-generally within a few minutes at most. Carefully wipe the exterior of the sample collection device with a clean cloth or towel.
7. Add about 5 grams (2 – 3 centimeters) of soil from the EnCore™ Sampler to the sample vial containing the preservative solution. Quickly brush any soil off the vial threads, and immediately seal the vial with the septum and screw cap. Store samples on ice at ≤ 6°C.

Note: When samples are known or suspected to contain high levels of carbonates, a test sample should be collected, added to a vial, and checked for effervescence. If a rapid or vigorous reaction occurs, discard the sample and collect low-concentration samples in vials that do not contain the preservative solution.

8. When practical, use a portable balance to weigh the sealed vial containing the sample to ensure that 5.0 ± 0.5 grams of sample were added. The balance should be calibrated in the field using an appropriate weight for the sample containers. Record the weight of the sealed vial containing the sample to the nearest 0.01 gram.

High-Concentration VOC Soil Samples

1. Add 10 milliliters of methanol to each vial.
2. Seal the vial with the screw cap and septum seal.
3. Affix a label to each vial to eliminate the need to label the vials in the field. This will ensure that the tare weight of the vial includes the label. The weight of markings added to the label in the field is negligible.
4. Weigh the prepared vial to the nearest 0.01 gram, record the tare weight, and write it on the label.

Note: Vials containing methanol should be weighed a second time on the day that they are to be used. Vials found to have lost methanol (reduction in weight of > 0.01 gram) should not be used for sample collection.

5. Using an EnCore™ Sampler, collect approximately 5 grams of sample as soon as possible after the surface of the soil or other solid material has been exposed to the atmosphere-generally within a few minutes at most. Carefully wipe the exterior of the sample collection device with a clean cloth or towel.

6. Add about 5 grams (2 – 3 centimeters) of soil from the EnCore™ Sampler to the sample vial containing the preservative solution. Quickly brush any soil off the vial threads, and immediately seal the vial with the septum and screw-cap. Store samples on ice at ≤ 6°C.
7. When practical, use a portable balance to weigh the sealed vial containing the sample to ensure that 5.0 ± 0.5 grams of sample were added. The balance should be calibrated in the field using an appropriate weight for the sample containers. Record the weight of the sealed vial containing the sample to the nearest 0.01 gram.

4.7.2.4. Other Parameters

Collect approximately one liter of soil for each sample, and follow procedures for sampling handling and preparation (see Section 4.7.4). Record the depth from the surface to the top and the bottom of the core, soil color, type, and other attributes in the FLB/FN. If the sample consists of two different types of soil (e.g., sand and clay, or different color layers), split the core as required so that only one soil type is present in the sample; record the depth of the change of soil types in the FLB/FN.

Following sample preparation and handling, cap sample bottles tightly, affix labels, and place the bottles in resealable plastic bags. The chemical preservation of soils generally is not required. However, samples should be cooled to ≤ 6°C as soon as possible.

4.7.3. Composite Sampling

Compositing is the process of physically combining and homogenizing several individual soil aliquots. Compositing provides for an average concentration of contaminants over a certain number of sampling points, which reduces both the number of required laboratory analyses and the sample variability. Compositing always should be implemented with caution. Composite samples should be collected only after full justification and documentation of rationale in the sampling plan. Composite sample collection techniques should not be used if justified solely on the basis of reducing sample testing costs. The method of compositing the sample should be documented and uniform to ensure future data comparability.

4.7.3.1. Composite Sampling Techniques

If composite samples are collected, the first step is to collect a soil sample from the sampling location specified in the sampling plan using the documented procedure. Any variation from the stated procedure or SAP must be recorded. Composite samples may be collected on the basis of biased sampling or a variety of statistical sampling techniques. Biased sampling is used when visual, odor, or volatile organic detection is found. A portion of the material is collected and combined with other positive areas. Two statistical sampling techniques that can be used for composite sampling are described below.

4.7.3.1.1. Random Sampling

Random sampling is the arbitrary collection of samples within defined boundaries of the area of concern. Random sample locations should be chosen with a random selection procedure (e.g., using a random number table). Each sampling point must be selected independently, so that all locations within the area of concern have an equal chance of being selected. Randomization is necessary to support probability or confidence statements about the sampling results. The key to interpreting these probability statements is the assumption that the site is homogeneous with respect to the parameters being monitored. The random sampling technique will not adequately characterize the true conditions of a heterogeneous site.

The following example illustrates how random soil sampling has been used to verify the achievement of soil remediation objectives:

Random Sampling Example. Approximately 300 tons of diesel contaminated soils were excavated from a railroad fueling operation and thinly spread over approximately one half acre to allow for biodegradation. A single composite soil

sample was to be collected quarterly for total petroleum hydrocarbons to monitor remedial progress. The composite sample was to be prepared from 6 discrete soil samples. To collect the 6 soil samples from random locations across the half-acre area, a grid consisting of 40 equally sized squares was placed on a site map showing the area. Each square was numbered from 1 – 40, and a random number generator was used to pick locations from the grid. The sampling team then collected discrete soil samples from each of the six locations and prepared a single composite sample for laboratory analysis.

4.7.3.1.2. Stratified Random Sampling

Stratified random sampling often relies on historical information and prior analytical results (or screening data) to divide the sampling area into smaller areas called strata. Each stratum is more homogeneous than the site as a whole. Strata can be defined based on various factors, including sampling depth, contaminant concentration levels, and contaminant source areas. Stratified random sampling imparts some control upon the sampling scheme but still allows for random sampling within each stratum. Different sampling approaches may be selected to address the different strata at the site. Stratified random sampling is a useful and flexible design for estimating the pollutant concentration within each depth interval or area of concern.

4.7.3.2. Sample Compositing Procedures

In most cases of sample compositing, equal amounts of material are collected and mixed in the sample container. Protocols for combining the sample are based on site conditions, the parameters being measured, the regulatory limit, and DQOs. The rationale for the use of glass, stainless steel, or polyethylene equipment for combining samples, and the rationale for combining the soil in equal amounts, proportional amounts, or other amounts should be documented.

Specify the method for selecting the composite aliquots and the compositing factor in the sampling plan. The compositing factor is the number of aliquots to be composited into one sample (e.g., 3 – 1, 10 – 1). Determine this factor by evaluating the detection limits for parameters of interest and comparing them with the selected action level for that parameter. Compositing also requires that each discrete aliquot be the same in terms of volume or weight and that the aliquots be thoroughly homogenized. Because compositing dilutes high-concentration aliquots, the applicable detection limits should be reduced accordingly. If the composite value is to be compared to a selected action level, then the action level should be divided by the number of aliquots that make up the composite to determine the appropriate detection limit (e.g., if the action level for a particular substance is 50 parts per billion (ppb), an action level of 10 ppb should be used when analyzing a 5-aliquot composite). The detection level need not be reduced if the composite area is assumed to be homogeneous in concentration (e.g., stack emission plume deposits of particulate contamination across an area, or roadside spraying of waste oils).

In an example situation of a soil sampling program designed to detect petroleum products in an area of homogenous concentration, an appropriate sample compositing technique would be to use an adequately sized resealable freezer storage bag. Sampling personnel would collect a minimum of three equally sized samples (10 is preferred) from designated sample locations and place those samples in the sample bag. Personnel would then close and secure the bag using care to eliminate trapped air and combine the samples by tumbling and kneading until fully mixed.

Soil samples should be homogenized after compositing is complete to ensure soil uniformity.

Note: Do not composite or mix soil samples that are to be tested for volatile organics.

4.7.4. Sample Handling and Preparation

Proper sample handling and preparation ensures that each sample container is filled with soil that represents the entire sample and that large rock fragments are either removed or included in each container in an amount proportional to their presence in the soil, as specified by the SAP.

Techniques for sample handling and preparation are provided in the subsections below.

4.7.4.1. Soil Homogenization

Homogenization is the mixing or blending of a soil sample to provide uniform distribution of contaminants. Ideally, proper homogenization ensures that portions of the containerized samples are equal or identical in composition and representative of the total soil sample collected. Incomplete homogenization will increase sampling error. Samples to be composited or split should be homogenized after all aliquots have been combined. Manually homogenize samples using a stainless steel spoon or scoop and a stainless steel bucket, or use a disposable scoop and pan.

Note: Do not homogenize soil samples that are to be tested for volatile organics.

4.7.4.2. Sieving

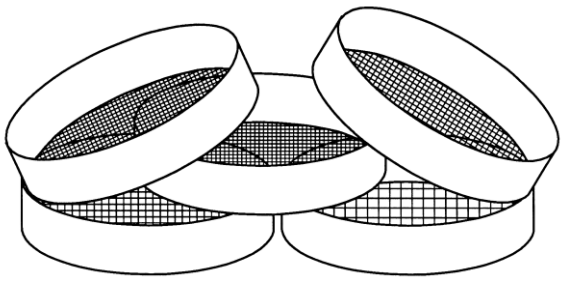
Sieving eliminates large rock fragments. Under some EPA protocols, only fine soil material should be analyzed; see Figure 4-5 for an illustration of sieves.

Note: Do not sieve soil samples that are to be tested for volatile organics.

Instructions for sieving are as follows:

1. Break up soil aggregates and pull apart any vegetation and root mat, if present. Weigh the non-soil vegetation fraction, and archive or discard, as required by the SAP.
2. Remove and weigh large rocks. Archive for possible analysis.

Figure 4-5. Sieves



3. Crush the entire soil sample with a rolling pin, stainless steel spoon, or similar tool. Mix thoroughly with a stainless steel spoon.
4. For samples of surface soil, sieve through a clean 0-mesh (No. 1, 2 mm) screen. Use a 3/8-inch standard sieve (9.5 mm) to screen samples that will be tested to determine whether the soil should be classified as hazardous waste under RCRA. Use a disposable stainless steel screen for samples to be analyzed for semivolatile organic contamination. Use Teflon® screens for samples to be analyzed for metal contamination.
5. If the soil is too wet or too cohesive to pass through the sieve, note that the required sieving was not done in the FLB/FN, and enter this notation on the Field Sampling Form. Inform the Sampling Program Manager that the sample could not be sieved.
6. Spread out the screened sample, mark off quarters, and take samples from each quarter in a consecutive manner until appropriate sample volume is collected. If specified, archive the remaining sample for future analysis.
7. Before shipping the samples to the laboratory, shake each sample container to mix thoroughly.

4.7.4.3. Splitting Samples

Many times samples are split between representatives of the property owner or between state or federal enforcement agencies so results may be independently verified. Soil samples split between laboratories are typically performed to evaluate laboratory quality. Soil samples should be split from a single sampling event following homogenization and sieving. Specific procedures for splitting samples for VOC, semivolatile organic, and metal analyses are described below.

- **Splitting Samples for VOC Analysis.** To split samples for VOC analysis, collect two core samples from adjacent locations. Alternatively, split a soil core longitudinally with a clean knife and place half of the core into each sample container, minimizing air

contact as much as possible. The method of splitting the sample may greatly affect the results. Documentation and execution of the splitting technique should be uniform to ensure data comparability.

- **Splitting Samples for Semivolatile Organic Chemical (SVOC) and Metal Analyses.** To split samples for semivolatile and metal analyses, place the soil in a clean stainless steel bowl. Crush and thoroughly mix the soil with a clean stainless steel spoon. Document the method used for sample mixing and placing into the sample containers to ensure data comparability. One method is to form mixed soil into a cone and divide in half vertically. Each set of sample containers is then filled with the soil from half of the pile.

4.8. Restoration of Sample Locations

Sample locations should be restored to eliminate tripping hazards and remove conduits for contaminated runoff to reach subsurface soils. Take precautions to prevent introducing contaminated soil into uncontaminated soil horizons or leaving contaminated soil exposed on an otherwise clean surface.

4.8.1. Backfill Sample Holes

Soil pits and boreholes should be backfilled after samples have been collected. For shallow pits and boreholes where only one soil horizon is involved, the Sampling Program Manager may deem it appropriate to backfill with material from the pit or hole if this action has been specified in the SAP.

If backfilling with removed material is not authorized by the SAP, or where more than one soil horizon is involved, the pit or borehole should be backfilled with clean soil or sand. The fill material should be added in layers no more than 6 inches thick. Each layer should be compacted before more soil is added. This procedure will minimize subsequent settling.

4.8.2. Grouting Boreholes

Boreholes that penetrate a confining layer (e.g., silt, clay, or rock that acts as the base of an aquifer) should be grouted to prevent migration of contaminated water between aquifers. Grouting consists of filling the borehole with concrete or bentonite slurry as specified by the Sampling Program Manager and the SAP. Record grouting details (e.g., depth of borehole, depth to confining layer, mix ratio, and amount of the grout used) in the FLB/FN for each borehole.

4.8.3. Replace Sod

Sod should be replaced in grass areas after the boreholes and pits are filled. The sod originally removed from the area should be used if it is still alive. Otherwise, commercial sod can be used or the area should be seeded, depending on the requirements of the facility.

4.8.4. Replace Pavement

Areas of pavement that were removed to obtain access to soil should be repaired after the pit or borehole is filled. As required by the facility, the patch may be cold patch asphalt, hot asphalt, or concrete.

4.9. Decontamination

It is generally not possible to have a separate set of precleaned stainless steel sampling equipment for each sample if significant numbers of samples are to be collected. Sampling equipment should be decontaminated prior to use to prevent contaminants from being transferred from one sample to the next. If sampling equipment must be reused, it must be decontaminated prior to sampling and between each sample location.

All field decontamination should take place on a decontamination pad lined with plastic. Solvent rinse liquids must be collected in dedicated containers. All aqueous decontamination liquids should be stored in DOT approved compatible containers (e.g., 55-gallon drum or appropriate size). If nitric acid is used to rinse the sampling equipment, the rinse liquids should be neutralized by adding lime to each drum (1 cup of slaked lime, $Ca(OH)_2$, per drum). If any hazardous chemical is used on site, the SAP must detail proper waste material handling procedures.

4.9.1. Decontamination Solutions and Supplies

Decontamination equipment, materials, and supplies are generally selected based on availability. Other considerations include the ease of decontaminating or disposing of the equipment. Most equipment and supplies can be easily procured such as softwash and rinse solutions. Children's wading pools also can be used. Large plastic garbage cans or other similar containers lined with plastic bags can help segregate contaminated equipment. Contaminated liquid can be stored temporarily in metal or plastic cans or drums. The following standard materials and equipment are recommended for decontamination activities:

- Solutions
  - Non-phosphate detergent
  - Selected solvents such as acetone, hexane, nitric acid, and isopropyl alcohol
  - Dilute bases
  - Tap water
  - Distilled or deionized water.
- Tools and Supplies
  - Long and short handled brushes
  - Bottle brushes
  - Drop cloth or plastic sheeting
  - Paper towels
  - Plastic or galvanized tubs or buckets
  - Pressurized water sprayers
  - Solvent sprayers
  - Aluminum foil
  - Trash bags
  - Trash containers
  - 55-gallon drums
  - Metal or plastic buckets or containers for storage and disposal of decontamination solutions.
- Solvent Rinses
  - 10% nitric acid is typically used for inorganic compounds such as metals. An acid rinse may not be required if inorganics are not a contaminant of concern.
  - Acetone (pesticide grade), hexane (pesticide grade), and methanol, only if sample is to be analyzed for organics.

Note: All cleaners or solvents must be approved by the Program Manager or designee. At least once a day, collect samples of the cleaner and water that have been used as a final rinse for the equipment for submission to the laboratory as an equipment rinsate blank.

Table 4-3 provides a summary of the solvent types and recommended solvent rinses for various types of pollutants.

Table 4-3. Soluble Contaminants and Recommended Solvent Rinse

Solvent[1]	Examples of Solvents	Soluble Contaminants
Water	Deionized water, tap water.	Low-chain hydrocarbons, inorganic compounds, salts, some organic acids, and other polar compounds.
Dilute Acids	Nitric acid Acetic acid, boric acid.	Basic (caustic) compounds (e.g., amines and hydrazines).
Dilute Bases	Sodium bicarbonate (e.g., soap detergent).	Acidic compounds, phenol, thiols, some nitro and sulfonic compounds.
Organic Solvents[2]	Alcohols, ethers ketones, aromatics, straight-chain alkalines (e.g., hexane), common petroleum products (e.g., fuel, oil, kerosene).	Nonpolar compounds (e.g., some organic compounds).
Organic Solvents[2]	Hexane	PCBs

[1]Material Safety Data Sheets (MSDSs) are required for all decontamination solvents or solutions as required by the Hazard Communication Standard.

[2]**WARNING:** Some organic solvents can permeate or degrade protective clothing.

4.9.2. Procedure

The following procedures should be used to clean field sampling equipment between samples. Note

that different procedures are used depending on whether the equipment will be used to collect samples for metals or organic analysis and the level of detection required for the compliance program. Cleaning and decontamination procedures for equipment used to collect soil samples for analysis for organic and inorganic chemicals are as follows:

- **Segregate Equipment Drop**
  - Place plastic sheeting on the ground. Size will depend on amount of equipment to be decontaminated.
  - Provide containers lined with plastic if equipment is to be segregated. Segregation may be required if sensitive equipment or mildly contaminated equipment is used at the same time as equipment that is likely to be heavily contaminated.
  - Deposit equipment used on site (e.g., tools, sampling devices, and containers, monitoring instruments radios, etc.) on the plastic drop cloth or sheet, or in different containers with plastic liners. Each will be contaminated to a different degree; segregation at the drop reduces the probability of cross contamination.
  - Loose leaf sampling data sheets or maps can be placed in plastic zip lock bags if contamination is evident.
- **Physical Removal With a High-Pressure Washer (Optional)**
  - A high-pressure wash may be required for compounds that are difficult to remove by washing with brushes. Hot water from the high-pressure washers is excellent at removing greasy or oily compounds.
  - High-pressure washers require water and electricity
  - A decontamination pad may be required for the high-pressure wash area. An example of a wash pad may consist of an approximately 1½-foot-deep basin lined with plastic sheeting and sloped to a sump at one corner. A layer of sand can be placed over the plastic, and the basin is filled with gravel or shell.
  - The sump is also lined with plastic, and a barrel is placed in the hole to prevent collapse. A sump pump is used to remove the water from the sump for transfer into a drum.
  - Heavy machinery is usually decontaminated at the end of the day unless site sampling requires the machinery be decontaminated more frequently. A separate decontamination pad may be required for heavy equipment.
  - Use high-pressure wash on grossly contaminated equipment. Do not use it on sensitive or non-waterproof equipment.
- **Physical Removal with Brushes and a Wash Basin**
  - Fill a wash basin, a large bucket, or child's swimming pool with non-phosphate detergent and tap water. Approximately 10 – 50 gallons of water may be required initially depending upon the amount of equipment to decontaminate and the amount of gross contamination.
  - Scrub equipment with soap and water using bottle and bristle brushes
  - Only sensitive equipment (e.g., radios, air monitoring and sampling equipment) which is waterproof should be washed
  - Equipment that is not waterproof should have plastic bags removed and wiped down with a damp cloth
  - Acids and organic rinses may also ruin sensitive equipment. Consult the manufacturers for recommended solutions.

- **Equipment Rinse**
  - Fill a wash basin, a large bucket, or child's swimming pool with tap water. Approximately 10 – 50 gallons of water may be required initially depending upon the amount of equipment to decontaminate and the amount of gross contamination.
  - Rinse soap off equipment with water by immersing the equipment while brushing. Repeat as many times as necessary.
- **Low-Pressure Rinse**
  - Fill a low-pressure sprayer with distilled or deionized water during the rinsing process. Approximately 10 – 20 gallons of water may be required initially depending upon the amount of equipment to decontaminate and the amount of gross contamination.
  - Rinse sampling equipment with distilled or deionized water with a low-pressure sprayer.

Note: Personal protective equipment (PPE) recommended for handling nitric acid includes nitrile gloves, boot covers, rubber apron or coated Tyvek® coveralls, and eye protection (e.g., face shields or goggles).

- **Nitric Acid Sprayers (Required Only if Metals Are a Contaminant of Concern)**
  - For low-level contamination or where equipment rinsate blanks demonstrate metals contamination, rinse stainless steel equipment with 10% nitric acid (trace metal or higher grade HNO_3 diluted with distilled or deionized water)
  - Fill a spray bottle with 10% nitric acid. An acid rinse may not be required if inorganics are not a contaminant of concern. The amount of acid will depend on the amount of equipment to be decontaminated.
  - Provide a 5-gallon bucket or basin to collect acid during the rinsing process
  - Rinse sampling equipment with nitric acid. Begin spraying (inside and outside) at one end of the equipment allowing the acid to drip to the other end into a 5-gallon bucket.
- **Low-Pressure Sprayers**
  - Fill a low-pressure sprayer with distilled or deionized water during the rinsate process.
  - Rinse sampling equipment with distilled or deionized water with a low-pressure sprayer.
- **Organic Solvent Sprayers**
  - Fill a spray bottle with an organic solvent. After each solvent rinse, the equipment should be rinsed with distilled or deionized water and air dried. Amount of solvent will depend on the amount of equipment to de-decontaminate.
  - Provide a 5-gallon bucket or basin to collect the solvent during the rinsing process
  - Solvent rinses may not be required unless organics are a contaminant of concern
  - Rinse sampling equipment with a solvent. Begin spraying (inside and outside) at one end of the equipment allowing the solvent to drip to the other end into a 5-gallon bucket.
  - Allow the solvent to evaporate from the equipment before going to the next step. A QC rinsate sample may be required.
- **Low-Pressure Sprayers**
  - Fill a low-pressure sprayer with distilled or deionized water. Use a 5-gallon container to collect water during the rinsate process.
  - Rinse sampling equipment with distilled or deionized water with a low-pressure washer.
- **Clean Equipment Drop**
  - Lay a clean piece of plastic sheeting over the bottom plastic layer. This will allow easy removal of the plastic in the event that it becomes dirty.

  - Provide aluminum foil, plastic, or other protective material to wrap clean equipment
  - Lay clean equipment on plastic sheeting. Let air dry, wrap sampling equipment with aluminum foil, plastic, or other protective material.
- **Record Information**
  - Information concerning decontamination methodology, date, time, and personnel should be recorded in the FLB/FN.

4.9.3. Preparation of Equipment Rinsate Blanks

Equipment rinsate blanks provide a check on the cleanliness of sampling equipment and the purity of the water or solvent used for the final rinse(s). See Chapter 3 for information on collecting equipment rinsate blanks.

At least one equipment rinsate blank should be submitted each day for each type of rinse solvent used (e.g., water, acetone). The SAP should specify the size and material of each sample bottle required for equipment rinsate blanks and any required preservatives for these liquid samples.

Equipment rinsate blanks consisting of solvents such as acetone or hexane will be classified as flammable liquids and will require special packaging (in metal cans). Special labeling and manifesting requirements apply for shipments of flammable liquids sent to the lab by common carrier.

4.10. Waste Material Storage and Disposal

All material generated during soil sampling projects should be stored as hazardous waste until disposal decisions are made based on generator knowledge or test results. This includes soil cuttings, equipment decontamination wastes, and used disposable PPE.

4.10.1. Soil Cuttings

Soil cuttings from boreholes and test pits may be classified as hazardous waste and should therefore be containerized and stored in accordance with EPA and facility requirements. Soil cuttings must not be used to fill the boreholes or test pits unless specifically authorized by the SAP or regulatory authority.

Soil cuttings should be placed on plastic sheets when generated. The soil should be stored in metal drums that are marked to indicate the source of the contents. The plastic sheets should be disposed with the used PPE.

4.10.2. Used Disposable PPE

All disposable solid contaminated equipment (e.g., plastic sheets, screens, coveralls, boot covers, etc.) should be placed in plastic bags temporarily, then sealed in metal barrels for final storage, transport, and disposal based on generator knowledge or test results.

4.11. Sampling Equipment List

Section 3.8 provides a generic sampling equipment list applicable to most sampling events. The following list provides additional equipment applicable to soil sampling. In most cases, only a portion of the equipment listed below would be required for a given sampling event.

- Equipment for accessing soils
  - Backhoe
  - Augers
  - Drill rigs
- Soil sampling equipment
  - Trowels, scoops, and spoons
  - Split-spoon sampler and hammer to advance.
  - Veihmeyer soil sampler outfit
  - Shelby tube
  - Continuous tube
  - Thin-wall tube sample
  - EnCore™ sampler
- Additional equipment
  - Maps and plot plan
  - Survey equipment or GPS to locate sampling points
  - Survey stakes or flags

- Decontamination supplies and equipment
- Canvas or plastic sheet
- Shovel (to refill sampling holes)
- Stainless steel mixing bowl
- Detergent
- Acetone, hexane, or biodegradable organic cleaner
- Nitric acid
- Tap water
- Distilled or deionized water (ASTM Type II)
- Storage and disposal containers for wash water, acid, solvents, and soil cuttings
- Lime to neutralize nitric acid wastes,
- Grouting materials such as concrete or bentonite slurry
- Tape to measure sample depth
- Vermiculite.

4.12. References

1 ASTM D5314 Standard Guide for Soil Gas Monitoring in the Vadose Zone2 California Environmental Protection Agency, Department of Toxic Substances Control, "Advisory Active Soil Gas Investigation," April 2012, http://www.dtsc.ca.gov/SiteCleanup/upload/VI_ActiveSoilGasAdvisory_FINAL_043012.pdf

3 DoD Vapor Intrusion Handbook, http://www.clu-in.org/download/char/dodvihdbk200901.pdf

4 USACE Sample Collection and Preparation Strategies for Volatile Organic Compounds in Solids, October 1998

Chapter 5. Aquatic Sediment Sampling

5.1. Purpose

This chapter provides general guidelines and procedures for sampling approaches, methods, and equipment for aquatic sediment characterization to assess risks at DoD sites. This chapter provides general guidance, and references appropriate detailed sampling approaches, methods, and equipment. Topics include sampling method selection; sediment manipulation methods to prepare for chemical analysis and toxicity testing; sampling of sediment pore water; and sampling of benthic invertebrate infauna (organisms that burrow in sediment (e.g., clams, worms)) and epifauna (organisms living on sediment surface and freely roaming, (e.g., some insects and crabs)). Key references for additional information are provided at the end of each section.

5.2. Scope

Aquatic sediments consist of particles of mineral or organic material that accumulate under surface water. The particles, which include solids and sludges that are suspended or settled in the water, are derived from rocks or biological materials that are either transported by flowing water bodies or situated beneath a static aqueous layer. Sediment types are classified by particle size, mineralogy, source materials, and site-specific variables. Sediment and sediment-related sampling and analysis is used to address risk to human health or the environment. Specific uses of sediment data include the following:

- Characterizing extent of contamination or risk associated with site and ambient conditions
- Determining impacts to benthic communities
- Evaluating toxicity through bioassays
- Estimating bioaccumulation of certain chemicals
- Evaluating impacts from pore water
- Evaluating impacts from sediment disturbance (e.g., currents, dredging, prop-wash and scour).

Some sediment sampling procedures may need to be modified to accommodate site conditions and equipment or logistic limitations (e.g., depth to sediment, difficulty of penetration of sediment). Field sampling should be conducted in accordance with appropriate federal, state, or local government regulations.

Sediment samples may be collected from streams, lakes, ponds, creeks, lagoons, surface impoundments, and coastal (marine/estuarine) waters, near the surface, or at deeper intervals. Benthic invertebrate collections are typically done at the surface or at shallow depths where organisms reside, and result in benthic community measures that may be used to compare to a reference or ambient community in order to determine whether the site sediments are impacted. Bioassay and bioaccumulation methods may be used to expose representative aquatic organisms to sediment, usually in a laboratory setting, to determine their response in comparison to a reference or ambient sediment response. Sediment pore-water sampling is also an option to determine risk of contaminants, or to assess the movement of groundwater through sediment in a groundwater discharge zone or hyporheic zone of flow.

5.3. Project Planning for Sediment-Related Sampling

As discussed in Chapter 2, the systematic planning process is critical to acquiring representative samples. However, sediment sampling introduces additional concerns. For example, sediment typically has low-level contaminant action levels compared to waste and soil media, and related problems with introducing trace-level cross-contamination from the bulky mechanical gear required for sampling. Clear and concise objectives should be identified to define the intent of the sediment-sampling program. The overall process includes the following steps:

5.3.1. Identify Project Goals

A key step in identifying project goals is to specify the problem and indicate decisions that need to

be made regarding it. A CSM is used to compile and summarize existing information and hypotheses regarding contaminant sources and migration pathways to prospectively-exposed human and environmental receptors. In many cases regarding sediments, the prospective impacts to these receptors is the decision. However, legal considerations may also be important (e.g., state laws specifying sediment cleanup requirements, or federal or state laws that establish hazardous or dangerous waste categories).

CSMs should consider the following as they influence the site decisions. Table 5-1 below shows an expanded list.

- Historical site use including known or suspected contamination in site media
- Site topographic and meteorological features, including water depth and sediment thickness
- The hydrodynamic conditions of the water body as related to physical sediment fate and transport, (e.g., runoff, current and deposition patterns, upwelling, and seepage patterns)
- Processes that influence the transport and concentrations of contaminants present (e.g., advection, dilution, sediment transport, biodegradation, and dispersion)
- The human and fish or wildlife utilization of the site (e.g., children accessing sediments on beaches, or wildlife consuming fish from the site)
- Processes that affect contaminant bioavailability.

5.3.2. Determine Data Needs

The project planning team should identify key inputs or data needs and provide narrative statements of how data will be used in decisions, i.e., data quality objectives. An important part of this process is the boundaries (spatial or temporal) of the study, which affect the scope of the investigation.

Typical decisions for sampling sediment include the following:

- Identifying contamination presence and extent
- Identifying sources of contamination
- Identifying whether contamination levels suggest adverse biological effect
- Identifying trends
- Establishing goals for sediment remediation
- Evaluating possible effects of dredged or fill material discharge.

For determination of adverse biological effects, there are several possible phases of inquiry and response, and the process selected should be described in the data quality objectives. What follows summarizes the process.

5.3.2.1. Develop a Screening-Level Chemical Evaluation

Develop a Screening-Level Chemical Evaluation that compares site sediment and/or fish/shellfish tissue concentrations to background and screening criteria in order to generate a list of contaminants of potential concern (COPC), and to determine whether additional investigations or actions are needed. Until recently, sediment screening has been based on bulk sediment concentrations compared to database-derived measures of effect (e.g., the National Oceanographic and Atmospheric Administration (NOAA) Screening Quick Reference Table (SQuIRT) values), or equilibrium-partitioning derived values that estimate the proportion of a substance in sediment pore water. Recently, researchers have developed better screening criteria that incorporate bioavailability as a predictor of toxicity and bioaccumulation. The National Research Council (NRC 2003) defines bioavailability processes as, "individual physical, chemical, and biological interactions that determine the exposure of plants and animals to chemicals associated with soils and sediments." Traditional methods to assess the potential effect of sediment contamination on human or ecological health use total bulk sediment contaminant concentrations. However, abundant research has shown that only a fraction (the bioavailable fraction) of an environmental contaminant may be taken up and may subsequently result in an effect on an organism; and that this concentration is often much less than the bulk concentration of these contaminants in the sediment.

Depending upon the project decision and the complexity of the investigation, bioavailability measures may be desirable to include in the investigation. An example bioavailability screen for divalent inorganic compounds is to collect data on acid volatile sulfides and simultaneously extracted metals. An example for neutral organic compounds is to use a method for collection of sediment pore water. Table 5-1 summarizes a variety of measures that affect bioavailability, and related measures that may require inquiry.

5.3.2.2. Characterize Exposure and Effect

Characterize Exposure and Effect using the COPCs identified, and conducting human health or ecological risk assessment, and determining the risk or hazard associated with the sediment. This step may also include comparisons of benthic communities of invertebrates at the site to a reference area community as a measure of effect. In Table 5-1, the rows titled, "Evaluate Ecological and Human Health Pathways and Endpoints" apply to this step.

5.3.2.3. Assess Risk Management

Assess Risk Management options regarding the site; these may lead to no action, or to a sediment removal, or in the case of sites managed under CERCLA, as amended, to a Feasibility Study and Record of Decision (ROD) regarding the extent of a response action.

5.3.3. Develop Data Collection Options

Specific considerations that may influence data collection strategies for sediments may include:

- Hydrologic information (e.g., runoff, current and deposition patterns, upwelling, seepage patterns)
- Water depth
- Thickness and type of sediment, especially regarding sediment grain size, as it affects sampling efficiency and sample representativeness
- Anthropogenic and natural loading (proximity of outfalls, seasonal patterns, relevant previous monitoring information)
- Contaminant bioavailability
- Type of benthic community being represented, as it affects the size and number of samples required for characterization; note that habitat structure and function may influence the community composition
- Potential for release of sediment chemicals to surface water via diffusion or advection
- Fate of sediment (e.g., lithic structure, current regime with regard to depositional and erosional conditions, and related activities such as dredging).

Specific measurements may include:

- Chemical data on bulk sediment and pore water
- Sediment toxicity (organism response)
- Tissue bioaccumulation (tissue levels upon exposure to sediment)
- Bioavailability measures
- Benthic community analysis (e.g., habitat structure, and benthic surveys). Although this chapter is limited to sediment and associated invertebrate communities, there are benthic fish species whose life cycles are coupled to sediment that may also be useful bioindicators. Examples include mummichog, sheepshead minnow, and oyster toadfish.

Table 5-1 below illustrates a range of activities and measures potentially associated with developing project objectives and data needs. Note that some of these evaluations and investigation methodologies are beyond the scope of this chapter, but are potential additional lines of evidence.

Appendix B of US EPA's *Methods for Collection, Storage, and Manipulation of Sediments for Chemical and Toxicological Analyses* (Ref. 1) illustrates some typical data quality objectives and measurement quality objectives for sediment investigations.

Table 5-1. Approaches Used to Assess Bioavailability of Chemicals for Sediment.
(Adopted from ITRC 2011.) The added phrase "as appropriate to the site" is intended to indicate that not all sites require this evaluation.

Scoping Element	Source of Information	Activity	Bioavailability Related Analyses/ Considerations
Review Site History	Review Available Data (e.g., hazard ranking documents)	Establish site boundaries, identify adjacent facilities Identify initial COPC Identify geochemical parameters Understand reference (background) conditions	Nature and extent of COPCs and exposure COPC mobility forms and pathways Data gap analysis (organic carbon, acid volatile sulfides and simultaneously extracted metals, redox, salinity, pH)
Identify Site Transport Processes	Groundwater Data, *as appropriate to the site*	Understand direction and flow Understand hyporheic zone mixing, if present	Flux measures in sediments via piezometers, direct pore water, or passive samplers
	Sediment Data	Assess bulk sediment	Analyses of COPC, total organic carbon, acid volatile sulfides and simultaneously-extracted metals, metals speciation as appropriate, and grain size
		Assess pore water, *as appropriate to the site*	Sample and analyze COPC via piezometers, direct pore water measurement by extraction or by passive samplers Estimate pore water fraction by Equilibrium Partitioning, acid volatile sulfides and simultaneously-extracted metals, the biotic ligand model, or other appropriate model(s)
		Assess diffusive flux, *as appropriate to the site*	Analyses of dissolved COPC immediately above sediment/water interface, *as appropriate to the site* Estimate flux based on models, such as the USACE RECOVERY model, a contaminated sediment-Water interaction model
	Potential Sediment Hydraulics	Assess Flood or ice scour, *as appropriate to the site*	Estimates and/or analyses of COPC desorption from resuspended sediments
		Assess wave/current-induced resuspension, *as appropriate to the site*	Redeposition of contaminated sediment
		Assess boat propeller wash, *as appropriate to the site*	Measures of total and dissolved COPCs, TOC and DOC estimates and/or analyses of COPC desorption from resuspended sediments

Scoping Element	Source of Information	Activity	Bioavailability Related Analyses/ Considerations
		Assess resuspension flux, *as appropriate to the site*	Resuspension of contaminated sediment Exposure to buried contaminated sediments Non-equilibrium conditions for organics Oxidation of metals Direct measures of COPCs in overlying waste and newly exposed sediments Changes in oxidation conditions Changes in salinity; estuarine/tidal wedge Estimates and/or analyses of COPC desorption from resuspended sediments
Evaluate Ecological and Human Health Pathways and Endpoints	Ecological receptor-based information	Evaluate receptor and exposure pathways ▪ Benthic invertebrates ▪ Fish and water column invertebrates ▪ Wildlife ▪ Plants	Plant tissue residue analysis, plant bioassays Community analyses, bioassays, tissue residue analysis, Equilibrium Partitioning and Biota-Sediment Accumulation Factor uptake models Tissue residue analysis (COPC and lipid), Biota-Sediment Accumulation Factor (BSAF), kinetic uptake models Tissue residue analysis (COPC and lipid), oral dose models, laboratory bioassays, field assessment of fecundity Animal testing for bioavailability (e.g., swine); tissue residue measure (COPC and lipid), oral dose models, laboratory bioassays
	Human Health-based information	Evaluate receptor and exposure pathways: ▪ Direct contact ▪ Ingestion	Water analysis for COPCs, partitioning variables (e.g., Octanol-Water Partition Coefficient (Kow)), oral dose In-vitro/in-vivo testing for bioavailability (e.g., swine oral and dermal dose models); bulk sediment analysis, partitioning measures , Tissue residue(s), fraction of COPC available for uptake (bioaccessibility), Identification of ingestion rates

For more information on project planning for sediment-related sampling, consult the following references:

- Methods for Collection, Storage, and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual (Ref. 1)
- Guidance Manual to Support the Assessment of Contaminated Sediments in Freshwater Ecosystems Volume I - An Ecosystem-Based Framework for Assessing and Managing Contaminated Sediments (Ref. 2)
- Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (Ref. 3)
- Implementation Guide for Assessing and Managing Contaminated Sediment at Navy Facilities (Ref. 4)
- Critical Issues for Contaminated Sediment Management (Ref. 5).

5.4. Developing a Sampling Strategy

This section describes development of data collection options, and finalizing the data collection program. Development of a sampling strategy for purposes of characterizing a sediment site should follow the fundamentals of the scientific approach, including appropriate quality control and quality assurance.

Factors such as physical site constraints, safety, and cost may influence sampling strategies. Project strategies should consider the current and potential future phases of an investigation, and select the methodologies appropriate to these phases. A "phased" investigative approach can be used to refine the CSM and address the data quality objectives for the investigation. It is important to consider exit strategies should the data indicate that further investigation is unnecessary. For example, comparison to conservative bulk sediment screening values or background comparisons are often used to determine the need for later stages of investigation. Should the screening values or background values be exceeded, intensified sampling could be initiated to identify or delimit a source area and release pattern, and to confirm whether the site concentrations represent site-related contamination.

Alternatively, a data collection program may be more comprehensive in the first phase, for example, when contamination is believed to be present, the source study and release pattern may occur at the beginning of the project.

Reference locations may be important for contaminant screening, or later in the process, for determining project-relatedness of sediment chemistry or risk. Selection of a sediment reference location requires matching sediment characteristics (e.g., grain-size ranges, TOC, pH, eH, and, where toxicity testing is desired, toxicity limits) from an unimpacted or non-site reference location to the site sediments. A reference site selection study should define what is intended: either a pristine reference ("natural" or "non-anthropogenically affected" reference) or a site that represents the conditions in the watershed apart from the site being investigated ("ambient" or "anthropogenically-affected" reference). In most DoD site investigations, the latter is desired; in some state programs, the former is mandated. To assure that grain-size, TOC, and eH conditions are comparable may require sampling several stations to achieve an acceptable match. Performance criteria for reference stations should be included in project plans. Sampling intensity at the reference station should also be sufficient to establish a statistically valid comparison between it and the investigation site.

Advanced methods to determine whether receptors are likely to show adverse effects, or to elucidate release patterns and refine the CSM with regard to contaminant mobility and bioavailability may also be included in a second or contingent phase of the investigation. Examples include bedded sediment bioaccumulation testing, collection of field organisms for tissue analysis, measures of pore water, or benthic mapping (section 5.8).

US EPA QA/G-5s (http://www.epa.gov/quality/qs-docs/g5s-final.pdf) provides useful guidance on statistical sample design including numbers and types of samples, selection of sample locations, sampling frequency, and sampling and analytical protocols. In addition, there are free software programs available such as ProUCL and Visual Sample Plan that permit estimation of numbers of samples required.

The analyte list for sediment and pore water sampling schema should anticipate the intended data uses. For instance, for toxicity testing, grain-size and total organic carbon are recommended; for some analytes (e.g., organotins), bulk sediment may not be an appropriate medium and pore-water analysis may be required. Some analytes (e.g., mercury) have a short holding time, which may affect the field schedule for delivery to analytical laboratories. There are also limitations on holding time for sediment prior to initiating biological testing. The sampling method and organism size to be retained from macro invertebrate surveys should anticipate the uses of data (e.g., taxonomic composition and mass, species diversity measures).

For more information on developing a sampling strategy, consult the following references:

- Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses (Ref. 1)
- Sampling for Contaminants In Sediments and Sediment Pore Water (Ref. 6)
- A Compendium of Chemical, Physical and Biological Methods for Assessing and Monitoring the Remediation of Contaminated Sediment Sites (Ref. 7)
- Contaminated Sediment Remediation Guidance for Hazardous Waste Site (Ref. 3)
- Ocean Testing Manual Evaluation of Dredged Material Proposed for Ocean Disposal (Ref. 8)
- Inland Testing Manual: Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S (Ref. 9)
- Guide for Incorporating Bioavailability Adjustments into Human Health and Ecological Risk Assessments at U.S. Navy and Marine Corps Facilities (Ref. 10)
- Incorporating Bioavailability Considerations into the Evaluation and Remediation of Contaminated Sediment Sites (Ref. 11)
- Assessment and Remediation of Contaminated Sediments (ARCS) Program - Assessment Guidance (Ref. 12).

5.5. Methods for Bulk Sediment Sampling

This section presents guidelines for collecting representative sediment samples, and targets the selection of appropriate equipment based upon a range of site conditions such as depth of water, depth of sediment to be sampled, and flow regimes.

Desirable attributes for sediment sampling gear include the following:

- Creates a minimal pressure wave when descending through the water
- Forms a nearly leak-proof seal when the sediment sample is taken
- Prevents winnowing and excessive sample disturbance when ascending
- Allows easy access to the sample surface so that undisturbed subsamples may be taken
- Allows vertical sectioning of undisturbed samples for profile examination
- Penetration well below the desired sampling depth is preferred to prevent sample disturbance as the device closes. A means of weight adjustment to assure penetration depths may be valuable.

5.5.1. Sediment Grab Sampling Methods

Grab samplers are excellent for providing quantitative data at a relatively low cost. Considerations for selection of core versus grab samplers are described below in Table 5-2.

Limitations of grab samplers include:

- Variability among penetration depth for samples depending on sediment properties
- Oblique angles of penetration which result in varying penetration depths within a sample
- Folding or disturbing the sample, resulting in the loss of information concerning the vertical structure of benthic communities in the sediments.

Some additional things to consider when choosing a sampler include:

- Water depth
  - In less than 4 m of water, with low current conditions and smooth water, the Birge-Ekman, petite Ponar, Ponar, Van Veen, and Peterson mini-Shipek grabs are recommended
  - For deeper waters or greater current, the Ponar or Van Veen are recommended.
- Sub-sampling from sampler directly
  - If sub-sampling from the sampler is desired, the Birge-Ekman, mini-Ponar, Ponar, Van Veen, or Shipek are recommended
  - If not, a Peterson, Smith-MacIntyre, or mini-Shipek are recommended.
- Target sample depths
  - Up to about 10 cm sample depth, a Birge-Ekman, Ponar, or Shipek or miniature versions of any of these are suitable
  - Up to about 30 cm, a Smith MacIntyre, Van Veen, or Petersen grabs are suitable.
- Target sample volumes to meet analytical requirements

- Up to about 3 L, the mini Birge-Ekman, petite Ponar, or mini-Shipek samplers are suitable
- 3 – 10 L samples may be collected with the Birge-Ekman, Ponar, or Petersen grabs
- Above 10 L, Smith-MacIntyre or Van Veen grabs are suitable.

The most common surface area sampled is about 0.1 m^2 in the Van Veen and Smith-MacIntyre grabs. Van Veen and box corers are also capable of sampling 0.06 m^2, compared to hand-held corers, which sample about 0.001 m^2.

Table 5-2. Selection Criteria for Core Sampler or Grab Sampler

Use a Core Sampler if:	Use a Grab Sampler if:
▪ Characterization of contamination in deeper sediments is important ▪ Comparison of recent surficial vs. historical deeper sediments is needed ▪ Reduced sediment disturbance needed ▪ Reduced oxygen exposure needed ▪ Sediments are soft and fine-grained.	▪ Large sediment volumes are needed ▪ Larger grain-size or hard sediments would hamper use of a core ▪ Larger surface area of surficial sediment needed (typical for benthic invertebrate sampling).

Sampling devices such as a Ponar or VanVeen with removable or hinged bucket covers are preferred to allow access to the surface of the sediment sample without loss of water or fine-grained sediments. Key sample collection issues for grab samplers include:

- **For Sediment Grab Samples to be Subsampled in the Laboratory.** The sample should be transferred carefully and directly into a labeled container that is made of a chemically inert material, tightly sealed, and air excluded.
- **For Sediment Grab Samples to be Subsampled in the Field.** Typically, the sediment is decanted into a cleaned bowl or bag for homogenization and sub-sampling. To minimize sediment handling and artifacts of sampling for volatiles, samples may be taken directly from the grab.

5.5.2. Sediment Core Sampling Methods

Core samplers (corers) are used to characterize contamination over a depth interval that includes sub-surface sediments. They also are used to obtain sediment samples for geological characterizations and dating, investigate the historical input of contaminants to aquatic systems, and to characterize the depth of contamination at a site. Corers are an essential tool for developing three-dimensional maps of sediment contamination. Collection of subsurface layers in addition to the surface layer of sediment permits evaluation of historical or long-term impact on site conditions, and development of site-specific sediment transport mechanisms to refine the CSM.

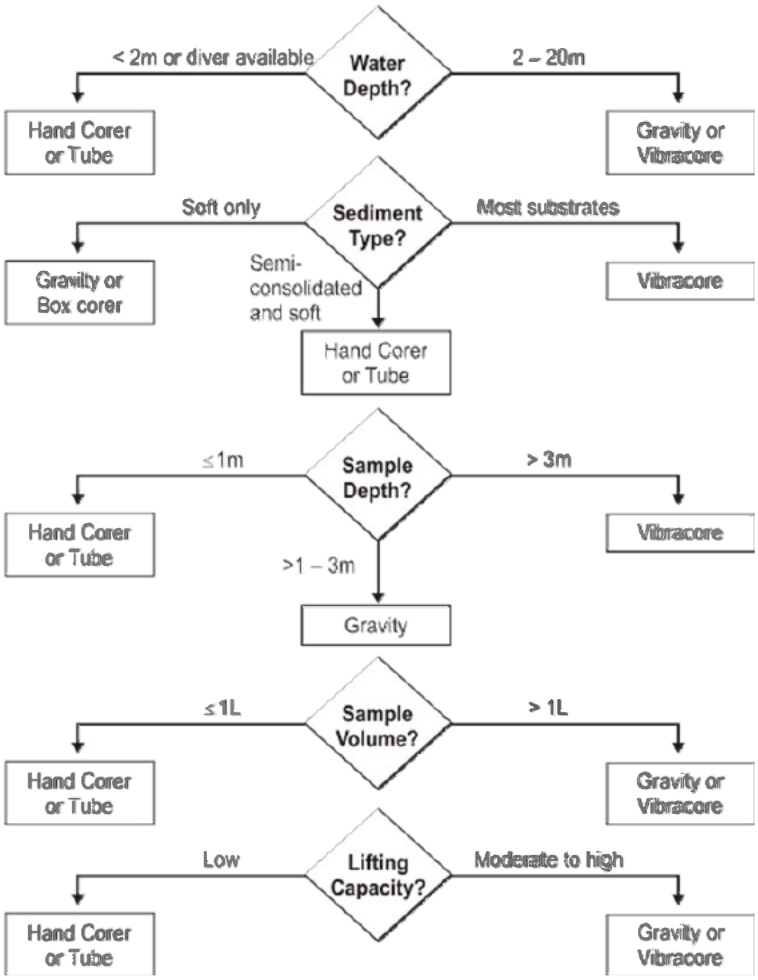
Selection of the most appropriate core sampler for a sampling event is determined based on water depth, particle size of the sediment, sediment sample depth, volume of sediment sample required for analysis, and available lifting capacity of the sampling platform/boat and winch equipment. Core samplers seldom are suitable for sampling benthic macro invertebrate samples due to the small area sampled. See Figure 5-1 for factors to consider when selecting a core sampler.

Because of the potential for a "bow wave" of sediment at the leading end of the core, resulting in compaction and inefficient flow of the sediment into the core sampler, percent recovery should be evaluated. Percent recovery is determined by dividing the internal recovery by the penetration depth. Internal recovery is the depth inside of the core tube from the top of the tube to the surface of the sediment. Core penetration is measured from the outside of the core. In recent projects in the Pacific Northwest (e.g., WindWard 2006) 75 percent core recovery has been regarded as an appropriate control limit on core recovery; however, it is recommended that project specific goals be determined.

For more information on methods for bulk sediment sampling, consult the following references:

- Standard Guide for Storage, Characterization, and Manipulation of Sediments for Toxicological Testing (Ref. 13)
- Guide for General Planning of Waste Sampling (Ref. 14)
- Guide for Core-sampling Submerged, Unconsolidated Sediments (Ref. 15)
- Standard Guide for Selecting Grab Sampling Devices for Collecting Benthic Macroinvertebrates (Ref. 16)
- Handbook of Techniques for Aquatic Sediments Sampling (Ref. 17)
- Manual of Aquatic Sediment Sampling (Ref. 18)
- Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual (Ref. 1)
- Sampling for Contaminants In Sediments and Sediment Porewater (Ref. 6)
- A Compendium of Chemical, Physical and Biological Methods for Assessing and Monitoring the Remediation of Contaminated Sediment Sites (Ref. 7)
- Ocean Testing Manual Evaluation of Dredged Material Proposed for Ocean Disposal (Ref. 8)
- Inland Testing Manual: Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. (Ref. 9).

Figure 5-1. Factors in Core Sampler Selection



5.6. Bulk Sediment Handling and Analysis

If a single core will be used to represent the site, then homogenization of selected intervals and sub-sampling should occur; but if several cores will represent the site (e.g., when average conditions are desired, or greater volumes of sediment are required for biological assays), then multiple cores should be composited by depth interval. If labile chemicals, metals with a critical oxidation state (particularly organotins and mercury), acid volatile sulfides, or volatile organic compounds are of concern, a glove box to maintain anaerobic conditions during the sub-sampling activities may be needed. In addition, shielding against ultraviolet light may be needed to assure the representativeness of sediment Polycyclic aromatic hydrocarbons (PAH) samples, as some of this suite of compounds may break down. As with grab samples, inert sampling gear and mixing apparatus should be used to avoid cross-contamination. U.S. EPA's *Methods for Collection, Storage, and Manipulation of Sediments for Chemical and Toxicological Analyses* lists additional recommendations for suitable sample containers, mixing gear, and sample preparation.

Once received at the laboratory, handling/manipulation procedures should be designed to maintain sample representativeness in terms of toxicity and chemistry by minimizing procedural artifacts. Some analytical procedures and toxicity test protocols necessitate specific manipulations for toxicity or elutriate testing.

Note: Specific analysis methods and protocols for performance of toxicity testing are beyond the scope of this document, but are available in the referenced literature.

A separate sample is usually taken for physical analysis if the sample amount is sufficient. For chemical analysis, sieving is not recommended, as it changes sediment composition (e.g., organic carbon). Sieving may be required to remove organisms that could interfere with intended biological testing. Hand-picking is recommended for debris. Should sieving be performed, it should be done for all samples to be tested, including control and reference sediments if the objective of the study is to compare results among stations.

Sediment storage for chemical analysis is typically done at <6 ºC; maximum holding times before extraction should be defined. National and regional guidance exists for maximum holding times prior to analysis.

Manipulation and storage of sediment for toxicological testing may have special requirements.

For more information on methods for bulk sediment handling and analysis, consult the following references:

- Standard Practice for Preparation of Sediment Samples for Chemical Analysis (Ref. 19)
- Standard Test Method for Measuring the Toxicity of Sediment-Associated Contaminants with Estuarine and Marine Invertebrates (Ref. 20)
- Standard Guide for Conducting Acute Toxicity Tests with Fishes, Macroinvertebrates, and Amphipods (Ref. 21)
- Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual (Ref. 1)
- Sampling for Contaminants In Sediments and Sediment Pore Water (Ref. 6).

5.7. Methods for Collection of Pore Water

Pore, or interstitial, water may contain contaminants partitioned from the surrounding sediment. In depositional sediments, contaminants in the pore water and in the solid phase are expected to be at thermodynamic equilibrium. This makes pore water useful for assessing contaminant levels and associated toxicity. Pore water is often isolated to provide either a matrix for toxicity testing and/or to provide an indication of the concentration and/or partitioning of contaminants within the sediment matrix. Pore water toxicity tests yield information not provided by solid-phase, elutriate, or sediment extract tests. Pore water toxicity testing has proved useful in sediment toxicity identification evaluations, and may be useful for weight of evidence regarding biological availability of some contaminants. It is critical to use the same protocol when comparing samples to one another.

In areas of known upwelling or downwelling groundwater flow through sediment, pore water may also reflect the groundwater to surface water flux conditions, and inform the CSM. Overall considerations for pore water investigations include mineralogy, subsurface flows, estimated pore water residence time, pH, temperature, redox potential, organic carbon, sulfides, and hardness (depending upon the water and metals).

Several approaches to determine pore water COPC concentrations are:

- Estimate of organics from bulk sediment concentrations (equilibrium partitioning theory)
- Estimate of metals bioavailability/toxicity via the molar ratio of acid volatile sulfides to simultaneously-extracted metals, or by the biotic-ligand model
- Traditional sediment collection followed by centrifugation or core squeezing and filtration and/or flocculation of residual particulates. The resultant supernatant (pore water) can be chemically analyzed or used for toxicity testing
- Sampling of pore water by use of suction devices, piezometers, or equipment such as the Trident System® and subsequent chemical analysis or toxicity testing
- In situ or ex situ placement of diffusion or equilibrium-based samplers directly into the sediment or extracted pore water, and measurement of either the sampler (i.e., Solid-

Phase Microextraction Devices (SPME), PE and Polyoxymethylene (POM) or the liquid contained therein (i.e., peepers). Note that some passive methods here indicated as in situ may also be applied in a laboratory setting.

Most sediment collection and processing methods likely affect pore water chemistry, contaminant bioavailability, and toxicity to some degree. "Direct" methods measure pore water chemistry and typically compare them to ambient water quality criteria or apply toxicity testing (e.g., *Daphnia* acute toxicity testing). However, relatively large volumes of water are required for toxicity testing. "Indirect" methods include peepers, dialysis bags, and passive media that can include binding agents in a bag with an ion-permeable hydrogel layer, or semipermeable membrane sorptive devices. In situ collection techniques may outperform ex situ methods for collecting pore water, as they are less subject to conditions introduced by sampling and extraction. However, in situ methods typically are restricted to waters where wading or diver activities may be applicable, and they produce relatively small volumes of pore water, which may not be suitable for the investigation needs. In situ suction devices include, push-point samplers, syringes, probes, and core-type samplers, and may be deployed primarily in soft sediments at depths to 30 centimeters.

Chemical artifacts may occur from exposure of interstitial water to oxygen. Ex situ bulk sediment centrifugation, pressurization, and suction are alternatives to in situ pore water collection, and although they may alter water chemistry, this may be necessary when larger sample pore water volumes are required, or when it is not logistically feasible to collect in situ samples.

Direct Pore Water Sampling. Small diameter piezometers may be placed in sediments where the water is shallow and the current is relatively weak. Clusters of such instruments may measure hydraulic head differences and provide pore water samples from different depths for contaminant concentration profiling. Collection can be done using peristaltic suction lift or a centrifugal or bladder pump. Suction may cause negative bias for dissolved gases and volatile organics. The pumping needs to be done at a very low rate to avoid mixing of the zones of interest. Piezometers offer advantages over diffusion samplers in that they can be sampled repeatedly, and they generally do not have volume limitations. Preservation of in situ anoxic conditions is generally not possible; however, in-line measurements of parameters such as DO and redox potential may be made to determine their approximate in situ values when suction lift is not used. Some examples of pore water samplers are:

- **Syringes.** May be used to take samples of pore water at different depths in a sediment profile in shallow or diver-accessible water depths. Pore water samples are obtained by pushing the needle to the desired depth and retracting the plunger. Syringes may not be effective in compacted sediments or gravels and can become plugged in very fine sediments. They generate relatively small volumes (up to about 0.25 L) of pore water.
- **Push-point samplers.** Useful primarily in shallow water although they can be deployed by a diver. They have a small diameter core barrel with lance tip and a "T" type handle. The small diameter barrel has holes drilled in the side at the bottom to allow water to enter. A solid plastic rod is placed in the barrel to prevent water and sediment from entering the sampler during pushing. When the sampling section of the barrel has been pushed to the target depth, the rod is withdrawn allowing pore water to enter. The water is sampled using a peristaltic pump or, in some cases, a syringe.
- **Drive-point piezometers.** Best for pore water samples at greater depth below water surface, and at greater intervals below sediment surface than push-point samplers. Drive-point piezometers may also be useful when sediment resists penetration of push-point devices. An example device configuration follows. A drive-point piezometer may be fitted to a drill rod, which is driven by an impact corer using a pneumatic hammer. The piezometer is stainless steel fitted with a bulkhead and tubing

barb, and with a screened section (typically #50 or 300 μm mesh). Pore water may be collected using a peristaltic pump connected by polypropylene tubing threaded through the hollow drill rod and attached to the barb fitting on the piezometer. The piezometer is driven to the first desired depth, and the first pore water sample collected after purging several casing volumes of water (e.g., four). If desired, following first collection, the piezometer may be driven to greater depth and another pore water sample collected following purging. For sampling at a separate location, a new, pre-cleaned piezometer should be used.

- **BAT™ sampler probe**. Consists of a tip and housing, which is sealed with a disc containing a flexible septum. The tip may be constructed of porous high-density polyethylene (HDPE) or of stainless steel to allow pore water to enter the sampler, which is under negative pressure. The stainless steel tip is driven to the desired sampling depth and a stainless steel screen is exposed that allows pore water to enter the sample housing. A tool containing an evacuated sample vial (35 – 500 mL) with a septum cap and a double-ended hypodermic needle is lowered down the push rod, and the needle penetrates the housing septum at the same time it penetrates the vial septum, thus permitting pore water to enter the vial. When the vial is full, the tool is retrieved, and the vial is stored for subsequent analysis. Porous HDPE filter tips are useful for assuring low suspended solids.
- **Trident Probe.** (Chadwick *et al.*, 2003; Chadwick and Hawkins 2008) is a hand- or diver-deployable direct push system that provides depth specific temperature and conductivity data. The on-board air hammer can drive the samplers into more compacted or stiff sediments than manual methods. It provides a better estimate where the groundwater/surface water interface is by looking at the differences in temperature and conductivity of the surface water versus water at depth, and permits selection of a sampling interval.

Following collection, pore water should be transferred to sample jars with no headspace before shipping to the laboratory at <6 ºC. *Transferring of pore water into a second jar should not be performed unless absolutely necessary*. For some chemicals, field preservation may be required.

Indirect or Passive Pore Water Samplers. These consist of bag samplers and sorbent samplers. Bag samplers include the following, and may be suitable for both inorganic and organic contaminants:

- **Peepers** and **Dialysis Bags.** In situ diffusion sampling methodologies that are suitable for shallow or diver-accessible depths. They are not standardized, and consist of small chambers with dialysis/cellulose membranes or mesh walls containing either distilled water or clean water of the appropriate salinity or hardness. The devices are buried in sediments and pore water is permitted to infiltrate the sampler. Peepers are generally limited to sediment depths of 0.2-10 cm, and generate up to 0.5 L of pore water. They require hours to several weeks to equilibrate with the sediment. There may be cross-contamination issues related to the construction materials, and biofouling may also cause artifacts. Peepers have also been used to expose organisms to sediments in situ. A possible issue with the mesh peepers is infiltration of colloidal particles into the devices.

The following are samplers that are suitable for inorganic compounds:

- **Diffusion Equilibrium in Thin Films (DET) Samplers.** Consist of hydrogel-immobilized binding agents that selectively attract ionic contaminants such as calcium, magnesium, sodium, iron, manganese, chlorine, sulfate, nitrate, alkalinity, and total CO_2. They are capable of rapid determination of flux, but they do not measure equilibrium pore water concentrations.
- **Diffusion Gradients in Thin Films (DGT).** Technique uses a similar approach to DETs to accumulate solutes on a binding agent after passage through a diffusion layer. A binding agent selective to the target ions in solution (e.g., a resin such as Chelex for metals), is immobilized in a thin layer of hydrogel separated from solution by an ion permeable hydrogel layer. Transport of ions occurs by mo-

lecular diffusion into the binding agent. Very rapidly, a steady-state linear concentration gradient is established between the solution and the binding gel, and in situ fluxes estimated.

Common features of the several of hydrophobic organic sorbent samples follow:

- Organic sorbents are designed to reach equilibrium with the freely dissolved contaminant phase in adjacent water. Quantitative results can be obtained because the sorbent typically has a known equilibrium coefficient that has been derived from laboratory calibration studies using representative compounds. Additionally, higher concentrations of contaminants occur in the sorbent, resulting in higher sensitivity than direct porewater measurements.
- The period of exposure to assure steady state depends upon the sorbent-water partitioning coefficient and volume of sorbent exposed to the pore water. High sorbent-water coefficients and large volumes of sorbent take longer for hydrophobic contaminants to equilibrate. Assurance or adjustments for steady state may be assessed (in order of preference) by loss of reference compounds with known characteristics that were introduced into the sorbent prior to placement, selection of appropriate sorbent thickness (hence volume), or by modeling contaminant transport into the sorbent.
- An advantage of some samplers is that a single device placed vertically in sediment can be subdivided into sectors that may be separately analyzed to generate a concentration profile. This use of a sorbent sampler is useful in monitoring the effectiveness of a sediment cap. The gradient of concentrations that occur can be further interpreted using advective flow modeling.
- Another advantage of sorbent samplers is that they equilibrate with truly dissolved portion of contaminants in water, hence do not measure colloidally-bound contaminants, do not require measurement of dissolved organic carbon to substantiate equilibrium partitioning calculations, and generally do not require analytical cleanup.

Note: Analytical cleanup may be required for sulfur compounds that interfere with PCB analysis.

- Passive samplers can function as biological surrogates ("biomimetics") for a measure of bioaccumulation of hydrophobic organic compounds.

The principal hydrophobic organic sorbent devices follow:

- **Semipermeable Membrane Devices (SPMD).** Consist of flat tubular low-density polyethylene membranes containing a thin film of a high-molecular weight lipid (triolein), and depend upon diffusion of organic chemicals across a semipermeable interface to the lipid. They are used for hydrophobic organic compounds, such as PCBs, PAHs, and organochlorine pesticides. SPMDs are relatively easy to install and may have low detection and quantitation limits. They measure pore water concentrations as a time-weighted average, as opposed to an equilibrium concentration. In an aquatic environment, the uptake rate into an SPMD is linear during the first 50 days, so that the equilibrium may be estimated. An embedded tracer with a known solution rate may be applied to the SPMD prior to deployment to confirm the calculations by observing losses over time.
- **Solid-Phase Microextraction Devices (SPME).** Disposable glass fibers approximately the diameter of a human hair, coated with thin layers of poly (dimethylsiloxane) (PDMS) which sorbs organic molecules such as PAH or PCB from sediment pore water or surface water. SPME advantages include: cylindrical geometry aids insertion in sediments with small diameter cylindrical tools, low limits of quantitation, and the ability to profile contamination in sediment. SPME samplers are available that have been calibrated for PAHs at very low levels. SPME fibers are prepared by sequential sonication with hexane, acetonitrile and water, and then inserted into sediment via a push-point device with wall perforations to permit access to pore water. After equilibration, which typically takes 1 - 2 weeks, the fibers are withdrawn, cut into

lengths of interest, and transferred to autosampling vials with a small volume of solvent (e.g., 100 µL), typically hexane or acetonitrile.

There are several commercially available SPME sizes consisting of varying core size and PDMS content in the coating. Those with a 1000-µm core are sturdy and resilient for field use; those with a 210 µm core are somewhat less sturdy and harder to process in the field into autosampler vials. Sorbent coats with 30-µm layers of PDMS are high capacity and have slower uptake kinetics. A good compromise between quick uptake kinetics and ease of use and processing in the field is a 15 µm PDMS layer on 1000 µm core.

Note: Steady-state corrections are required for PCB congeners with Log K_{ow}s > 6.

- **Polyethylene (PE) Sampler**. Consists of readily-available polyethylene (e.g., 25 µm sheets) material resembling a painter's drop cloth; these may be placed into sediment or in surface water. PE samplers have been calibrated for PCBs, PAHs and other organic compounds. The rectangular geometry and pliability may require a frame for placement in situ, and direct extraction to autosampling vials is difficult. PE samplers have excellent detection limits, but also have high sorbent-water partition coefficients, which suggests longer times to steady state relative to PDMS devices.
- **Polyoxymethylene (POM) Sampler**. Similar to the PE sampler, and consists of readily-available 76 µm thick rectangular strips. POM Samplers have been used to measure sediment pore water and landfill leachate. The rectangular geometry permits placement into sediment primarily in the near-surface, and makes extraction to autosampling vials difficult. POM Samplers have excellent limits of quantitation, but high sorbent-water partition coefficients, which slow uptake kinetics relative to PDMS.

Ex situ Pore Water Techniques. Centrifugation, squeezing, and vacuum extraction/filtration are commonly used. These extraction methods may be done in the field or in the laboratory, but extraction in the laboratory just prior to analysis or testing is preferable, so that the sample is maintained as close to its original state as much as possible during transport and storage.

- Centrifugation of homogenized sediment allows collection of large volumes of pore water, and may be accomplished in an anoxic atmosphere (e.g., under nitrogen gas). Samples are typically divided among several centrifuge tubes. Centrifugation speed may have a marked influence on concentrations and toxicity. For toxicity testing, sediments should be centrifuged at 10^4 x g for 30 minutes to remove colloids. However, if toxicity testing of the interstitial fluids is the objective, this may also reduce the toxicity of the water due to the lack of colloidal contaminants. Less centrifugal force may be appropriate for contaminant studies.
- Sediment squeezing and vacuum extraction/filtration may be accomplished by relatively low-cost mechanical devices with a filter. There are also possible effects to equilibrium partitioning, internal mixing, and electrolyte changes. EPA (2001b) recommends application of moderate positive or negative pressures along with electrolyte (conductivity) monitoring during extraction. In addition, that extraction should be performed at in situ ambient temperatures to reduce alterations to interstitial water composition that may occur at temperatures different from ambient conditions.

For more information on methods for collection of pore water, consult the following references:

- Standard Practice for Preparation of Sediment Samples for Chemical Analysis (Ref. 19)
- Coastal Contaminant Migration Monitoring: The Trident Probe and UltraSeep System: Hardware Description, Protocols, and Procedures. (Ref. 22)
- Monitoring of Water and Contaminant Migration at the Groundwater–Surface Water Interface (Ref. 23)
- Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses (Ref. 1)

- Incorporating Bioavailability considerations into the Evaluation and Remediation of Contaminated Sediment Sites (Ref. 11)
- Sampling for Contaminants In Sediments and Sediment Pore Water (Ref. 6).

5.8. Benthic Macroinvertebrate Investigations

When conducting a sampling event to evaluate benthic or biological activity in aquatic sediment, specially designed sampling equipment is used to retain the biological content in the sediment. Sampling is typically limited to the upper 10 inches of the sediment layer, where benthic organisms are active.

The first part of the benthic macroinvertebrate sampling section describes methods for collection. The second part describes data acquisition and analysis.

Benthic habitats are bottom environments with distinct physical, geochemical, and biological characteristics. Benthic habitats vary widely depending upon their location and depth, and may be characterized by dominant structural features and biological communities. Estuarine and nearshore benthic habitats can be highly diverse, including shallow submerged mudflats and sandflats, rocky hard-bottom habitats, seagrass beds, kelp forests, shellfish beds, rivers, creeks, marshes, streams and coral reefs. Data on substrate type, topography, benthos, water and sediment quality, and presence or absence of toxins are all necessary to create an accurate picture of a habitat and associated ecological risk. Data from the benthos field sampling or surveys provide information on species abundance, distribution, and biomass. They may be collected by point sampling (grab or core), by tow (dredge, seine, trawl or net), by capture (cages, traps) by photographic surveys, or by other methods. Field information such as vessel type, start and end dates; investigator, and institution/agency; station numbers, positions and times; and equipment and methods are reported for each survey. Environmental data reported at each sampling site may include meteorological and sea surface conditions; surface and bottom temperature, salinity, and water quality; and sediment characteristics. Biological data would include quantity of individual organisms and total weight of organisms for each collected species.

Marine organisms are adapted to live in particular habitats, and knowledge of these sediment characteristics can provide insight into the physiology and ecology of the organisms sampled. Benthic macroinvertebrates tend to have high site fidelity and integrate long-term changes in ecosystems to inform sediment investigations of impact due to contamination. Individual macroinvertebrate species have sensitive life stages that respond to stress and integrate effects of short-term environmental variations, whereas community composition depends on long-term environmental conditions. In addition to taxonomic identification, benthic macroinvertebrate investigations may require knowledge of the feeding group to which a species belongs; for example, suspension feeders and deposit feeders. Method selection to provide for interpreting benthic invertebrate data requires knowledge of regional patterns of species abundance. Benthic community measures are often combined with chemistry and toxicity data to assess sediment impacts.

Contaminants found in marine sediments may threaten water quality, the health of aquatic organisms, and human health. Many pollutants are highly toxic and can persist in the environment for years. This can cause long-term health problems in marine invertebrates and fish such as tumors, reproductive problems, and fin rot.

Environmental contaminants may also be transferred through the food web, adversely affecting fisheries or posing a risk to human health.

The physical characteristics of the study area including water clarity, depth, circulation, currents, bottom topography, sediment quality, and study-area size influence what tools may be used effectively for macroinvertebrate surveys. Bottom characteristics may dictate the specific tools to be used for benthic investigations, as do physical characteristics of sediments. When a sediment study area is flat or gradually sloping and contains primarily fine-grained sediments, fine-scale sam-

pling is typically preferred for defining habitat types.

As with sediment sampling, the type of benthic macroinvertebrate sampling gear depends on the nature of the substrate to be sampled. The sampling area should focus on the most predominant substrate available (in many estuaries and coastal marine areas this will be soft sediments of mud through sand grain sizes). Sampling for sediment biota is typically limited to the depth of sediment where benthic organisms are active, and this is case-specific. In slow-flowing freshwater environments, the biologically-active zone is typically shalow; however, in flowing water and estuarine/marine environments, it may be deeper.

According to U.S. EPA, numbers and kinds of macroinvertebrates collected by a particular grab are influenced by the habitat and substrate type sampled, penetration depth of the sample, the completeness of closure of the jaws (suggesting potential loss of sample during retrieval), and potential washout of surface organisms due to a shock wave associated with the sampler deployment, and stability of the sampler in particular for high water velocities.

Regional guidance may aid in developing a plan for benthic macroinvertebrates. For example, the Puget Sound Estuary Program, as applied to Puget Sound, shows the following recommendations (additional annotations in italics):

Kind of Sampler: Modified Van Veen

Area to be Sampled: 0.1 m^2

Sample Replication *(when variance is important)*: four to five per station

Sieve Mesh Size: 1.0 mm *(note, however, that Atlantic coast programs often use a 0.5-mm mesh screen)*

Initial Sieving Location: Vessel

Use of Relaxant Chemicals: Not recommended; *in some cases relaxants will reduce body distortion of soft-bodied creature; however relaxants my cause some taxa to lose limbs or other features.*

Use of Biological Stains: Rose Bengal

Level of Taxonomy: Species or Higher

Sampling Season: Variable

Recommendations for selection of benthic invertebrate samplers follow:

- Birge-Ekman, Van Veen, Ponar, and Smith-McIntyre grabs are often selected for infauna in soft substrates (river backwaters, lakes, and low-current velocity marine/estuarine conditions). Table 5-3 below summarizes characteristics of grab samplers.
- Core samplers may be used, but they sample a very small area and volume of sediment, thus representativeness of the community may be insufficient; however, this depends upon the abundance of the community, and multiple cores may be composited to provide sufficient area/volume. See Table 5-4 below for comparison of coring methods.
- For harder substrates and particularly for epifaunal invertebrates, seines and trawls may be used; however, seines and trawls typically only gather larger organisms.
- In flowing water, several techniques may be used to harvest sediment-associated biota. See Table 5-5 below for a summary of Stream Net Samplers used to collect organisms from flowing water.

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Table 5-3. Advantages and Disadvantages of Commonly Used Grab Samplers

Device	Use	Sample Depth (cm)	Sample Volume (L^3)	Advantages	Disadvantages
Orange Peel	Marine waters and deep lakes	0 – 18	10 – 20	▪ Comes in a range of sizes	▪ Need large boat, powered winch and cable line ▪ Blocking of jaws may cause sample loss
Smith-McIntyre	Deep lakes, rivers, and estuaries	0 – 4 (in deep sand)	10 – 20	▪ Reasonable quantitative samples ▪ The trigger plates provide added leverage essential to its penetration of substrate	▪ Heavy, need boat and power winch ▪ Spring-loaded jaws, hazardous ▪ Inadequate for deep burrowing organisms
Birge-Ekman, small	Lakes and marine areas; soft sediments, silt, and sand	0 – 10	≤ 3.4	▪ Handles easily without winch or crane ▪ Can be adapted for shallow water use ▪ Good for soft sediments, sand, and silt ▪ Allows sub-sampling	▪ Restricted to low current due to light weight and messenger activation ▪ May exceed target penetration depth ▪ Sub-sampling may be restricted by size of top flaps
Birge-Ekman, large	Lakes and marine areas; soft sediments, silt, and sand	0 – 30	≤ 13.3	▪ Can be adapted for shallow water use ▪ Good for soft sediments, sand, and silt ▪ Allows sub-sampling	▪ Restricted to low current conditions ▪ Penetration depth can exceed desired level due to weight of sampler ▪ Heavy, requires winch
Ponar, standard	Deep lakes, rivers, and estuaries; useful on sand, silt, or clay	0 – 10	7.25	▪ Most universal grab sampler ▪ Adequate on most substrates ▪ Large sample obtained intact, permitting sub-sampling ▪ Good for coarse and firm bottom sediments	▪ May not close completely, resulting in sample loss ▪ Metal frame may contaminate sample ▪ Heavy, requires winch
Ponar, petite	Deep lakes, rivers, and estuaries; useful on sand, silt, or clay	0 – 10	1.0	▪ Adequate for most substrates that are not compacted	▪ May not penetrate sediment to desired depth, especially in consolidated sediments ▪ Susceptible to incomplete closure and loss of sample ▪ Requires more casts to obtain sufficient sample if many analyses needed

Device	Use	Sample Depth (cm)	Sample Volume (L^3)	Advantages	Disadvantages
Van Veen	Deep lakes, rivers, and estuaries; useful on sand, silt, or clay; effective in marine environments in deep water and strong currents	0 – 30	18 – 75	▪ Adequate on most substrates that are not compacted ▪ Large sample obtained intact, permitting sub-sampling ▪ Available in stainless steel	▪ May not close completely, resulting in sample loss ▪ May close prematurely in rough waters ▪ Metal frame may contaminate sample ▪ Heavy, requires winch
Modified Van Veen (e.g., "Ted Young Grab")	Lakes and marine areas	0 – 15	≤ 18.0	▪ Fluorocarbon plastic liner can help avoid metal contamination ▪ Screened bucket cover helps reduce bow wave effects	▪ Requires winch ▪ Relatively expensive
Petersen	Deep lakes, rivers, and estuaries; useful on most substrates	0 – 30	9.45	▪ Provides large sample ▪ Penetrates most substrates	▪ Shock wave from descent may disturb fine-grained sediment ▪ Lacks lid cover to permit sub-sampling ▪ May not close completely, resulting in sample loss ▪ Metal frame may contaminate sample ▪ Restricted to low current conditions ▪ May exceed target penetration depth
Shipek, standard	Used primarily in marine waters and large, inland lakes and reservoirs; not useful for compacted sandy clay or till substrates	0 – 10	3.0	▪ Sample bucket opens to permit sub-sampling ▪ Retains fine-grained sediments effectively	▪ Metal frame may contaminate sample ▪ Heavy, requires winch ▪ Can result in loss of the topmost 2–3 cm of very fine, unconsolidated sediment
Shipek, mini	Lakes, useful for most substrates that are soft	0 – 3	0.5	▪ Handles easily without winch or crane from most platforms	▪ Requires vertical penetration ▪ Samples small volume ▪ May lose fine-grained sediment ▪ May close prematurely

Table 5-4. Advantages and Disadvantages of Commonly Used Core Samplers
(For illustrations of specific coring equipment, see http://clu-in.org/programs/21m2/sediment/)

Device/ Dimensions	Use	Sample Depth (cm)	Sample Volume (L^3)	Advantages	Disadvantages
Fluorocarbon plastic or glass tube (3.5 – 7.5 cm inner diameter (I.D.); 120 cm long)	Shallow wadeable waters or deep waters if SCUBA available; soft or semi-consolidated deposits	0 – 10	0.096 – 0.44	▪ Preserves layering and permits historical study of sediment deposition ▪ Minimal risk of contamination ▪ Rapid; samples immediately ready for laboratory shipment	▪ Small sample size necessitates repetitive sampling
Hand corer with removable fluorocarbon plastic or glass liners (3.5 – 7.5 cm I.D.; 120 cm long	Same as above except more consolidated sediments can be obtained	0 – 10	0.96 – 0.44	▪ Same advantages as fluorocarbon plastic or glass tube ▪ Penetrates substrate with greater ease through use of handles	▪ Small sample size necessitates repetitive sampling ▪ Requires careful handling to prevent spillage ▪ Requires removal of liners before repetitive sampling ▪ Barrel and core cutter metal may contaminate sample
Box corer	Same as above but the depth of the unconsolidated sediment must be at least 1 m	0 – 70	≤ 30.0	▪ Collects large, undisturbed sample; optimal for obtaining intact subsamples	▪ Difficult to handle ▪ Relatively heavy, requiring larger vessel and power winch to deploy
Gravity corer, Phlegar Corer (3.5 cm I.D., 50 cm long)	Deep lakes and rivers; semi-consolidated sediments	0 – 50	≤ 0.48	▪ Reduces risk of sample contamination ▪ Maintains sediment integrity relatively well ▪ Penetrates with sharp cutting edge	▪ Requires careful handling to avoid sediment spillage ▪ Requires repetitive and time-consuming operation and removal of liners due to small sample size
Gravity corer, Kajak-Brinkhurst Corer (5 cm I.D., 70 cm long)	Deep lakes and rivers; soft fine-grained sediments	0 – 70	≤ 1.37	▪ Collects greater volume than the Phlegar Corer	▪ Same as Phlegar Corer
Benthos gravity corer (6.6, 7.1 cm I.D., 3 m long)	Soft, fine-grained sediments	0 – 3 m	≤ 10.26	▪ Retains complete sample from tube because the core valve is fitted to the core liner ▪ Fins promote vertical penetration	▪ Requires weights for deep penetration so the required lifting capacity is 750 – 1,000 kg ▪ Requires vertical penetration ▪ Compacts sediment sample

Device/ Dimensions	Use	Sample Depth (cm)	Sample Volume (L^3)	Advantages	Disadvantages
Alpine gravity corer (3.5 cm I.D.)	Soft, fine-grained semi-consolidated substrates	≤ 2 m	≤ 1.92	▪ Allows different penetration depths due to interchangeable steel barrel	▪ Lacks stabilizing fins for vertical penetration ▪ May penetrate non-vertically and incompletely ▪ Requires a lifting capacity of 2,000 kg ▪ Disturbs sediment stratas and integrity ▪ Compacts sediment sample
Piston corers	Ocean floor and large deep lakes; most substrates	3 – 20 m	5 – 40	▪ Typically recovers a relatively undisturbed sediment core in deep waters	▪ Requires lifting capacity of > 2,000 kg ▪ Piston and piston positioning at penetration may fail ▪ Disturbs surface (0 – 0.5 m)
BMH-53 piston corer	Waters ≤ 2 m deep with extension rod; soft deposits	≤ 2 m	≤ 2	▪ Piston provides for greater sample retention	▪ Cores must be extruded onsite to other containers ▪ Metal barrels introduce risk of metal contamination
Boomerang corer (6.7 cm I.D.)	Ocean floor (up to 9,000 m deep)	1 m	3.52	▪ Requires minimal shipboard equipment so small vessels can be used	▪ Only penetrates 1.2 m ▪ Requires calm water for recovery ▪ Loses 10 – 20% of sample
Vibracorer (5.0 – 7.5 cm I.D.)	Continental shelf of oceans, large lakes; sand, silty sand, gravelly sand substrates	3 – 6 m	5.89 – 13.25	▪ For deep profiles it effectively samples most substrates with minimum disturbance ▪ Can be used in over 20 m of water depth ▪ Portable models can be operated from small vessels (e.g., 10 m long)	▪ Labor intensive ▪ Assembly and disassembly might require divers ▪ Disturbs surface (0 – 0.5 m) layer ▪ Special generator may be needed ▪ Heavier models require larger boat and power winch to deploy

Table 5-5. A Summary of Stream Net Samplers Used to Collect Organisms from Flowing Water

Net Sampler	Habitats and Substrates	Effectiveness of Device	Advantages	Limitations
Surber Stream Bottom Sampler	Shallow, flowing streams, less than 32 cm in depth with good current; rubble substrate, mud, sand, and gravel	Performance depends on current and substrate	Encloses area sampled; easily transported or constructed; samples a unit area	Difficult to set in some substrate types, that is large rubble; cannot be used efficiently in still, slow-moving streams
Portable Invertebrate Box Sampler	Same as Surber	Same as Surber	Same as Surber except completely enclosed with stable platform; can be used in weed beds	Same as Surber
Hess Sampler	Same as Surber	Same as Surber	Same as Surber except completely enclosed with stable platform; can be used in weed beds	Same as Surber
Hess Stream Bottom Sampler	Same as Surber	Same as Surber	Same as Surber except completely enclosed with stable platform; can be used in weed beds	Same as Surber
Stream-bed Fauna Sampler	Same as Surber	Same as Surber	Same as Surber except completely enclosed with stable platform; can be used in weed beds	Same as Surber
Drift Nets	Flowing rivers and streams; all substrate types	Effective in collecting all taxa which drift in the water column	Low sampling error; less time, money, and effort; collects macroinvertebrates from all substrates; usually collects more taxa	Unknown where organisms come from; terrestrial species may make up a large part of a sample in summer and periods of wind and rain; does not collect non-drifting organisms

For separating biota from sediment, standardized sampling techniques (both collection and sieve mesh size) should be followed. The use of different sieve mesh sizes for screening benthic samples limits the comparability of results between marine monitoring studies. A major advantage of using a smaller mesh size is the retention of both juvenile and adult organisms as well as large-and small-bodied taxa; however, a disadvantage is the increased time and cost of sample processing.

On-board the vessel, sieving typically occurs prior to sample preservation. If it is necessary to hold samples for later sieving, preservation proceeds sieving. When sub-sampling (sub-coring within a grab or core sample) is necessary, issues related to sub-sampling include representativeness (some benthic species have patchy distributions); and possibly damage to organisms such as worms, thereby diminishing the number of specimens that can be identified. All organisms found within the sub-core should be counted and identified.

5.8.1. Benthic Habitat Mapping

Benthic habitat mapping provides a method for relating source and distributions of contaminated sediments to sensitive or valuable aquatic resources and overall benthic habitat quality. Benthic surveys require the use of physical and biological sampling techniques. Large study areas require wide area assessments with remote sensing via hydrographic and sonar surveys to determine the physical characteristics of the benthic site without disturbing the bottom. Differing topography, sediment, and vegetation types may be resolved from sound and light reflectance patterns. Ground-truthing with finer-scale sampling methods should be used to validate interpretations of the remote-sensing data.

No single mapping method provides a comprehensive picture, so the ability to integrate, analyze, and interpret several different types of data is required in order to conduct a field-scale ecological risk assessment. Regardless of which methods are used, benthic data must be analyzed and interpreted for use in benthic habitat mapping. The analysis tools include GIS, habitat spatial analysis, and statistical or visual evaluation of benthic data and contaminant concentrations. The benthic habitat may need to be monitored over time to determine the effects of habitat change due to natural or human impacts, and to assure effective implementation of remediation strategies.

5.8.2. Toxicity Testing in Microcosms or Mesocosms

Toxicity testing of benthic macroinvertebrates, discussed briefly in Section 5.6, can complement the sediment quality and associated risk. Standard toxicity practices usually involve laboratory or field exposure chambers where organisms are exposed to natural or elevated contaminant concentration levels to assess acute and chronic risks. Attempts to obtain field data for risk assessment of contaminants released into marine/estuarine systems are often complicated by a number of factors such as complex circulation and mixing patterns, stratification, dynamic, short-term changes as well as seasonal movements of biota, and the ecosystem's physical scale.

In recent years, microcosm and mesocosm testing has gained wide acceptance for ecological risk assessment. Microcosms and mesocosms are simulated ecosystems containing water, sediment, and communities of plants and invertebrates from field sites to be established in laboratory aquaria or in designed field systems using enclosures or caissons. Temperature, rainfall, sunlight, sediment disturbance, water circulation, bioturbation, and other natural processes can affect chemical behaviors, making it difficult to determine precisely the fate and effects of contaminants within a complex ecosystem. These simulated systems permit environmental variables to be controlled in a manner that cannot be achieved in field studies. Simulated systems may be used to evaluate higher-level ecological effects of chemicals on populations and communities. They also allow monitoring of biodegradation, natural attenuation, biota population and habitat recovery, and bioremediation.

Tests conducted in simulated ecosystems are subject to constraints that restrict the effect of physical forces, limit physical scale of the test, and introduce biases from chemical partitioning

and processing along the walls of the test system. These constraints should be considered in the evaluation, but the simulated ecosystem approach still has broad application as a model of dynamic marine systems.

Mesocosms are large-scale systems that allow investigators to study and collect data over a large area. These systems are usually outdoor systems such as ponds or enclosures within a larger body of water, typically a lake, river, marsh, or ocean. For sediment ecological risk assessment purposes, the microcosm approach generally allows more efficient data collection.

Microcosm testing results are considered by most regulatory authorities to be more representative of natural conditions than results of conventional toxicity tests, which justifies the use of a smaller safety factor. For example, many aquatic populations and communities tolerate chemical exposures higher than the 50 percent lethal concentration (LC_{50}), and even sensitive test species tolerate exposures greater than the no-effect concentration (NOEC), due to factors such as population recovery or succession, water dilution, sediment transport, and other environmental factors. Microcosm results may be used to justify a higher effects threshold in these cases. Extended benthic toxicity studies can be used to justify a more accurate and less conservative assessment of ecological risk. Many regulatory authorities acknowledge that effects to the benthic community are not ecologically significant should the population recovery occur within a reasonable period of time, typically a growing season. Mirocosms have been used to demonstrate recovery in the following ways:

- Addition of spiked sediments to field sediments allows chemicals to partition between water and sediment as they would do in a natural environment; a water-sediment system may reduce toxicity by sorption which reduces the bioavailability of the compound in the water-sediment system compared to a water-only system
- Variation of chemical concentrations over time, to simulate exposure patterns typically observed in the field when chemicals disappear due to degradation or water movement
- Periodic reintroduction of invertebrates or algal organisms, which simulates natural immigration and allows observation of population recovery
- Simulation of conditions during which chemical concentrations in the water decrease over time, which may demonstrate recovery of invertebrate populations
- Benthic colonization by invertebrate species and populations may be evaluated by transferring contaminated field sediments in open tray containers to uncontaminated or reference field sites, where they are periodically monitored. Benthic colonization and recruitment from the water column may be measured by invertebrate community indices (species, abundance, diversity, evenness, dominance, richness). Benthic colonization may also be investigated by transferring contaminated sediments from the field to a flow-though, unfiltered laboratory seawater system where observations and measurements can be made more frequently.

For more information on benthic macroinvertebrate investigations, consult the following references:

- Standard Test Method for Measuring the Toxicity of Sediment-Associated Contaminants with Estuarine and Marine Invertebrates (Ref. 20)
- Standard Test Method for Measuring the Toxicity of Sediment-Associated Contaminants with Freshwater Invertebrates (Ref. 24)
- Standard Guide for Conducting Sediment Toxicity Tests with Polychaetous Annelids (Ref. 25)
- Estuarine and Coastal Marine Waters Bioassessment and Biocriteria Technical Guidance (Ref. 26)
- Environmental Monitoring and Assessment Program Surface Waters: Field Operations and Methods for Measuring the Ecological Condition of Wadeable Streams (Ref. 27)
- Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: *Periphyton*,

Benthic Macroinvertebrates and Fish (Ref. 28)

- Methods for Measuring the Toxicity and Bioaccumulation of Sediment-associated Contaminants with Freshwater Invertebrates - Second Edition (Ref. 29)
- Methods for Assessing the Chronic Toxicity of Marine and Estuarine Sediment-associated Contaminants with the Amphipod *Leptocheirus Plumulosus* (Ref. 30)
- Comparisons of Boating and Wading Methods Used to Assess the Status of Flowing Waters (Ref. 31)
- Logistics of Ecological Sampling on Large Rivers (Ref. 32).

5.9. References

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Chapter 6. Surface Water Sampling

6.1. Purpose

This chapter provides general guidelines and procedures for sampling approaches, methods, and equipment used for surface water sampling. Following these guidelines and procedures will greatly enhance the representativeness of the samples and accurately characterize source conditions. This chapter will help project planning and sampling personnel to evaluate available information on a sampling location, select an appropriate sampling approach, select and utilize sampling equipment, and incorporate appropriate QA/QC samples.

6.2. Scope

Surface waters are water bodies that rest or flow over land, with a surface that is open to the atmosphere. Surface water samples are collected from streams, rivers, lakes, ponds, creeks, lagoons, estuaries, surface impoundments, or coastal waters. Samples can be collected at the surface level of the subject water body or at a prescribed depth interval. Samples can be analyzed to characterize surface water quality or determine pollutant concentrations.

The procedures presented in this chapter are typical and can be modified as required to accommodate site conditions and equipment or procedural limitations. Field sampling should be conducted in accordance with appropriate federal, state, or local government compliance requirements and guidelines.

6.3. Project Planning

This section provides an overview of the planning process for conducting a surface water sampling program. Included in this section is a discussion of sampling strategy, development of a site-specific SAP, and QA considerations.

Before a surface water sampling program can begin, concise objectives should be developed regarding the intent of the sampling program. The objectives provide the framework for developing a sampling strategy for the site and preparing the SAP.

6.3.1. Sampling Strategy

The sampling strategy is designed around the objectives and begins with a review of the CSM. Refer to Chapter 2 for more information on CSM development. This model will help the Project Manager determine whether samples should be collected at the surface level or at a depth interval. The model also will help to determine whether a sample should be collected at a single location and point in time, or whether multiple samples should be collected over time, locations, or depth intervals and combined into a representative sample for analysis. From this information, the Project Manager can establish appropriate sampling locations, number and type of samples required, and an appropriate type of sampling equipment for the site conditions.

6.3.2. Site-Specific SAP

The goal of a surface water sampling program is to collect a representative sample of the current surface water conditions. The development of a site-specific SAP is the first step toward collecting a representative surface water sample. Each SAP is an instruction manual for field personnel. It should be built around the objectives and sampling strategy. See Chapter 2 of this handbook for a detailed discussion of SAP development applicable to all sampling programs.

The SAP should consider a variety of factors, including site hydrogeology, the condition and accessibility of sampling locations, suspected pollutants, DQOs, analytical methods, detection limits, surface water collection methods, sample handling procedures, and safety precautions.

The SAP cannot be implemented effectively if field personnel do not understand its contents. Many times, the primary reason that surface water sampling events are problematic is that the person preparing the SAP is not the person in the field. One method that alleviates this problem is assigning a Sampling Team Leader who is responsible for all activities in the field. The Sampling Team Leader has the appropriate level of training and experience, and will work closely

with those individuals preparing the SAP to understand fully the objectives of the program. The Sampling Team Leader is responsible for all individuals in the field. If required, he or she also is responsible for providing additional training to field personnel before fieldwork begins.

6.3.3. QA

The level of data quality for each surface water sampling program, and many times for each specific sampling event, depends on the intended use of the data. It is important to remember, regardless of the level of QA/QC for any surface water sampling program, that sample integrity must be maintained during sample collection. Laboratory analysis, no matter how sophisticated, is representative only if the sample supplied to the analyst has retained its integrity.

To determine the level of quality required for each surface water sampling program or event, Site Managers and those responsible for data integrity should begin with a systematic planning process that helps define the DQOs. The DQOs clarify the study objectives, define the most appropriate type of data to collect, determine the most appropriate conditions for data collection, and specify tolerable error limits on decisions that will be used as the basis for establishing the quantity and quality of data needed to support the decision. See Chapter 2 of this manual for detailed information on QA/QC, including the systematic planning process, development of DQOs, and preparation of SAPs.

The following protocol should be used to ensure integrity and accuracy of the data collected during surface water sampling:

- The laboratory analysis should be performed by an appropriately certified or accredited laboratory for the required methodology
- All samples must be accompanied by a completed COC record
- The field blank, trip blank, equipment blank, and field duplicate samples should be collected, as appropriate, to provide for data evaluation to determine the accuracy and representativeness of surface water samples
- The field decontamination process must be followed properly to ensure QC of the field sampling
- MS/MSDs should be performed by the laboratory at a rate of one set per analyte, matrix, and preparation batch of up to a maximum of 20 samples, to validate the method selected with the matrix being analyzed
- The specific frequency of QC sample collection should be specified in the SAP, which is discussed in Chapter 2 and Appendix C.

Final data should be reviewed for correctness of numerical input, equation selection, and numerical calculations. Each site QA/QC varies with the degree of contamination, regulatory requirements, and site location.

6.4. Hazards and Safety Precautions

A site-specific HASP that addresses all anticipated hazards for each task should be prepared. The following discussion addresses common hazards associated with surface water sampling activities. Refer to Chapter 2 of this handbook for specific hazard identification techniques and detailed control methods.

When sampling surface impoundments, appropriate precautions must be employed to ensure the safety of sampling personnel. The sampling team member collecting the sample should not get too close to the edge of the impoundment, where bank failure may cause the sampler to lose his balance. The person performing the sampling should be on a lifeline and wear appropriate PPE. When performing sampling from a boat in an impoundment or flowing waters, follow appropriate boating safety procedures. In any situation where a body of water being sampled is deeper than two feet, the sampling team should wear coast guard-approved life vests.

If the surface impoundment contains known or suspected hazardous substances, the need to collect samples versus the potential risk to sampling personnel must be considered. If sampling is determined to be necessary, appropriate protective measures (e.g., use of a flat-bottomed boat

for increased stability, life vests and preservers, and a back-up team) must be implemented.

When working with potentially hazardous materials, follow appropriate OSHA health and safety procedures.

6.5. Field Preparation

Surface water samples are collected from different types of water bodies with variable site conditions. Regardless of the water source, the following tasks should be completed prior to any sampling event:

- Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies needed
- Obtain the necessary sampling and monitoring equipment, decontaminate or pre-clean the equipment, and ensure that it is in working order
- Prepare scheduling, and coordinate with staff, clients, and regulatory agencies, if appropriate
- Perform a general site survey prior to site entry, in accordance with the site-specific HASP
- Use stakes, flags, buoys, or portable GPS coordinates to identify and mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. If collecting sediment samples, this procedure may disturb the bottom, resulting in the suspension of fine sediment particulates into the water column. To avoid sediment disturbance, river or stream sampling should start from downstream location toward upstream location.

6.5.1. Representative Sampling Considerations

To collect a representative sample, the hydrology, shape, and size of an impoundment should be determined prior to sampling. This will aid in determining the presence of phases or layers in lagoons, flow patterns in streams, and appropriate sample locations and depths.

A preliminary surface water quality survey should measure pH, temperature, and DO at points along shorelines, wetlands, creeks, and ponds. Measurements should be collected at 1meter intervals from the substrate to the surface using the appropriate monitoring instruments. For shallow waters, measurements should be taken within the top 12 inches of the water column. Measurements of pH, temperature, DO, conductivity, and oxidation-reduction potential can assist in the interpretation of analytical data and the selection of sampling sites and surface water sample collection depths.

Consider the following factors when selecting a sampling device for collecting surface waters:

- Will the sample be collected from shore or from a boat?
- At what depth should the sample be collected?
- What is the overall depth and flow direction of the river or stream?
- What type of sample will be collected (e.g., water or lagoon liquids)?

For contamination of surface water from a point source, such as an outfall or sewer line, sampling may be based on visual evidence of seepage or discharge streams. Sampling points should be established at the locations where distinct changes in pH, temperature, DO, or conductivity indicate the possible presence of contamination or leachate discharge. A GPS unit may be used to determine the coordinates of the sampling location in terms of latitude and longitude. Field equipment that should be available at the time of sampling is listed in Section 6.7.

Prior to sampling at each location, record the following information in the FLB/FN:

- Sample location, ID number, date, and water temperature at the time of collection
- pH, DO, conductivity, and depth of water (if applicable) at the sample collection location, along with any equipment calibration data
- Water depth at the midpoint or center of the water body, if applicable

- Description of site and weather conditions at time of sampling, as well as the physical characteristics of the sample.

6.5.2. Point Source Investigations

A contaminant in a discharge that feeds into a water body at a discernible, confined, and discrete conveyance is defined as a point source pollutant. An example of a point source discharge is effluent from a storm water sewer into a river through a pipe, ditch, or tunnel. Point sources are regulated under the CWA and NPDES, through permit application and approval. Sampling of these sources may be performed for characterizing discharges for permit application, with the collected data serving as a basis for establishing permit requirements for monitoring and reporting. Monitoring and analytical requirements are established by permit on a site-specific basis.

Storm water and other effluent samples that feed into a surface water body should be collected at the point source. To ensure that representative point source samples are collected in storm water investigations, specific criteria for the type of storm event that is sampled have been established. Criteria recommended by the EPA for NPDES sampling include the depth of the storm must be greater than 0.1 inch of accumulation, the storm must be preceded by at least 72 hours of dry weather, and the depth of rain and duration of event should not vary by more than 50 percent from the average depth and duration. These criteria ensure that adequate flow will be discharged, allow for build-up of pollutants during a dry interval, and ensure that the storm would be representative. State requirements may differ.

6.5.3. Nonpoint Source Investigations

A pollutant that feeds into a water body from a source that cannot be traced back to a single origin, such as storm water runoff, is termed a nonpoint source pollutant. These pollutants are monitored to determine impacts on the water quality of rivers, streams, and bays for compliance with state and local management plans.

When sampling for a nonpoint source investigation, it is important to consider special properties and precautions when developing a representative sampling design, which include:

- **Stratification.** Water body stratification occurs as a result of temperature or thermal conditions. Water temperature profile controls circulation in the water body. Warmer, less dense surface water and colder, deeper water become stratified with rapid variance of temperature and increasing depth intervals. Chemically induced stratification results when levels of a water body are separated by a steep salinity gradient. Still-water bodies, such as lakes and reservoirs, have a greater tendency to stratify than rivers or streams. One layer or zone of the water body may be exposed to a discharge point, the atmosphere, or another pathway of contamination, which can yield characteristics that are different from other layers or zones in the water body.
- **Current.** The movement, or current, in a water body can disturb mixing zones and reduce the chances of obtaining a representative sample
- **Storm Events.** Storms may turn over strata in a water body and reduce the representativeness of a sample. Precipitation or runoff may increase or reduce representative concentrations of contaminants of interest.
- **Time of Year.** Temperate water bodies experience overturn during the fall and spring season. As the air temperature warms or cools with the start of the new season, conditions in the lake change from stratified to isothermal, causing the entire water body to mix and overturn, until stratification is re-established. Time of year also influences rainy and dry periods, which affect total volume and velocity.
- **Circulation.** Movement in a water body may be the result of wind action or water density gradients. Sediment distribution may be dominated by water motion.
- **Velocity.** The speed at which a surface water body flows affects the selection of sampling locations, times, equipment, and techniques. When sampling at a river bend, velocity is the

greatest where the radius is smallest (i.e., towards the inside bank).

- **Turbidity.** Surface water can contain contaminants that adhere to the particles of suspended solids or fine particulates of sediment. These suspended sediments adhere to the water surface and will add to the water sample. Turbidity will vary due to mixing and settling in the water body.
- **Salinity.** The natural salt concentration, or salinity, of a water body may vary with proximity to the ocean, seasonal gradients, and stratification. Tidal phases of the water body must also be considered when sampling in saline waters.

For water quality investigations, surface water runoff samples should be collected at upstream and downstream locations on a subject water body. In areas where tidal influence is a consideration, a timed composite sample should be taken, with care to avoid cross-contaminating the samples. The composite sampling procedure must be based on the DQOs for data interpretation and assessment. Identify specific sampling locations and procedures in the SAP.

Additional sampling locations might be considered, depending upon the size of the site, the number of streams or rivers near the site, and the location of natural drainage swales and wetlands. If contamination of a river is suspected or documented, river or sea water levels and corresponding flow should be monitored upstream from the site and downstream from any leachate seeps or runoff. This information can be used to assess dilution effects and potential seasonal variations in contaminant concentrations due to changing water levels.

Often, the U.S. Geological Survey (USGS), state agencies, and public water supplies monitor river and stream flow and water quality at various points along major rivers or streams. Resulting data are publicly available and can be used for determining water levels, flow rates, and drainage and water quality information. Precipitation data can be acquired from local weather bureaus or the National Climatic Data Center in Asheville, North Carolina.

Nonpoint sources may feed into intermittent streams. These streams often transport contamination from a site because of surface water runoff during or after a period of heavy rainfall. If contamination is suspected because of seasonal runoff, surface water samples should be collected during and/or immediately following periods of heavy rainfall.

For investigations of compliance with storm water permit, an evaluation of the optimal sampling locations should be made. The EPA storm water program provides guidance for selecting potential sampling locations and determining the concentration of contaminants during rainfall events. It is particularly important to sample the storm flow runoff from the first 30 minutes of significant flow if not otherwise specified in the storm water permit. One sample should be collected where runoff or overflow enters the stream as well as other locations upstream of the site. Intermittent streams are not usually monitored by other agencies, so the stream depth, width, and flow rate during or after periods of heavy rainfall should be measured. The USGS can be consulted for an estimation of water drainage in particular areas.

Storm water permits often require the collection of one grab sample of constant volume, not less than 100 milliliters, every 20 minutes during the storm event, over a period of at least 3 hours. These grab samples are combined into a composite sample for analysis. Refer to Section 6.6 for more information on grab samples and composite samples. As an alternative to a time-weighted sample, a flow-weighted sample may be taken in which the volume of each grab sample to be composited is proportional to the flow rate of the discharge at the time the sample was collected.

6.5.4. Leachate

In most cases, a leachate well is installed as part of a remedial action or site characterization. Leachate wells are monitored following groundwater sampling procedures as defined in the operating permit of the facility or site.

Leachate sample collection locations should include the outfalls to shorelines. The location of

leachate discharge ultimately depends on the site's physical and geological characteristics. Leachate can move laterally below ground toward a creek or stream to affect surface water quality. Samples should be collected both upstream and downstream of the site to determine the extent of contamination. In some cases, the leachate can outcrop at the top and the side of the site and flow with the surface water body. Samples should be collected not only at the leachate seeps but also upstream of them.

At each seep location, the sampler should collect samples by immersing the sample container directly in the seep. If the depth of water in the seep is not sufficient to submerge the sample container, then use a dedicated pre-cleaned container to collect the sample.

For any sample collection method used, more than one round of sampling is recommended for characterization of leachate. A minimum of two sampling events, one during a dry period and another during or immediately after precipitation, should be performed to determine variability in leachate composition. The collected samples are analyzed for any combination of the following parameters: priority pollutant organics, metals, cyanide, biochemical oxygen demand (BOD), chemical oxygen demand (COD), pH, total dissolved solids (TDS), total suspended solids (TSS), oil and grease, TOC, chloride, nitrate, phosphate, ammonia, and sulfide. All samples should be analyzed according to the permit requirements.

6.5.5. Wetland Sampling

Contaminant sources may exist around natural wetlands or other sensitive environments. Contamination from these sources can migrate from the site through surface water into wetlands, which can adsorb heavy metals and complex organics, affecting the health of the wetlands. Wetlands are defined in accordance with the *Federal Manual for Identifying and Delineating Jurisdictional Wetlands* (U.S. Fish and Wildlife Service et al., 1989).

Wetlands sampling for chemical and biota studies may be performed as part of permit applications. Composite or grab samples of surface water or sediment may be collected as described in the permit or defined in the SAP. The SAP will describe the procedures to meet the DQOs for interpreting the environmental impact of suspected contamination. When sampling in a designated wetland, it is vital to minimize the impact of the sampling event on the environment.

6.6. Sampling Procedures

Prior to initiating any field sampling activity, sampling personnel should review the HASP. All monitoring instruments and PPE should be checked thoroughly at this time. Prior to sampling at each location, water monitoring equipment probes should be decontaminated using procedures appropriate for the contaminant present and then rinsed thoroughly with ASTM Type II or better quality water.

Surface water sampling includes the collection of samples from lakes, ponds, streams, and rivers. It may be necessary to collect liquid samples from lagoons, surface impoundment, sewers, and leachate seeps. Actual sampling situations encountered in the field may vary according to the site. The most important goal of surface water sampling is to collect a representative sample of the appropriate horizons or phases present in the liquid.

Surface water can be collected either as a grab or as a composite sample. A grab sample is an individual sample collected randomly at a specific time element. A composite sample is a representative sample prepared from a combination of multiple grab sample aliquots collected at periodic time intervals or locations. A composite sample can also be a representative sample taken at a single sample point collected over an extended time interval. Grab samples collected for further preparation of a composite sample must be proportional. The time interval either between each aliquot or between the volume of each aliquot must be proportional to either the stream flow at the time of sampling, or the total stream flow since the collection of the previous aliquot. Aliquots may be collected manually or automatically using specially designed equipment. Sam-

ples that require analysis for VOAs should be submitted to the laboratory as a grab sample rather than a composited sample to minimize the potential loss of the volatile contaminants.

6.6.1. Operation of Sample Collection Devices

Sampling personnel must be properly trained in the operation of sample collection devices and should review the manufacturer's instructions prior to sample collection. Sampling operations must comply with all health and safety and QA/QC requirements, and all sampling equipment must be properly cleaned and decontaminated between each collected sample.

6.6.1.1. Laboratory-Cleaned Sample Bottle

The most widely used method for collecting surface water samples is immersion of a laboratory-cleaned sample bottle or certified pre-cleaned bottle into the water to be sampled. Alternatively, a laboratory-cleaned dipping bottle can be used to fill sample bottles if immersion of the actual sample bottle is not feasible.

Sample Bottle Use Procedures

1. Ensure the bottles are intact, with proper fitting lids with linings that are compatible with the contaminant under investigation.
2. Remove the lid, keeping it free from contamination during sampling. Immerse the bottle into the surface water to the proper depth interval and allow the water to run slowly into the bottle until it is full to zero headspace. Replace the lid.

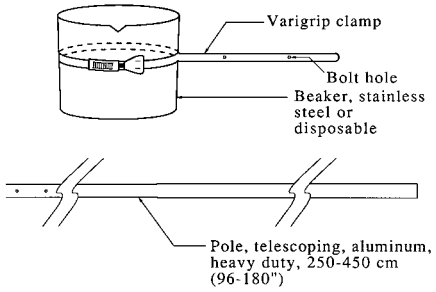
Note: Collect samples for VOC analysis first to prevent loss of volatiles due to disturbance of the water. Section 6.6.2.1 discusses collection procedures for VOC samples.

6.6.1.2. Pond Sampler

The pond sampler (also called the dipper cup sampler) is used to collect liquid samples from disposal ponds, pits, lagoons, and similar reservoirs (see Figure 6-1). The sampler consists of an adjustable clamp attached to the end of a two- or three-piece telescoping aluminum tube, which serves as the handle. Tubes can be readily purchased from most hardware or swimming pool supply stores. The clamp is used to secure a sampling beaker. The adjustable clamp and sampling beaker (stainless steel or Teflon®) can be obtained from most laboratory supply houses. The sampler can also be constructed of a polyethylene cup with a pole that is joined in a single fabrication.

Figure 6-1. Pond Sampler

QUANTITY	ITEM
1	Clamp, adjustable, 6.4 to 8.9 cm (2 1/2" to 3 1/2") for 250 to 600 ml (1/2 to 1 1/4 pt.) beakers.
1	Tube, aluminum, heavy duty, telescoping extends 2.5 to 4.5 m (8 to 15 ft.) with joint cam locking mechanism. Pole diameters 2.54 cm (1") in diameter and 3.18 cm (1 1/4") in diameter.
1	Beaker, tetrafluoropoly-ethylene or stainless steel, 250 ml (1/2 pt.).
1	Bolts 6.35 by 0.64 cm (2 1/4 by 1/4") NC.
1	Nuts, 0.64 cm (1/4") NC.



Pond Sampler Use Procedures

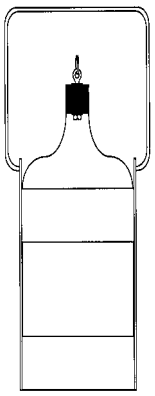
1. Assemble the sampler in accordance with the manufacturer's instructions. Ensure the sampling beaker or sample bottle is clamped securely to the pole.
2. Slowly submerge the beaker with minimal surface disturbance.
3. Retrieve the pond sampler from the surface water with minimal disturbance.
4. Remove the cap from the sample bottle and slightly tilt the mouth of the bottle below the dipper edge.
5. Pour the sample slowly into the appropriate sample container, allowing the sample stream to flow gently down the inside wall of the sample container with minimal entry turbulence.

6.6.1.3. Weighted Bottle Sampler

The weighted bottle sampler can be used to sample liquids from storage tanks, wells, sumps, or other reservoirs that cannot be adequately sampled with another device (see Figure 6-2). The

sampler consists of a bottle (usually glass) a weight sinker, a bottle stopper, and a line used to open the bottle and to lower and raise the sampler. This sampler uses a stainless steel or carbon steel bottle basket that also serves as the weight sinker.

Figure 6-2. Weighted Bottle Sampler



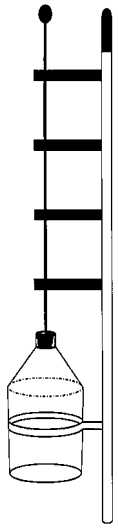
Weighted Bottle Sampler Use Procedures

1. Assemble the sampler in accordance with the manufacturer's instructions.
2. Lower the sampling device to the predetermined depth.
3. When the sampler is at the required depth, pull out the bottle stopper with a jerk of the sampler line and allow the bottle to fill completely. (This is usually when air bubbles cease.)
4. Retrieve the sampler and transfer the sample to the appropriate sample container.

6.6.1.4. Wheaton Dip Sampler

The Wheaton dip sampler is useful for collecting liquid samples from shallow areas (see Figure 6-3). The sampler consists of a glass bottle mounted on a metal pole of fixed length. Attached to the bottle's screw cap is a suction cup mounted on another metal pole.

Figure 6-3. Wheaton Dip Sampler



Wheaton Dip Sampler Use Procedures

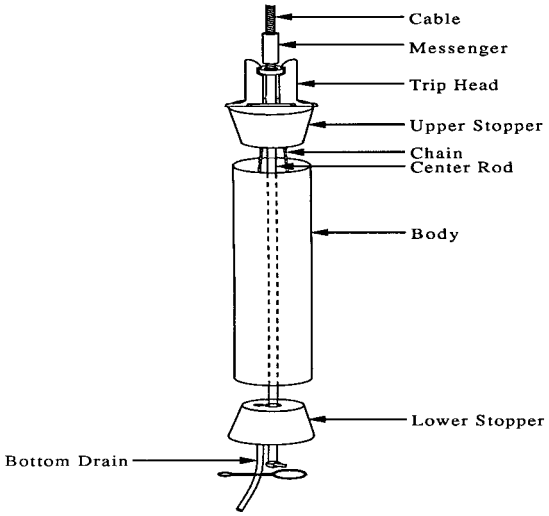
1. Assemble the sampler in accordance with the manufacturer's instructions.
2. Extend the device to the sample location, and lower to the predetermined depth.
3. Turn the metal pole attached to the suction cup to open the sample bottle.
4. When the bottle is full (usually when air bubbles cease), screw the cap back on to seal the sampling container and retrieve the sample.
5. Transfer the sample to the appropriate sample container.

6.6.1.5. Kemmerer Depth Sampler

The Kemmerer depth sampler is used to collect liquid samples from lakes, storage tanks, tank trailers, vacuum trucks, or anywhere collection depth prevents the use of other sampling devices (see Figure 6-4).

The Kemmerer depth sampler consists of an open tube with two sealing end pieces or stoppers. The end pieces can be withdrawn from the tube and set in the open position until the sampler is at the required sampling depth. Then, a weighted messenger is sent down the line or cable, releasing the end pieces and trapping the sample within the tube.

Figure 6-4. Kemmerer Depth Sampler



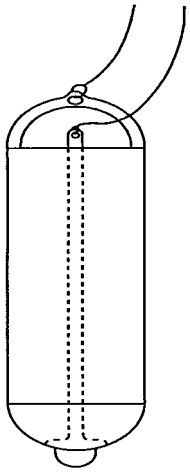
Kemmerer Depth Sampler Use Procedures

1. Set the sampler so that the sealing end pieces are pulled away from the sampling tube, allowing the water to pass through the tube.
2. Lower the sampling device to the predetermined depth. Avoid bottom disturbance.
3. Once the sampler reaches the required depth, send down the messenger, closing the sampling device.
4. Retrieve the sampler, and discharge the first 10 – 20 milliliters from the bottom drain to clear any potential contamination of the valve.
5. Pour the sample into the appropriate sample container.

6.6.1.6. Bacon Bomb Sampler

The Bacon bomb sampler is a widely used, commercially available sampler designed for sampling liquids at a depth interval (see Figure 6-5). The Bacon bomb sampler is constructed of brass or stainless steel and is available in two sizes (1.5 inches or 3.5 inches in diameter with volumes ranging from 4 or 32 fluid ounces, respectively). The sampler is equipped with a spring loaded trigger that allows liquid to enter the collection chamber when opened. When the trigger is released, liquid is prevented from flowing into or out of the collection chamber.

Figure 6-5. Bacon Bomb Sampler



Bacon Bomb Sampler Use Procedures

1. Lower the sampler carefully to the desired depth, allowing the line for the trigger to remain slack at all times. When the desired depth is reached, pull the trigger line until taut. This will allow the sampler to fill.
2. Release the trigger line, and retrieve the sampler.
3. Transfer the sample to the appropriate sample container by pulling upon the trigger.

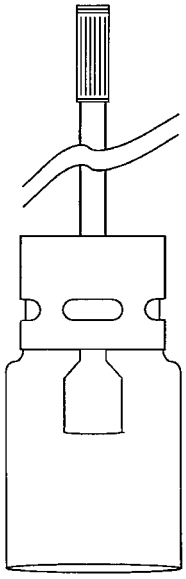
6.6.1.7. PACS Grab Sampler

The PACS grab sampler can be used to collect liquid samples from lagoons, ponds, or containers with restricted access (see Figure 6-6). For water and liquid waste sampling, the narrow neck model is useful for maintaining the collected sample inside of the device. The sampler consists of a 1,000-milliliter bottle screwed onto the end of a 6-foot fixed or telescoping handle.

PACS Grab Sampler Use Procedures

1. Assemble the sampler in accordance with the manufacturer's instructions.
2. Submerge the sampler into the liquid to be sampled.
3. Once the sampler has reached the required depth, open the sampler using the control valve at the top of the handle.

Figure 6-6. PACS Grab Sampler



4. After the sample is collected (usually when air bubbles cease), close the sample bottle.
5. Retrieve the sampler.
6. Pour the sample into the appropriate sample container.

6.6.1.8. Point Source Bailer

Point source sampling is performed to collect samples from distinct levels or points of inflow. To accomplish this task, a point source bailer can be used that yields negligible disturbance and mixing with water at different levels. This specially designed bailer has dual ball valves on both the top and bottom of the sampling chamber to isolate the sample at a discrete depth from mixing with other depth intervals.

Point Source Bailer Sampler Use Procedures

1. Assemble the sampler in accordance with the manufacturer's instructions.
2. Lower the bailer slowly to the desired sample depth on a support line. As the bailer is lowered, both ball valves are open, allowing the water to flow through the sampler.
3. On reaching the sampling depth, the bailer is raised using the support cable. The weight of the water and upward movement of the bailer keep both ball valves closed. The top ball valve prevents the sample in the bailer from mixing with water at higher levels.
4. Once at the surface, the bailer is emptied by opening the top vent and allowing the water to drain slowly through the sample release device into the sample container.

6.6.1.9. Automatic Samplers

An automated sampling system, consisting of a pump, flow sensor, distribution system, and sample containers can be used under appropriate conditions for collecting point source samples. An automated system is typically employed for collecting a composite point source sample over an extended time interval according to preprogrammed criteria. Automatic samplers can minimize labor requirements, reduce risk of human error during sampling, and provide the opportunity for remote triggering of sampling according to site conditions. Automatic sampling can be limited by cost impact from equipment and installation, and potential for crosscontamination during sampler operation. The system is not appropriate for sample collection of sources that require analysis for VOCs and chlorine, as well as microbiological agents, such as fecal coliform and *E. coli*. Automated samplers are often customized for a specific project and site conditions. Operating instructions should be developed and implemented on a project-specific basis.

Use automatic samplers when several sites are to be sampled at frequent intervals or when a continuous sample is required. Composite samplers can be used to collect time composite or flow proportional samples. In the flow proportional mode, some samplers are activated by a compatible flow meter. Refer to your specific flow meter operating manual for details on meter operation. For older models, flow proportional samples can be collected using a discrete sampler and a flow recorder, and manually compositing the individual aliquots in flow proportional amounts.

6.6.1.9.1. Installing and Programming the Automatic Composite Sampler

Use all new or pre-cleaned pump tubing each time the sampler is brought to the field and set up. Select tubing construction for the pump head and sampling train according to the analytes of interest and the allowable construction materials.

1. Cut the proper length of pre-cleaned Teflon® or Tygon® tubing.
2. Collect equipment blanks at a frequency of 5% of the samples by passing analyte-free water through the equipment that is exposed to the sample.
3. Put the collection sieve and tubing in the appropriate sample location in the wastewater stream, using conduit if necessary to hold it in place. Ensure the supporting conduit does not contaminate the incoming sample water.
4. Program the sampler per manufacturer's directions and as required in the permit or work plan conditions.
5. For a time composite sample, program the sampler to collect a minimum of 100 mL for each sample interval. Adjust the volume collected according to the duration of the sampling event, the sampling interval, and the size of the container.
6. For a flow proportional sample, program the sampler to collect a minimum of 100 mL for each sample interval, with the interval predetermined based on the flow of the waste stream.
7. Automatic Sampler Security: A lock or seal may be placed on the sampler to prevent or detect tampering. However, this procedure does not prevent tampering with the sampler tubing.

6.6.1.9.2. Sample Acquisition

1. At the end of each sampling period, stir the contents of the compositing jug (sample) and siphon contents (poured if no visible solids) into the appropriate sample containers. If the sampler was set up to collect discrete samples, ensure that the contents of each container are adequately mixed while pouring the sample into the sample container.
2. Immediately preserve the sample; if required, cap and label the sample container.

6.6.1.9.3. Long-Term Deployment of Automatic Composite Samplers

In certain sampling situations, automatic composite samplers are permanently installed at the sample stations and remain in the field for months or even years. Under these conditions, there are specific sampling issues that need to be addressed.

6.6.1.9.4. Sample Preservation

1. If the only analyte of interest is Total Phosphorus, and the project is unrelated to an NPDES permit, the sample must be chemically preserved with sulfuric acid (H_2SO_4) but does not need to be cooled to $\leq 6^{\circ}C$with wet ice. Other analytes will need chemical preservation and cooling.
2. The acid must be in the container prior to drawing the first composite sample into the container. When using large (i.e., 3-gallon) composite sample containers, and there is potential for the sample size to vary greatly due to variable flow rates at the site, the volume of acid for preservation should be small (e.g., 1 – 2 mLs of 50% H_2SO_4). Do not over acidify the sample. Upon sample pick-up, if needed, add additional acid to achieve the proper pH adjustment (i.e., $pH \leq 2$) for preservation.
3. Cool samples with ice or refrigeration.

6.6.1.9.5. Cleaning Requirements

1. Clean composite sampler containers after collection of each composite sample using cleaning solutions and procedures.
2. Composite sample containers may be cleaned either in the field or in a fixed-base operation. Demonstrate cleaning effectiveness by collecting equipment blanks on the composite sample containers according to the frequency specified by the manufacturer. Typically, collect sampler container equipment blanks by adding a minimum of 1 L of analyte-free water to the cleaned sample container, mix the water thoroughly within the container, and then pour off an aliquot for analysis.
3. Replace tubing at a minimum of every six months. Inspect the tubing each time the composite sample container is picked up. If there is evidence of loss of elasticity or discoloration or other conditions (such as algal growth) that would impact the quality of the sample, then replace the tubing prior to the end of the six-month interval. Collect an equip-

ment blank each time new tubing is installed in the auto sampler. Collect this equipment blank by passing analyte free water through the entire length of the new tubing being deployed at each station. If the tubing is being replaced for multiple autosamplers at the same time, one equipment blank may be collected on the entire length of replacement tubing. Collect this equipment blank by passing analyte-free water through the entire length of new tubing.

6.6.1.10. Summary of Surface Water Sampling Devices

A summary of collection devices that are designed for collecting surface samples, including their advantages and disadvantages for use, are presented in Table 6-1.

6.6.2. Sample Collection Procedures

For detailed sampling procedures and preservation of samples, refer to Appendix B of this handbook. It is important to remember that COC procedures should be followed for all surface water sampling events and that all samples are to be preserved with ice to 4 ± 2ºC during both sample collection and shipment to the laboratory. Details regarding the use of COC procedures are provided in Chapter 3.

6.6.2.1. Sampling for VOCs

Use the following procedures for collecting samples for VOCs:

1. Remove the cap from a 40-millileter septum (Teflon®-lined silicon rubber) vial. Avoid contact with the inner surface.
2. Add the established amount of HCl necessary for sample preservation (if pre-preserved vials have not been supplied by the laboratory, pre-preserved vials cannot be used if the actual VOC collection container is dipped into the water being sampled).
3. Fill the vial with sample water, taking care to minimize aeration, and screw the cap on tightly to achieve zero headspace.
4. If effervescence occurs due to high carbonate salts in the samples, do not add acid preservative, and contact the Project Manager for appropriate actions such as reduced sample holding times.
5. Inspect the vial for air bubbles. If air bubbles are present, discard the sample and restart with step 1.
6. Label the vial, and place it in a resealable bag. Place the sample vials in a cooler with bagged ice sufficient to cool to 4 ± 2ºC.
7. Record all appropriate data in the FLB/FN.

6.6.2.2. Samples for SVOCs

Use the following procedures for collecting samples for SVOCs:

1. Remove the Teflon®-lined cap from a 1-liter amber glass bottle. Avoid contact with the inner surface of the cap.
2. Fill to the neck of the bottle with surface water. Add chemical preservatives, if required by the permit or method. Record the amount, type of preservative, and other preservation data per the SAP. Pre-preserved bottles also may be used for sampling surface water for extractable organics analysis, unless the sample is collected directly into the container.
3. Replace the cap tightly, attach the sample label, and place the sample bottle in a cooler with bagged ice sufficient to cool to≤6°C.
4. Fill additional bottles by repeating steps 1 – 3.
5. Record all appropriate data in the FLB/FN.

6.6.2.3. Sampling for Additional Parameters

1. Remove the cap from the sample bottle. Avoid contact with the inner surface of the cap.
2. Fill about 90 percent of the bottle with surface water, and preserve to a pH of < 2 with nitric acid. Pre-preserved sample bottles also may be used for metals analysis.
3. Record the amount, type of preservative, and other preservation data per the SAP. Replace the cap tightly, attach label, and place the sample bottle in a cooler with bagged ice sufficient to cool to≤6°C, if required by the permit or method.
4. Fill additional bottles by repeating steps 1 – 3.
5. Record all appropriate data in the FLB/FN.

6.6.2.4. Sampling for Additional Parameters

1. Remove the cap from the sample bottle. Avoid contact with the inner surface of the cap.
2. Fill the bottles per the SAP or method requirements.
3. Add the appropriate preservative to the samples, if required.
4. Replace the cap tightly.
5. Attach label.
6. Place sample bottles in a cooler with enough bagged ice to cool them to≤6°C, if necessary.
7. Record all appropriate data in the FLB/FN.

6.7. Sampling Equipment List

Section 3.8 provides a generic sampling equipment list applicable to most sampling events. The following list provides additional specific equipment that may be applicable to surface water sampling.

- Preservation chemicals and reagents
- pH meter, DO meter, conductivity meter, and thermometer
- Sample collection devices
  - Pond sampler
  - Weighted bottle sampler
  - Wheaton dip sampler
  - Kemmerer depth sampler
  - Bacon bomb sampler
  - PACS grab sampler
  - Point source bailer
  - Automatic sampler system
- Stainless steel tape and measuring rod
- Field blanks
- Trip blanks when measuring VOCs
- Cleaning materials and reagents
- Decontamination materials and detergent
- Dedicated, pre-cleaned dipping devices or bottles, if necessary.

Table 6-1. Sampling Devices for Collecting Surface water

Collection Device	Advantages	Disadvantages
Laboratory-Cleaned Sample Bottle	• Easy to use. • Low contamination risk. • No decontamination required.	• Difficult to label wet bottle. • Pre-preserved bottles cannot be used. • Exterior of bottle may contact the sample.
Pond Sampler	• Easy and inexpensive to fabricate. • Samples to depths of 3.5 meters.	• Difficult to obtain a representative sample in stratified liquids. • Difficult to decontaminate when viscous liquids are encountered.
Weighted Bottle Sampler	• Can be fabricated or purchased. • Remains unopened until it reaches sample depth.	• May be incompatible with some liquids. • Laboratory-supplied bottle may not fit into the sampler. • Mixing of the sample may occur.
Wheaton Dip Sampler	• Allows discrete samples to be taken at depth.	• Sampling depth is limited by the length of the poles. • Exterior of bottle may contact the sample.
Kemmerer Depth Sampler	• Ability to sample at various and great depths. • Allows discrete samples to be taken at depth.	• Sampling tube is exposed to water while traveling down to sampling depth.
Bacon Bomb Sampler	• Allows discrete samples to be taken at depth.	• Difficult to decontaminate. • If brass construction, may not be appropriate in metals analysis or toxicity testing. • Difficult to transfer sample to container. • The sample can become aerated.
PACS Grab Sampler	• Allows discrete samples to be taken at depth.	• Depth of the sampling is limited by the length of the pole. • Difficult to decontaminate.
Point Source Bailer	• Allows discrete samples to be taken at depth.	• May be difficult to operate. • Difficult to decontaminate.
Automated Sampler	• Allows discrete samples to be taken at depth.	• Not appropriate for collecting samples requiring VOC and microbiological analysis.

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Chapter 7. Storm Water Sampling

7.1. Purpose

Military bases and other federal facilities are regulated under the NPDES storm water program. The industrial permit program, the Municipal Separate Storm Sewer Systems (MS4) permit program, and the Construction Activities Permit Program may apply to military bases and other federal facilities. See Section 7.2 for an overview of Phase I and II storm water regulations. The following classes of discharges are regulated under NPDES storm water permit coverage:

- Operators of MS4s located in urbanized areas (UAs) or where designated
- Industrial facilities in any of the 11 categories that discharge to an MS4 or to waters of the United States. All categories of industrial activities (except construction) may certify to a condition of "no exposure" if their industrial materials and operations are not exposed to storm water, eliminating the need to obtain storm water permit coverage.
- Operators of construction activities that disturb one or more acres of land and construction sites less than one acre are regulated if part of a larger plan of development.

Storm water sampling at MS4s, industrial facilities and construction sites, including those at DoD installations, may be required to verify permit compliance. The need for storm water sampling will be determined based on the type of permit the facility obtains. For example, if a DoD industrial facility is located within a state that uses the Multi-Sector General Permit (MSGP), then analytical monitoring of outfalls associated with specific industrial sectors is required quarterly during permit years two and four. Other states may issue a general storm water permit, which requires sampling only for specific types of industrial activities. Each permit provided to the facility will outline the specific sampling and analysis requirements. This is the first step to determine:

- Sampling requirements
- The outfalls to be monitored
- The types of samples that need to be collected (e.g., grab vs. composite, first flush)
- The types of pollutants to be analyzed.

This chapter provides an overview of the:

- Federal storm water regulations including permitting requirements
- Activities at DoD facilities that may impact storm water
- Compliance monitoring strategies including sampling and analysis, QA, and health and safety requirements for storm water monitoring
- Commercially available equipment used for storm water monitoring.

7.2. Storm Water Program Overview

This section provides an overview of the federal storm water program including the differences between Phases I and II of the regulation, and permitting options for both industrial facilities and construction sites. A detailed description of the storm water regulations and permitting steps for DoD facilities can be found in the U.S. Army Environmental Center's *Storm Water Guidance Manual*, dated July 27, 2005.

7.2.1. Regulatory Summary

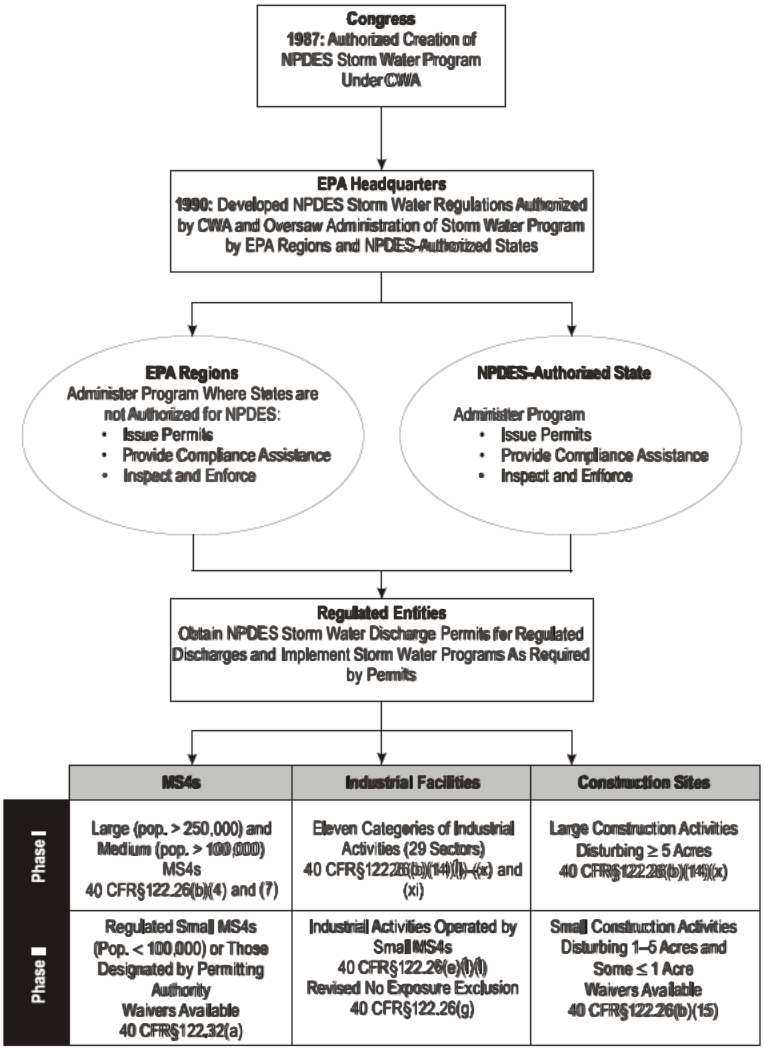
The CWA was amended in 1972 to prohibit discharges of any pollutant to waters of the United States from point sources[1] unless that discharge was authorized by a NPDES permit. Originally, EPA efforts to track point sources and improve water quality under the NPDES program focused on reducing pollutants in industrial wastewater and municipal sewage. Studies in the late 1980s, however, indicated that while wastewater regula-

[1] A point source is defined under 40 CFR § 122.2 as "…any discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collecting system, or vessel or other floating craft from which pollutants are or may be discharged." Since the definition of a point source is broad and can vary among individual states, installation staff should contact the appropriate NPDES permitting authority to verify a point source discharge.

tions had dramatically decreased the amount of pollutants in the nation's waters, these waters were still polluted. The major source of pollutants entering the waterways was determined to be from storm water runoff rather than from industrial or municipal discharges. Utilizing the CWA amendments of 1987, EPA promulgated NPDES Phase I storm water regulations in 1990 and Phase II regulations in 1999 to address storm water runoff from point sources (excluding agricultural runoff). These point sources include storm water runoff from MS4s, storm water discharges from certain industrial activities, and storm water runoff from construction activities. Figure 7-1 provides an overview of the NPDES storm water regulations. Specific requirements for the Phase I and Phase II rules are described below.

Additionally, Section 303(d) of the CWA, requires that states develop lists of impaired waters and establish Total Maximum Daily Loads (TMDL) for those waters. A TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still safely meet water quality standards.

Figure 7-1. Overview of NPDES Storm Water Regulations



7.2.1.1. Phase I Regulations

The NPDES Phase I regulations require the following types of activities and systems to obtain storm water discharge permits:

- Industrial activities in 11 categories
- Construction activities disturbing five or more acres of land
- Medium MS4s (serving populations of 100,000 – 250,000)
- Large MS4s (serving populations > 250,000)
- No exposure exemption for light industry.

7.2.1.2. Phase II Regulations

The Phase II program expanded Phase I by requiring storm water discharge permits from the following activities and systems:

- Small MS4s (populations < 100,000) in UAs
- Municipal industrial facilities similar to those under Phase I
- Small construction sites disturbing one to five acres
- Construction activities disturbing less than one acre if the site is part of a larger common plan of development or sale
- Two new classes of discharges: 1) particulate matter from roof stacks and vents not otherwise regulated; and 2) visible "track out" or windblown raw materials.

This storm water sampling chapter will focus on both DoD industrial facilities and large and small construction activities at DoD installations. Information on storm water sampling at MS4s is beyond the scope of this document.

7.2.2. Permitting Requirements

A number of DoD facilities conduct industrial operations that require storm water permitting. Some of these operations include munitions manufacturing (e.g., chemical plants), metal fabrication and plating, equipment maintenance, power generation, fuel transfer and storage, and waste management areas. Regulated industrial activities at DoD facilities may be covered by an individual storm water permit or a General Storm Water Permit (GP) from either EPA or the state environmental agency. An individual permit can be more intensive, with more site-specific requirements, while the GP application process and permit requirements are usually more streamlined and less stringent. Specific permit requirements vary depending on permit type and EPA or state requirements. States with NPDES permitting authority may impose more stringent requirements or expand the scope of their programs to meet state priorities or watershed requirements.

Construction activities at DoD facilities must also comply with storm water permitting requirements. Two types of storm water permits are available for construction activities. A GP, which is typically used for construction activities, and less commonly, an individual permit. EPA and states encourage developers, construction contractors and federal facilities to apply for construction GPs when necessary, although there may be certain situations where the permitting authority would require an individual permit. For example, if the operator of a construction activity is proposing to discharge an unallowable non-storm water discharge into an impaired water body, then the permitting authority may require coverage under an individual permit.

EPA defined a regulated construction activity in the Phase I storm water rules to include:

> "…all clearing, grading, and excavation activities, except operations that result in the disturbance of less than 5 acres of total land area. Construction activity also includes the disturbance of less than 5 acres of total land area that is part of a larger common plan of development or sale if the larger common plan will ultimately disturb 5 acres or more..."

This definition was expanded by the Phase II requirements to include small construction activities that disturb one to five acres of land, or less than one acre if the construction activities are part of a common development or sale (40 CFR § 122.26(b)(15)).

Various ground-disturbing projects at DoD facilities are considered to be regulated construction activities and would require a storm water construction permit and sampling if they disturb one or more acres of land, and result in a point source discharge into waters of the United States. Typical installation construction activities may include but are not limited to:

- Clearing of an area to construct a new munitions plan
- Grading activities associated with demolition or remediation
- New road construction or full-depth reconstruction of existing roads
- Construction of housing units, offices, training facilities, or commissaries
- Combat Engineer Company training activities.

Coverage under the federal Construction General Permit (CGP) authorizes the permittee to discharge the following during construction, provided that all terms of the permit are being met:

- Storm water discharge associated with construction activities from either large or small construction sites including storm water discharge that disturbs less than one acre that is part of a larger common plan of development or sale that, when combined, disturbs one acre or more
- Storm water discharge from sites disturbing less than one acre, but designated by EPA as needing coverage under the CGP
- Storm water discharge from construction site support activities directly related to the construction site with CGP coverage (e.g., concrete or asphalt batch plants, equipment staging yards, material storage areas, track-out roadways, etc.)
- Any discharge authorized by a different NPDES permit commingled with discharge authorized by the CGP.

Additionally, the federal CGP authorizes the following non-storm water discharge, if the non-storm water component of the discharge is in compliance with Subpart 3.5 (Non-Storm Water Discharge Management) of the CGP:

- Discharge from fire-fighting and fire hydrant flushings
- Water used for vehicle and external building washing where detergents are not used
- Water used to control dust in accordance with Subpart 3.4.G of the CGP
- Potable water, including uncontaminated water line flushing
- Pavement wash water where spills or leaks of toxic or hazardous materials have not occurred (unless all spilled material has been removed) and where detergents are not used
- Uncontaminated air conditioning or compressor condensate
- Uncontaminated groundwater or spring water
- Foundation or footing drains where flows are not contaminated with process materials
- Uncontaminated excavation dewatering and landscape irrigation.

All other discharges associated with the construction activity are prohibited by the CGP and will require coverage under an individual storm water permit or another type of NPDES permit.

7.3. Storm Water Compliance

The intent of the Phase I and Phase II regulations are to prevent storm water from becoming contaminated by industrial or construction activities, rather than requiring quantitative monitoring of storm water outfalls. To implement the intent of the regulation, the control authority (EPA or the state) requires a systematic approach be taken to identify the facility's potential storm water impacts, and to mitigate these impacts through a series of best management practices (BMPs). BMPs can be either non-structural or structural. Non-structural BMPs include procedural changes such as not allowing off-loading of fuel during rain events, covering of storm-drains during material transfer, or not storing materials outside. Structural BMPs are physical changes to the facility or implementation of technologies to prevent pollutants from leaving an industrial

facility or construction site. Structural BMPs may include items such as check-dams for controlling runoff and trapping sediment, storm water retention ponds for capture of sediment, and storm drain valves to prevent releases from leaving a facility.

The first step in the systematic process to prevent contaminated storm water from leaving the industrial facility or construction site requires development of a storm water pollution prevention plan (SWPPP). The SWPPP describes issues such as potential locations for storm water contamination, possible pollutants, drainage patterns, outfalls, and BMPs that could be established to prevent polluted runoff. The storm water permit, along with information gathered during preparation of the SWPPP, provide DoD's environmental staff with the information needed to develop a compliance monitoring program for the site.

The remainder of this section discusses SWPPP development for both industrial facilities and construction sites. It provides insight into the types of pollutants expected at DoD industrial facilities and construction sites, and the current technologies and techniques being used to verify compliance through either visual monitoring or collection and analysis of storm water samples.

7.3.1. Development of a SWPPP

Preparation of a pollution prevention plan is the first step toward compliance with the storm water regulations. The SWPPP identifies the sources and types of storm water pollution associated with all industrial and construction activities covered under the GP/Individual Permit. It describes the BMPs that the installation will implement to reduce or eliminate pollutant sources and describes the monitoring requirements to verify compliance. The bullets below describe information that is provided in the primary sections of an SWPPP. See EPA's *Storm Water Management for Industrial Activities: Developing Pollution Prevention Plans and Best Management Practices,* for more guidance on preparing an SWPPP for industrial discharges.

- **Pollution Prevention Team.** The first step in developing and implementing an SWPPP is to identify a qualified individual or team of individuals who will be responsible for developing the plan and assisting with implementation. This team should represent all relevant departments in the industrial areas covered by the permit. The plan must describe the responsibilities of each team member as they relate to specific components of the plan.
- **Description of the Facility and Potential Pollution Sources.** The SWPPP must identify the activities, materials, and physical features of the regulated activity at the installation that may contribute significant amounts of pollutants to storm water runoff, or may result in pollutant discharges through a separate storm sewer system or storm water drainage system during dry weather. If there is a significant amount of pollution running onto the facility from an adjacent property, addressing or diverting this run-on should be addressed in the SWPPP. If it cannot be addressed, the permitting authority should be notified.
- **Description or Map of Site and Receiving Waters/Wetlands.** The map must include the location of all outfalls covered by the NPDES permit. It must also denote the storm water drainage patterns, locations where significant materials are exposed to rainfall and runoff, locations of major spills and leaks that have occurred in the drainage areas of the permitted outfalls within 3 years prior to receiving the Notice of Intent (NOI) to discharge storm water; and other installation-specific information.
- **Summary of Potential Pollutant Sources.** Provide a narrative description of activities, materials, and physical features of the installation that are potential pollutant sources affecting storm water quality. Describe areas of the installation that are subject to reporting under Section 313 of EPCRA.

- **Significant Spills and Leaks.** Provide a list and description of cause, type, volume, location, and response actions taken for each significant spill or leak of toxic or hazardous pollutants that occurred within 3 years prior to the date of the submission of the NOI.
- **Allowable and Prohibited Non-Storm Water Discharges.** Include a certification signed by an authorized individual to affirm that discharges from the installation have been tested or evaluated for the presence of non-storm water discharges. The certification ensures that the installation is only discharging non-storm waters allowable under the GP.
- **Selection and Implementation of Storm Water Controls.** Evaluate, select, and describe the pollution prevention measures, BMPs, and other controls that will be implemented at the installation to control storm water pollutants. The appropriateness of each selected control and how each control will address one or more of the potential pollution sources identified must be explained. This includes discussing how the individual controls relate to one another as a whole, and producing an integrated approach for preventing and controlling storm water pollution.
- **Storm Water Monitoring Requirements.** Monitoring requirements must be detailed in the SWPPP. Monitoring requirements will be detailed in the storm water permit provided by the regulatory authority and will range from visual monitoring of storm water to collection and analysis of storm water samples. The storm water monitoring section must also include a schedule that details the frequency that storm water monitoring must be performed.
- **Internal Reporting of Storm Water Information.** A reporting system must be established to ensure timely reporting of storm water management-related information to appropriate installation personnel. A description of the reporting system must be included in the SWPPP.
- **Copy of Permit.** A copy of the permit language and the confirmation letter received from the NOI processing center must be included with the SWPPP.
- **Certification.** The SWPPP must be signed and certified by the ranking officer of the installation, such as the commander or his or her duly authorized representative (an individual or a position). The representative is only duly authorized if the ranking officer documents it in writing and provides this letter to the permitting authority.

The SWPPP, along with the permit language, will help the environmental staff at a DoD facility evaluate the proper monitoring requirements for their storm water. Information collected while developing the SWPPP will help the on-site environmental staff choose the storm water monitoring locations and identify the pollutants that can be reasonably expected in storm water runoff. Information in the storm water permit provided by the control authority will help the environmental staff determine the types of monitoring that must be conducted to verify compliance (e.g., visual observations, sampling) and the frequency of monitoring.

7.3.2. Compliance Monitoring at Industrial Sites

Storm water regulated by the Phase I and Phase II rules are typically generated by either industrial or construction activities at DoD facilities. Industrial activities are identified by specific Standard Industrial Classification (SIC) codes. Other operations with no designated SIC code, such as landfills or hazardous waste treatment storage and disposal facilities, require permitting if other additional industrial activities occur at the facility are permitted. Although there is no specific SIC code that applies to all DoD facilities, the Phase I regulations state that EPA intends to address DoD facilities engaged in industrial activities as "federal facilities that meet the description of the facilities listed in the regulation" (53 FR 49416, 49432; 07 December 1988).

Table 7-1 lists some of the industrial-type activities common at DoD facilities that may require storm water permitting and possibly compliance sampling.

Table 7-1. Potential Industrial Activities at DoD Installations with Storm Water Considerations

Industrial Activity at DoD Installations	Phase I Industrial Classification	Classification Under 2000 MSGP	Chemical Sampling[a]	Additional SWPPP Reqs.[b]
Motor Pools	**(viii) Transportation facilities.** Only if related to another regulated industrial activity at the facility.	Although motor pools alone are not considered Sector P with regard to monitoring requirements, they are still considered an industrial activity and must be covered by the SWPPP if any other industrial activity requires the facility to obtain a Phase I permit.	Yes	No
Airfields	**(viii) Transportation facilities.** Only if maintenance, cleaning, or deicing activities occur.	Sector S. Installation needs permit coverage if aircraft maintenance, equipment cleaning, or deicing occurs – regardless of amount of fluid used. Deicing areas include runways, taxiways, ramps, gates, and areas where planes are deiced. Sector monitoring requirements do not apply if installation uses < 100,000 gallons of glycol-based fluid per year, or < 100 lbs. of urea/yr.	Yes	Yes
Wastewater Treatment Plants	**(ix) Treatment works**. Design flow > 1.0 million gallons per day (MGD) or are required to have an approved pretreatment program.	Sector T, Treatment Works. Applies only if unit has design flow > 1.0 MGD or is required to have an approved pretreatment program.	No	Yes
Hazardous Waste TSDFs	**(iv) Hazardous waste.** Only for facilities requiring a RCRA permit.	Sector K. Only if installation has a RCRA permit. This includes hazardous waste landfills.	Yes	No
Open Burn/Open Detonation Sites	**(iv) Hazardous waste.** Only if RCRA permitted facility.	Sector K. Only if the installation has a RCRA permit.	Yes	No
Department of Logistics Terminals/ Loading Facilities	**(xi) Light industry.**	None.	No	No
Tech Shops with Electroplating Operations	**(i) Facilities subject to effluent limitation guidelines.**	Sector AA. Produces plated ware or fabricated metal products, except for electrical-related, machinery, and transportation equipment.	Yes	Yes
Tech Shops with Metal Fabrication Operations	**(xi) Light industry.**	Sector AA. See above.	Yes	Yes
Ammunition/Ordnance Production Operations	**(xi) Light industry.**	Sector AA. See above.	Yes	Yes
Missile & Missile Parts Production	**(xi) Light industry.**	Sector AB. Produces industrial and commercial machinery or transportation equipment.	No	Yes
Aircraft Parts Fabrication	**(xi) Light industry.** If not associated with an airfield, or **(viii) Transportation**. If associated with an airfield.	Sector AB. If not associated with an airfield, or Sector S if associated with an airfield.	No	Yes
Tech Shops with Electrical	**(xi) Light industry.**	Sector AC.	No	No

Industrial Activity at DoD Installations	Phase I Industrial Classification	Classification Under 2000 MSGP	Chemical Sampling[a]	Additional SWPPP Reqs.[b]
Component/ Equip. Production				
Steam Electric Power Generating Stations	**(vii) Steam electric power generating facilities.**	Sector O. Facilities that generate steam electric power using coal, oil, natural gas, nuclear power or dual-fuel co-generation facilities.	Yes	Yes
Operations that Print & Publish DoD or Installation Documents, Periodicals, Newspapers	**(xi) Light industry.**	Sector X.	No	Yes
Misc. Service & Repair Shops, Including Electrical Shops, Furniture, Refrigeration, & Privately Owned	**None.**	None.	N/A	N/A

[a]Chemical sampling is required only if the installation meets the definition of the SIC code.
[b]The MSGP specifies additional information that must be included in the SWPPP for these sectors.

7.4. Visual Monitoring of Storm Water from Industrial Facilities

The majority of storm water monitoring at DoD industrial facilities will be audited for structural and non-structural BMPs, visual monitoring of outfalls for dry-weather flows, and visual water quality monitoring of outfalls during storm events. Visual monitoring requirements will be outlined in either the GP or the individual permit and should be included in the SWPPP, along with the locations of BMPs and storm water outfalls, drainage patterns, and potential industrial-type pollutants that could be expected based on material storage and use at the facility.

Visual monitoring of storm water outfalls during dry weather situations are conducted to determine if there are illicit connections to storm sewers that may result in the non-permitted discharge of industrial wastewater, sanitary water, non-contact cooling waters, condensates, blow down, foundation drains (i.e., groundwater) or other types of water used at the facility. If dry-weather visual monitoring discovers flow at storm water outfalls, then visual characterization of the discharge should be recorded to help identify the source.

Some characteristics that are helpful in identifying the source of the dry-weather flow include:

- Color and odor
- Turbidity
- Temperature
- Oil sheen
- Foam
- Floating particulates (e.g., paint, plastics).

If the source of the non-permitted discharge is not identified by visual observations, then collection and analysis of grab or composite samples of the dry-weather flow may be required to identify the source. Once the source of the dry-weather flow has been identified, either the illicit connection to the storm sewer must be removed or the facility must obtain a NPDES permit for discharge from the source to surface water through the storm water outfall. Figure 7-2 is a sample checklist, reproduced from EPA's NPDES *Storm Water Sampling Guidance* that can be used for dry weather visual observations.

7.5. Collection of Storm Water Samples

Data that characterize storm water discharge are valuable to permitting authorities and the permit-

ted facility for several reasons. First, storm water sampling provides a means for evaluating the environmental risk of the storm water discharge by identifying the types and amounts of pollutants present. Evaluating these data helps determine the relative potential for the storm water discharge to contribute to water quality impacts or water quality standard violations. In addition, storm water sampling data can be used to identify potential sources of pollutants. These sources can then be either eliminated or controlled more specifically by the permit.

Industrial group or individual permitees that are required to collect samples must follow specific storm event criteria to ensure the analytical results are representative. EPA's criteria for sampling a storm event are listed below:

- The storm must result in > 0.1 inch accumulation
- The storm must be preceded by 72 hours of dry weather
- Where feasible, the depth of rain and duration of the event should not vary by more than 50 percent from the average depth and duration.

These criteria were established to: 1) ensure that adequate flow would be discharged; 2) allow for build-up of pollutants during dry weather intervals; and 3) ensure that the storm would be representative, i.e., typical for the area in terms of intensity, depth and duration. Data collected from the storm event may include the following:

- Total discharge volume
- Rainfall duration
- Maximum flow rate
- Rainfall amount
- Method of flow measurement (or estimate)
- Time from the last date that 0.1 inches of rain fell
- Date of the storm event.

Storm water samples should be taken at a storm water point source. A point source is defined as any discernible, confined, and discrete conveyance, including (but not limited to) any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel, or other floating craft from which pollutants are or may be discharged (as per 40 CFR 122.2). Included in the definition of storm water "point source" is storm water from an industrial facility that enters, and is discharged through a municipal separate storm sewer. In short, most storm water discharges can be defined as point source discharges, since they ultimately flow into some form of conveyance such as a channel or swale.

Industrial facilities with a general permit or individual permit that requires compliance sampling are usually required to collect and analyze a grab sample taken within the first 30 minutes of a storm event and flow-weighted composite samples from each of the industrial storm water point source outfalls identified in the Storm Water Pollution Prevention Plan (SWPPP). If possible, all outfalls should be sampled during the same representative storm event. The descriptions of each storm event and the outfalls sampled must be recorded.

7.5.1. Sampling Locations

The ideal sampling location would be the lowest point in the drainage area where a conveyance discharges storm water to waters of the United States or to a municipal storm sewer system. This sample point should also be easily accessible on foot in a location that will not cause hazardous sampling conditions. Ideally, the sampling site should be on the applicant's property or within the municipality's easement. If not, the field personnel should obtain permission from the owner of the property where the discharge outfall is located. Typical sampling locations may include the discharge at the end of a pipe, a ditch, or a channel, however, logistical problems with sample locations may arise (e.g., nonpoint discharges, inaccessibility of discharge point, etc.). Logistical problems with sample locations and suggested solutions are described in Figure 7-3 . In many cases, it may be necessary to locate the sampling point further upstream of the discharge point, such as in a manhole or inlet. If the storm water at a selected location is not representative of a facility's total

runoff, the facility may have to sample at several locations to best characterize the total runoff from the site. In situations where discharge points are difficult to sample, the permitted facility should take the best sample possible and explain the conditions in the documentation maintained with the SWPPP.

7.5.2. Staffing Considerations

Staffing needs for sampling must be determined by the permitted facility. Factors in making the determination include the number of sample locations, the size of the area to be sampled, how far apart the locations are, the type of sampling required, the technique to be used, the number of samples to be taken (depending on how many parameters must be analyzed), and safety considerations. Sampling training is important to the success of storm water discharge characterization. Sampling conducted by untrained personnel may result in data that is unrepresentative of the individual facilities storm water discharge. This data may be rejected by a permitting authority, which would then require another sampling effort.

Figure 7-2. Checklist for Conducting Dry Weather Evaluations

1. Date of Inspection: _____
2. Facility name and address: _____
3. End Date of last rain event: _____
4. Inspector name: _____
5. Type of outfall
   □ Concrete □ Pipe □ Grassed
   □ Rock □ Other
6. Is there viable flow from the pipe?
   □ Yes □ No
   If yes, check all that apply. If no, go to number 7.
   - □ Colored water (describe) _____
   - □ Odor* (describe) _____
   - □ Murky
   - □ Floating objects (describe) _____
   - □ Absence of plant life surrounding conveyance
   - □ Scum
   - □ Oily sheen
   - □ Sludge present
   - □ Clear water
   - □ Stains on conveyance
   - □ Notable difference in plant life surrounding conveyance
   - □ Suds □ Other: _____

   *e.g., rotten eggs, earthy, chemical, chlorine, soap, putrescence, gasoline, musty, etc.

   Estimate the flow either visually or by describing the width, height, and shape of the conveyance and the approximate percentage of the conveyance where flow is present or the approximate depth of the flow. Describe your estimate.
7. Is there standing water present?
   □ Yes □ No
   If yes, check all that apply. If no, go to number 8.
   - □ Colored water (describe) _____
   - □ Odor* (describe) _____
   - □ Murky
   - □ Floating objects (describe) _____
   - □ Absence of plant life surrounding conveyance
   - □ Suds
   - □ Oily sheen
   - □ Sludge present
   - □ Clear water
   - □ Stains on conveyance
   - □ Notable difference in plant life surrounding conveyance
   - □ Scum □ Other: _____

   *e.g., rotten eggs, earthy, chemical, chlorine, soap, putrescence, gasoline, musty, etc.
8. From the inspection locations, can you see any unusual piping or ditches that drain to the storm water conveyance?
   □ Yes □ No
9. Is there any overload flow visible from the discharge location? □ Yes □ No
10. Are there dead animals present?
    □ Yes □ No

Signature:

Figure 7-3. Solutions to Sampling Location Problems

Problem:	Sampling where storm water commingles with process or non-process water.
Solution:	Attempt to sample the storm water discharge before it mixes with the non-storm water discharge. If this is not possible, sample the discharge during dry and wet weather and present both sets of data to the permitting authority. This will provide an indication of the contribution of pollutants from each source.
Problem:	Numerous small point discharges.
Solution:	Impound channel or join flow by building a weir or digging a ditch to collect discharge at a low point for sampling purposes. This artificial collection point should be lined with plastic to prevent infiltration and/or high levels of sediment. Or, sample at several locations to represent total site runoff.
Problem:	Inaccessible discharge point, such as underwater discharges or unreachable discharges (e.g., out of a cliff).
Solution:	Go up the pipe to sample, i.e., to the nearest manhole or inspection point. If these are not available, tap into the pipe or sample at several locations to best represent total site runoff.
Problem:	Managing multiple sampling sites to collect grab samples during the first 30 minutes (industrial facilities only).
Solution:	Have a sampling crew ready for mobilization when forecasts indicate that a representative storm will occur, or sample several different representative events. For most parameters, automatic samplers may also be used to collect samples within the first 30 minutes triggered by the amount of rainfall, the depth of flow, flow volume or time.
Problem:	Commingling of parking lot runoff with discharge associated with industrial activity.
Solution:	The combined runoff must be sampled at the discharge point as near as possible to the receiving water or the parking lot drain inlet if there is one.
Problem:	Sampling in manholes.
Solution:	Sample in manholes only when necessary, as this requires training on confined space entry.
Problem:	Run-on from other property.
Solution:	If possible, estimate the volume of off-site run-on contributions and off-site run-on sources of pollutants to perform a mass balance calculation. Include this information in the permit application. If this estimation is not possible, provide a narrative discussion of the upstream site (e.g., is it developed, if so the type of facility, the types of pollutants that may be present on the site, etc.).

7.5.3. Sample Type: Grab and Composite Storm Water Samples

Because of the variable nature of storm water flows during a rainfall event and different analytical considerations for certain pollutants, the storm water regulations establish specific requirements for sample collection techniques. To comply with storm water requirements, the sample type (grab or composite) must be collected in accordance with 40 CFR 122.21(g)(7) and 40 CFR Part 136. Definitions of grab and composite storm water samples are listed below.

- **Grab Sample.** A grab sample is a discrete, individual sample taken within a short period of time, usually < 15 minutes. Analysis of grab samples characterizes the quality of a storm water discharge at the given time of the discharge.
- **Composite Sample.** A composite sample is a mixed or combined sample that is formed by combining a series of individual and discrete samples of specific volumes at specified intervals. Although these intervals can be time-weighted or flow-weighted, the storm water regulations require the collection of flow-weighted composite samples. This means that discrete aliquots or samples are collected and combined in proportion to flow volume rather than time. Composite samples characterize the quality of a storm water discharge over a longer time period, such as the duration of a storm event. Flow-weighted composite samples must be collected during the first 3 hours of discharge or the entire discharge (if it is < 3 hours) for industrial facilities.

Storm water permits clearly specify which pollutants must be analyzed by grab sample and which by composite sample. Although the requirements in 40 CFR 122.21(g)(7) do not explicitly specify either manual or automatic sampling techniques, the approved analytical methods contained in 40 CFR Part 136 direct that grab samples must be manually collected for certain pollutants. Table 7-2 provides a list of the typical pollutants that are required for storm water permit compliance,

and the type of sample (grab or composite) that must be collected. The actual list of pollutants for each facility will be included in the storm water permit. The advantages and disadvantages of using manual versus automatic sampling techniques for storm water samples are provided in Table 7-3.

7.5.4. Storm Water Sampling from Retention Ponds

If storm water from a facility discharges after flowing through a retention pond or other treatment system, sample as the storm water flows out at the discharge point. Ponds may hold storm water for a time before discharge begins. Sample within the first hour, preferably 30 minutes from when the pond begins to discharge.

Retention ponds with greater than a 24-hour holding time for a representative storm event may be sampled by grab sample. Composite sampling may not be necessary. The rationale for this is because the water is held for at least 24 hours, a thorough mixing can occur within the pond. Therefore, a single grab sample of the effluent from the discharge of the pond may represent a composite of the storm water contained in the pond. However, if the pond does not thoroughly mix the discharge, thereby compositing the sample, then a regular grab and a composite sample taken at multiple times should be taken at the inflow to the pond. Since each pond will vary in its capability to composite the water, permittees must carefully evaluate whether the pond is thoroughly mixing the discharge.

Factors such as pond design and maintenance are important in making this evaluation. For example, poor pond design, where the outfall and inflow points are too closely positioned, can cause short-circuiting and inadequate mixing. In addition, poor maintenance may lead to excessive re-suspension of any deposited silt and sediment during heavy inflows.

Because of these factors, the permittee should determine the best location to sample the pond (e.g., at the outfall, at the outfall structure, or in the pond) to ensure that a representative storm water sample is taken. If adequate compositing does not occur within the pond, the permittee should conduct routine grab and flow-weighted composite sampling.

Table 7-2. Typical Storm Water Pollutants, Possible Analytical Methods, and Sample Collection Techniques

Storm Water Pollutant	Possible Analytical Method	Sample Technique
pH	Field measurement	Grab
Temperature	Field measurement	Grab
Oil and Grease	EPA 1664	Grab
TSS	EPA 160	Flow-Weighted Composite
BOD_5	EPA 405	Flow-Weighted Composite
COD	EPA 410	Flow-Weighted Composite
Nitrate and Nitrite Nitrogen	EPA 353	Flow-Weighted Composite
Ammonia Nitrogen	EPA 350	Flow-Weighted Composite
Fecal Coliform	Standard Methods 9222	Grab
Fecal Streptococcus	Standard Methods 9230	Grab
Total Phosphorous	EPA 365	Flow-Weighted Composite
Priority Metals	EPA 200, 200, 200, and 245 (Mercury Only)	Flow-Weighted Composite
Total Cyanide	EPA 335	Flow-Weighted Composite
Total Phenolics	EPA 420	Flow-Weighted Composite
VOCs	EPA 1624	Grab
SVOCs	EPA 1625	Flow-Weighted Composite
Pesticides	EPA 1657	Flow-Weighted Composite

Table 7-3. Comparison of Manual and Automatic Sampling Techniques for Collection of Storm Water Samples

Sampling Technique	Advantages	Disadvantages
Manual Grabs	Appropriate for all pollutants Minimum equipment required	Labor intensive Environment possibly dangerous to field personnel May be difficult to get personnel and equipment to the storm water outfall within the 30 minute requirement Potential for human error
Manual Flow-Weighted Composites (multiple grabs)	Appropriate for all pollutants Minimum equipment required	Labor-intensive Environment possibly dangerous to field personnel Human error may have significant impact on sample representativeness Requires flow measurements taken during sampling
Automatic Grab Samplers	Minimizes labor requirements Reduced risk of human error Reduced personnel exposure to unsafe conditions Sampling may be triggered remotely or initiated according to present conditions	Samples collected for oil and grease (O&G) may not be representative Automatic samplers cannot collect samples for VOCs analysis Costly if numerous sampling sites require the purchase of equipment Requires equipment installation and maintenance Requires operator training May not be appropriate for pH and temperature measurement May not be appropriate for parameters with short holding times (e.g., fecal streptococcus, fecal coliform chlorine)

Sampling Technique	Advantages	Disadvantages
		Cross-contamination of aliquot if tubing/bottles not properly washed
Automatic Flow-Weighted Composite Samplers	Minimizes labor requirements Reduced risk of human error Reduced personnel exposure to unsafe conditions May eliminate the need for manual compositing of aliquots Sampling may be triggered remotely or initiated according to on-site conditions	Not acceptable for VOCs sampling Costly if numerous sampling sites require the purchase of equipment Requires equipment installation and maintenance, may malfunction Requires initial operator training Requires accurate flow measurement equipment tied to sampler Cross-contamination of aliquot if tubing and bottles not properly washed

7.6. Obtaining Flow Data

In addition to collecting samples of storm water discharges, permittees must collect data characterizing the flow rate and flow volume for each storm water discharge sampled. Flow rate is the quantity of storm water discharged from an outfall per unit of time. Total flow is a measure of the total volume of storm water runoff discharged during a rain event. Flow rate and volume either can be measured specifically or can be estimated, based on rainfall measurements, velocities, and depth of flows. To collect flow-weighted composite samples, flow rate data is necessary to combine proportional volumes of individually collected aliquots. Permittees must also report the mass of pollutants contained in storm water discharges. To determine mass loadings of pollutants, applicants must measure both discharge flow rate and pollutant concentration. This section presents methods for obtaining flow data.

7.6.1. Measuring Flow Rates

Flow rates for storm water discharges are most accurately measured using primary flow measuring devices such as weirs, simple flumes, and Palmer-Bowlus flumes. Weirs consist of a crest located across the width of an open channel (located at a right angle to the direction of the flow). The flow of water is impeded, causing water to overflow the crest. Weirs are inexpensive and particularly valuable in measuring flow in natural or manmade swales because they are easily installed in irregular shaped channels. When flow exceeds the capacity of the weir and water overtops the weir crest, flow depth actually diminishes as the water approaches the weir and flows cannot be measured accurately. Figure 7-4 is a diagram of a weir system showing the method to calculate flow through a weir.

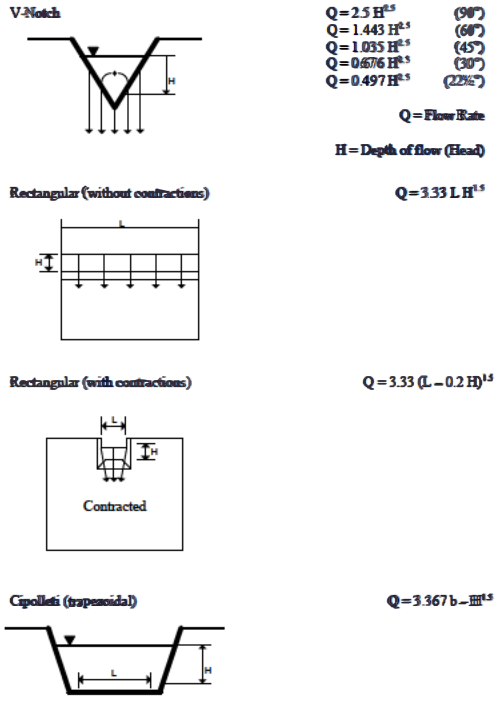
Flumes are structures that force water through a narrow channel. They consist of a converging section, a throat, and a diverging section. Figure 7-5 is a diagram of a flume and flow rates through the flume. Flumes have fixed specifications relating to geometric shape; they vary only in throat width. Due to these geometric constraints, flumes may be expensive to install. They typically are used in permanent flow measurement points and are most commonly placed in concrete-lined channels. However, flumes can also be used in temporary points. Flumes can provide accurate measurements for a relatively wide range of flow rates.

Palmer-Bowlus flumes are also used for flow measurement at some facilities. Palmer-Bowlus flumes are designed for installation in an existing circular channel (e.g., a manhole channel) and are available as portable measurement devices. Figure 7-6 is a diagram of a Palmer-Bowlus flume flow measurement system. While Palmer-Bowlus flumes are inexpensive, self cleaning, and easy to install, they can only measure accurately over a narrow range of flow rates. The flow from a Palmer-Bowlus flume is calculated using the height between the floor of the flume portion and the water level, not the total head of the water level.

Where flow measurement devices are not already installed, portable devices should be considered.

There are many permanent and portable types of flow measurement devices available. Proper analysis of site discharge conditions must be conducted prior to purchase and implementation of these devices.

Figure 7-4. Weirs



Source: Civil Engineering Reference Manual, 5th Edition, by Michael R. Lindeburg, PE, with permission from the publisher, Professional Publications, Inc., Belmont, California, 1989.

Figure 7-5. Flumes

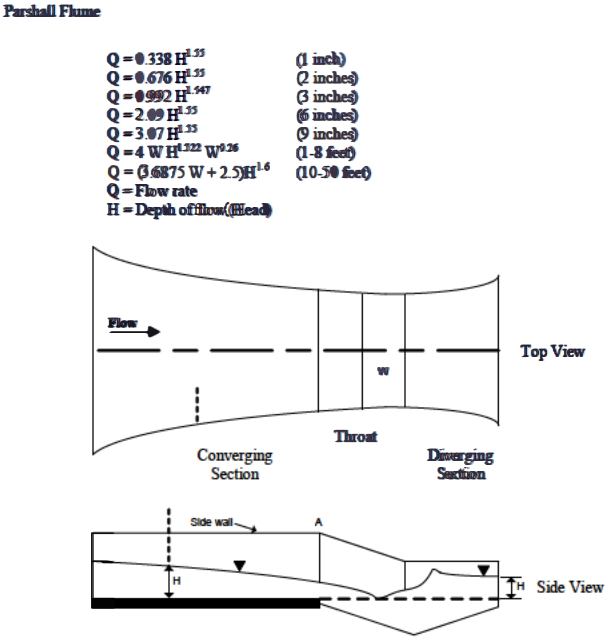


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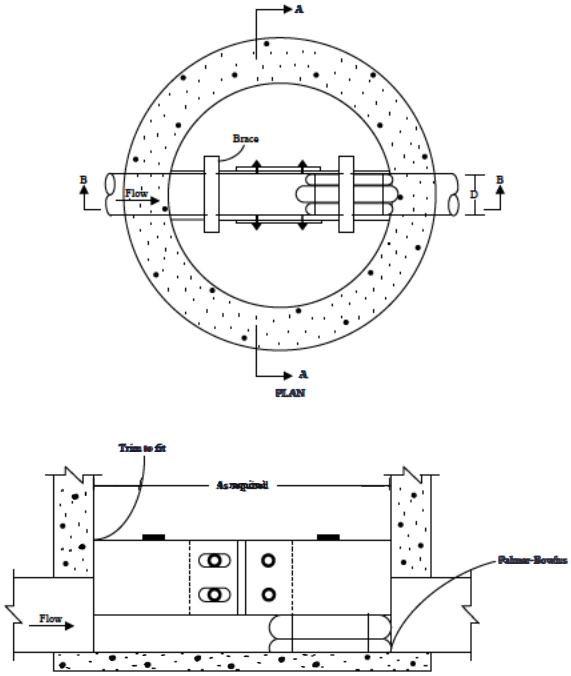
Figure 7-6. Palmer-Bowlus Flume



Source: Wastewater Engineering: Treatment, Disposal, Reuse. 2nd Edition, Metcalf & Eddy, Inc., with permission from the publisher, McGraw-Hill Book Co., New York, 1979.

7.7. Compliance Monitoring at Construction Sites

CGPs may require that a visual inspection program be implemented to periodically evaluate the integrity of the BMPs and visually observe and note the condition of storm water leaving the construction site. CGPs may also require that a SAP be developed and conducted for pollutants which:

- Are not visually detectable in storm water discharges
- Are known to occur on the construction site
- Could cause or contribute to an exceedance of water quality objectives in the receiving water.

Pollutants that should be considered for inclusion in the sampling and analysis strategy are those identified during development of the SWPPP. The CGP requires that the SWPPP identify a strategy for conducting the sampling and analysis, including the frequency and location(s) at which sampling will be conducted. Sampling for non-visibly detectable pollutants is usually required under the following two conditions:

- Visual inspections, currently required before, during, and after storm events, indicate that there has been a breach, malfunction, leakage, or spill from a structural BMP that could result in the discharge of pollutants in storm water and the pollutants would not be visually detectable
- Storm water encounters soil amendments, other exposed materials, or site contamination that is discharged at a location off of the construction site.

A sample of uncontaminated (background) storm water from the site must be collected for comparison with the sample(s) collected from storm water suspected of containing construction-related pollutants. The CGP may also state that the SWPPP needs to describe the sampling procedure, location, and rationale for obtaining the uncontaminated sample of storm water.

7.7.1. "Known or Should Be Known Pollutants" at Construction Sites

Pollutants can be considered "known" or "should be known" to occur on the construction site if they are currently in use or are present because of previous land uses. These may include the following materials:

- Used in the construction activities
- Stored on the construction site
- Spilled during construction operations and not cleaned up
- Stored or used in a manner that presented the potential for a release of the materials during past land use activities
- Spilled during previous land use activities and not cleaned up
- Applied to the soil as part of past land use activities.

Construction material inventories and the project SWPPP should provide adequate information on materials currently in use or proposed for use on the construction site. Dischargers should review existing environmental and real estate documentation to determine the potential for pollutants to exist on the construction site because of past land use activities. Potential sources of information for previously existing contamination and past land uses include environmental assessments, initial studies, environmental impact reports or environmental impact statements prepared under the requirements of NEPA, and Phase 1 assessments prepared for property transfers. In some instances, the results of soil chemical analyses may be available and can provide additional information on potential contamination.

7.7.2. Deciding When Sampling Is Required at Construction Sites

All construction projects must ensure that proper inspections are conducted throughout the duration of the project to make sure that appropriate BMPs have been implemented, are being maintained, and are effective in preventing potential pollutants from coming in contact with storm water and causing or contributing to an exceedance of water quality objectives in the receiving waters.

The frequency of sampling for non-visible pollutants must be determined based on the exposure of pollutant sources. Runoff only needs to be sampled when there is exposure of a pollutant source to storm water that enters a storm drain or surface water. Inspections of material storage areas that identify a non-structural or structural BMP failure that exposes potential non-visible pollutants to storm water that runs off the construction site will trigger a requirement for sampling and analysis. If spills are cleaned up and the contaminated material is isolated, eliminating exposure to storm water runoff, then sampling is not necessary. For instances when the potential for previously existing contamination is identified, it may be appropriate to conduct screening analysis during the first one or two storm events of the season to determine if the potential contaminant is running off the construction site. Figure 7-7 provides a flow chart to help determine when sampling and analysis is required.

7.7.3. When Sampling and Analysis May Not Be Required at Construction Sites

Sampling and analysis is typically not required under the following conditions:

- Where a construction project is "self-contained," meaning that the project generates no runoff or any potential runoff discharges containing pollutants, or pollutants can be totally contained within the construction project site without discharging to a water body or storm drain system
- Where construction materials and compounds are kept or used so that they are not in contact with storm water (e.g., in water-tight containers, under a water-tight roof, inside a building, etc.)
- Where for specific pollutants, the BMPs implemented at the construction site fully contain the exposed pollutants (e.g., bermed concrete washout area)
- For building materials that are in their final constructed form or are designed for exposure (e.g., fence materials, support structures and equipment that will remain exposed at the completion of the project, etc.)
- Where pollutants may have been spilled or released on site, but have been properly cleaned up and storm water exposure has been eliminated prior to a storm event
- For stockpiles of construction materials for which both cover and containment BMPs have been properly implemented to protect them from run-on and from contributing pollutants to storm water runoff.

However, a contingency sampling strategy should be prepared in the event of an incidental discharge. The SWPPP should also describe why sampling and analysis is not expected to be needed.

7.7.4. When Sampling and Analysis May Be Required at the Construction Site

Sampling and analysis is required when non-visible pollutants have the potential to contact storm water and run off the construction site into a storm drainage system or water body. Examples of this situation follow:

- Where construction materials and compounds are stored or used such that they may encounter storm water
- For construction projects that utilize soil amendments that can encounter storm water runoff. (If independent test data are available that demonstrate acceptable concentration levels, sampling and analysis may not be required. Contact the appropriate regulatory authority to determine acceptable concentration(s) of the material(s) in question.)
- When a leak or spill occurs prior to a storm event and is not fully contained and cleaned up
- When a leak or spill occurs during a storm event and cannot immediately be isolated or cleaned up, and the possibility of an off-site discharge exists
- When, during regular inspections of stockpiles, it is discovered that cover and containment BMPs have been compromised and storm water encounters the stockpiled materials resulting in runoff discharging into a storm drain system or water body

- When material storage BMPs have been compromised, breached, or have failed. If determined that sampling is needed, storm water runoff samples must be collected regardless of the time of year, status of the construction site, or day of the week. Samples should be collected during the first 3 hours of runoff. Storm water inspections and sample collections are required even during weekends or holidays.

A list of potential pollutants must be developed based on a review of potential sources from the SWPPP. It should include construction related materials, soil amendments, and historic contaminants. Identify from this list those pollutants that are not visibly detectable. These constituents will likely require sampling and analysis of runoff if the materials are exposed to storm water. Consult with an analytical laboratory or water quality chemist to determine if there are field tests or indicator parameters that can be used. Table 7-4 is a list of typical construction materials that might cause non-visible contamination of runoff if exposed to storm water.

7.7.5. Deciding Where to Sample at a Construction Site

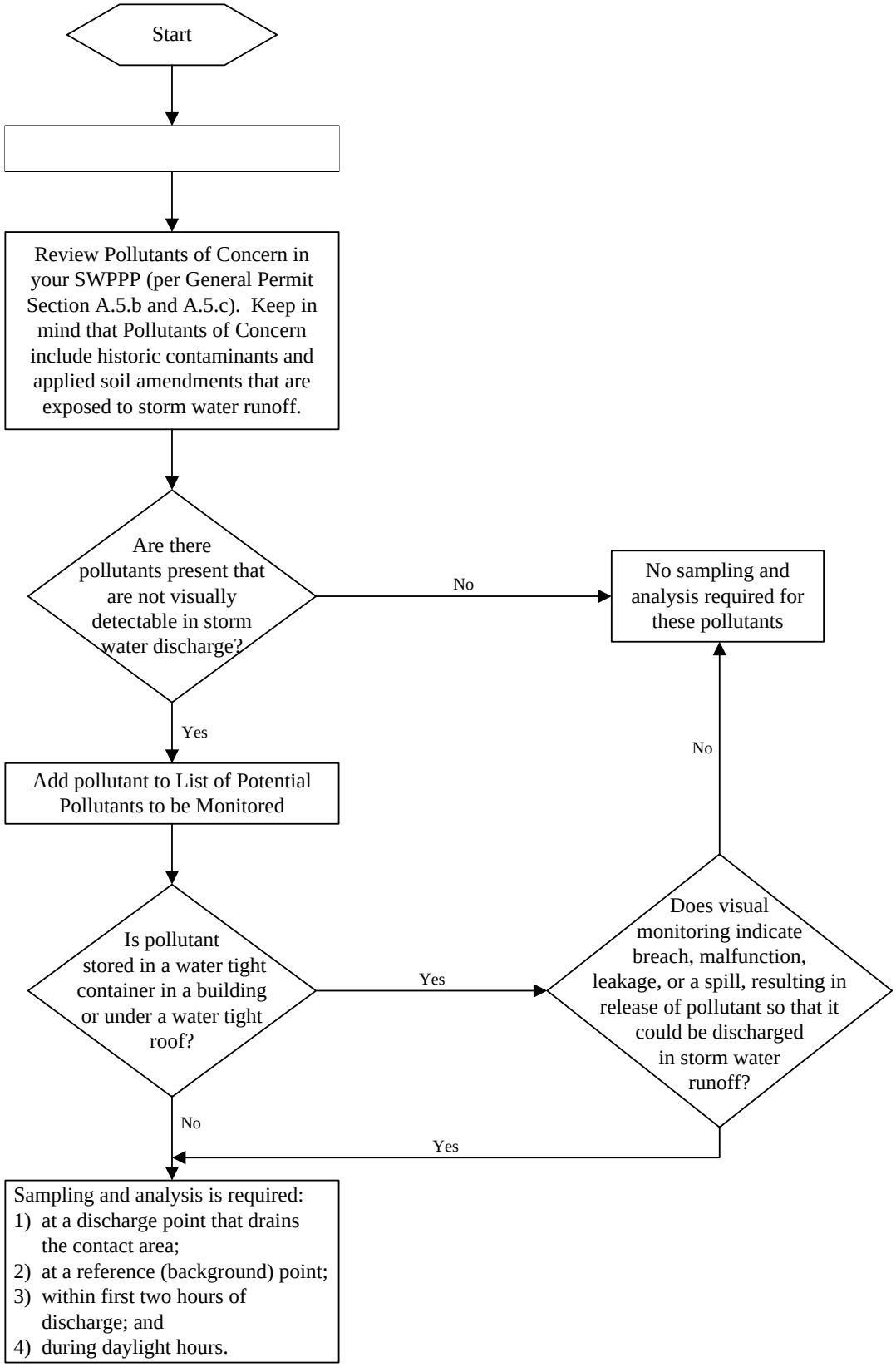
Sampling locations must be identified that provide information on both the runoff quality that is affected by material storage, historic contamination or other exposed potential pollutants, and the background runoff quality (i.e., uncontaminated sample). Material storage may be confined to a small area of the project site while historic contamination or exposed materials such as soil amendments, may be widely spread throughout the construction site. For this reason, the sampling locations identified for these two types of potential pollutants may be different.

Samples must be collected at locations identified in the SWPPP or areas identified by visual observations or inspections where there has been a structural BMP failure or breach that can be safely accessed. A location that is not affected by material storage activities or by runoff from material storage areas should be selected as a background or reference sampling location for collecting the uncontaminated runoff sample. For a widely spread potential contaminant, sampling locations may need to be selected at the perimeter of the site, where storm water enters (unaffected by site activities) and leaves (affected by site activities).

Table 7-4. List of Common Potential Non-Visible Pollutants

Category	Potential Pollutant Source	Field Indicator of Pollutant Release	Laboratory Analysis
Line Flushing	Chlorinated water	Colorimetric kit	Residual chlorine
Portable Toilets	Bacteria, disinfectants	N/A	Total/fecal coliform
Concrete & Masonry	Acid wash	pH meter	pH
	Curing compounds	pH meter	pH, alkalinity, VOCs
	Concrete rinse water	pH meter	pH
Painting	Resins	N/A	SVOCs
	Thinners	N/A	VOCs
	Paint strippers	N/A	VOCs
	Solvents	N/A	VOCs
	Adhesives	Phenols kit	Phenols, SVOCs
	Sealants	N/A	SVOCs
Cleaning	Detergents	Colorimetric kit	Surfactants, phosphates
	Bleaches	Colorimetric kit	Residual chlorine
	Solvents	N/A	VOCs
Landscaping	Pesticides/herbicides	N/A	Check with analytical laboratory
	Fertilizers	N/A	Nitrate, ammonia, phosphorous
	Lime and gypsum	pH meter	Acidity/alkalinity
	Aluminum sulfate, sulfur	pH meter	TDS, alkalinity
Treated Wood	Copper, arsenic, selenium	Metals test kits may be available	Metals
Soil Amendments & Dust Control	Lime, gypsum	pH meter	pH
	Plant gums	N/A	BOD
	Magnesium chloride	N/A	Alkalinity, TDS
	Calcium chloride	N/A	Alkalinity, TDS
	Natural brines	N/A	Alkalinity, TDS
	Lignosulfonates	N/A	Alkalinity, TDS

Figure 7-7. Decision Diagram to Determine When Construction Storm Water Sampling is Necessary



7.7.6. Collection of Construction Storm Water Samples

The conditions for collection of storm water samples from construction sites are similar to those outlined in Section 7.3.2 for industrial sites. For instance, characteristics of the storm event must be appropriate, e.g., accumulation depth, representative storm, etc., and the sample collection methods must adequately characterize the discharge. On-site environmental personnel responsible for storm water management at DoD construction sites should consult their CGP or the local permitting authority to determine specific sampling requirements.

The collection and handling of storm water runoff samples requires special care to ensure the integrity and validity of the samples. A COC form must follow the sample from the collection through the analysis process to document appropriate control of the sample prior to analysis. Additional documentation to track other information of interest, (e.g., field conditions or required field measurements) should be recorded on a field tracking form. Every sample must be collected with care to ensure that the sample is representative of the runoff being tested, collected in the right kind of container, preserved by chemical additives, and kept cold in accordance with the test method's specifications, until delivered to an analytical laboratory. Some types of samples have very short holding times and must be analyzed before this holding time is exceeded. Sample handling requirements and documentation form the basis of your sampling QA program. More details regarding QA planning are provided in Chapter 2 of this handbook.

Before starting any sampling program, contact the analytical laboratory that will analyze the storm water samples. Make sure to select a laboratory that will provide the technical support that is needed, such as properly cleaned and preserved sampling containers and COC forms. Some laboratories can assist in identifying courier services available to transport samples to the laboratory. All these details need to be planned in advance of sample collection. The analytical laboratory should also be consulted on requirements for additional samples to be collected for QA/QC purposes.

Both field and/or analytical analysis methods can be used to meet the permit requirements. Field techniques have the advantage of providing immediate results. However, there are only a limited number of analyses that can be conducted in the field. Some constituents (e.g., pH) can be evaluated in the field with special equipment. Field samples must be collected and analyzed according to the specifications of the manufacturer of the sampling devices employed. Field equipment must be used by trained staff, and the equipment must be calibrated and maintained according to the manufacturer's specifications.

7.7.7. Coupling Visual Observations with Sampling Results

If visual inspection of non-structural and structural storm water BMPs used to contain non-visible pollutants at a construction site indicates that a BMP has failed or been compromised, then field monitoring of the storm water for non-visible pollutants is required. Of course, any structural BMP that has been visually inspected and found breached or compromised should be immediately repaired or replaced. The intent of conducting field monitoring for non-visible pollutants is to obtain an immediate indication if storm water that is discharging from a site has been contaminated. An immediate indication of a polluted discharge requires an immediate response in the form of back tracking from the point of discharge to find the source and take appropriate measures to prevent a recurrence of a polluted discharge. If at all feasible, the contaminated discharge should be contained and prevented from being discharged off site. After taking steps to correct the failed non-structural or structural BMP, it is advisable that field monitoring be conducted to verify that pollutants are no longer in the storm water.

7.7.8. Retention of Data

Results of field measurements and laboratory analyses must be kept in the SWPPP, which is required to be kept on the project site until the Notice of Termination (NOT) is filed and approved by the appropriate control authority. It is also recommended that field training logs, COC forms, and other documentation relating to sampling and analysis be kept with the project's SWPPP. The GP requires that records of all inspections, compliance certifications, and noncompliance reporting must be retained for a period of at least 3 years from the date generated or after project completion, whichever is greater . Also note that continual monitoring of the non-structural and structural BMPs is required until the NOT has been filed and approved.

7.8. Storm Water Sampling Equipment

Automated storm water sampling and flow measurement equipment is available for a variety of situations. This equipment is designed to operate with little or no operator attention, eliminating the expense of mobilizing sampling teams during storm events. Site environmental personnel tasked with storm water sampling are encouraged to discuss their specific site conditions with equipment vendors to be certain the correct equipment is purchased.

7.9. Hazards and Safety Pre-Warnings

A project-specific HASP should be prepared for each planned storm water sampling event. Section 2.4 discusses preparation of project-specific HASPs for all types of planned sampling activities. Since storm water sampling is conducted during poor weather conditions, the following specific health and safety issues related to storm water sampling need to be considered:

- Hazardous weather conditions (e.g., wind, lightning, flooding, etc.)
- Sampling in confined spaces such as manholes
- Hazards associated with chemicals
- Biological hazards such as rodents and snakes
- Physical hazards (e.g., traffic, falling objects, sharp edges, slippery footing, and the potential for lifting injuries from opening or removing access panels and manhole covers, etc.).

It is essential that sampling personnel be aware of these hazards. Sampling personnel should be trained to evaluate potentially hazardous situations and develop ways for handling them. Since sampling hazards can be life threatening, safety must be the highest priority for all storm water sampling personnel.

7.10. QA/QC

If the permit does not contain adequate sampling information, a SAP should be prepared for collection of storm water samples at DoD industrial facilities and construction sites. Chapter 2 discusses development of SAPs. In general, the storm water SAP will document the planned activities for storm water data collection and will provide a project-specific blueprint for obtaining the storm water samples needed to verify compliance with the permit conditions. In general, the SAP will document the following:

- What samples are desired
- How, where, and when the samples are to be collected
- Required sample size, containers, and preservation
- Required sampling documentation, distribution, and storage
- The turnaround times as required by the permit or regulation
- Where samples are to be sent for analysis
- Analytical QA/QC samples
- Sample disposal.

The SAP provides an in depth description of the policies, organization, sampling activities, and QC procedures necessary for achieving project objectives. QC procedures are described in detail to ensure a high level of quality in the collection and analysis of the data and the

handling of samples. Major elements in the SAP include:

- Title and approval page
- Distribution list
- Project organization
- Project overview and schedule
- Project quality objectives and measurement performance criteria
- Sample collection, documentation handling, tracking and custody procedures
- QC samples
- Analytical requirements and procedures
- Data management tasks
- Assessment and response tasks.

The SAP should be prepared well in advance of the planned sampling activities to allow for approvals, laboratory coordination, and sampling personnel training and awareness.

7.11. Sampling Equipment List

Section 3.8 provides a generic sampling equipment list applicable to most sampling events. The following list provides additional specific equipment applicable to storm water sampling:

- Map of sampling location(s)
- Sampling SOP
- FLB/FN
- Pen(s)
- Containers
- Preservatives
- Labels
- Markers
- Coolers
- Ice
- Packing Material
- Packaging Tape
- COC form
- Custody seals (if required)
- Decontamination storage containers, equipment, and materials
- Personal safety equipment, safety test equipment
- Field screening or testing equipment, standards, reagents, and SOP
- Testing Field Forms or Logbooks.

Chapter 8. Groundwater Sampling

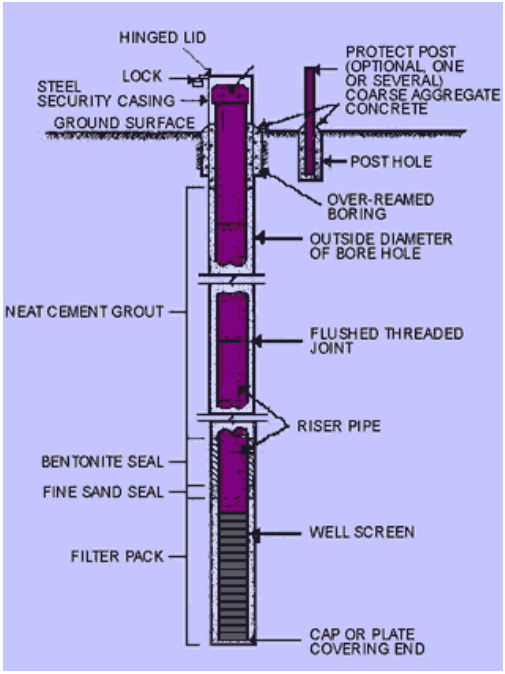
8.1. Purpose

This chapter provides procedures for obtaining representative samples of groundwater.

8.2. Scope

Groundwater monitoring wells, underground injection wells, and industrial wells are the potential sources of groundwater samples. This chapter includes the minimum criteria to be followed to obtain representative samples. Variations from these criteria should be necessary only when required by regulatory practices (e.g., state-specific requirements) or site historical data gathering practices. Analytical data derived from samples obtained in a way that does not follow the documented sampling plan should not be accepted. For construction and design of groundwater monitoring wells, refer to ASTM D5092-04, *Standard Practice for Design and Installation of Groundwater Monitoring Wells*. Figure 8-1 displays a diagram of a typical groundwater monitoring well.

Figure 8-1. Diagram of a Typical Monitoring Well



Source: Natural Resources Conservation Service.

8.3. Project Planning

This section provides an overview of the planning process for conducting a groundwater sampling program. Included in this section is a discussion of sampling strategy, development of a site-specific SAP, and QA considerations.

Before groundwater sampling begins, clear and concise objectives must be developed regarding the intent of the sampling. The objectives provide the framework for developing a sampling strategy for the site and preparing the SAP. Some common objectives of groundwater sampling might include verifying that pollutants are not migrating off site, defining the vertical and horizontal extent of pollutant concentrations from a known source, or evaluating the progress of groundwater remedial activities. Once the objectives are established, a sampling strategy can be developed.

8.3.1. Sampling Strategy

The sampling strategy is designed around the objectives and should utilize the conceptual site model. The model takes into consideration historical site use, known or suspected pollutant releases, and site geology and hydrogeology. The conceptual site model is dynamic and is constantly revised as new information is collected and processed. The model focuses on contaminant fate and transport processes, the control of geologic materials on the contaminant pathways (e.g., depositional environments, geologic structure, soil characteristics), the types of contaminants present (hydrophobic versus hydrophilic), and the processes that influence the concentrations of contaminants present such as dilution, biodegradation, and dispersion. More information on conceptual site models can be found in Chapter 2 of this handbook.

8.3.2. Site-Specific SAP

Groundwater sampling should collect a representative sample of the current groundwater conditions over a known or specified volume of aquifer. Procedures that minimize disturbance to the aquifer will yield the most representative

groundwater samples. The development of a site-specific SAP is the first step toward collecting a representative groundwater sample. Each SAP is an instruction manual for field personnel and should be built around the objectives and sampling strategy. See Chapter 2 for a detailed discussion of SAP development applicable to all sampling programs. The discussion below focuses on SAP development for groundwater sampling programs specifically.

The SAP should consider a variety of factors, including site hydrogeology, the condition and accessibility of monitoring wells, suspected pollutants, DQOs, analytical methods and detection limits, the groundwater collection method, sample handling procedures (e.g., filtration, preservation requirements, COC), and safety.

The SAP cannot be implemented effectively if field personnel do not understand its contents. Many times the primary reason that groundwater sampling events are problematic is that the person preparing the SAP is not the person in the field. One method that alleviates this problem is assigning a Sampling Team Leader who is responsible for all activities in the field. The Sampling Team Leader will work closely with those individuals preparing the SAP to understand fully the objectives of the project. The Sampling Team Leader is responsible for all individuals in the field. If required, he or she also is responsible for providing additional training to field personnel before fieldwork begins.

8.3.3. QA

Groundwater monitoring programs encompass a variety of information sources and include both primary and secondary data collection. These data sources are used to continuously update the conceptual site model and allow Site Managers to make decisions regarding further investigation, additional monitoring, remediation alternatives, or site closure.

The level of data quality for each groundwater monitoring program, and many times for each specific sampling event, depends on the intended use of the data. For example, the level of QA/QC needed for groundwater samples that are collected on a monthly basis to monitor the progress of remedial activities may be different from that for groundwater samples collected because of an enforcement action. It is important to remember, regardless of the level of QA/QC for any groundwater sampling, that sample integrity be maintained during sample collection. Laboratory analysis, no matter how sophisticated, is representative only if the sample supplied to the analyst has retained its integrity. During ongoing groundwater monitoring studies, consistency of sampling is crucial to the interpretation of the data over the year or years.

To determine the level of quality required for each groundwater sampling event, Site Managers and those responsible for data integrity should begin with a systematic planning process that helps define the DQOs. The DQOs clarify the study objective, define the most appropriate type of data to collect, determine the most appropriate conditions for data collection, and specify tolerable error limits on decisions that will be used as the basis for establishing the quantity and quality of data needed to support the decision. Detailed information on QA/QC, including the systematic planning process, development of DQOs, and preparation of SAPs, is available in Chapter 2 of this handbook.

QA/QC related specifically to groundwater monitoring programs can be categorized into the following four areas:

1. Use of secondary data for preparation of the conceptual site model
2. Impacts of sampling equipment and well construction materials on sample integrity
3. Equipment decontamination, and
4. Collection of QC samples.

8.3.3.1. Secondary Data

Secondary data are those data collected in addition to sampling data. For a groundwater sampling program, secondary data may include items such as historical records regarding site use, spills, and corrective actions on neighboring properties; current and historical subsurface

utility maps; locations of previous above-ground and below-ground structures; possible disposal areas; and areas containing fill materials or other antidotal agents. These data aid the site manager in selecting groundwater sampling locations or determining possible pollutants.

For secondary data, acceptance criteria are used in place of the measurement performance criteria typically used for laboratory data. In general, acceptance criteria are used to assess secondary data adequacy and evaluate uncertainty in the results derived from the use of secondary data sources. For example, the Project Manager for the groundwater monitoring program may require interviews of former employees to validate the location of disposal areas found on historical site maps. In this case, the acceptance criteria are the verbal confirmation of the disposal areas by the former employees. The SAP for each groundwater monitoring project will explain the acceptance criteria for determining which sources of data are sufficient to support the project objectives.

8.3.3.2. Equipment Specifications for QC

The materials used for constructing groundwater sampling equipment are critical to the collection of valid monitoring data, particularly when volatile organic, pH-sensitive, or valence-reduced chemical constituents are being evaluated. The construction materials that come into contact with the sample are as critical as the composition of the laboratory sample containers. The recommended materials for bailers, pump parts, tubing, other sampling devices, and associated apparatuses in decreasing order of preference are as follows: Teflon®, stainless steel 316, stainless steel 304, polypropylene, linear polyethylene, polyvinyl chloride (PVC), Viton®, and conventional polyethylene.

Most regulatory programs require that bailers be constructed of Teflon® or stainless steel. Additionally, any other devices contacting the water to be sampled should be constructed of Teflon® or stainless steel. Exceptions to this requirement should be confirmed and approved by the regulatory program having project oversight authority. Tubing used in well evacuation may consist of materials other than Teflon®, but this tubing may not be used for sample collection. Tubing should be dedicated for use in each individual well for that particular sampling event.

8.3.3.3. Equipment Decontamination

Decontamination of existing and new equipment is required prior to use in the field. Section 8.5.3 describes decontamination procedures for various types of groundwater sampling equipment. These procedures must be followed to prevent cross-contamination between sites and within the site. Equipment field blanks may be collected at the start and end of the sampling event to determine the cleanliness of the sampling devices and evaluate the cleaning techniques used in the field. Decontamination procedures for all equipment that contacts groundwater must be included in the SAP.

8.3.3.4. QC Samples

In an attempt to identify external variables affecting groundwater sample integrity, a program of QC blanks should be initiated. For volatile parameters, the QC blank sample program is a two-track approach using both a trip and a field blank. The trip blank acts as a check on potential contamination sources in the sample container, method blank water (including preservative), and sample transport and storage. The field blank acts as a check on the cleanliness of the sampling equipment, potential atmospheric contamination, and the effects of sampling procedures such as preservation on the analytes of interest. Complete documentation on the sources of these materials will assist with any problem solving.

Equipment field blanks may be collected at the start and end of the sampling event to determine the cleanliness of the sampling devices and evaluate the cleaning techniques used in the field.

Trip blanks, field blanks, and rinsate blanks typically are prepared with metal-free and organic-free water purchased from a chemical supply company or provided by the laboratory that is performing chemical analyses on the groundwater samples.

Field duplicates or splits are collected in the field in double the number of bottles required for the regular sample. A duplicate sample is collected concurrently, under comparable conditions, with a first sample. Duplicate samples are QC samples that are used to assess data repeatability based on field conditions. Split samples are two or more representative portions taken from one sample in the field or in the laboratory and analyzed by different analysts or laboratories. Split samples are QC samples that are used to assess analytical variability and comparability. Samples sent to the same laboratory are duplicates, and samples sent to a different laboratory are splits. Both duplicate samples and split samples shall be field homogenized and shipped to the laboratories as blind samples. Duplicate samples provide a total precision of field sampling precision and lab analysis. Analytical data from these samples will determine field precision (duplicate) or project precision (split).

Field spikes are prepared in compliance with permit or regulatory requirements. Field spikes determine field accuracy or laboratory accuracy. To prepare a field spike, a known amount of contaminant is placed or spiked into the sample in the field. Samples and spikes are handled in the same manner. Field spikes help to assess analytical method performance and contaminant deterioration or degradation during sample handling, transport, and analysis.

8.4. Hazards and Safety Precautions

The HASP should address all anticipated hazards for each task. The following discussion contains common (and commonly overlooked) hazards associated with groundwater sampling activities. Refer to Chapter 2 for specific hazard identification techniques and detailed control measures.

8.4.1. General Safety

Some of the general safety hazards associated with groundwater sampling programs include the following:

- Moving sampling equipment and containers across rough terrain either by hand or by driving off road
- Conflicts with other uses of the area, such as traffic conflicts when sampling next to roads
- Sampling from deep sampling monitoring wells or open holes using hand-held sampling equipment.

8.4.2. Subsurface Hazards

Groundwater sampling, particularly monitoring well installation, is an intrusive activity that could expose sampling personnel to unidentified subsurface hazards, as discussed below.

8.4.2.1. Buried Munitions

If the probability of encountering buried munitions during the sampling program is moderate to high, a RESS waiver from the relevant explosives safety authority may be required prior to disturbing the site. In addition, a qualified explosives safety expert will be required to accompany the investigation team. See DoD TP18 for the minimum qualifications for unexploded ordnance technicians and personnel. The site should be checked by qualified personnel with ground-penetrating radar and/or metal detectors before any samples are collected. Only trained and certified personnel should handle or sample explosive or suspected explosive materials.

8.4.2.2. Buried Utilities

The use of in situ groundwater sampling probes to install monitoring wells can damage buried utilities, including electrical and telephone lines and gas, steam, water, and industrial pipelines. Facility records should be reviewed carefully to identify any buried utilities in the sampling area. The site should be checked with ground-penetrating radar and/or metal detectors if there is any question as to the presence of subsurface utilities.

8.4.2.3. Toxic Chemicals

Collecting groundwater samples poses the risk of exposure to hazardous chemicals. The following major exposure scenarios should be evaluated.

- **Skin Contact with Contaminated Water.** Taking groundwater samples using hand-held samplers usually results in the requirement to handle wet equipment that can drip and splash.

Decontamination of sampling equipment also can result in splashes of contaminated water. Field sampling and decontamination personnel should wear waterproof rain gear or coated Tyvek® coveralls if there is a possibility of contact with contaminated water.

- **Ingestion of Contaminated Water.** Ingestion can occur when food or drink is exposed to contaminated water or is picked up with contaminated gloves. Field personnel should not eat, smoke, or chew gum or tobacco when working with contaminated water. Drinking water should be kept in closed squirt bottles or should be stored outside the contaminated area.
- **Inhalation of Toxic Vapors**. The exposure of contaminated water to ambient air may generate toxic vapors from the evaporation of VOCs. The HASP should establish air-monitoring requirements for intrusive work and specify what air monitoring equipment be used and the criteria for the use of respirators. Either air-purifying respirators or supplied-air respirators may be required, depending on the toxicity of the chemicals present, the capabilities of the monitoring equipment, and the warning properties of the vapors.
- **Confined Space Hazards.** In general, wells more than 4 feet deep are considered confined spaces. However, any well installed in contaminated soil or water should be considered a confined space, because flammable vapors or toxic gases, including hydrogen cyanide and hydrogen sulfide, could accumulate. All applicable confined space entry requirements should be imposed and detailed in the HASP.

WARNING: Care should be taken to avoid breathing in vapors that may escape from the well.

8.5. Field Preparation

The key to any successful field sampling program is preparation. This section describes the preparations that should be made prior to personnel entering the field to conduct a groundwater sampling event.

8.5.1. Access and Identification

Access to monitoring wells may be difficult, and the wells themselves hard to locate in the field. The Field Team Leader responsible for the groundwater sampling should obtain recent well location maps prior to the sampling event. In addition, because access to some locations may require permission from current owners or operators of the site, the Field Team Leader should contact the site owner or operator in advance of each sampling event to obtain access and inform those individuals responsible for the site that groundwater sampling is scheduled. Monitoring wells usually have a friction cap or a screw cap and should be locked. Therefore, keys to unlock the wells and tools for removing caps often are necessary.

If several monitoring wells must be sampled, proper identification of each well is essential. The well permit number or any other assigned number should be known. If numbers are not assigned, a precise field description of each well location will avoid confusion of the sample results. When several monitoring wells of known or suspected contamination will be sampled, the least-contaminated well should be sampled first. Subsequent samples then should be collected from wells in an ascending order of contamination. Well head readings using PIDs or FIDs can aid in determining the order in which wells should be sampled by providing information on contamination levels.

8.5.2. Sampling Equipment Selection

The equipment used for specific groundwater sampling events can vary greatly, depending on the following factors:

- Type of well
- Depth of well
- Diameter of well casing
- Depth to water
- Contaminants likely to be encountered
- Analytes of interest
- Length of open hole (bedrock well)
- Type, slot size, and length of screen

- Expected recharge rate of well.

The equipment required for groundwater sampling generally falls into two categories: 1) equipment used to evacuate water in the well casing, i.e., well development, and 2) equipment used to collect a discrete sample for analysis. However, in some instances, the device used for evacuation may be the same as that used for sample collection.

8.5.2.1. Field Measurement Equipment

Prior to well evacuation, groundwater level measurements are made in each groundwater monitoring well. If either floating or settled organic phases are expected in the groundwater, the thickness of these phases also should be measured. The equipment typically used to measure groundwater levels includes the following:

- Electronic tape that signals to the user when the water level is reached
- A hydrocarbon interface probe affixed to an electronic tape to measure the depth to either the floating or the settled organic phase, and the thickness of the phase.

8.5.2.2. Well Evacuation Equipment

Evacuation or purging of the water column in a monitoring well is required prior to sample collection to remove the standing water column and induce groundwater flow from the surrounding formation into the well. One exception to this standard procedure is if the objective of the sampling event is to determine the presence of dense or light non-aqueous phase liquids or stagnant water. The following types of pumps are available for well purging:

- Suction lift pump/centrifugal pump
- Portable submersible pump
- Peristaltic pump
- Air lift pump
- Bladder pump (gas squeeze pump)
- Packer pump
- Gas piston pump
- Gas displacement pump
- Inertial pump.

8.5.2.3. Sample Collection Equipment

The types of equipment available for groundwater sample collection include the following:

- Bottom fill bailer (single or double check valve)
- Peristaltic pump
- Bladder pump
- Packer pump
- Inertial pump
- Syringe sampler
- Disposable equipment.

Site-specific sampling conditions will dictate the optimal sampling equipment. Generally, sampling equipment that minimizes agitation, air content, gas exchange, and depressurization is preferred.

A list of additional sample collection equipment is provided at the end of this chapter.

8.5.3. Equipment Cleaning and Decontamination

For each sampling event, all field measurement and sampling equipment that will enter the well must be cleaned prior to its entry. Field measurement equipment, such as water level indicators, should be cleaned in the following manner:

1. Wipe with a paper towel to remove visual debris
2. Wash with tap water and a laboratory-grade glassware detergent
3. Rinse with tap water
4. Perform an ASTM Type II water rinse.

Sampling equipment should be cleaned using documented cleaning procedures. The sampling equipment then should be wrapped in clean foil and dedicated to a specific well for the day's sampling. The sampling equipment should remain wrapped in this manner until immediately prior to use. Additionally, bailers and sample bottles must be physically separated from pumps and generators during transport and storage. Pumps and equipment not amenable to precleaning should be field-cleaned using documented cleaning procedures. Down-hole devices

such as water level indicators should not be transported in a vehicle storing gasoline or gasoline powered equipment or other volatile contaminants such as degreasers, cleaning solvents, and other volatile organics.

8.6. Sampling Monitoring Wells

This section describes the procedures for sampling monitoring wells. It describes collection of field measurements, well evacuation procedures, and groundwater sampling procedures.

8.6.1. Field Measurements

CAUTION: Be certain that the proper well is being selected. The misidentification of a sampling point in the field will result in data that may adversely affect important decisions.

8.6.1.1. Physical Measurements

Once a well has been located and properly identified, note the field measurements listed below in the FLB/FN.

- Diameter of protective outer casing
- Security and integrity of the well
- Well number and well permit number
- Inner diameter and construction material of inner well casing
- Total depth of well from the top of the inner casing or surveyor's mark, if present (measured to 0.01 foot, or as appropriate).

8.6.1.2. Water Level Measurements

Well depths and water table depths can be determined using various measuring devices. A commonly used device is the electronic water level indicator. This unit has a tape divided into incremental measurements of 0.01 feet and two conductors forming a probe. When groundwater is encountered, the circuit is completed causing a signal (e.g., light, meter, or audible buzzer) to activate. The depth to groundwater is then measured from this point to the reference mark on the inner casing of the monitoring well.

Water indicator paste or gel acts as a colorimetric test method when the paste comes into contact with water. It is applied to the bottom few feet of a measuring tape or rod. The tape or rod is then lowered into the well and remains for less than 1 minute. The wetted tape/stick gives the depth to the top of the liquid and the color change section indicates the depth to water. This procedure is accurate to ± 0.02 feet.

Wells with a non-aqueous phase liquid layer on the surface pose a problem when measuring the level of groundwater. A more accurate and easier device to use is the interface probe. This probe uses an optical sensor to determine if the probe is in liquid, and a conductivity sensor to determine if the probe is in water. When using this probe, each phase can be measured independently. The hydrocarbon/air interface reading should be taken first, going down from the air to the hydrocarbon surface to prevent any dripping hydrocarbons from enhancing the thickness reading. The hydrocarbon/water reading is best taken going up from the water to the hydrocarbon layer to prevent hydrocarbons from coating the conductivity probe, which also would enhance the hydrocarbon thickness reading. Prior to taking the hydrocarbon/water reading, the probe should be lowered quickly through the hydrocarbon layer, minimizing the contact time of the probe in the hydrocarbon phase.

The key to accurate readings by any method is proper collection of measurements from the same survey point, preferably by the same person and tape to avoid any procedural differences. Each reading should be made three to four times. All well measurements should be performed the same day and prior to evacuation of any wells that could influence groundwater elevations in the area of investigation.

Water level elevation equipment should be properly decontaminated to avoid cross-contamination. In certain circumstances, sensitive components of an interface probe may be compromised by the use of standard decontamination solvents. The manufacturer's specifications for decontaminating interface probes should be consulted before using any solvent.

For each water level measurement, the following data should be recorded in the FLB/FN:

- Depth from casing top to water (recorded to 0.01 foot, or as appropriate)
- Thickness of floating product, if any
- Calculation of the linear feet of water in well by subtracting the depth to water from the total depth of well.

Note: Water levels should be obtained from all wells prior to purging and sampling the first well, thus avoiding interference problems. This procedure also allows personnel to determine if any well is damaged or may pose a problem for sampling.

Using the physical measurements and water level measurements, the amount of water within the entire well casing can be calculated by multiplying the linear feet of water by the volume per foot for the proper diameter casing.

Table 8-1. Volume of Water per Linear Foot in Various Casing Sizes

Casing Diameter (foot)	Gallons/Linear foot
2 inch (0.1667)	0.1632
4 inch (0.3333)	0.6528
6 inch (0.5000)	1.4688
8 inch (0.6667)	2.6112
10 inch (0.8333)	4.0800
12 inch (1.0000)	5.8752

Example:

Total depth of well casing:	100 ft.
Depth to water:	-20 ft.
Linear feet of water:	80 ft.
2-inch casing:	x 0.1632
Amount of water in casing:	13 gal.

Table 8-1 above shows the volume of water per linear foot of various casing sizes (inner diameter) of monitoring wells.

The amount of water in the casing then should be multiplied by three to determine the minimum volume to be purged from the well prior to sample collection. The total volume purged should not exceed five times the amount of standing water in the well.

Alternatively, the following formula can be used to determine the number of gallons in any diameter well:

Number of gallons = $5.8752 \times C^2 \times H$

where: C = casing diameter in feet

H = height of water column in feet

8.6.1.3. Physio-Chemical Parameters

Information including specific conductance, pH, temperature, DO, oxidation-reduction potential, and turbidity may be recorded during well purging and before and after sample collection.

In some cases, additional physio-chemical analyses may be required to support the engineering of future or current treatment processes. Samples for these purposes are often collected for analysis of common cations (Na^+, K^+, Ca^{+2}, and Mg^{+2}) and anions (CO_3^{-2}, SO_4^-2, Cl^-, and NO_3^-), dissolved iron and manganese, TDS, TSS, TOC, and dissolved carbon. These are common and inexpensive analyses.

8.6.2. Well Development and Purging

Well development and well purging are two similar operations that are conducted to ensure that groundwater from a surrounding formation flows into the monitoring well for sampling. Each of these operations is discussed in the following subsections.

8.6.2.1. Well Development

Well development typically is performed shortly after construction of the monitoring well to ensure that free-flowing groundwater will enter the monitoring well. Well development also is designed to provide removal of the following:

- Drilling fluid residues remaining in the bore hole or surrounding aquifer
- Imported drilling water lost to the aquifer during the drilling procedure
- Groundwater in the bore hole or surrounding aquifer that has been affected by the drilling process or drilling or well construction materials.

As well as:

- Restoration of the hydraulic properties of the formation immediately surrounding the monitoring well.

The length of time for groundwater conditions to become representative (stabilization period) at and near the monitoring well will vary depending on site hydrogeologic conditions, drilling methods, and monitoring well development methods. Groundwater flow velocities are typically less than 1 foot per day, and natural flushing rates are generally slow. If a monitoring well is drilled, installed, and developed so that a 14-foot radius around the well was left as unrepresentative, and a natural groundwater flow rate was 1 foot per day, it would take 14 days for representative groundwater to reach the well. Sampling a monitoring well immediately after development generally will not be representative of the static groundwater quality conditions at the horizontal and vertical location of the monitoring well intake interval. Therefore, all newly constructed and developed monitoring wells should be allowed to stabilize and equalize with the aquifer for a minimum of 2 weeks prior to sampling.

The installation and construction of monitoring wells may alter the quality of groundwater in the surrounding aquifer. Site-specific subsurface conditions should be used to determine the appropriate well development techniques. Many times, a combination of the techniques discussed below will be necessary to produce a properly developed monitoring well. Also discussed below are certain outcomes inherent to well development techniques that can be mitigated by following the 14-day stabilization period:

- High velocity air jetting, air lift, or surge block development methods may introduce air into the aquifer surrounding the monitoring well. This air has the potential for altering groundwater quality, particularly for VOCs.
- Over-pumping of a monitoring well for development may draw groundwater to the monitoring well from considerable distances. This water may not be representative of the horizontal and vertical location of the monitoring well, especially so for isotropic and/or bedrock aquifers.
- Organic drilling fluid residues and inorganic residues of bentonite have been found to remain in and near wells, even after proper development. These residues have been found to affect water quality, including the chemical oxygen demand of groundwater samples, for up to 100 days after completion of development.
- Non-aqueous phase liquid contaminants may be pushed away or drawn to a monitoring well location during development, depending on the development method, resulting in non-representative groundwater samples.
- Suspended sediment not completely removed by development and not allowed to settle out may affect the quality of groundwater samples obtained from the well. Therefore, a period of time is required to allow a sand/gravel pack to settle around a monitoring well screen.

Groundwater pollution investigations often base expensive site-related investigatory and remedial action decisions on initial (first sampling event after development) groundwater sample analyses. Therefore, before groundwater samples are collected, a complete understanding of the design, construction, and hydrogeologic setting of the monitoring well is necessary to interpret properly any analytical results.

8.6.2.2. Well Purging

It is generally accepted that water in the well casing is non-representative of the formation water and should be purged prior to collection of groundwater samples. Monitoring well purging is a procedure that draws fresh groundwater from the surrounding formation into the well immediately prior to sample collection. Wells are purged to some extent for the following reasons:

- The presence of the air interface at the top of the water column results in an oxygen concentration gradient with depth
- Loss of volatiles up the water column
- Leaching from or sorption to the casing or filter pack

- Chemical changes due to clay seals or backfill
- Surface infiltration.

Many methods may be used for well purging. Not all are acceptable under all conditions. The selection of a method is usually dictated by the depth to water and local agency requirements. The preferred and most commonly used methods involve the use of a centrifugal or peristaltic pump (when the depth to water is < 25 feet) and a submersible pump (when the depth to water is > 25 feet).

It is important to ensure that the purging procedure or equipment does not cause cross-contamination from one well to the next. Therefore, the preferred method employs dedicated tubing (new dedicated linear polyethylene ASTM drinking water grade) and pumps. Because it may not be practical to dedicate a pump to a specific well, it is permissible to decontaminate this equipment between wells. Methods for decontamination should be specified in the site-specific SAP.

Prior to purging, check the well for floating product. During purging, the pump intake or tubing should be kept at a maximum distance of 6 feet below the water level to prevent disturbance of sediment on the bottom of the well. The pump intake or tubing should be lowered as the water level decreases to maintain this distance and ensure sufficient distance from the air/water interface. In instances where the total depth of standing water in the well casing is less than 6 feet, begin purging near the top of the water column and lower the tubing as stated above. Following this procedure, Field Sampling Personnel should ensure that all static water is removed prior to sampling.

Note: The disposal or discharge of floating product or hydrocarbons, and the discharge of highly contaminated water, may require special purge water collection and disposal procedures.

Regardless of the purging procedure used, the evacuation rate should not exceed that of well development. Such an exceedance would cause a "redevelopment" of the well, resulting in a turbid sample. Cleaned equipment entering the well should not be allowed to contact the ground or any other potentially contaminated surfaces such as gasoline pumps. If contact should occur, the item should not be placed in the well or used for evacuation.

The following information should be recorded in the FLB/FN for each monitoring well sampled:

Before Purging

- Date, time, and weather conditions
- Well number and permit number
- PID or FID reading taken from the well immediately after the cap is removed
- Presence and thickness of free product
- pH, DO, temperature, and specific conductivity
- Total depth of well from the top of inner casing or surveyors mark if present
- Depth from the top of inner casing to the top of screen
- Depth from the top of inner casing to water
- Estimated water volume in well.

After Purging

- Start and end time purging
- Purge method
- Purge rate(s)
- Total volume purged
- pH, DO, temperature, and specific conductivity.

After Sampling

- Start and end time for sampling
- pH, DO, temperature, and specific conductivity
- Sampling method.

Any field observations made during the groundwater sampling event (e.g., slow recharge, turbidity, odor, sheens, and PID or FID readings) also should be reported.

Air-sensitive parameters such as DO, pH, temperature, and specific conductance are best analyzed with the use of a flow-through cell, eliminating sample exposure to air. However, monitoring of these air-sensitive parameters for well

stability may not be a reliable indicator of when to collect a representative sample. Therefore, if a constant monitor is not used during well purging, a sample should be collected within 2 hours after 3 – 5 volumes of water have been purged from the well. The volume evacuated and the evacuation rate should be recorded after each purge and sample event, and repeated for subsequent sampling events. This procedure should provide consistent samples from each well.

Every reasonable effort should be made to keep pumping rates low to avoid over-pumping or pumping the well to dryness. Pump rates may be adjusted and pumping times extended to remove the required three to five well volumes. Sampling should never occur more than 24 hours after purging. To avoid altering the hydrogeologic properties of the aquifer near the well, the evacuation rate of a monitoring well should not exceed that of the development of the well.

In some situations, evacuation of 3 – 5 volumes may be impractical in wells with slow recoveries. If a well has been pumped to near dryness at a rate of less than 0.5 gallons per minute, the well should be allowed to recover to a volume sufficient for sampling. If necessary, sampling within the 2-hour limit may be exceeded to allow the well to recover sufficiently for sampling. If a well has been pumped to dryness, a minimum of 20 minutes of waiting time is required prior to sampling, or follow regulatory requirements.

There are several reasons why the well should not be pumped below the level at which the groundwater enters the well. In certain formations, water entering the well at the top of the screened area will fall into the pumped dry well. This cascading effect may aerate the groundwater to be sampled, thus resulting in the loss of VOCs. Secondly, pumping to dryness can cause dehydration of the saturated zone; again, VOCs may be lost due to aeration within this zone. Additionally, other contaminants may absorb to formation materials where a dehydrated zone is created. As a result, samples collected upon the recharge of a well pumped to dryness may not correctly characterize groundwater quality.

Another problem with excessive purging is the entrainment of soils and other solids from the formation into the well. Soils may contain either metals or hydrophobic organic compounds that become entrained into the well, resulting in an overestimation of certain analytes. Soil particles can be filtered from the sample; however, filtration may remove potentially mobile (contaminant-associated) constituents, resulting in artificially low concentrations. One method to reduce entrainment of soil and other particulates into the well is by using low-flow purging and sampling techniques.

8.6.2.3. Low-Flow Sampling and Purging

The term “low-flow” refers to the pumping rate during purging and sampling, which affects both the velocity that is imparted to the formation pore water in the immediate vicinity of the well screen, and drawdown of the water level in the well. When performed correctly, low-flow sampling collects water from the formation surrounding the screen and avoids collecting stagnant water from any blank casing above the screen. Low-flow purging and sampling reduces the effects of the sampling on the system being sampled.

If little or no information about the groundwater system is known, the pump intake may be set at or near the middle of the well screen. However, if available, knowledge of the well-specific hydrogeology, boring logs, well construction, and well location relative to the lateral and vertical contaminant distribution in the formation should be considered when placing the pump intake. The source of water moving into the screened interval of the well under pumping conditions is strongly influenced by the hydrogeology. In wells where the screened interval intersects zones of contrasting hydraulic conductivities, the composition under steady state purging conditions will be flow-weighted in proportion to the hydraulic conductivity from any given point in the flow field.

The objective is to pump in a manner that minimizes stress (drawdown) to the system to the extent practical, while taking into account established site sampling objectives. The pumping

rate must be low enough to minimize mobilization and entrainment of particulate matter that is not mobile under non-pumping conditions. Typically, flow rates between 0.1 and 0.5 liters per minute are used; however, the selection of an appropriate flow rate is dependent on site-specific hydrogeology. Water level drawdown provides the best indication of the stress imparted by a given flow rate for a given hydrological situation. Measure the initial static water level, and then monitor the water level of the well during purging using either a continuous water-level measurement device such as a pressure transducer or bubbler, or make periodic measurements (every 1 to 2 minutes) using an electric tape or similar measuring device. If drawdown is rapid and continuous, reduce the pumping rate until drawdown stabilizes. If drawdown is very slow or imperceptible, the pumping rate can be increased. When drawdown and water-quality indicator parameters (e.g., conductivity, DO) have stabilized, sampling can begin in accordance with the site's approved sampling and analysis plan.

In general, the advantages of low-flow purging and sampling include the following:

- More representative of the mobile load of contaminants (dissolved and colloid-associated)
- Minimal disturbance of the well, thereby minimizing sampling artifacts
- Less operator variability, and greater operator control
- Reduced stress on the formation (minimal drawdown)
- Less mixing of stagnant casing water with formation water
- Reduced need for filtration
- Smaller purging volume, which decreases waste disposal costs and sampling time
- Better sample consistency, and reduced artificial sample variability.

Some disadvantages of low-flow purging include the following:

- Generally not suitable for use in low-yield wells
- Higher initial capital costs for items like a variable flow-rate pump or flow-through cell
- Greater set-up and purging time in the field
- Need to transport additional equipment to and from the site
- Increased training needs.

Even in low-yield wells, low-flow purging and sampling may be more suitable than high-flow, or purging to dryness and sampling by bailer or pump as soon as the well recovers. Aeration of the water column in a well caused by excessive drawdown or pumping a well dry can significantly alter water quality, affecting redox-sensitive metals, and causing increased turbidity and loss of volatile constituents. If a well is evacuated to dryness or below the well screen, sampling records should document the event because sample integrity may be severely altered. For very low-yield wells, or wells with severe turbidity problems, passive or no-purge sampling methods may be more appropriate and should be considered.

For additional information and more specific procedures, see ASTM D 6771, *Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Groundwater Quality Investigations*.

8.6.3. Pumps

This section provides a discussion on various pumps used for sampling groundwater.

8.6.3.1. Suction Lift Pumps/Centrifugal Pumps

Suction lift pumps (e.g., diaphragm and centrifugal pumps) are used at the ground surface with polyethylene tubing inserted into the well. They are used to evacuate the well prior to sampling. The tubing should be new, dedicated to a particular monitoring well, and equipped with a decontaminated foot check valve to avoid having aerated water from the pump spill back into the well.

If a foot check valve is not used, care should be taken to ensure that the entire pump impeller chamber is drained after use and then thoroughly decontaminated. Also, when removing tubing

without a foot check valve after evacuation, the pump should continue to operate to keep purged water remaining in the tubing and pump chamber from spilling back into the well.

The limitation posed by this type of pump is its suction capability. Generally, the water level must be within 25 feet of the ground surface.

Note: Take care to ensure that *only* ASTM Type II or better quality water that is free from chlorine residual and potential contaminants is used to prime the centrifugal pump. These pumps may be used only for well evacuation, not for groundwater sampling.

8.6.3.2. Portable Submersible Pumps

When the depth to water is greater than 25 feet, and if the diameter of the well casing will allow, a portable submersible pump should be used. The pump should be lowered carefully into the well, trailing a discharge hose, electrical cables, and a security cable constructed of approved material (e.g., single-strand stainless steel or polyethylene). The security cable should support all of the weight of the pump. Hoses and cables can be bundled together at 10-foot intervals with plastic electrician's ties or stainless steel clamps.

CAUTION: Duct or electrical tape must not be used at a level that will be submerged into the water column. It is important that the hose and electrical line be fed so they do not jam between the pump and the casing. Similarly, the hose and electrical line must be pulled up ahead of the pump during removal.

Once the end of the purged line is fitted with a gate valve in the closed position, the submersible pump should be lowered to the appropriate depth. The pump then can be turned on and the gate valve adjusted to provide the correct flow rate. During evacuation, it may be necessary to lower the pump as the static groundwater level drops.

If a portable gasoline generator is used, it should be placed downwind and at some distance away from the well so fumes from the generator will not affect sample quality. The generator should only be operated during the purging process and not during sample collection.

The pump should be fitted with dedicated tubing for the discharge of evacuation water. As with suction lift pumps, submersible pumps should be equipped with a check valve to avoid having water from the pump spill back into the well. If the same submersible pump is to be used for more than one well, then the pump should be decontaminated between well locations to ensure that no cross-contamination occurs.

Submersible pumps are susceptible to clogging. Turbid groundwater or poorly developed monitoring wells are likely to impede the evacuation process. Take care not to let the pump draw from the bottom of the well where silts and sands may be taken up by the pump.

8.6.3.3. Peristaltic Pumps

A peristaltic pump is a self-priming suction lift pump used at the ground surface. It consists of a rotor with ball bearing rollers. One end of dedicated tubing is inserted into the well. The other end is attached to a flexible tube that has been threaded around the rotor, out of the pump, and connected to a discharge tube. The liquid moves entirely within the sample tube, with no part of the pump contacting the liquid. The bottom length of tubing should be equipped with a foot check valve to avoid having water from the pump and tubing spill back into the well.

Use of a peristaltic pump for well evacuation is limited to its suction capabilities. Generally, a peristaltic pump cannot be used to evacuate wells with a depth to water of greater than 25 feet. Due to the volume present in large-diameter and high-yield wells, peristaltic pumps are not recommended.

8.6.3.4. Air Lift Pumps

Air lift pumps generally are used for well development and not for well evacuation prior to sampling. If logistics dictate that air lift pumps are the only alternative for evacuation, they should be used only for wells screened below the water table. Tubing connected to air lift pumps should be placed above the well screen because air may become trapped in the screen or filter pack. Entrapped air can alter the oxidation-reduction potential of the aquifer material around the well bore, which can affect the chemical composition

of groundwater samples. In addition, only oil-free compressors should be used.

8.6.3.5. Bladder Pumps (Gas Squeeze Pumps)

A bladder pump consists of a stainless steel cylindrical housing that encloses a flexible membrane. A screen is attached to filter any material that can clog the check valves located above and below the bladder. The pump works as follows: water enters the membrane through the lower check valve, and compressed gas is injected through a separate line to the space between the bladder and the pump housing. As the bladder is squeezed, the water in the bladder closes the lower check valve and flows through the upper check valve. As the air pressure is released, the upper check valve closes and water enters the pump through the lower check valve. The compressed gas does not come into contact with the sample water.

The bladder pump is used much like a portable submersible pump, except that no electrical lines are lowered into the well. The source of gas for the bladder is either bottled gas or an on-site oilless air compressor. Disadvantages posed by using the bladder pump include the large gas volumes needed, especially for greater depths, and the potential for bladder rupture and slow evacuation rates.

The preferred material of construction for bladder pumps and any tube, joint, or other fixture that remains in contact with the groundwater is Teflon® or stainless steel.

8.6.3.6. Packer Pumps

Packer pumps consist of two expandable bladders that, when inflated, isolate a section of the well bore between them. They deflate for vertical movement within the well. The advantage of this type of pump is that a smaller volume of water is required to be evacuated prior to sampling. Also, several zones within a single well can be sampled. The sampler must be sure the zone that is being sampled and packed is isolated from the other zones.

Packer pumps are constructed of rubber and can be used with submersible, gas lift, and suction pumps. Exposures to high-level contamination may deteriorate the rubber with time.

8.6.3.7. Gas Piston Pumps

The gas piston pump provides continuous sample withdrawal at depths greater than possible with most other methods. The pump consists of a stainless steel alternating chamber between two pistons. Pressurization of the alternating chamber activates the pistons, which allows water to enter during the suction stroke, and forces water to the surface during the pressure stroke.

8.6.3.8. Gas Displacement Pumps

Gas displacement pumps work by using gas to force water out of a discharge line. They consist of a cylinder with a check valve and two lines, an air supply line and a water discharge line, and a connection to the top. As the pump is lowered into the water, it fills by hydrostatic pressure. When air pressure is applied, the check valve seals and water is forced out of the discharge line. When the air pressure is released, the pump chamber fills and the cycle repeats.

8.6.3.9. Inertial Pumps

The inertial pump consists of a single tube or pipe with a foot check valve at one end. The check valve allows water to enter the pipe but stops it from draining out.

The pump is operated by raising and lowering the tube over a short distance with rapid strokes. The movement causes the water inside the pump to travel upward due to its inertia. The movement can be accomplished manually or with a powered unit.

The advantages of using an inertial pump are its ease of operation and low cost. However, the inertial pump has several disadvantages, which are listed below.

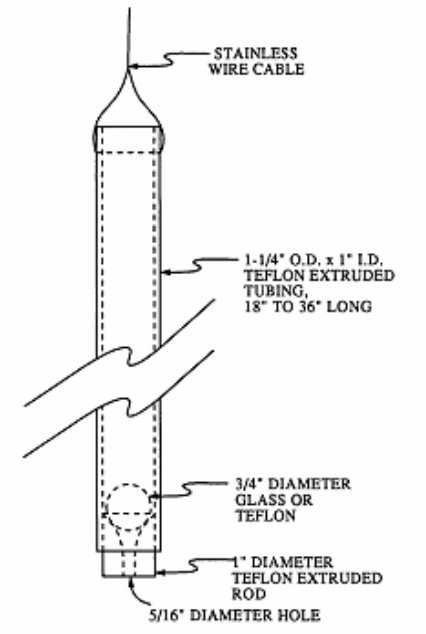
- Its manual operation is labor intensive, although mechanical advantage devices are available
- The tubing and foot assembly must be dedicated to a well
- Use in slow-recharge wells may cause the water level to drop significantly and result in

aeration of the water column during purging of the well. Conversely, the inertial pump device can be overwhelmed in a rapidly recharging well leading to insufficient evacuation of the water column.

8.6.3.10. Hand Bailing Techniques

Hand bailers come in a variety of sizes and volumes to accommodate most well casing diameters; see Figure 8-2 for an illustration of a

Figure 8-2. Bottom Fill Bailer



bottom fill bailer. Hand bailing may be conducted if no other method of evacuation can accomplish the task and the procedure is specified in the SAP. However, bailing is the least recommended procedure for well purging due to the potential for aerating the well water or possibly introducing contaminants during the bailing procedure. Bailing is the least recommended method of purging when samples are to be collected for VOC analysis. If hand bailing is the method of evacuation, it must be performed with a laboratory-cleaned and dedicated Teflon® or stainless steel bailer. An additional laboratory-cleaned and dedicated bailer is required for sample collection.

The bailer should be lowered slowly into the well, using care not to aerate the groundwater to be sampled. The preferred apparatus is a Teflon®-coated stainless steel cable attached to a low-gear-ratio winch, which is connected to a tripod standing over the well. This apparatus is preferred because it provides the most reproducible bailing method. If this apparatus is not available, the bailer may be lowered by hand using a Teflon®-coated stainless steel leader.

Note: Braided stainless steel cable is coated with manufacturing oils that make decontamination difficult. Therefore, Teflon® coated, stainless steel is required for the bailer leader since it will come into contact with the groundwater.

Take care if using stainless steel cable clamps to secure the leader to the bailer. The integrity of the Teflon® may be compromised by compression while tightening the clamps, thus exposing the braided wire. All cut ends of leaders must have an end cap to prevent exposure of the stainless steel wire.

8.6.4. Groundwater Sampling Procedures Using Monitoring Wells

After purging the required volume of water from the well, sampling can begin. If the well is a quick recharger, sampling of the well should occur immediately after evacuation. In most cases, the time lapse between evacuation and sampling should not exceed 2 hours.

If several monitoring wells must be sampled, proper identification of each well is essential. The well permit number or any other assigned number should be known. If numbers have not been assigned, a precise field description of each well location will avoid confusion of the sample results. When several monitoring wells of known or suspected contamination will be sampled, the least-contaminated well should be sampled first. Subsequent samples then should be collected from wells in ascending order of contamination. Well head readings using PIDs or FIDs can aid in determining the order in which wells should be sampled by providing information on contamination levels.

Field personnel should pay strict attention to proper decontamination procedures during groundwater sampling; see Section 8.3.3.3.

A variety of techniques and equipment (including several of the pumps discussed in Section 8.6.3) can be used to collect groundwater samples, as discussed in the following subsections. The order in which samples should be collected from each well, regardless of sampling device, is as follows:

1. VOAs
2. Purgeable organic carbons
3. Purgeable organic halogens (POXs)
4. Total organic halogens (TOXs)
5. TOC
6. Base neutrals/acid extractables
7. Oil and grease/total petroleum hydrocarbons (O&G/TPH)
8. PCBs/pesticides
9. Total metals
10. Dissolved metals
11. Phenols
12. Cyanide
13. Sulfate and chloride
14. Turbidity
15. Nitrate and ammonia
16. Preserved inorganics
17. Radionuclides
18. Non-preserved inorganics
19. Bacteria.

This collection order takes into consideration the volatilization sensitivity of groundwater samples. Additional information on the order of sample collection can be found in RCRA and the *Groundwater Monitoring Technical Enforcement Guidance Document*, September 1986.

8.6.5. Overview of Passive Groundwater Sampling in Monitor Wells

Passive groundwater sampling, sometimes called "no-purge" sampling, employs devices and techniques to obtain quantitative information about the concentrations of analytes of interest from a groundwater monitoring well under ambient flow conditions. The original suggested groundwater application was for long-term monitoring at well-characterized sites (Vroblesky, 2001); however, the depth-specific nature and other characteristics of passive samples also can make them very useful for site characterization.

Passive samplers rely on the natural movement of groundwater through the screened interval of a monitor well to sample groundwater from the adjacent aquifer. In a properly constructed and developed monitor well, water in the screened interval is constantly replaced by water from the adjacent aquifer. The screened or open interval of a well does not contain stagnant water, but rather is in constant hydraulic communication with the aquifer. The rate of exchange is driven by the natural gradient of the groundwater system, and depends on the magnitude of the gradient and hydraulic conductivity of the aquifer. The well screen and sand pack of a properly designed well have a combined hydraulic conductivity greater than that of the aquifer materials, and thus provide a preferential path that concentrates flow from the surrounding aquifer through the well bore across the screened interval. Groundwater flux through the screened interval typically is greater than flow through the immediately adjacent aquifer.

Passive samplers typically are deployed on a weighted line at a specifically chosen depth within the saturated portion of the screened or open interval of a well. Care must be taken to ensure that the sampler is placed at the selected depth within the screened interval, and that the entire sampling device remains submerged for the entire deployment period.

In contrast to samples collected using a pump or conventional rigid bailer, passive sampling has negligible effect on the ambient flow in a well, and does not alter the natural steady state conditions of the water column being sampled. Induced flow, even at low-flow rates (i.e., 200 – 500 mL/minute) may change conditions in the water column, and artificially elevate turbidity by mobilizing particles that are immobile under laminar flow in the aquifer.

8.6.5.1. Comparison of Passive Samples to Pumped Samples

Passive and pumped sample collection methods each have specific characteristics that should be considered when selecting a sampling method, and when analyzing groundwater analytical data. Passive samplers collect depth-specific samples representing a very limited depth interval (typically not more than 1 to 2 feet) of the water column in the well. They represent only the water to which the sampler is exposed under ambient flow conditions. Because passive sampling does not affect flow through the well screen by pumping, purging, or otherwise mixing the water column, passive samples represent water from a confidently known, specific depth interval in the water column.

Under ambient flow, water in the sampled interval typically is dominated by horizontal movement of water across the well screen, yielding a sample that is representative of water at that depth interval in the adjacent aquifer. However, various degrees of well-specific vertical mixing are present in the screened intervals of many wells under ambient flow. In some wells, this in-well mixing obscures the details of analyte stratification in the aquifer, though in other wells, contaminant stratification in the aquifer is clearly present in the water column of the screened interval. Passive samplers have revealed vertical concentration gradients in the well water column over intervals as short as three feet. If the screened interval intersects zones of different pressure head, vertical flow through the well will result. Water in the sampled interval will be biased toward that from the zone of higher head. In wells having a screened interval greater than 5 to 10 feet, obtaining a synoptic vertical profile of concentration by spacing multiple passive samplers in vertical series should be considered for the initial passive sampling event (Vroblesky, 2001a; ITRC, 2004). If stratified, the interval of highest concentration can be monitored subsequently using a single sampler.

Pumped samples, both low-flow and high-volume purge, collect a flow-weighted sample biased toward any zones of higher conductivity intersected by, or adjacent above or below the screened interval. Also, flow induced by pumping, even at low-flow rates, can mobilize and suspend solids that are immobile under ambient laminar flow conditions in the aquifer, thereby artificially elevating turbidity. This can result in measured concentrations being affected by the sampling process, particularly for metals. Vertical flow through the well caused by the screen intersecting zones of different head also can bias the representativeness of low-flow samples, as well as that of passive samples, particularly if net vertical flow through the well bore exceeds the purge rate (sampled water will be biased toward the source of flow). Side-by-side comparisons and historical data show that concentration results obtained by low-flow sampling most often are very similar to concentration results obtained by passive sampling (ITRC, 2007). Understanding differences that may be observed often can provide valuable insight into contaminant distribution and hydrologic characteristics of a site.

8.6.5.2. Characteristics of Passive Samples

Passive samplers:

- Represent a short, discrete interval of the water column in the screened interval of a well
- Can provide a vertical concentration gradient profile of the water column and identify whether contaminant stratification is present in the well
- Improve consistency of monitoring data over time by reducing the number of variables in sample collection such as pump intake depth, adequate duration of low-flow purging, pumping rate, etc.
- Eliminate or minimize turbidity
- Greatly reduce field equipment needs thereby facilitating sampling where access is difficult, or where discretion is desired
- Eliminate purge-water production, and costs for its handling and disposal
- Can be deployed in most monitor wells (i.e., 1-inch diameter or greater)
- Have no practical depth limit

- Allow rapid field sample collection; no time is needed for purging or set up of equipment
- With few exceptions, can remain deployed in a well for up to a year without loss of integrity, allowing the retrieval of a sample and replacement of the sampler for the next round of sampling during a single site visit.

Some of these characteristics can be either an advantage or a disadvantage, depending on sampling objectives. Many of these characteristics serve to substantially reduce field labor and equipment cost, particularly for long-term monitoring programs. Field sampling cost reduction in long-term monitoring programs is typically between 40 and 70 percent (ITRC, 2004; ITRC 2007).

8.6.5.3. Limitations of Passive Sampling

Passive samplers:

- Require time for equilibration (typically up to two weeks)
- Are inappropriate for sampling where the objective is to determine water quality from a well under pumping conditions (e.g., a drinking water production well)
- Provide limited sample volume, although minimum sample volumes actually required for a single analysis by many common analytical methods are often substantially less than those routinely requested by the laboratory (see ITRC, 2007, Appendix A).

8.6.5.4. Types of Passive Samplers

Passive groundwater samplers can be grouped logically into three types, based on the operating mechanism.

Diffusion-based Samplers. Rely on diffusion of analytes from the well water into a sampler made of a semi-permeable membrane material, initially filled with deionized, analyte-free water. When deployed to a specific depth in a well, analyte concentrations in the sampler reach and maintain equilibrium with concentrations in the water to which they are exposed. The time required for equilibration depends primarily on properties of the membrane material, the diffusive characteristics of each analyte, and the temperature of the groundwater. The appropriate period of deployment also considers the time required for well flow dynamics and ambient conditions to re-stabilize from placement of the sampler or other disturbance. The rule of thumb is that a 14-day deployment period is ample for most types of diffusion samplers, analytes, and hydrologic conditions (ITRC, 2004; ITRC, 2007). Because analytes always diffuse across the membrane from higher to lower concentration, the samplers maintain equilibrium concentrations and track changes in concentration in the well water (within the equilibration time lag period) regardless of how long the sampler was deployed in the well. The very small pore sizes of diffusion sampler membrane materials eliminate turbidity, thus diffusion samplers represent only the truly aqueous (dissolved) concentrations of analytes.

Polyethylene Diffusion Bag (PDB) Sampler. (Vroblesky and Hyde, 1997; Vroblesky, 2001; ITRC, 2004) was the first diffusion sampler to become widely known for sampling groundwater. PDBs are constructed of low-density polyethylene tubing of 4 mil thickness, having a pore size of about 10 angstroms. They are appropriate for sampling only hydrophobic (low water solubility) VOCs, chlorinated solvents, and short chain aliphatic hydrocarbons (up to about C10). The hydrophobic nature of the polyethylene membrane makes PDBs inappropriate to sample for analytes that are highly soluble in water (e.g., ketones, alcohols, etc.) or dissolved ionic species (e.g., metal cations, anions). Tables listing many field- and laboratory-tested analytes are found in Vroblesky (2001a), Vroblesky and Campbell (2001), ITRC (2004), and ITRC (2006).

Regenerated Cellulose Dialysis Membrane Sampler. (Imbrigiotta and others, 2007) is similar in concept to the PDB, but uses a hydrophilic cellulose membrane. The dialysis membrane sampler was developed and demonstrated by researchers at the US Geological Survey (Ehlke and others, 2004) to provide a passive diffusion-type sampler appropriate for inorganic as well as organic analytes. It has been demonstrated as suitable for sampling dissolved concentrations of

major cations and anions, most trace metals, all analytes on the EPA Method 8260B list, semi-volatile organic compounds, many explosives, total dissolved solids, electrical conductance, dissolved organic carbon, and dissolved gases. Field and laboratory test results from dialysis membrane samplers for many analytes are listed in ITRC (2006; Tables 4-1 and 4-2). The pore size of about 18 Angstroms excludes all suspended colloidal size particles, and organic molecules >~8000 Daltons. Field-ready dialysis samplers are not currently commercially available, but can be constructed easily and economically from the component materials. One potential disadvantage of the dialysis sampler is that the cellulose membrane is subject to biodegradation, typically losing integrity in about 3 to 4 weeks in most wells, and thus cannot be deployed for extended periods (e.g., between quarterly long-term monitoring events).

Water from all equilibrium-type diffusion samplers should be transferred immediately upon retrieval to appropriate laboratory containers for transport and storage to minimize analyte loss, particularly if volatile compounds are of interest. Because diffusion through the membrane is reversible, VOC losses or other changes begin occurring as soon as the sampler is removed from the intended sampling location.

Whole-water grab samplers obtain an instantaneous sample of the water from a specific depth in the water column of a well (ITRC, 2007).

Whole-water Grab Sampling Devices. Are among the oldest groundwater sampling devices (e.g., rigid bailer). However, recent improvements in design and sampling methods provide samples from a specifically designated and confidently known depth in the water column, and recommend an equilibration period of several days to two weeks (ITRC, 2007) for both the well and sampler to reach equilibrium with ambient conditions before sample collection. Equilibration avoids analyte loss from the sample to sampling equipment, which can be significant, and allows elevated turbidity and effects of sampler placement or other disturbance to dissipate before sample collection. The sample is collected immediately prior to, or as a result of sampler retrieval. Properly collected whole-water grab samples capture suspended particles that are naturally mobile in the aquifer under ambient laminar flow conditions, but do not have elevated turbidity resulting from the sampling activity. One of the more recently developed devices seals the sample in situ at the sampling point in containers (e.g., 40-mL VOA vials or other containers) that can be placed directly into auto-samplers at the laboratory, thus eliminating all exposure of the sample to air or other influences. Sample transfer can cause loss of VOC analytes, and exposure to air can cause changes in oxidation-reduction potential affecting redox-sensitive metal concentrations.

Accumulation–type Samplers. Rely on both diffusion and adsorption of analytes. Analytes diffuse through a semi-permeable membrane and are accumulated onto an adsorbent medium within the sampler. Both the diffusion membrane and adsorbent material must be appropriate for the analyte(s) of interest. The total analyte mass accumulated on the adsorbent medium over the entire deployment period is measured. Accumulation samplers have been used to sample surface water (e.g., bioaccumulation studies) for several decades (e.g., the SPMD, Polar Organic Chemical Integrative Sampler (POCIS)) (ITRC, 2006; Verreydt, 2010), and for air and soil vapor studies (ITRC, 2006). More recently the methodology has been applied to determine VOC concentrations in groundwater wells using the Gore™ Module (ITRC, 2007). An average accumulation rate over the deployment period is easily calculated, but estimates of concentration in the medium being sampled depend on a significant number and range of analyte-specific, sampler-specific, and environmental variables (e.g., membrane and analyte diffusion properties, adsorbent uptake rate, temperature, pressure, etc.). Proprietary empirical data for the Gore Module is used to infer VOC concentrations in groundwater. Accumulation samplers have a particular advantage in that the deployment period can be extended to concentrate analyte mass and detect analytes

present in the environment at concentrations too low to be detected by other sampling methods.

Tables listing media and common analytes addressed by many passive sampling devices mentioned above, advantages and limitations specific to each type of device, as well as summary of the availability and cost of each type of passive device are found in ITRC (2007, Tables 14-1, 14-2, 14-3), and in Verreydt and others (2010).

8.6.5.5. References for Passive Sampling

For more information on passive sampling, see the following references:

Ehlke, T.A., Imbrigiotta, T.E., and Dale, J.M., 2004, *Laboratory Comparison of Polyethylene and Dialysis Membrane Diffusion Samplers*, Groundwater Monitoring & Remediation, 24(1):53-59

Imbrigiotta, T.E., Trotsky, J.S, and Place, M., 2007, *Demonstration and Validation of a Regenerated-cellulose Dialysis Membrane Diffusion Sampler for Monitoring Groundwater Quality and Remediation Progress at DoD Sites*, Final Technical Report ESTCP Project ER-0313.

ITRC (Interstate Technology & Regulatory Council), 2004, *Technical and Regulatory Guidance for Using Polyethylene Diffusion Bag Samplers to Monitor Volatile Organic Compounds in Groundwater*, ITRC Technical and Regulatory Guidance, Report DSP-3, February, 2004.

ITRC (Interstate Technology & Regulatory Council), 2006, *Technology Overview of Passive Sampler Technologies*, Diffusion/Passive Sampler Team, Report DSP-4.

ITRC (Interstate Technology & Regulatory Council), 2007, *Protocol for Use of Five Passive Samplers to Sample for a Variety of Contaminants in Groundwater*, ITRC Technical and Regulatory Guidance, Report DSP-5.

Verreydt, G., Bronders, J., Van Keer, I., Diels, L., and Vanderauwera, P., 2010, *Passive Samplers for Monitoring VOCs in Groundwater and the Prospects Related to Mass Flux Measurements*, Goundwater Monitoring & Remediation, 30(2):114-126.

Vroblesky, D.A. (2001a). *User's Guide for Polyethylene-Based Passive Diffusion Bag Samplers to Obtain Volatile Organic Compound Concentrations in Wells, Part 1: Deployment, Recovery, Data Interpretation, and Quality Control and Assurance*, U.S. Geological Survey Water Resources Investigations Report 01-4060.

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Vroblesky, D.A., and Campbell, T.R., 2001, *Equilibration Times, Stability, and Compound Selectivity of Diffusion Samplers for Collection of Groundwater VOC Concentrations*, Advances in Environmental Research, 5:1-12.

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8.7. In Situ Groundwater Sampling Using Probes

This section provides a description of the equipment and techniques that can be used to collect samples using probes rather than monitoring wells. It is important to check with state environmental agencies to determine if groundwater data collected from probes can be used for decision-making purposes or site closure.

A relatively new development in groundwater sampling technology has been the design of in situ sampling probes, which allow for the collection of groundwater samples without the installation of permanent wells. A hydropunch operates in conjunction with conventional cone penetrometer rigs. The category of in situ sampling probes also includes a variety of driven probes, which can be retrieved after sampling or left in place as permanent sampling points. These devices often are used during the preliminary site characterization stage or where only a shallow water table is to be sampled. The portable in situ

samplers can be valuable in determining the best location for permanent monitoring wells.

CAUTION: Not all states accept groundwater data collected with probes. Site Managers should consult state environmental agencies when developing the SAP to determine how groundwater data from probes can be used.

8.7.1. In situ Well Installation

Direct push technology (DPT) is an example of an in situ groundwater sampling tool that can be used to install point-in-time groundwater sampling probes and wells. A description of some DPT technologies is provided below.

8.7.1.1. Point-in-Time Groundwater Sampling Probes

Point-in-time probes, also referred to as "temporary samplers" or "grab samplers," are used to collect samples rapidly to define groundwater conditions during one sampling event. They are usually less than 2 inches in outside diameter (OD) and are generally constructed of steel or stainless steel. Direct-push methods (percussion or static weight) are used to advance point-in-time samplers below the static water level in unconsolidated formations. Generally, groundwater flows into the sampler from an exposed screen under ambient hydrostatic pressure. Groundwater may be collected from the sampler using bailers or pumps, or the sampler may be retracted to the surface to obtain the water sample. Once sampling is completed, these devices are removed and the boring should be abandoned in accordance with local regulations.

8.7.1.2. DPT-Installed Groundwater Monitoring Wells

DPT-installed monitoring wells permit short-term or long-term monitoring of groundwater. They are usually 2 inches in diameter or less and constructed of PVC or stainless steel. Because monitoring wells are installed for periods of several months to several years, the annulus of the boring around the well casing is usually sealed to prevent migration of contaminants into the aquifer. Surface protection is required to prevent tampering with the well. A slotted or screened section permits groundwater to flow into the well under ambient hydrostatic pressure. Groundwater may be collected from monitoring wells using bailers, various pumps, or passive sampling devices.

8.7.2. Point-in-Time Sampling

Ideally, DPT point-in-time and monitoring well groundwater sampling equipment should be used together to maximize their effectiveness. Point-in-time sampling techniques generally are better for identifying plume boundaries, hot spots, preferred pathways, or other monitoring points of interest.

A variety of point-in-time groundwater sampling tools are available for site characterization, including the following:

- Sealed-screen samplers
- Multi-level samplers (or vertical profilers)
- Open-hole samplers.

With these tools, the time needed to retrieve the sample will vary according to the hydraulic conductivity of the sampling zone. In general, sampling within coarse-grained sediments takes minutes, while sampling within fine-grained sediments can take several hours or more. In situations where slow recharge inhibits the timely collection of groundwater samples, the sampler may be left in place to recharge while the DPT rig is moved to a new sampling location.

8.7.2.1. Sealed-Screen Samplers

Sealed-screen samplers typically consist of a short (6 inch – 3-foot) screen nested within a sealed, watertight tool body. Because the screen is not exposed to the formation as the sampler is advanced into the subsurface, the screen does not become plugged or damaged. In addition, the potential for cross-contamination is greatly reduced and a true depth-discrete sample that is representative of the target sampling zone can be collected. The sample volume collected with some sealed-screen samplers is limited by the volume of the sample chamber.

To collect the sample, the sealed-screen sampler is advanced to the target sampling depth, and the protective outer rod is retracted, exposing the screen to groundwater. Groundwater flows

through the screen and into the drive rods or sample chamber under the hydraulic head conditions that exist at that depth. O-ring seals placed between the drive tip and the tool body help ensure the sampler is watertight as it is driven to the target sampling interval. The integrity of the seal often can be checked by lowering an electronic water level indicator into the sampler prior to retracting the protective outer rod.

8.7.2.2. Multi-level Samplers

Multi-level samplers, most of which are exposed-screen samplers, are DPT equipment capable of collecting groundwater samples at multiple intervals as the sampling tool is advanced. One benefit is they do not have to be withdrawn for sample collection or decontamination. The terminal end of a typical multi-level sampling tool has a 6 inch – 3 foot-long screen made up of fine mesh, narrow slots, or small holes. The screen remains open to formation materials and water while the tool is advanced. Samples are collected either continuously or periodically as the tool is advanced to vertically profile groundwater chemistry and aqueous-phase contaminant distribution.

Multi-level samplers can be used to measure water levels at discrete intervals within moderate- to high-yield formations to assist in defining vertical head distribution and gradient. Additionally, some of these tools can be used to conduct hydraulic tests at specific intervals to characterize the hydraulic conductivity in formation materials and identify possible preferential flow pathways and barriers to flow.

8.7.2.3. Open-hole Sampling Methods

Open-hole sampling is conducted by advancing drive rods with a drive point to the desired sampling depth. Upon reaching the sampling depth, the rods are withdrawn slightly, which separates them from the drive tip and allows water to enter the rods. The water can be sampled by lowering a bailer into the rods or by pumping. The open-hole method is feasible only within formations that are fairly cohesive; otherwise, the formation may flow upwards into the rods when they are withdrawn, preventing samples from being collected. With single-rod systems, open-hole sampling can be conducted only at one depth within a borehole because the borehole cannot be flushed out between sampling intervals, which could cause cross-contamination. Dual-tube systems, on the other hand, can be used to conduct multilevel sampling.

8.7.3. DPT Monitoring Well Installation

A variety of DPT methods are available for installing temporary or permanent monitoring wells. The two main installation methods used are exposed-screen and protected-screen wells. These methods are discussed in detail in ASTM D6724 and D6725, and are summarized here. As with conventional well installations, hydraulic connections should not be created between otherwise isolated water-bearing strata. In addition, precautions should be taken to minimize turbidity during the installation of filter packs and the development and sampling of DPT wells.

8.7.3.1. Exposed-screen Well Installation Methods

With exposed-screen well installation methods, the well casing and screen are driven to the target depth using a single string of rods. Because the screen is exposed to formation materials while it is advanced, proper well development is important to remove soil from screen slots. This method is not recommended for installing well screens within or beneath contaminated zones because drag-down of contaminants with the screen may cross-contaminate sampling zones and can prevent the acquisition of samples representative of the target zone. Exposed-screen well installation methods should be used only in upgradient areas that are known to be uncontaminated. Also, some states prohibit the practice of allowing the formation to collapse around a well screen during the construction of a monitoring well. Therefore, state regulations should be consulted before selecting exposed-screen techniques.

8.7.3.2. Protected-screen Well Installation Methods

When installing a protected-screen well, the well casing and screen are either advanced within or

lowered into a protective outer drive rod that has already been driven to the target depth. Once the well casing and screen are in place, the drive rod is removed. Alternatively, the casing, screen, and a retractable shield may be driven simultaneously to the target depth. Once in place, the screen is exposed and the entire unit remains in the ground. If there is sufficient clearance between the inside of the drive rod and the outside of the well casing and screen, a filter pack and annular seal may be installed by tremie (an apparatus for depositing and consolidating concrete under water) from the surface as the drive casing is removed from the hole. Several filter packing and annular sealing approaches are available, depending on the equipment used for the installation. Regardless of the method of installation, the filter pack should be sized appropriately to retain most of the formation materials.

The most common protected-screen method for installing DPT wells is to advance an outer drive casing equipped with an expendable drive tip to the target depth. The well casing and screen are then assembled, lowered inside the drive casing, and anchored to the drive tip. The drive casing seals off the formations through which it has been advanced, protecting the well casing and screen from clogging and from passing through potentially contaminated intervals. The position and length of the screen should be selected to match the thickness of the monitoring zone, which can be determined by using additional information, such as cone penetration testing (CPT) logs or continuous soil boring logs.

8.8. Sample Handling and Collection

This section provides guidance on sample handling procedures, such as filtration, and specific techniques for collection of samples that will be analyzed for various classes of groundwater pollutants, such as SVOCs. For detailed sampling procedures and preservation of samples, refer to Appendix B of this handbook. It is important to remember that COC procedures should be followed for all groundwater sampling events and that all samples (except for metals) remain on ice during both sample collection and shipment to the laboratory. Details regarding the use of COC procedures are provided in Chapter 3.

8.8.1. Sampling for Metals

Certain regulations require metals analyses to be performed on unfiltered groundwater samples. The reason for these requirements is to obtain a representative sample as it actually occurs in the aquifer and to maintain consistency between sample handling for inorganic and organic analyses. If a particular situation demands consideration of dissolved metals, both filtered and non-filtered samples should be collected for analysis. The regulatory document or approved SAP should be consulted for monitoring requirements.

The differences obtained as a result of sample handling (filtered versus non-filtered) are dependent on the type of association between the specific inorganic ion and the particulate matter. Studies show that when an inorganic ion is not closely associated with particulate matter (e.g., sodium), the differences between total and dissolved concentrations are small and random.

Ideally, the sample can be split into two portions, one for filtration and the other for immediate preservation and subsequent analysis for total metals concentration. By analyzing the two fractions separately, differences between dissolved and total metals can be compared.

The decision of whether to filter metals samples should be based on the physical quality of the samples, the objectives of the monitoring program, and the policy of the regulation or agency controlling the sampling event. If filtering is allowed and chosen, it is imperative that it be performed in a manner that will preserve the integrity of the sample and allow for consistent reproduction of technique.

Filtration of groundwater samples for dissolved metals analyses should be performed with a precleaned filtering apparatus. Sampling devices should be cleaned using ultra-pure nitric acid when low-level metals contaminants are being measured. Filtration must be done immediately upon sample collection, prior to preservation. Samples transported to the lab for filtration and

preservation should be documented, because sample composition will change during transport. The sample should be collected and filtered through a 0.45-µm pore diameter cellulose acetate filter. If using a vacuum filter is impractical, pressure filtration must be performed. Care should be taken to follow the manufacturer's recommended procedure if vacuum filtration is used. All filter apparatus should be laboratory-cleaned and dedicated; however, disposable filters are acceptable. For each sampling event, a new disposable filter must be used to avoid cross-contamination of samples.

Groundwater samples to be analyzed for both total metals and dissolved metals are collected in plastic bottles and preserved with nitric acid to pH < 2. All appropriate data should be recorded in the FLB/FN.

8.8.2. Sampling for VOCs

At each site, samples for analysis of VOCs are collected first. Care should be taken to prevent volatilization of the sample when placing groundwater into the vial. Groundwater samples collected for analysis of VOCs, either from passive diffusion bags, low-flow pumps, or bailers, must be placed into 40-milliliter vials with a septum.

A sacrificial 40-milliliter sample should be obtained to determine preservation requirements before VOC samples are collected. Fill the vial with sample water, then add 1:1 HCl, drop-by-drop, and test the pH until it is < 2. If the test sample effervesces when the HCl is added, the samples should not be acid preserved and should be analyzed within 7 days of collection. Record the amount of HCl added. Alternatively, prepreserved VOC vials may be obtained from the analytical laboratory.

The procedure for collecting a VOC sample is described below:

1. Remove the cap from a 40-mililiter septum (Teflon®-faced silicon rubber) vial. Avoid contact with the inner surface.
2. Add the established amount of HCl necessary for sample preservation (if prepreserved vials have not been supplied by the laboratory).
3. Fill the vial with sample water, taking care to minimize aeration, and screw on the cap tightly to achieve zero headspace. The Teflon®-lined side of the cap must face the aqueous sample.
4. Inspect the vial for air bubbles. If air bubbles are present, discard the vial and restart with step 1.
5. Label the vial, and place it in a resealable bag.
6. Record appropriate data in the FLB/FN.

8.8.3. Sampling for Extractable Organics

The procedure for collecting groundwater samples for analysis of SVOCs is described below.

1. Remove the Teflon®-lined cap from a 1-liter amber glass bottle. Avoid contact with the inner surface of the cap.
2. Fill the bottle with groundwater.
3. Replace the cap tightly, attach the sample label, and place the sample bottle in a cooler with enough bagged ice to cool the sample to ≤ 6°C.
4. Repeat steps 1 through 3 for additional samples.
5. Record appropriate data in the FLB/FN.

8.8.4. Sampling for Cyanide

The procedure for collecting groundwater samples for analysis of total cyanide is described below.

1. Place groundwater into a 1-liter wide-mouth plastic bottle.
2. Determine if sulfide is present. Pour a small aliquot of sample from the 1-liter wide-mouth plastic bottle into a clean 100-mililiter beaker and test for sulfide using a lead acetate test strip. If sulfide is:
   - Present and visible solids are present, go to step 3
   - Present and no visible solids are present, go to step 5

- Not detected, go to step 8.

3. If sulfide is present and visible solids are present, filter the sample through a 0.45-µm cartridge filter within 15 minutes of collection. The sample should be pumped through the filter using new Tygon® tubing into a second clean, 1-liter wide-mouth plastic bottle.
4. Place the spent 0.45-µm cartridge filter in a 1-gallon resealable bag, label the bag with the appropriate sample number and collection time, and place the filter cartridge and bag into the freezer. The frozen filter can be sent to the laboratory for analysis of cyanide.
5. For the presence of sulfide, add 1 gram of solid lead carbonate to the 1-liter wide-mouth sample bottle, cap the bottle, and mix by inverting the bottle several times.
6. Check for the removal of sulfide. Pour a small aliquot of lead carbonate-treated sample into a clean 100-milliliter beaker and test for sulfide again using the lead acetate test strip. If sulfide is present, add another gram of lead carbonate to the sample, cap the bottle, and mix by inverting the bottle several times. Repeat this step until sulfide is not detected by the lead acetate test strip.
7. Filter the lead carbonate-preserved sample through a new 0.45-µm cartridge filter to remove residual chemical addition and lead sulfide formed during the precipitation reaction. Collect the filtrate in a clean 1-liter plastic wide mouth bottle. Discard the 0.45-µm cartridge filter.
8. Determine if total chlorine is present. Pour a small aliquot of sample from the 1-liter wide-mouth plastic bottle (preserved, if sulfide was present) into the appropriate vials of the chlorine test kit and analyze for total chlorine. If total chlorine is present in the sample, add 0.1 gram of sodium borohydride ($NaBH_4$), cap the bottle, and mix by inverting the bottle several times. If chlorine is not detected, go to step 10.
9. Check for the removal of chlorine. Pour a second small aliquot of $NaBH_4$-treated sample into the appropriate vials of the chlorine test kit and analyze for total chlorine. If chlorine is present, add another 0.1 gram of $NaBH_4$. Repeat this step until chlorine is no longer detected. Generally, 0.1 gram/liter $NaBH_4$ will reduce 50 mg/liter of chlorine.
10. Adjust the pH of the sample to > 12 using sodium hydroxide (NaOH), and place the sample on ice to lower the temperature to ≤ 6°C prior to shipping to the laboratory. When the sample has cooled, pack and ship using normal procedures. Record all preservation procedures in the FLB/FN.

8.8.5. Sampling for Conventional Parameters and Nutrients

Conventional pollutants typically include BOD, O&G/TPH, TOC, COD, TDS, TSS, and chloride. Nutrients include ammonia, nitrate, and total phosphorous. Bottle and preservation requirements will differ based on each particular analyte. The procedure for collecting groundwater samples for analysis of conventional pollutants and nutrients is described below:

1. Remove caps from sample bottles. Avoid contact with the inner surface.
2. Fill bottles to about 90 percent full. Add appropriate preservative to the samples per Appendix B of this handbook or the SAP.
3. Replace and tighten caps, attach labels, seal in resealable bags, and place sample bottles in a cooler with enough bagged ice to cool the samples to ≤ 6°C.
4. Record all appropriate data in the FLB/FN.

8.8.6. Sampling for Radioactive Elements

Groundwater samples typically are analyzed for the following radioactive constituents: gross alpha, gross beta, tritium, strontium-90, combined radium-226/228, and uranium. Other radioactive elements, such as plutonium, cesium-137, or americium-241, also may be included in groundwater sampling programs, depending on the historical uses at the site. The types of sample bottles and the required volume of the groundwater sample will vary depending on the radioactive element. The SAP must contain information on sample bottles, sample preservation, and sample

holding times for specific radioactive elements that will be analyzed. When preparing the SAP, refer to the Multi-Agency Radiological Laboratory Analytical Protocols (MARLAP) guidance on field sampling of radioactive analytes (http://www.epa.gov/radiation/docs/marlap/402-b-04-001b-10-final.pdf).

Note: Shipment of radioactive samples to the laboratory may require special handling procedures. Samples to be shipped off site must be field-screened to determine the levels of radiation present. The screening will allow for proper packaging and shipping via International Air Transport Association (IATA) Dangerous Goods Regulations. By IATA definition, a material with an activity level of more than 2,000 pCi/g is considered radioactive. If groundwater samples exceed this level, special IATA packaging procedures are required for shipment by air. Packaging procedures for radioactive samples must be included in the SAP, and special training of field personnel may be required for the handling and packaging of radioactive groundwater samples.

8.8.7. Sampling for Light, Non-aqueous Phase Liquids

Light, non-aqueous phase liquids (LNAPLs) are generally considered to be low density, immiscible organics, including gasoline, petrochemicals, and other chemicals with specific gravities of less than water. They are usually present in aquifers as a separate phase due to their low solubility in water. These chemicals tend to float on the water surface in a water table environment and commonly occupy the capillary fringe zone above the water table. If LNAPLs are suspected to be floating on the water table, all shallow wells installed in the area under investigation must be screened across the water table.

Note: Samples of the floating organic layer must be collected before the well is purged.

In a confined aquifer, LNAPLs are found along the upper surface of the permeable material and also within the overlying confining layer. When immiscible organics with a specific gravity less than water are the contaminants of concern, or if contaminants are suspected in more than one stratified layer in the well column, sampling procedures must be modified. It may be necessary to lower the sampling bailer to a particular depth in the well or to utilize a double check-valve bailer. Sampling procedures for LNAPLs differ substantially from those for other pollutants. If more than one distinct LNAPL layer is present in a well, each layer should be sampled. Samples should be analyzed for chemical composition (e.g., for VOCs and base-neutral extractables) and physical parameters (e.g., specific gravity, water solubility, vapor pressure of the liquid, and Henry's Law Constant).

Measurement of the thickness of the floating layer can be accomplished by using a water indicator paste or gel with a weighted steel tape to determine the depth to the top of the floating layer and to the water surface. The difference between these two readings is the thickness of the floating layer. Measurement of the thickness of the floating layer also may be accomplished by using an interface probe or a clear Teflon® bailer (if the product thickness is less than the length of the bailer). Electric water level sounders will not work properly for these determinations.

After a monitoring well is initially constructed, it should be developed and pumped to remove stagnant water. Then the well should sit idle for at least 2 weeks to allow the water level and floating layer(s) to stabilize fully. Prior to purging the monitoring well, a sample of the floating layer can be obtained using a bailer that fills from the bottom.

The collection of a water sample from a well containing free-floating product is challenging and at times problematic. This is true even if the LNAPL floating in the well has been removed during the purging process (the LNAPL can still coat the inside casing, or be entrained in the screen and sand pack, and likely is emulsified below the air/water interface). Care should be taken to lower the bailer just through the floating layer but not significantly down into the underlying groundwater. Care also should be taken in proper planning when sampling water from such wells and interpreting the resulting data (e.g., to determine if the sample is representative of the actual groundwater concentrations). Various sampling methods may be used to provide greater confidence in the results of the analysis. Stilling

tubes may be used to help prevent the sampling device from contacting residual LNAPL that can impact the collected water sample. Discrete interval samplers also may be used to ensure that emulsified product does not enter the sampler during emplacement below the water level in the well. Samples should be analyzed to determine the chemical composition and physical properties of the LNAPL. After following typical evacuation procedures discussed previously in this section, a sample of formation water may be obtained from the well.

8.8.8. Sampling for Dense, Non-aqueous Phase Liquids (DNAPLs)

DNAPLs include chlorinated solvents and other chemicals with specific gravities greater than water. They are usually present in aquifers as a separate phase due to their low solubility in water. DNAPLs tend to migrate downward through both the unsaturated zone and the saturated zone due to their high density. If the volume of the DNAPL introduced into the subsurface is larger than the retention capacity of the vadose and saturated zones, a portion of the DNAPL will spread out as a layer of free liquid on the bottom of the aquifer or on lower permeability beds within the aquifer.

Measurement of the thickness of DNAPLs must be performed prior to purging the well. Measurement of the DNAPL can be accomplished by using a water indicator paste or gel with a weighted steel tape (if no LNAPL is present) to determine the depth of the top of the DNAPL and the bottom of the well. The difference between these two measurements is the thickness of the DNAPL. An interface probe also may be used to measure DNAPL thickness in the well.

Note: Samples of the settled organic layer must be collected before the well is purged.

Prior to purging the monitoring well, a sample of the DNAPL can be obtained using a dual check-valve bailer or a bladder pump. If both LNAPLs and DNAPLs are present, it may be necessary to purge the well of one casing volume of water prior to sampling the DNAPL. Efforts should be made not to disturb the DNAPL in the bottom of the well by setting the pump intake of the submersible or suction-lift pump several feet above the DNAPL.

Samples should be analyzed to determine the chemical composition of the DNAPL and its physical properties (e.g., specific gravity, water solubility, equilibrium vapor pressure of the liquid, and Henry's Law Constant). After the well is purged, a sample of the groundwater may be obtained for laboratory analysis.

8.9. Sampling Industrial Wells

This section provides a brief discussion on sampling industrial wells used to extract process water and potable water. Site Managers should always consult the state environmental agencies drinking water division to determine specific requirements.

When sampling industrial wells, it is desirable to sample as close to the well source as possible. Samples should be taken directly from the well head whenever possible to eliminate treatment interferences, possible changes in quality within the lines, and mixing of water from other wells.

Large-capacity wells that are "on-line" during monitoring can be sampled immediately. Wells that are "off-line" must be purged and pumped to waste prior to sampling. Fifteen minutes or more of pumping is suggested. Access to municipal well systems, well houses, and other related structures will require the assistance of the site manager or water department employee. Prior notification is essential.

8.10. Aquifer Testing

At sites with contaminated groundwater, aquifer testing may be performed to determine site-specific aquifer properties that help define the transport of groundwater and contaminants. If groundwater remediation is appropriate, an aquifer pumping test may be performed. During a pumping test, groundwater is removed from the aquifer for a period of several hours or days. Sampling of the extracted water is required to determine its disposal requirements. Samples are typically collected from the containment vessel

using a bailer, or directly filling sample bottles from a port on the container.

Long-term aquifer tests can be used to estimate contaminant loading on treatment systems by collecting samples from a sample tap in the pump discharge pipe at various times over the duration of the aquifer test. This provides a more realistic estimate of treatment system loading than using individual samples collected from monitoring wells. Use of monitoring well samples alone can result in an overestimation of contaminant loading (and overdesign of the treatment process) if groundwater concentrations decrease over the course of the pumping test.

8.11. Well Decommissioning or Abandonment

This section provides an overview of the requirements for well decommissioning and abandonment. It is important that Site Managers check with state environmental agencies to determine specific requirements.

Unsealed or improperly sealed groundwater monitoring wells, including DPT wells, may threaten public health and safety and the quality of groundwater resources. Proper well abandonment accomplishes the following:

- Eliminates the physical hazard of the well (the actual hole in the ground)
- Eliminates a pathway for migration of contamination
- Prevents hydrologic changes in the aquifer system, such as the changes in hydraulic head and the mixing of water between aquifers.

The proper decommissioning method will depend on both the reason for abandonment and the condition and construction details of the boring or well.

Typically, well abandonment is the responsibility of the property owner and must be done according to state regulations. In the absence of more stringent regulatory standards, the procedures outlined below represent minimum guidelines for proper abandonment of wells and borings. These steps may be applicable, but not limited to, public and domestic water supply wells, monitoring wells, borings, or drive points drilled to collect subsurface information, test borings for groundwater exploration, and dry wells (drains or borings to the subsurface).

1. The well should be plugged to prevent the entrance of surface water, circulation of water between or among producing zones, or any other process resulting in the contamination or pollution of groundwater resources.
2. The well should be chlorinated prior to abandonment using a chlorine solution with a minimum concentration of 150 ppm.
3. The entire depth of the well should be checked before it is sealed to identify any obstruction that could interfere with sealing operations.
4. The well bore should be filled and sealed completely with bentonite cement grout.
5. The grout material should be placed in a way that prevents voids in the grout or dilution of the grout.
6. The abandoned well or bore should not become a channel for the vertical movement of water or other substance to potable groundwater resources.
7. Upon completion of well abandonment, the top of the casing and grout material should not be terminated more than 4 feet below the ground surface of the final grade.

8.12. Sampling Equipment List

Section 3.8 of this handbook provides a generic sampling equipment list applicable to most sampling events. The following list provides additional equipment applicable to groundwater sampling. In most cases, only a portion of the equipment listed below would be required for a given sampling event.

- Water level indicator
- Steel line and chalk
- Electric tape (e.g., interface probe, slope indicator, M-scope)
- Well evacuation equipment
  - Suction lift pump/centrifugal pump
  - Portable submersible pump

  - Peristaltic pump
  - Air lift pump
  - Bladder pump (gas squeeze pump)
  - Packer pump
  - Gas piston pump
  - Gas displacement pump
  - Inertial pump
- Groundwater sampling equipment
  - Passive diffusion bags for VOCs
  - Bottom fill bailer (single or double check valve)
  - Peristaltic pump
  - Bladder pump
  - Packer pump
  - Inertial pump
  - Syringe sampler
- Additional equipment
  - VOCs detection devices, such as PID or FID
  - Appropriate hand tools
  - Keys to locked wells
  - Filtering devices
  - Field measurement instrumentation (e.g., temperature, specific conductance, pH, DO, turbidity)
  - Plastic sheeting
  - Dedicated, pre-cleaned stainless steel pitchers, or an equivalent dipping device
  - Calibrated bucket for purged water measurement
  - Distilled or deionized water or ASTM Type II water
  - Laboratory-grade glassware, detergent, or cleaning materials
  - Empty drums for collection of purged water
  - Stainless steel clamps.

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Chapter 9. Drinking Water Sampling

9.1. Purpose

This chapter provides standard drinking water sampling procedures that accurately represent the condition of drinking water and comply with federal guidelines.

9.2. Background

The SDWA was passed in 1974 to protect public health by regulating the nation's public drinking water supply. The law was amended in 1986 and 1996 to expand its scope and increase the number of regulated contaminants. The SDWA authorizes EPA to set national health-based standards to minimize the concentration of harmful contaminants in drinking water and protect the population from naturally occurring or manmade pollutants. Currently, there are 96 drinking water contaminants regulated under the SDWA.

The SDWA applies to every public water system (PWS) in the United States. There are more than 170,000 PWSs that provide piped water for human consumption in the United States. A PWS is defined as having at least 15 connections or regularly serving at least 25 customers for at least 60 days per year. PWSs are classified as either community water systems (CWSs), which number about 60,000, or non-community water systems (NCWSs), which number about 110,000. A CWS supplies water to the same population year round while a NCWS is defined by the population served (e.g., transient or non-transient). A transient non-community water system (TNCWS) serves the public, but not the same individuals, for more than 6 months, such as in campgrounds. A non-transient non-community water system (NTNCWS) serves the public and the same population for more than 6 months, but not year-round, such as in schools. The majority of the population in the United States receives drinking water from a CWS. Household wells are exempt from regulation, but the recent promulgation of the Ground Water Rule (GWR) incorporates all PWSs that use groundwater as a source.

While a TNCWS is monitored for a few contaminants (e.g., bacteria, nitrate, and nitrite), CWS and NTNCWS monitoring is more extensive. The breadth of monitoring required by the SDWA is dependent on the section of the drinking water system identified (e.g., source water, treatment, distribution system, or tap), the number of customers, and the source of the water. Source water (i.e., groundwater, surface water, or groundwater under the influence of surface water) and the point-of-entry into a water treatment system have modest monitoring require-ments that are usually handled by annual sampling for inorganic chemicals, nitrate, nitrite, radionuclides, synthetic organic chemicals (SOCs), VOCs, and asbestos. As the drinking water progresses through the distribution system, the microbiological monitoring requirements increase, as does the analysis for residual disinfectant and contaminants related to treatment and conveyance (e.g., trihalomethanes (THMs), lead, and copper). For a utility serving more than 10,000 customers, as many as 50 microbiological samples per month can be required. Section 9.7.2.4 indicates the number of samples that would be required for smaller PWSs. To learn the exact monitoring requirements for a particular drinking water system, refer to 40 CFR 141 or the EPA *Interactive Sampling Guide for Drinking Water System Operators* (http://www.epa.gov/safewater/smallsys/samplingcd.html), or consult state drinking water program coordinators.

The National Primary Drinking Water Regulations (NPDWRs) specify health-based, enforceable maximum contaminant levels (MCLs) for specific pollutants found in drinking water or require treatments to remove contaminants to a safe level. The MCL is the concentration of pollutant that will have no known or expected risk to human health if consumed in drinking water. Utilities are required to test for each applicable pollutant and ensure that the MCLs are being achieved. The SDWA, as amended and codified in CFR 141.151, requires utilities to provide an annual report to customers attesting to the condition of the water with the associated MCLs.

National Secondary Drinking Water Regulations (NSDWRs) specify non-enforceable levels of contaminants in drinking water that are intended to mitigate suspected but unproven health risk consequences, and conservatively serve as a goal that providers of drinking water should strive to meet maximum contaminant level goals (MCLGs). MCLGs can carry some public health considerations but also carry aesthetic characteristics such as taste and odor. An action level (AL) is the maximum concentration of a contaminant that would have no adverse health effect if consumed in drinking water. An AL is health-based and, like an MCL, prompts aggressive action by the utility to reduce the concentration of the pollutant to safe levels. Usually ALs are related to the treatment techniques applied to drinking water.

Because of the SDWA, EPA has introduced a number of rules to address specific problems related to drinking water safety. The titles of most of the rules are self-explanatory and result in some additional monitoring and reporting. The drinking water safety rules developed by EPA are as follows.

- **GWR.** Focuses on increased protection from microbes in ground water.
- **Total Coliform Rule (TCR).** Tightens the SDWA's requirements on the concentration of bacteria in treated water because positive coliform tests can indicate treatment problems.
- **Surface Water Treatment Rule (SWTR).** Addresses the control of *Giardia* and viruses. Subsequent revisions include *Cryptosporidium* disinfection or removal.
- **Lead and Copper Rule (LCR).** Deals with potentially toxic levels of metals derived from plumbing materials in the distribution system and ways to minimize their concentration. Tests that exceed the AL for lead or copper can trigger extensive home monitoring.
- **Arsenic Rule (AR).** Reduces the MCL for arsenic from 50 µg/L to 10 µg/L. Additional treatment could be needed to meet the new MCL.
- **Disinfectants and Disinfectant Byproducts Rule (DDBPR), Stage 1 and Stage 2.** Regulates the halogenated chemicals produced by the disinfection of drinking water. THMs, haloacetic acids (HAA5), Bromate, and Chlorite are common disinfection byproducts (DBPs) regulated by the EPA.
- **Unregulated Contaminants Monitoring Rule (UCMR).** Preserves the public health of citizens by identifying new or emerging pollutants associated with source water, drinking water treatment, distribution systems, and consumption.
- **Interim Enhanced SWTR.** Created in February 1999 to improve the control of microbial populations, particularly *Cryptosporidium*, while balancing the risks from the production of disinfection by-products.
- **Long-Term Stage 1 SWTR.** Became effective in January 2002 and built on the control of microbial populations, specifically *Cryptosporidium*. It strengthened the filtration requirements, implemented the Stage 1 DBP Rule, and incorporated smaller water systems.
- **Long-Term Stage 2 Enhanced SWTR.** Became effective in 2006 as a further extension of the *Cryptosporidium* and microbial control requirements of the earlier rules. All systems using surface water or water directly under the influence of surface water are included. The rule requires routine sampling for *Cryptosporidium*. Treatment depends on the levels of *Cryptosporidium* reported.

All of the sampling and analytical requirements associated with the recently promulgated rules are included in the EPA Interactive Sampling Guide for Drinking Water System Operators and on EPA's website, http://www.epa.gov/safewater.

9.3. Scope

This chapter provides the following procedures for sampling groundwater and surface water supplies for monitoring drinking water quality:

- Microbiological, inorganic, and organic sampling

- Monitoring of metals at the tap
- Monitoring of turbidity levels for surface water supplies.

To meet the requirements of the SDWA and the related contaminant regulations, as well as ensure the quality of a drinking water supply, a comprehensive drinking water sampling program must be developed. The drinking water sampling program should include detailed information about the water source, entry point, treatment process, and distribution system. This information will help samplers determine which monitoring requirements apply to a particular drinking water supply. Monitoring requirements for source water sampling or point-of-entry sampling can be modest when compared with monitoring requirements for points further along in a distribution system, or for a system serving a large population. The drinking water sampling program must consider the monitoring requirements for each component of the water distribution system to ensure that all applicable regulations are met. A comprehensive drinking water sampling program should compare samples collected from the source water, entry point after treatment, and distribution system to determine the effect of treatment and plumbing systems on drinking water quality.

9.4. Project Planning

This section describes the steps in planning a drinking water sampling program. Before each drinking water sampling program can begin, concise objectives must be developed regarding the intent of the sampling program. The objectives provide the framework for developing a sampling strategy and preparing the sampling and analysis plan.

9.4.1. Sampling Strategy

The sampling strategy will help the project manager determine the appropriate sampling locations, sample numbers, and sample frequency based on the following:

- Water source
- Source vulnerability
- Analyses to be performed
- Regulatory requirements
- DQOs
- The population served
- Anticipated or potential contaminants
- System size.

9.4.2. Site-Specific SAP

A site-specific SAP should be prepared and reviewed by appropriate regulatory personnel prior to starting any sampling event to ensure the proper location, parameters, and number of samples are taken to meet compliance requirements. The specific monitoring and reporting requirements of the SDWA are beyond the scope of this handbook.

The site-specific SAP is an instruction manual for field personnel. It should be built around the objectives and sampling strategy. The SAP must consider a variety of factors including the water source, condition and accessibility of sampling locations, suspected contaminants, analytical methods and detection limits, collection methods, sample handling procedures, and safety. See Chapter 2 for a detailed discussion of SAP development applicable to all sampling programs.

Note: Site-specific sampling requirements are unique, and local, state, and federal regulatory authorities should be consulted to ensure the drinking water sampling program is adequately prepared.

The SAP cannot be implemented effectively if field personnel do not understand its contents. Field personnel should fully understand the SAP, and additional training should be provided prior to field activities, if necessary.

9.4.3. Certification

Some states might have certification programs that require drinking water samples collected for SDWA compliance be collected by approved individuals. Some states also have certification training programs and require samplers to be certified for collecting drinking water samples. Local health and environmental departments require that water samples be collected in accordance with federal, state, or local regulations. A review of the sampling plan must ensure that the

samples collected will meet the necessary local and state requirements for sampling personnel.

Only laboratories that are certified by the local, state, or federal program with jurisdiction are allowed to perform compliance testing for microbiology, inorganic, organic, and radiochemistry analytes. However, any person acceptable to the state can perform analyses for turbidity, chlorine residual, and pH if primacy has been granted.

EPA- or state-certified laboratories should supply the blanks, containers, and preservatives for sampling. These must be free of the contaminants at the detection levels. These materials should be traceable and documented as free of contaminants to aid the data reviewer and to avoid resampling due to avoidable contamination.

9.4.4. Analytical Methods

When taking samples for regulatory compliance, EPA-approved methods must be used. Approved methods are listed in 40 CFR 141 and Appendix B of this handbook.

9.4.5. Quality Assurance

Use the following protocol to ensure integrity and accuracy of the data collected during drinking water sampling. The laboratory analysis must be performed by a certified laboratory for the method required.

All samples must be accompanied by a complete COC record. Field blanks, trip blanks, and field duplicates can be collected as part of the QA plan to enable data evaluation for accuracy and integrity of drinking water sampling. QA/QC varies with the regulatory requirements and site location for each sample.

Detailed information on QA/QC, including the systematic planning process, development of DQOs, and preparation of QAPPs, is available in Chapter 2 of this handbook.

9.4.5.1. Trip Blanks

Trip blanks (or transport blanks) should be prepared by the laboratory and usually consist of two laboratory-filled vials in each container used to ship water VOC samples. The trip blank is analyzed to show that contamination does not occur during transportation of the VOC samples to the laboratory.

9.4.5.2. Field Blanks

Field blanks are samples of reagent water that are transferred from one vessel to another at the sampling site. Typically, the laboratory will fill sample bottles with ASTM Type I or II water, seal the bottles, and ship them to the sampling site along with the empty bottles. The field crew will transfer the reagent water to another set of clean sample bottles in the field and transport or ship the field blanks with the actual samples to the laboratory. This blank is used to show that the sampling procedures and atmosphere at the sampling site have not caused contamination. Additional reagent water should be available in field to ensure no air bubble in field blanks.

9.4.5.3. Field Duplicates

Field duplicates are collected from field-homogenized samples, stored in two separate containers, and analyzed separately at the same laboratory. For VOCs, field duplicates are two separate samples that are collected as close as possible to the same point in space and time, stored in separate containers, and analyzed separately at the same laboratory. These duplicates are useful in documenting the precision of the sampling process.

9.5. Hazards and Safety Precautions

A site-specific HASP that addresses all anticipated hazards should be prepared for each task. Specifically, the HASP should address the following hazards that could be associated with drinking water sampling:

- Exposure to biological and chemical contaminants during sample collection
- Exposure to reagents used for sample preservation
- Physical and biological hazards associated with sampling sites specifically when sampling surface waters or wells.

Refer to Chapter 2 of this handbook for specific hazard identification techniques and detailed control methods.

9.6. General Sampling Procedures

General sampling procedures for each common type of drinking water sampling are described in this section.

9.6.1. General Tap Sampling

General tap sampling is appropriate for most drinking water sampling parameters and is the most common drinking water sampling method.

9.6.1.1. Appropriate Parameters

Tap sampling is an acceptable sampling method for the following parameters:

- Inorganic contaminants
- Microbiological
- Metals
- SVOCs
- DPBs
- Radionuclides.

9.6.1.2. Sampling Procedures

The general procedure for collecting samples from a tap includes the following steps:

1. Determine the appropriate sample location and assemble all necessary materials. The proper preservative should be added by the laboratory or be available in the field for addition to the sample. A dechlorinating agent is used when sampling chlorinated waters (such as those found in the distribution system). Handle the sterilized containers carefully to avoid contamination.
2. Go to the sampling location(s) specified in the SAP. Drinking water sampling locations are usually located in the distribution system and are accessible during the day. Examples include hospitals, city buildings, restaurants, pump stations, and dedicated sampling stations. The tap should be clean and in good condition (i.e., no leaks). To minimize contamination, avoid drinking fountains and faucets with swivel necks unless specific point-of-use concerns arise. If the sampling location does not have an accessible tap, then a separate, clean, 1-liter plastic or glass (as appropriate) container should be used to dip and fill the sample bottle(s). Point-of-use filters and leaking taps or faucets that allow water to flow outside of the tap should be avoided.
3. Before turning on the tap, remove any aerator, strainer, or hose to prevent contamination; however, you might not be able to remove the aerator or find a non-swivel faucet. The screen should be removed prior to sampling for bacteria or volatile organics because the screen tends to aerate the water, resulting in the loss of some organics and non-representative samples. The removal of the screen should be documented. When sampling for bacteria, do not take a sample from a swivel faucet, because the joint can harbor a significant bacterial population.
4. Open the cold-water tap, and allow the system to flush to clear the service line from the building to the distribution main. Allow the water temperature to stabilize for 2 – 3 minutes before collecting the sample.
5. Fill out the sample label using waterproof ink. Be sure to clearly identify the exact sample collection location and the date and time of collection. If the sample collection point has a specific coded identification, include it on the label and the COC record along with the sampler's name.
6. Adjust the flow from the tap to about 500 milliliters (1 pint) per minute (approximately ⅛-inch diameter stream).
7. Check for steady flow. Do not change the water flow once sampling has started.
8. Remove the bottle cap or open the plastic bag. Add preservative if required. Position the bottle or bag under the water flow. Hold the bottle in one hand and the cap in the other. When filling a bottle, tip the bottle slightly so that water flows down the side wall of the container. Fill the bottle to the shoulder about ¼ inch from the top of the bottle. For VOCs, fill the bottle just to the point of overflowing. If using a plastic bag sampling container, fill it to the marked fill line. If the preservative is acid, add it after the sample is collected.

WARNING: Do not lay the cap down or put it in a pocket. Do not contaminate the sterile bottle (or bag), touch the inside of the cap with your fingers, or permit the faucet to touch the inside of the bottle or bag. Do not rinse out the bottle or bag before collecting the sample.

9. For chlorinated systems, check the chlorine residual and record; see Section 9.7.1.
10. Place the cap on the bottle and screw it down tightly. If using a plastic bag, pull the wire tabs and whirl the bag three times for a tight seal.
11. Turn the tap off. Replace the aerator, strainer, or hose.
12. Check that the information on the label is correct.
13. Complete the necessary forms with the appropriate information, including the PWS identification number, exact sample collection location, date and time, and type of sample (e.g., raw, tap, entry point, distribution system). Specify the type of analysis to be run. Complete a COC record.

9.6.2. Service Line Sampling

Service line sampling is required if a limited lead service line replacement program is being considered or when the service line material is unknown.

9.6.2.1. Appropriate Parameters

Service line sampling is an acceptable method for sampling metals.

9.6.2.2. Sampling Procedures

The general procedure for collecting samples from a service line is as follows:

1. Determine the appropriate service line sample location and assemble all necessary materials. The proper preservative should be added by the laboratory or available in the field for addition to the sample. Handle the sterilized containers carefully to avoid contamination.
2. Fill out the label for the sampling bottle in waterproof ink. Be sure to clearly identify the exact sample collection location and the date and time of collection. If the sample collection point has a specific coded identification, include it on the label and the COC record along with the sampler's name.
3. Using one of the following three procedures, ensure that service line water is being sampled:
   a) At the tap, flush an appropriate volume of water from the building plumbing before collecting the sample. This removes the water contained in the pipes between the sampling tap and the service lines. Use a container, such as a pitcher or bucket, for measuring the volume of water wasted. Table 9-1 provides an abbreviated list of the volume to be flushed.
   b) For single-family homes, allow the water to run until there is a significant change in its temperature. The temperature change indicates that water is flowing from the service line(s) outside the home.
   c) Locate or install a sampling tap directly on the service line, and sample from this tap.

Table 9-1. Approximate Volume, in Gallons, of Flush Water for Various Sizes and Length of Copper Pipe

Nominal Pipe Size (inches)	Length of Pipe (inches)					
	10	20	30	40	50	100
½	0.1	0.2	0.3	0.4	0.5	1.0
¾	.23	.16	0.4	0.9	1.1	2.3
1	.41	.82	1.2	1.6	2.0	4.1

4. After step 3a, 3b, or 3c, immediately collect the sample in a 1-liter plastic bottle or collapsible container while the water is still flowing. For 3c, turn on the service line tap, and collect the water immediately. Remove the bottle cap, or open the plastic bag. Add preservative if required. Position the bottle or bag under the water flow. Hold the bottle in one hand and the cap in the other. Fill the bottle to the shoulder, about ¼ inch from the top of the bottle. If using a plastic bag sampling container, fill it to the marked fill line.

WARNING: Do not lay the cap down or put it in a pocket. Do not contaminate the sterile bottle (or bag), touch the cap with your fingers, or permit the faucet to touch the inside of the bottle or bag. Do not rinse out the bottle or bag before collecting the sample.

5. For chlorinated systems, check the chlorine residual and record; see Section 9.7.1.
6. Place the cap on the bottle and screw it down tightly. If using a plastic bag, pull the wire tabs and whirl the bag three times for a tight seal.
7. Turn the tap off.
8. Check that the information on the label is correct.
9. Complete the necessary forms with the appropriate information, including the PWS identification number, exact sample collection location, date and time, and type of sample (e.g., raw, tap, entry point, distribution system). Specify the type of analysis to be run. Complete a COC record.

9.6.3. First-Draw Sampling

First-draw samples are taken to show compliance with ALs. The water in the plumbing must stand motionless in the pipes for at least 6 hours. Taps within a work site building can be secured with tape noting the date, time, and person securing the area. Post signs to warn potential users not to turn on the water during the test period.

9.6.3.1. Appropriate Parameters

First-draw sampling is an acceptable method for sampling metals, particularly copper and lead.

9.6.3.2. Sampling Procedures

The following is a detailed first-draw sampling procedure.

1. All samples for compliance monitoring must be first-draw samples, taken from a kitchen cold water or bathroom cold water sink tap; avoid drinking water fountains. The proper preservative should be added by the laboratory or available in the field for addition to the sample. Handle the sterilized containers carefully to avoid contamination.
2. Fill out the sample label to indicate the date and time of sample collection, the location, type of samples, and the sampler's name. The site should be sealed, or a certification by the homeowner must be signed to indicate the length of time the system was not used.

CAUTION: Any use of the taps during the 6-hour rest time that the tap is to be secured will invalidate that tap for sampling. Do not turn valves or otherwise mechanically shut down the tap as this can release high amounts of lead and copper into the waterline. Secure taps by taping and posting notices.

3. Before turning the tap water on, remove the cap from the container and position the container under the kitchen or bathroom sink faucet. Turn on the cold water and begin filling the container. Do not put the cap of the container down on any surface. Hold the bottle in one hand and the cap in the other.

WARNING: Do not lay the cap down or put it in a pocket. Do not contaminate the sterile bottle, touch the cap with your fingers, or permit the faucet to touch the inside of the bottle. Do not rinse out the bottle before collecting the sample.

4. Fill the bottle to the shoulder, about ¼ inch from the top of the bottle.
5. Turn off the water tap. Place the cap on the bottle and screw it down tightly.
6. Check that the information on the label is correct.
7. Complete the necessary forms with the appropriate information, including the PWS identification number, exact sample collection location, date and time, and type of sample (e.g., raw, tap, entry point, distribution system). Specify the type of analysis to be run. Complete a COC record.

9.6.4. Source Water Sampling (Surface Water)

Source surface water sampling is appropriate for drinking water parameters because initial contamination will determine the level of treatment required to be in compliance with federal, state and local statutes.

9.6.4.1. Appropriate Parameters

Source water sampling of surface waters is an acceptable sampling method for the following parameters:

- Microbiological
- Metals
- SVOCs
- Inorganic contaminants
- Radionuclides.

9.6.4.2. Sampling Procedures

Refer to Chapter 6, Surface Water Sampling, for further guidance and sampling procedures.

9.6.5. Source Water Sampling From a Well

Source water sampling from wells is appropriate for most drinking water sampling parameters, as it will determine the level of treatment required to bring the water into compliance with federal, state, and local statutes.

9.6.5.1. Appropriate Parameters

Source water sampling of wells is an acceptable method for the following parameters:

- Microbiological
- Metals
- SVOCs
- Inorganic contaminants
- Radionuclides.

9.6.5.2. Sampling Procedures

The general procedure for collecting source water samples from wells is as follows:

Obtain as much information as possible from the well owner, including depth of the well, well yield, formation in which the well is completed, screen depth and length, well construction material, diameter of casing and when and by whom the well was installed. This information should be verified if possible by obtaining drilling logs, etc. With this information, the correct sampling approach, as well as the number of gallons to be evacuated, can be determined so that the collected sample represents the condition of the groundwater.

1. When collecting a sample from an operating domestic well, it is essential to evacuate the plumbing and water storage tank. Running the water for a minimum of 15 minutes before collection is a good rule of thumb; however, a longer evacuation period is desirable. Listen for the pump or the electric circuit to the pump to come on, indicating that the plumbing is being evacuated.
2. Determine if any treatment units are installed on the system. Treatment such as softening, iron removal, turbidity removal, disinfection, and pH adjustment can provide misleading analytical results depending on the parameters of interest. Carbon filters for the removal of organics are also increasingly popular and can alter sampling results. If a treatment system is in use, a basement or outside faucet can bypass such treated water.

Note: Sampling from the cold water faucet is preferred to avoid samples heated by the water heater.

3. A brief inspection of the system should be performed to locate the well, pump, storage tanks, and any treatment systems. Samples should be taken as close to the pumping well as possible and prior to any storage tanks or treatment systems. If a sample must be taken following a treatment unit, the type, size, and purpose of the unit should be noted in the FLB/FN.
4. Faucets, particularly kitchen faucets, usually have a screen installed on the discharge. The screen should be removed prior to sampling for bacteria or volatile organics because the screen tends to aerate the water, resulting in the loss of some organics, resulting in a non-representative sample. The removal of the screen should be noted. When sampling for bacteria, do not take a sample from a swivel faucet because the joint can harbor a significant bacterial population.

Note: A homeowner's plumbing system should not be tampered with in any way, except for removal of the faucet screen with permission from the homeowner.

For long-term monitoring projects utilizing domestic wells, a specific tap or faucet should be

designated as the target sample access point for accurate reproducibility of future samples.

9.7. Parameter-Specific Sampling Procedures

Sampling procedures for regulated and unregulated contaminants are presented in this section by group for the most frequently collected parameters. Sampling procedures for newly regulated contaminants and other parameters of concern can be found in EPA approved methods (http://water.epa.gov/scitech/drinkingwater/labcert/methods_index.cfm)

The parameters and method-specific QC are found in the approved drinking water methods. This section provides common parameter-specific sampling procedures that meet federal requirements. State and local requirements can be different or more stringent; therefore, the sampler should always check state and local sampling requirements before the start of sampling.

9.7.1. Field Data

pH, temperature, chlorine residual, and turbidity measurements are conducted in the field at the start of sample collection.

9.7.1.1. Applicable Regulations

The SDWA requires EPA to institute rules and regulations to ensure that drinking water is safe to consume. The SWTR and subsequent amendments, were promulgated to minimize pathogen contamination in drinking water. These are discussed in Section 9.2. Disinfection and filtration for surface water and groundwater under the influence of surface water is required.

Chlorine residual must be checked to determine preservation, holding time, and, in the case of bacteria testing, data interpretation. Chlorine residual is measured when collecting samples in the drinking water program as free chlorine residual. Total chlorine residual is measured by water supply systems during treatment design, process control studies, or for distribution system problem solving.

MCL or Sampling Values. The regulator should specify the requirements for pH, temperature, and chlorine residual values for compliance. The turbidity after conventional or direct filtration should be ≤ 0.3 nephelometric turbidity units (NTU) in 95% of all monthly samples collected. At no time should the turbidity exceed 1.0 NTU. Slow sand and diatomaceous earth filtration systems must achieve a filtered water turbidity level of ≤ 1 NTU in 95% of the measurements each month (limits can vary by state). At no time can the filtered water turbidity exceed 5 NTU.

9.7.1.2. Number and Frequency of Drinking Water Samples

The pH, temperature, chlorine residual, and turbidity samples should be representative of the system's filtered water. These measurements should be collected once per day and at the start of each sample collection. Turbidity must be monitored every 4 hours on combined filter effluents, although individual states can reduce this requirement to once-per-day for slow sand or alternative filtration devices. For individual filters, turbidity must be monitored every 15 minutes.

9.7.1.3. Sampling Locations

The regulator should specify where the pH, temperature, and chlorine residual samples must be taken for compliance. One turbidity sample should be taken at each entry point into the distribution system.

9.7.1.4. Analytical Methods

The free chlorine residual method uses the reagent diethylphenylenediamine (DPD) in a colorimetric test to determine the amount of free chlorine available for disinfection. Total chlorine indicates how much of the added chlorine reacted with the indigenous components in the sample and can be determined by adding small amounts of potassium iodide to the DPD solution and recording the difference. The reagent used must be clearly identified as measuring either free chlorine or total chlorine. The results reported must also indicate free or total chlorine measurements.

Nephelometery is a standard test method for turbidity. It is based on comparison of the intensity of light scattered by the contained static water sample under defined conditions to the intensity of light scattered by a reference standard

in the sample container. The higher the intensity of scattered light, the higher the turbidity of the sample.

9.7.1.5. Sample Volume

Sample volume depends on the method used for each parameter; refer to Chapter 13 for a discussion of pH, temperature, and chlorine residual field measurements. The turbidity volume collected should be sufficient to:

- Ensure a representative sample
- Allow for replicate analysis (if required)
- Minimize waste disposal
- Comply with the analytical method used.

9.7.1.6. Bottle Type

Bottle type depends on the method used for each parameter; refer to Appendix B for a discussion of pH, temperature, and chlorine residual field measurements. Samples for turbidity should be collected in plastic or glass bottles, as specified by the selected analytical method.

9.7.1.7. Sampling Procedures

The field testing procedures for pH, temperature, and chlorine measurements are presented in Chapter 13. Chlorine residual test kits, including instructions, are available for drinking water testing to measure free or total chlorine. An example of a chlorine residual method can be found in Chapter 13. Most kits use DPD powder, tablets, or drops of liquid placed in a glass tube containing the sample. A color change after adding the reagent indicates that free chlorine is present. In some kits, the color is measured against a field comparator or portable spectrophotometer showing concentration in mg/L or ppm.

If a free residual chlorine level of 0.1 ppm is detected, this test will show as a trace of pink color. Trace colors are visible by looking down the tube and against a white background, which ensures no reflection from any red or pink surrounding surfaces. Interferences in the measurement of chlorine can cause variations to the color or affect the color formation. Any unusual color formations or colors must be noted for proper data interpretation. Note in the FLB/FN the results in mg/L, the date and time of the sampler, the name of the sample, as well as any observations made during the sampling or analysis. If chlorine is not detected in the test, write "not detected."

A one-time demonstration of technician proficiency should be on file in the training records. The one-time demonstration should include a standard curve, a low-level measurement standard, and an annual performance evaluation sample for chlorine and pH.

For turbidity sampling, all bottles must be thoroughly cleaned and rinsed with turbidity free water prior to sample collection. Turbidity samples are collected typically during general tap sampling, source water sampling from surface water, and source water sampling from wells. Refer to Sections 9.6.1, 9.6.4, and 9.6.5, respectively, for general sample collection procedures.

9.7.1.8. Preservation Requirements

There are no preservation requirements associated with sampling pH, temperature, or chlorine residual. Ensure that samples for turbidity are cooled to $\leq 6°C$.

9.7.1.9. Holding Time

Samples for pH, temperature, and chlorine residual must be analyzed immediately, which generally means within 15 minutes of sample collection. Samples for turbidity should be analyzed as soon as possible after collection. If storage is required, samples maintained at $\leq 6°C$ can be held for up to 48 hours.

9.7.2. Microbiological

This section covers specific sampling requirements for the following microbiologicals:

- Coliforms
- *Cryptosporidium*
- *Giardia*.

9.7.2.1. Coliforms

Coliforms are a group of closely related bacteria that are generally harmless, but do contain some species that are human pathogens. They are natural and common inhabitants of the soil and ambient waters, such as lakes and rivers. Coliforms can be inactivated by treatment or die off

naturally in a manner similar to most bacterial pathogens and many viral pathogens. Therefore, if coliforms are found in the distribution system, pathogens also could be present.

9.7.2.2. Applicable Regulations

The TCR introduced in Section 9.2 was established by the SDWA with sample requirements primarily based on the presence or absence of total coliform bacteria rather than on the number of coliforms detected in the samples. The TCR exists to protect public health by determining the presence of disease-causing pathogens in drinking water.

The TCR became effective December 31, 1990 and supersedes the old National Interim Primary Drinking Water Regulations (NIPDWR) for maximum microbiological contaminant levels (effective June 24, 1977). The rule requires that total coliform-positive samples be further tested for fecal coliform or *Escherichia coli* (*E. coli*) and that a set of repeat samples be collected for each total coliform-positive sample. When coliforms are detected, additional routine samples must be collected the following month.

9.7.2.3. MCL

For systems collecting fewer than 40 samples per month, no more than one sample per month is allowed to be positive for total coliform. For systems collecting greater than 40 samples per month, no more than 5% of all monthly samples are allowed to be positive. If a system exceeds the monthly MCL, the public must be notified within 14 days per the requirements established in the Public Notification Rule. If an acute MCL violation occurs (i.e., when any fecal coliform is detected on a repeat sample) the public must be notified within 72 hours.

9.7.2.4. Number and Frequency of Samples

The number of samples that must be taken monthly is based on the population served by the water system. Table 9-2 provides an abbreviated list of minimum monthly monitoring requirements. Many community systems routinely sample more than the minimum to monitor the system's status.

Table 9-2. Microbiological Monitoring Frequency for Routine Sampling in PWSs

Population Served	Minimum Routine Samples/Month*
25 – 1,000	1
1,001 – 2,500	2
2,501 – 3,300	3

***** The regulator can specify a sampling frequency of less than once per month for selected systems. A CWS serving more than 3,300 must refer to the CFR. Contact your state drinking water representative for details.

Compliance with the TCR is based on the presence or absence of total coliform bacteria. If all routine samples test negative (absent) for the presence of total coliforms, no additional testing is required for that monitoring period, regardless of whether sampling is routinely conducted monthly, quarterly, or annually. However, the rule requires that total coliform-positive samples (presence) be further tested for fecal coliform or *E. coli* and that a set of three repeat samples be collected for each total coliform-positive sample monthly, quarterly, and annually. Systems that collect one routine sample or fewer per month must collect a fourth repeat sample. If total coliforms are detected in any routine or repeat sample, the sampler must collect at least five routine samples the next month. Table 9-3 provides an abbreviated list of the required frequency for repeat sampling.

Table 9-3. Monitoring and Repeat Sampling Frequency After a Total Coliform-Positive Routine Sample

# of Routine Samples/Month	# of Repeat Samples	# of Routine Samples Following Month
1/month*	4	5/month
2/month	3	5/month
3/month	3	5/month

***** Or fewer.

All repeat samples must be collected within 24 hours of notification of the total coliform-positive result, unless the state waives this requirement.

Each set of repeat samples must include the following:

- One sample at the same tap as the original sample
- One sample within five service connections upstream
- One sample within five service connections downstream.

If a system has only one service connection, the state can authorize the system to collect the required set of repeat samples over 4 days, rather than within 24 hours, after being notified of a total coliform-positive result. Per state discretion, such systems can collect a larger volume repeat sample (or samples) instead of the standard 100-milliliter container (e.g., a single 400-milliliter repeat sample or two 200-milliliter repeat samples in one or more sample containers of any size as long as the total volume collected is at least 400 milliliters). If a system collects more than one routine sample per month, the total volume required would be 300 milliliters.

9.7.2.5. Sample Locations

Samples for the TCR are collected from the distribution system based on the number and frequency requirements.

9.7.2.6. Analytical Methods

The method used for fecal coliform and *E. coli* analysis depends on that used for the total coliform test and must be listed as approved for compliance monitoring. EPA Method 1604 is commonly used for total coliforms.

9.7.2.7. Sample Volume

The sample volume depends on the analytical method used. However, at a minimum, one 100-milliliter sample must be collected per test.

9.7.2.8. Bottle Type

Sample containers for collecting coliform samples must be sterilized, hold at least 120 milliliters (4 ounces) of water, and contain sodium thiosulfate if the sampled water is chlorinated. Bottles can be plastic or glass. The laboratory normally supplies the container. Glass-stoppered bottles must be covered with aluminum foil or char-resistant paper prior to sterilization. The covering on the top ensures that the seal between the stopper and the bottle is not contaminated, thus minimizing the potential for contaminating the sample when it is opened. Some labs furnish a single-service, sterilized, polyethylene bag or bottle containing a sodium thiosulfate tablet. The laboratory should perform sterility checks (one per lot) prior to releasing the containers for collecting samples. The laboratory normally provides instructions to go along with the sample containers it has supplied. Refer to those when provided.

9.7.2.9. Sampling Procedures

The laboratory that supplies the sampling containers might provide instructions for the type of monitoring being performed. Be sure to refer to those instructions when provided. Total coliform samples are collected typically during general tap sampling, source water sampling from surface water, and source water sampling from wells. Refer to Sections 9.6.1, 9.6.4, and 9.6.5, respectively, for general sample collection procedures.

9.7.2.10. Preservation Requirements

Coliform samples must be refrigerated or cooled to $\leq 10^{o}$C immediately after sampling.

9.7.2.11. Holding Time

The laboratory must receive and begin analyzing coliform samples within 30 hours of collection. If the laboratory is nearby, refrigerate the samples

with ice packs and deliver them directly. Samples analyzed by an off-site laboratory should be shipped on ice via overnight service on the day they were collected.

9.7.2.12. Cryptosporidium and Giardia

Cryptosporidium is a genus of protozoan parasites potentially found in water and other media. The recent taxonomy of the genus *Cryptosporidium* includes two species that use humans as hosts: *C. hominis* and *C. parvum*.

Giardia is a genus of protozoan parasites potentially found in water and other media. The recent taxonomy of the genus *Giardia* includes one species that uses humans as hosts: *G. lamblia* (also called *G. intestinalis* or *G. duodenalis*).

Applicable Regulations. Under the 1996 SDWA Amendments, EPA must supplement the existing 1989 SWTR with additional pathogen control requirements. Several additions to the rule have resulted in the Long-Term 2 Enhanced SWTR, which focuses on the control of *Cryptosporidium* and microbial pathogens.

MCLG. The Interim Enhanced Surface Water Treatment Rule (IESWTR) has an MCLG of zero or a 99% removal for systems that filter.

Number and Frequency of Drinking Water Samples. Monitoring of source water is required to determine the level of treatment for *Cryptosporidium*. Monthly samples are required for the first 2 years, with the level of *Cryptosporidium* determining the level of any subsequent treatment. Most systems will not require additional treatment. A 6-year follow-up sample is required to ensure continued compliance. Small systems can monitor for *E. coli* and will monitor for *Cryptosporidium* only if the *E. coli* concentrations exceed a specified level.

Sampling Locations. Samples are collected from source water for distribution systems.

Analytical Methods. EPA Method 1623 can be used to measure both *Cryptosporidium* and *Giardia*. Prior to analysis, the water sample must be filtered and the extraneous materials retained on the filter. Qualitative analysis is performed by scanning each slide well for objects that meet the size, shape, and fluorescence characteristics of *Cryptosporidium* and *Giardia* oocysts. Quantitative analysis is performed by counting the total number of objects on the slide confirmed as oocysts. Quality is assured through reproducible calibration and testing of the filtration, immunomagnetic separation (IMS), staining, and microscopy systems.

Sample Volume. The sample volume depends on the analytical method used. Generally, 10-liter bulk samples are taken.

Bottle Type. Ten-liter collapsible containers generally are used for collecting *Cryptosporidium* and *Giardia*. These containers must be sterilized, and are normally supplied by the laboratory. The laboratory should perform sterility checks (one per lot) prior to releasing the containers for collecting samples. The laboratory typically provides instructions to accompany the sample containers. Refer to those when provided.

Sampling Procedures. The laboratory that supplies the sampling containers can provide instructions for the type of monitoring being performed. Be sure to refer to those instructions when provided. *Cryptosporidium* and *Giardia* samples are collected typically during general tap sampling, source water sampling from surface water, and source water sampling from wells. Refer to Sections 9.6.1, 9.6.4, and 9.6.5, respectively, for general sample collection procedures.

Preservation Requirements. Ambient water samples are dynamic environments and, depending on sample constituents and environmental conditions, *Cryptosporidium* and *Giardia* oocysts present in a sample can degrade, potentially biasing analytical results. Samples should be chilled to reduce biological activity between collection and analysis.

If samples are collected early in the day, they should be chilled by storing in a refrigerator between 1°C and 10°C or on ice in a cooler. If the sample is pre-iced before shipping, the ice should be replaced with fresh ice immediately before shipment. If samples are collected later in the day, these samples can be chilled overnight in a refrigerator between 1°C and 10°C. This pro-

cedure should be considered for bulk water samples that will be shipped off site because it minimizes the potential for water samples collected during the summer to melt the ice in which they are packed and arrive at the laboratory at > 20°C. If samples are shipped after collection at > 20°C with no chilling, the sample will not maintain the temperature necessary to retard microbiological activity and will not present a representative sample for analysis.

PWSs shipping samples to off-site laboratories for analysis should include in the shipping container a means for monitoring the temperature of the sample during shipping to verify that the sample did not freeze or exceed 20°C. PakSense labels adhere to the samples and provide accurate readings of the temperature environment experienced by the samples in shipment.

Holding Time. Sample preparation must be initiated within 96 hours of sample collection (if shipped to the laboratory as a bulk sample) or filtration (if filtered in the field). The laboratory must complete elution, concentration, and purification in one workday. It is critical that these steps be completed in one workday to minimize the time that any target organisms present in the sample sit in eluate or concentrated matrix. This process ends with the application of the purified sample on the slide for drying.

9.7.3. Metals

EPA has determined that metals are health concerns at certain levels of exposure. Young children and pregnant woman are especially at risk from high levels in their blood. Some of the most pronounced effects in children are interference with growth, deficits in IQ, and altered physical and mental development.

Applicable Regulations. The SDWA has established MCLs for various metals (see Table 9-4). The LCR applies to lead and copper and addresses the effects of plumbing materials on the distribution system as well as ways to minimize their concentration.

Table 9-4. Metal MCL or AL

Metal	MCL (mg/L)
Antimony	0.006
Arsenic	0.010
Barium	2
Beryllium	0.004
Cadmium	0.005
Chromium	0.100
Copper	AL= 1.3
Lead	AL= 0.015
Mercury	0.002
Selenium	0.05
Sodium	20
Thallium	0.002

Prior to December 1992, the MCL for lead was 0.05 mg/L. Since then, instead of establishing a new MCL, a treatment technique requirement is triggered by exceeding an AL. The AL for lead is 0.015 mg/L, and the AL for copper is 1.3 mg/L measured at the 90th percentile at the consumer tap. This means that some samples can exceed 0.015 mg/L for lead and 1.3 mg/L for copper and still not exceed the AL. Specific rules for calculating the 90^{th} percentile can be found in 40 CFR 141.80.

Number and Frequency of Samples. All systems must be monitored annually for all regulated metals except for lead and copper. Sodium samples must be collected annually for surface waters, and every 3 years for groundwater sources. In areas where the sodium content is variable, more frequent analyses might be required. All systems must be monitored for lead and copper for a minimum of two consecutive 6-month periods until one of the following occurs.

- Lead or copper concentrations exceed the MCLs or ALs. Then, additional samples from the distribution system and point of entry must be collected for water quality parameters and corrosion control treatment studies performed and reviewed by state personnel.
- Lead and copper concentrations meet the MCLs or ALs for two consecutive periods. Then, the water supply can petition the regulator to reduce the number of tap water

sampling sites and reduce the frequency of collection.

The number of lead and copper samples taken during the 6-month sampling period is based on the population and the results from previous samples. After two 6-month sampling periods of meeting the MCL or AL, a system can request reduced monitoring (see Table 9-5). Monitoring frequency also can be reduced after several years of meeting the AL. Refer to 40 CFR 141 for specific information.

Table 9-5. Number of Samples for Standard and Reduced Monitoring for Lead and Copper

System Size (Population Served)	Number of Sites (Standard Monitoring)	Number of Sites (Reduced Monitoring)
3301 – 10,000	40	20
501 – 3,300	20	10
101 – 500	10	5
up to 100	5	5

Sampling Locations. State-approved sampling locations should be selected if any have been designated. If not, representative sampling locations should be selected. First-draw samples should be collected at cold-water taps in homes and buildings that are at high risk for lead and/or copper contamination. In addition, samples must be obtained from each entry point to the distribution system (EPTDS). For a surface water system, the plant effluent tap might be an appropriate sampling location. For a well discharging directly into a distribution system (also known as an EPTDS), a tap on the well's discharge piping after any treatment would be appropriate.

Analytical Methods. The method used for metal analysis must be listed as approved for compliance monitoring. Inductively coupled plasma-atomic emission spectrometry (ICP-AES, EPA Method 200.8) is a common method used for metal analysis. The analysis involves multi-elemental determinations by ICP-AES using sequential or simultaneous instruments. The instruments measure characteristic atomic-line emission spectra by optical spectrometry. Samples are nebulized, and the resulting aerosol is transported to the plasma torch. Element-specific emission spectra are produced by a radio-frequency inductively coupled plasma. The spectra are dispersed by a grating spectrometer, and the intensities of the line spectra are monitored at specific wavelengths by a photosensitive device. Photocurrents from the photosensitive device are processed and recorded by a computer system.

Mercury can be analyzed using the automated cold vapor technique. The flameless atomic absorption (AA) procedure is a physical method based on the absorption of radiation at 253.7 nm by mercury vapor. The mercury is reduced to the elemental state and aerated from solution. The mercury vapor passes through a cell positioned in the light path of an atomic absorption spectrophotometer. Absorbance (peak height) is measured as a function of mercury concentration and recorded in the usual manner.

If additional analytical sensitivity is required for mercury (ng/L), EPA Method 1631, Mercury in Water by Oxidation, Purge and Trap and Cold Vapor Atomic Fluorescence Spectrometry (CVAFS) can be employed. A water sample is chemically treated to produce volatile mercury and separated from the solution by purging with an inert gas. The mercury is collected on a gold trap and subsequently desorbed into a fluorescence spectrometer where the intensity of its fluorescence is measured and compared with the intensity of the standards. At this level of detection, precluding the introduction of contamination is critical; care must be taken to insure that clean/ultra clean sampling, transportation and analysis techniques are used. Guidance on these techniques can be found in *Guidance for Implementation and Use of EPA Method 1631 for the Determination of Low-Level Mercury* (EPA 821-R-01-023) and EPA Method 1631.

Sample Volume. Sample volume is specified by the method or the laboratory. One-liter samples are usually taken.

Bottle Type. Sampling containers for metals can be made of plastic or glass and should be 1-liter in volume. A 1-liter plastic bottle is most commonly used.

Sampling Procedure. There are two types of metal sampling procedures.

1. Service line sampling; see Section 9.6.2.
2. First-draw sampling; see Section 9.6.3.

Preservation Requirements. If the analytical requirements are for total metals, field preservation is recommended. Samples are preserved by adding approximately 3 milliliters of concentrated ultrapure nitric acid to the sample bottle. Be extremely careful when adding the acid. Check the sample pH with litmus paper. Indicate if the sample pH is < 2. If the pH is not < 2, add acid in 1-milliliter increments until the pH is < 2. Record the amount of acid used, the ultimate sample pH, the date and time of preservation, the person performing the preservation, and the source of the acid used. Indicate on the label whether the sample has been acidified. If the analytical requirements are for other than total metals, check with the method for specific preservation techniques and requirements.

WARNING: Concentrated acids and other chemical preservatives represent a safety concern. Refer to the HASP and Chapter 2 for related precautions and PPE.

Holding Time. Samples can be shipped to the laboratory and preserved by the laboratory within 14 days after sample collection. Samples preserved at the laboratory are not to be analyzed until 24 hours after preservation. Preserved samples should be analyzed as soon as possible, but are stable (except mercury) for up to 6 months.

9.7.4. Nitrates/Nitrites.

Nitrate is a form of nitrogen combined with oxygen. It can be converted in the body to nitrite. High concentrations of nitrate can cause serious illness in infants less than 6 months of age. Nitrate, one of the most widespread of contaminants, can get into water if a well is improperly constructed or located where it is subject to sources of contamination.

Applicable Regulations. NPDWRs establish MCLs for nitrates and nitrites.

MCL. The MCL for nitrate is 10 mg/L, and the MCL for nitrite is 1 mg/L.

Number and Frequency of Samples. One sample should be collected from each entry point or from points in the distribution system that represent each source or treatment plant. The frequency of sampling for initial nitrate monitoring is one sample per quarter for surface water and one annual sample for groundwater. If sample results are greater than 50 percent of the MCL, then quarterly monitoring should be performed until four reliable and consistent sample results that are less than 50 percent of the MCL are obtained. The state may allow a reduced sampling frequency for surface water (annually), provided that analytical results from four consecutive quarters are less than 50 percent of the MCL. For groundwater, the state may return sampling frequency to annually after four consecutive quarterly samples are less than 50 percent of the MCL.

Sampling Locations. Drinking water compliance samples for nitrates and nitrites are taken at the entry point to the distribution system after treatment. Surface water supplies can take samples from the distribution system at a point that is representative of each source after treatment.

Analytical Methods. If an ion chromatograph (IC) is available, nitrates can be analyzed by EPA Method 300. In this method, a small volume of sample is introduced into an IC. The anions of interest are separated and measured using a system consisting of a guard column, separator column, suppressor device, and conductivity detector.

Sample Volume. Sample volume is specified by the method or the laboratory. One-liter samples are usually taken

Bottle Type. Both nitrate and nitrite samples should be collected in 1-liter glass or plastic bottles.

Sampling Procedures. Nitrate and nitrite samples typically are collected during general tap

sampling, source water sampling from surface water, and source water sampling from wells. Refer to Sections 9.6.1, 9.6.4, and 9.6.5, respectively, for general sample collection procedures.

Preservation Requirement. Samples should be preserved per method requirements. All samples should be packed on ice to lower the temperature to ≤ 6°C.

Holding Time. Nitrate and nitrite samples should be delivered by the sampler or shipped to the laboratory by overnight courier. Results can be reported as nitrate/nitrite, nitrate only, or nitrite only. Samples of non-chlorinated water must be analyzed within 14 days. Nitrate from chlorinated supplies must be analyzed within 28 days. Samples for nitrite must be analyzed within 48 hours of sample collection. When nitrite and nitrate need to be determined separately, the holding time of 48 hours for nitrite must be met.

9.7.5. Pesticides and Synthetic Organic Chemicals

Organic compounds that volatilize at temperatures greater than 150°C and do not decompose are termed semivolatile organic compounds (SVOCs). The synthetic organic chemicals regulated by the SDWA are SVOCs that fall into the categories of polychlorinated biphenyls (PCBs), pesticides, fungicides, and herbicides. These compounds are commercially produced with applications for agriculture and home use. If incorporated into the water supply, they could impart significant health risks and are consequently regulated under the SDWA.

Applicable Regulations. Since the establishment of the SDWA Amendments of 1986, EPA has established MCLs for PCBs, 23 pesticides, and six other synthetic organic chemicals.

MCLs. A list of drinking water MCLs can be found on the EPA's website, http://water.epa.gov/drink/contaminants/index.cfm.

Number and Frequency of Samples. For systems serving about 50,000 customers and operating within the MCLs, one sample per year is required. For systems operating above the MCLs, quarterly samples are required. The number of samples required and frequency of sampling varies with system size. Consult 40 CFR 141 or http://www.epa.gov/safewater for additional details.

Sampling Locations. State-approved sampling locations should be selected if any have been designated. If none have been designated, representative sampling locations should be selected. Samples are collected after treatment at the treatment plant, or at the entry point to the distribution system, making sure each individual source of water is represented in the sample.

Analytical Method(s). The EPA 500 series methods are designed to identify and quantify organic compounds in municipal drinking water. These methods are cited under the SDWA.

Sample Volume. Sample volume will vary with the parameter being tested. Generally two 1-liter samples are collected.

Bottle Type. All methods require the sample to be collected in glass bottles with Teflon®-lined lids. The size and number of containers will vary depending on the number of parameters to be monitored. In most cases, samples are collected in two 1-liter amber-glass bottles and preserved. Exceptions exist and the methods must be reviewed prior to sampling to ensure the proper size, number, and types of containers are selected.

Sampling Procedures. Samples for pesticides and synthetic organic chemicals are collected typically during general tap sampling, source water sampling from surface water, and source water sampling from wells. Refer to Sections 9.6.1, 9.6.4, and 9.6.5, respectively, for general sample collection procedures.

Preservation Requirement. The preservatives used vary in concentration, addition, and type, depending on the method, parameters to be measured, and the matrix (refer to 40 CFR 141). All samples should be cooled to ≤6°C during transportation and storage. Chlorinated and non-chlorinated water supplies are preserved using different preservatives. Preservatives include sodium thiosulfate to remove chlorine, HCl to

stabilize the pH and reduce biological activity, and other chemicals such as mercuric chloride. The use of mercuric chloride requires that the samples and waste material be treated as a hazardous waste for mercury.

9.7.6. DBPs

Chlorine and other chemical disinfectants have been widely used by PWSs as a principal barrier to microbial contaminants in drinking water. DBPs are formed when disinfectants interact with organic and inorganic materials in source waters.

The levels of DBPs in finished water also are dependent on the pH, temperature, concentration of precursor materials, and age of the water in the distribution system. Drinking water can vary significantly from one point in a distribution system to another. The regulated DBPs included in this section are:

- Bromate
- Chlorite
- HAA5
- Total trihalomethanes (TTHMs).

Applicable Regulations. DBPs are regulated through the Stage 1 and Stage 2 of the DDBPR. The Stage 1 DDBPR applies to water systems that add a chemical disinfectant. The Stage 2 DDBPR, finalized in January 2006, makes incremental changes to the Stage 1 rule for additional protection of public health.

The Stage 2 DDBPR is designed to protect public health by supplementing existing drinking water regulations with risk-targeted monitoring and compliance determinations for MCLs. Under the Stage 2 DDBPR, a water system will conduct an evaluation of its distribution system to identify the locations with high DBP concentrations. These locations will then be used as the sampling sites for DDBPR compliance monitoring. Monitoring is required for populations of over 10,000.

MCL. The MCL for each disinfection byproduct covered in this section can be found in Table 9-6.

Table 9-6. DBPs/MCLs

Disinfection Byproduct	MCL (mg/L)
Bromate	0.010
Chlorite	1.0
HAA5	0.060
TTHMs	0.080

Number and Frequency of Drinking Water Samples. The number of samples, frequency, and location of monitoring is dependent on source water, distribution size, initial monitoring results, and state requirements. In general, sampling is required annually for small ground water systems and small subpart H systems. Sampling is required once per quarter for all other systems.

Sampling Locations. Samples are collected within the distribution system after treatment.

Analytical Methods. Ion chromatography by EPA Method 300 is a common method used for the analysis of the inorganic fraction of DBPs. A small sample volume is introduced into an IC. The anions of interest are separated and measured using a system consisting of a guard column, analytical column, suppressor device, and conductivity detector. The organic DBPs are extracted and analyzed using gas chromatography (GC) or GC/MS techniques. EPA Methods 501 and 524 are commonly used for TTHMs, and EPA Method 552 is commonly used for HAA5.

Sample Volume. Sample volume is specified by the method or the laboratory. Two 40- or 60-milliliter samples are usually taken

Bottle Type. The laboratory normally supplies the containers, preservatives, and blank water for DBP sampling. Recommended containers are glass, 60- to 120-milliliter screw-cap vials with a Teflon®-faced silicone septum. The preservatives, containers, and blank water should be traceable and controlled to ensure no detectable DBPs are present.

Sampling Procedures. DPB samples are collected typically during general tap sampling, source water sampling from surface water, and source water sampling from wells. Refer to

Sections 9.6.1, 9.6.4, and 9.6.5, respectively, for general sample collection procedures. Collect all samples in duplicate, and prepare two field blanks for each sampling site. Collect samples as follows:

1. Hold the vial at an angle, and fill it as near to the top as possible without overflowing. Be careful not to rinse out the preservative. No air bubbles should pass through the sample as the bottle is filled.

WARNING: Do not lay the cap down or put it in a pocket. Do not contaminate the sterile bottle (or bag), touch the cap with your fingers, or permit the faucet to touch the inside of the bottle or bag. Do not rinse out the bottle or bag before collecting the sample.

2. When sampling from an open body of water, fill a clean, empty (no preservative), 1-quart, wide-mouth bottle with sample and carefully fill two sample vials from the wide-mouth bottle. Discard the water in the wide-mouth bottle after filling the vials.
3. If a preservative is to be added, do not completely fill the vial until after the preservative has been added. After the preservative is added, carefully fill the bottle.
4. When filling the bottle, form a meniscus (the curved upper surface of a liquid formed by surface tension) or gently pour sample water from the vial cap to top off the bottle and form a meniscus.
5. Screw the cap on the bottle so that the shiny, Teflon® side of the septum is in contact with the water. Do not touch the septum, and do not over-tighten.
6. Invert the bottle, tap against your other hand, and check for air bubbles. If any are present, add additional water to reform the meniscus and check again until no air bubbles are present.

WARNING: Air bubbles larger than approximately 1 millimeter can invalidate the sample. Glass vials must be filled completely and handled with care to prevent spillage.

Preservation Requirement. For collecting chlorinated samples, a dechlorinating agent such as 25 milligrams ascorbic acid should be pre-added by the laboratory supplying the sample containers. If gases are not to be determined, sodium thiosulfate can be used as the dechlorinating agent. It should rapidly dissolve as the bottle is filled. For samples that require HCl, add one drop of HCl to each 20 milliliters of sample volume. Add the water before the HCl to ensure that the HCl and sodium thiosulfate do not react to form sulfur dioxide, which can affect the laboratory results. Sample pH should be < 2 after adjustment. Table 9-7 gives a summary of recommended preservatives for different VOCs.

WARNING: Concentrated acids and other chemical preservatives represent a safety concern. Refer to the HASP and Chapter 2 for related precautions and PPE.

Table 9-7. Recommended Preservatives for VOCs

Constituents	Chlorinated	Non-chlorinated
Halocarbons & Aromatics	HCl + reducing agent	HCl
THMs	Reducing agent (HCl optional)	None required

Holding Time. Pack the samples and blanks with ice to lower the temperature to ≤6°C. Ship to the laboratory by overnight courier or deliver directly. Refer to method holding time requirements.

9.7.7. Radionuclides

The EPA sampling requirement for radionuclides is intended to improve public health protection by reducing exposure to, and the related cancer risk posed by, radionuclides.

Applicable Regulations. Since December 2003, the Radionuclide Rule has included the existing MCLs for combined radium-226 and radium-228, gross alpha particle radioactivity, and beta particle and photon activity. The rule also established a new MCL for uranium. It is important to note that the Radionuclide Rule regulates CWSs only.

MCL. The MCL for each regulated radionuclide can be found in Table 9-8.

Table 9-8. Radionuclide MCL

Radionuclide	MCL
Alpha particles	15 picocuries per liter (pCi/L)
Beta particles and photon emitters	4 millirems per year
Radium-226 and radium-228	5 pCi/L
Uranium	30 µg/L

Number and Frequency of Drinking Water Samples. Samples for radionuclides are collected once every 4 years unless more frequent sampling is required by the state. Initial monitoring is performed by collecting one sample per quarter for 1 year. Repeat monitoring can be reduced to a single grab sample, if approved by the state. If gross alpha particle activity is found to be above the MCL, additional monitoring for radium-226 and radium-228 might be required. If the water source is near nuclear facilities, additional parameters (e.g., tritium, strontium-89, strontium-90, iodine-131, and cesium-134) might need to be monitored. These additional parameters will be specified in the state or federal permit.

Sampling Locations. State-approved sampling locations should be selected if any have been designated. If not, representative sampling locations should be selected. For a surface water system, the plant effluent tap might be an appropriate sampling location. For a well discharging directly into a distribution system (also known as an EPTDS), a tap on the well's discharge piping after any treatment would be appropriate.

Analytical Methods. Alpha particles are measured by reducing the sample using evaporation or a suitable chemical method to the minimum weight of material having measurable alpha activity. Alpha radioactivity is measured by an instrument composed of a detecting device, amplifier, power supply, and scaler– the most widely used being proportional, and scintillation counters. Gross alpha can be measured using EPA Method 900.

Beta radioactivity can be measured by one of several types of instruments composed of a detecting device and combined amplifier, power supply, and scaler– the most widely used being proportional or Geiger-Muller counters. Where a wide range of counting rates is encountered (0.1 – 1,300 counts per second), the proportional-type counter is preferable due to a shorter resolving time and greater stability of the instrument. The test sample is reduced to the minimum weight of solid material having measurable beta activity by precipitation, ion exchange resin, or evaporation techniques. Beta particles entering the sensitive region of the detector produce ionization of the counting gas. The negative ion of the original ion pair is accelerated towards the anode, producing additional ionization of the counting gas and developing a voltage pulse at the anode. By use of a suitable electronic apparatus, the pulse is amplified to a voltage sufficient for operation of the counter scaler. The number of pulses per unit of time is related to the disintegration rate of the test sample. Gross beta radiation also can be measured using EPA Method 900.

Radium-226 and radium-228 are measured by using sequential precipitation and an internal proportional counter or scintillation counter. Radium-226 and radium-228 in water are concentrated and separated by coprecipitation with sulfates of lead and barium and purified by ethylenediaminetetraacetic acid (EDTA) chelation. After 36-hour ingrowth of actinium-228 from radium-228, actinium-228 is carried on yttrium oxalate, purified, and beta-counted. Radium-226 in supernatant is precipitated as sulfate, purified, and alpha-counted (per 7500-Ra B), or is transferred to a radon bubbler and determined by an emanation procedure (per 7500-Ra C; the preferred method).

Solvent extraction technology is a common method for isolating and concentrating uranium in drinking water by counting via a high-resolution alpha-liquid-scintillation spectrometer. To determine total uranium, as well as limited isotopic uranium (^{238}U and ^{234}U) by activity in drinking water, a 200-milliliter acidified water sample is first spiked with ^{232}U as an isotopic tracer, boiled briefly to remove radon, and evaporated until less than 50 milliliters remain. The solution is then

made approximately 0.01 M in diethylenetriaminepentaacetic acid (DTPA), and the pH is adjusted to between 2.5 and 3.0. The sample is transferred to a separatory funnel and equilibrated with 1.50 milliliters of an extractive scintillator containing a dialkyl phosphoric acid extracting agent. Under these conditions, only uranium is quantitatively transferred to the organic phase while the extraction of undesired ions is masked by the presence of DTPA. Following phase separation, 1.00 milliliters of the organic phase is sparged with dry argon gas to remove oxygen, a chemical quench agent, and counted on a high-resolution alpha-liquid-scintillation spectrometer and multichannel analyzer (MCA). Radium-226 can be measured using EPA Method 903, and radium-228 can be measured using EPA Method 904.

Sample Volume. Sample volumes will vary depending on the analytical requirement. Generally, 1 gallon is collected per sample. Sample volumes being collected must be confirmed with the laboratory performing the analysis.

Bottle Type. Containers suitable for radionuclide sampling are either a one pre-cleaned 1-gallon Nalgene plastic bottle, or two pre-cleaned 2-liter plastic bottles per sample.

Sampling Procedures. Radionuclide samples typically are collected during general tap sampling source water, sampling from surface water, and source water sampling from wells. Refer to Sections 9.6.1, 9.6.4 and 9.6.5, respectively, for general sample collection procedures.

Preservation Requirement. Preservation for radionuclides is based on the method, parameter, and state requirements. Cesium-134 is preserved with HCl to pH < 2. Tritium and iodine-131 are not chemically preserved. All other regulated radionuclide parameters are preserved with nitric acid to pH < 2. If preservation is not performed in the field, the preservative can be added upon arrival at the laboratory. The preservative must be added within 3 days of collection, and analysis must not begin until 16 hours after acidification. Preservatives must be checked for the absence of the radionuclides being monitored.

Holding Time. Samples must be delivered to the analytical laboratory within 3 days for proper testing.

9.8. Sampling Equipment List

Section 3.8 provides a generic sampling equipment list applicable to most sampling events. The following list provides specific equipment applicable to drinking water sampling.

- Chlorine
  - Chlorine test kit or DPD test kit
- Microbiological
  - 120 milliliters plastic or glass containers (sterilized)
  - Sodium thiosulfate – a preservative
  - 10-liter collapsible containers
- Metals
  - First Draw
    - 1-liter bottle, plastic or glass
    - Nitric acid – a preservative
    - Warning signs to notify potential users not to turn on taps during testing period
  - Service Line Samples
    - Pitcher or bucket
    - Sampling tap
    - 1-liter bottle, plastic or glass
    - Nitric acid – a preservative
- Synthetic Organic Chemicals
  - Sulfuric acid (for nitrate non-chlorinated water only)
  - Sodium thiosulfate – a dechlorinating agent
  - HCl – a preservative
  - Mercuric chloride – a preservative
  - 1-liter amber glass bottles with Teflon®-lined lids

Note: Samples will be considered a hazardous material once mercuric chloride is added.

- DBPs
  - 40-milliliter amber vials with Teflon®-faced silicone septa
  - Ascobic acid – a dechlorinating agent
  - HCl – a preservative if sampling for halocarbons or aromatics
  - 1-quart wide-mouth bottle

- Radionuclides
    - HCl – a preservative if sampling for Cesium-134
    - Nitric acid – a preservative for all other radionuclides except for tritium and iodine-131
    - 1-gallon or two 1-liter plastic or glass bottles, volume dependent upon sample.

Chapter 10. Waste Sampling

10.1. Purpose

This chapter provides general procedural guidance to technical personnel who sample underground storage tanks (UST), drums, cylinders, articles containing PCBs, investigation derived waste (IDW), and other sources of solid or hazardous wastes that pose a potential threat to human health and the environment. Waste sampling may be performed for site assessments or for meeting regulatory requirements mandating proper storage, handling, and disposal of materials in drums, cylinders, USTs, articles containing PCBs, oil spills, and other solid wastes.

10.2. Scope

The overall objectives of waste sampling are to determine waste composition and meet regulatory monitoring requirements. Waste sampling activities need to be conducted properly to protect the health of those carrying out the sampling and ensure the accuracy and reliability of the sampling results. Waste sampling oversight should be maintained by following a previously prepared SAP; see Chapter 2 for more information. The sampling procedures, documentation, packaging, handling, and transportation requirements contained in the SAP should be followed. Refer to Chapter 3 for a complete discussion of sampling preparation and sample collection requirements applicable to all types of sampling programs.

The following sampling subjects are included within the scope of this chapter:

- USTs
- PCBs
- Containers and drums
- Oil spills
- Waste characterization
- Surface sampling
- Sewage sludge.

WARNING: Sampling personnel should be specifically trained, qualified, and certified to perform waste sampling operations due to the potential for encountering extreme safety hazards during these operations.

Specific objectives of waste sampling, as addressed in this chapter, are as follows:

- Provide relevant data for the protection of personnel
- Determine the presence of any USTs, drums, cylinders, articles containing PCBs, or other solid or hazardous wastes that require special handling
- Determine waste characteristics such as toxicity and physical hazards from reference or known sources
- Determine alternative disposal criteria in accordance with federal, state, and local regulations
- Determine special procedural requirements for the handling and sampling of PCB-contaminated articles, containers, and transformers
- Evaluate the SPCC plan (along with proper health and safety procedures) to ensure that spill sampling requirements are satisfied subsequent to an accidental release from the site
- Define practices and procedures for safe handling of drums and cylinders containing solid or hazardous materials or wastes
- Promote the safe handling of known hazardous materials.

Note: Personnel should follow special precautionary measures with unlabeled drums, cylinders, USTs, articles containing PCBs, and other wastes unless their contents are characterized or known.

10.2.1. USTs

UST sampling provides information used to determine compliance with regulations applicable to USTs that contain petroleum products and stored chemical substances. If locating the USTs is an issue, then an electromagnetic wave device, electrical resistivity meter, or ground-penetrating radar can be used to estimate the location of buried tanks.

The following references contain guidance on UST sampling:

- **40 CFR 112.** EPA Regulation on Oil Pollution Prevention
- **40 CFR 280.** EPA Technical Standards and Corrective Action Requirements for Owners and Operators of USTs.

These references cover the following situations:

- When tank volume, including piping, is 10 percent or more beneath the ground surface
- When a tank holds RCRA hazardous wastes, or a mixture of such wastes and other regulated substances.

These federal regulations also outline procedures for EPA approval of a state program to operate in place of federal UST requirements. State standards must be no less stringent and must provide adequate enforcement of compliance with these standards. The sampling of USTs should comply with all applicable federal, state, and local regulations pertaining to the management of listed USTs. Sampling event planners should identify the regulatory requirements (including the compliance of each UST) for sampling, monitoring, and removal, where necessary.

10.2.2. PCBs

PCB sampling provides information and guidance for PCB handling in accordance with applicable federal, state, and local regulations.

The following references provide information on PCB sampling, access, and storage:

- **TSCA.** PCB requirements, as implemented by EPA regulations
- **40 CFR 761.** EPA regulations on PCB Manufacturing, Processing, Distribution in Commerce, and Use of PCBs and PCB Items.

Some regulatory requirements from the previously listed references are as follows:

- Areas contaminated with PCBs in regulated amounts must be closed to the public
- All PCB transformers must be registered with the appropriate fire department and labeled per EPA requirements
- PCB storage areas and transport vehicles should be marked with special labels per applicable DOT regulations
- Non-leaking PCB articles and equipment, or leaking PCB items placed in non-leaking containers, may be put in temporary storage areas for up to 30 days
- The site-specific SPCC plan should include PCB sampling and follow proper health and safety procedures for sampling personnel
- PCB transformers or PCB-contaminated materials must be moved to a permanent storage facility if they have been stored in a temporary facility for more than 30 days
- PCB waste is subject to a 1-year time limit for storage and disposal. Conditional extensions can increase this limit by an additional year (40 CFR 761.65)
- Post-cleanup sampling should be performed to verify conformance with cleanup standards (40 CFR 761.125).

When performing field sampling for PCBs, proper health and safety protocol must be followed in accordance with OSHA 29 CFR 1910.120. All items containing PCBs, or unknown items potentially related to PCBs, should be considered potentially contaminated with PCBs and handled according to regulations unless sampling results prove otherwise.

10.2.3. Containers and Drums

Container and drum sampling provides information and guidance applicable to the regulation of container and drum handling in accordance with federal, state, and local regulations. Container and drum sampling poses unique obstacles to sampling personnel, including drum staging, identification, and opening. Containers include compressed gas cylinders.

The condition and content of drums will determine the appropriate procedures for handling drums prior to sampling. All drums should be visually inspected to gain as much information as possible about their content. In most compliance cases, the materials contained in the drum are known. Appropriate procedures for handling the suspected materials should be followed. However, depending on site control of the materials placed in drums, additional safety practices should be considered.

Prior to drum sampling, a survey can be made to classify the drums into preliminary hazard categories, such as the following:

- Chemical incompatibility
- Leaking or deteriorated
- Bulging
- Explosive or shock sensitive
- Laboratory waste.

As a precautionary measure, all unknown drums should be handled and sampled with a minimum of Level B protection (per 29 CFR 1910.120) to characterize the content of the drums. The drum survey should also address unstacked and unorganized drums.

WARNING: Opening drums presents a major health and safety hazard. Accidents may include detonation, explosion, fire, vapor generation, and physical injuries. Proper precautionary measures must be taken while performing drum sampling.

The following references provide information on drum/container sampling:

- **OSHA 29 CFR 1910 and 1926.** General Safety and Health Standards and Safety and Health Regulations for Construction
- **40 CFR 265.** National Standards for the Management of Hazardous Waste
- **49 CFR 171–178.** Established regulations for the Safe and Secure Transportation of Hazardous Materials in Commerce.

10.2.4. Oil Spills

Oil spill sampling offshore and ashore includes the methodology to collect samples following accidental discharge of oil from the site. Ashore oil spill sampling is typically oil sampling at the beach but should not be limited to only surface sampling of the oil. There are two portions of ashore oil spills that are important to sample: 1) the surface layer (0 – 15 centimeters), which reflects the accumulation of the oil from an offshore spill following washout to the beach, and 2) long-term deposition of the contaminated products several feet deep at the beach.

The following references provide information on oil spill sampling:

- **40 CFR 109.** EPA Regulation on Criteria for State, Local and Regional Oil Removal Contingency Plans
- **40 CFR 110.** EPA Regulation on Discharge of Oil
- **40 CFR 300.** EPA Regulation on National Oil and Hazardous Substances Pollution Contingency Plan under CERCLA.

Oil spill sampling includes sampling the spill first. Because each spill and spill site is unique, it is impossible to establish step-by-step guidelines for oil spill sampling. Spill samples should be collected as soon as possible, gathering the greatest volume of oil before it spreads out or disperses. This technique also minimizes the effects of weathering alteration on the spilled oil. Offshore and ashore oil spill sampling should be in concurrence with the SPCC plan and the site-specific HASP. The HASP provides technical guidance associated with collection of samples.

10.2.5. Solid and Hazardous Waste Characterization

Waste sampling provides the identification of waste present, characterizes the waste, and aids in the determination of adverse effects to human health and the environment. This information ultimately supports the selection of disposal options available in accordance with federal, state, and local regulations. RCRA, an amendment to the SWDA to ensure that solid wastes are managed in an environmentally sound manner, provides the following two distinct, yet interrelated, programs:

- **Subtitle D**. Promotes and encourages the environmentally sound management of solid waste
- **Subtitle C.** Promotes and encourages the environmentally sound management of hazardous waste.

10.2.5.1. Characteristics of Hazardous Waste

Characteristic hazardous wastes exhibit any of the following:

- Ignitability
- Corrosivity
- Reactivity

- Toxicity.

10.2.5.2. Ignitability

Ignitable hazardous wastes include the following:

- Liquids (other than aqueous solutions) containing less than 24% alcohol by volume with a flash point of less than 60°C (140°F)
- Non-liquids capable, under standard temperature and pressure, of causing fire through friction, absorption of moisture, or spontaneous chemical changes and, when ignited, of burning to create a hazard
- Ignitable compressed gases
- Oxidizers.

10.2.5.3. Corrosivity

Corrosive hazardous wastes include the following:

- Aqueous solutions having a pH of ≤ 2 or ≥ 12.5
- Liquids that corrode carbon steel at a rate > 6.35 millimeters (0.250 inch) per year.

10.2.5.4. Reactivity

Reactive hazardous wastes have any of the following attributes:

- Cause explosions, toxic fumes, gases, or vapors when heated compressed, or mixed with water
- Are normally unstable and readily undergo violent change without detonating
- Are cyanide- or sulfide-bearing wastes
- Are capable of detonation or explosive reaction when subjected to a strong initiating source or heated under confinement
- Are readily capable of detonation or explosive decomposition or reaction at standard temperature and pressure
- Are listed as forbidden Class A or Class B explosives.

10.2.5.5. Toxicity

A solid waste exhibits the characteristic of toxicity when the extract from a representative sample of the waste contains any of the contaminants listed in Table 1 of 40 CFR 261.24 at the concentration equal to or greater than the respective value given in that table.

10.2.5.6. Listed Hazardous Wastes

Hazardous wastes are also listed in 40 CFR 261.31 – 34. These lists contain industry and EPA hazardous waste numbers, descriptions, and hazard codes (indicating type of hazard). "Non-specific source" wastes such as degreasing solvents are assigned EPA hazardous waste designation numbers beginning with "F." Wastes that contain pure or commercial-grade unused chemical solvents are assigned EPA hazardous waste designation numbers beginning with "P" or "U;" commercial chemicals on these lists are regulated as hazardous wastes when discarded. Note that "K-list" wastes (hazardous wastes from specific sources) involve in-process wastes and generally are not applicable to this discussion.

10.2.5.7. Characterization by Sampling

Characterizing waste by sampling can be quite expensive. It is preferable to identify wastes by determining the origin of the waste. Once the origin of the waste has been identified, knowledge of the process used to generate the wastes (e.g., raw material consumption, products, and by-products) can be used to narrow the list of analytical methods required for characterizing wastes. For containerized wastes, identifying labels or reviewing paperwork associated with the containers may also narrow the list of analytical methods required. Associated paperwork may include waste manifests, disposal logs, and MSDSs. By reducing the number of analytical tests required, the sampling costs, sample volumes, and resulting waste are reduced.

Field analytical techniques have made significant improvements in rigor and credibility. Computerization and miniaturization are contributing to technology improvements and innovations. These improvements allow for more frequent use of field testing to characterize wastes rather than collecting samples and sending them to a laboratory for analysis. Field analytical methods may be employed if sufficient documentation can be provided to support the proper application of the method. The selected field analysis method

should demonstrate method quantitation limits below the action level or levels of concern. Field analysis allows for streamlining of the site investigation process.

10.2.6. Sewage Sludge

Sewage sludge sampling includes collecting and analyzing representative samples of sewage sludge prior to land application, surface disposal, or firing in a sewage sludge incinerator. Sewage sludge sampling also includes sampling of domestic sewage prior to disposal. Sampling data allow for the characterization of sewage sludge to determine disposal methods in accordance with federal, state, and local regulations. The CWA and RCRA are examples of two applicable federal regulations. The CWA regulates beneficial use and disposal of sewage sludge, and RCRA regulates disposal of non-hazardous sludge in a municipal landfill and land disposal of hazardous sludge.

Guidance for sewage sludge sampling is contained in the following references:

- **40 CFR 258.** EPA Regulation on Criteria for Municipal Solid Waste Landfills
- **40 CFR 268.** EPA Regulation on Land Disposal Restrictions
- **40 CFR 503.** EPA Regulation on Standards for the Use or Disposal of Sewage Sludge.

10.2.7. IDW

IDW is waste that is generated in the process of investigating contaminated or potentially contaminated sites. IDW can include purge water, cuttings from well installation, drilling mud, soil from collection of samples, and contaminated PPE. IDW should be sampled and disposed of in accordance with the SAP, contractual requirements, and state and federal requirements. IDW management has the potential for considerable effort and expense, and should be considered when planning an investigation. IDW will generally be sampled using the techniques described in section 10.5 of this chapter.

For more information on managing IDW, consult the EPA's *Guide to Management of Investigative-Derived Wastes* (http://www.epa.gov/superfund/policy/remedy/pdfs/93-45303fs-s.pdf).

10.3. Hazard and Safety Precautions

See Chapter 2 of this handbook for a discussion of health and safety elements applicable to most sampling programs. The following hazards, discussed below, are specific to waste sampling:

- Container hazards
- USTs and other confined spaces
- Explosive hazards.

10.3.1. Container Hazards

Reseal open bungs and drill openings as soon as possible with new bungs or plugs to avoid vapor release. If an open drum cannot be resealed, place it into an overpack drum.

Bulging drums are extremely hazardous. Whenever possible, do not move drums that may be under internal pressure, as evidenced by bulging or swelling.

Laboratory packs (categorizing small containers of chemicals, solvents, industrial supplies, etc. in metal drums for disposal) can be an ignition source for fires at hazardous waste sites, as they sometimes contain shock-sensitive materials. Treat such containers as explosive materials, and use extreme care when opening these packs. Prior to opening laboratory packs, make sure all non-essential personnel are moved to a safe place. Whenever possible, use a grappler unit constructed for explosives containment for initial handling or sampling of such laboratory packs. Sampling personnel should maintain continuous communication with the Site Safety Officer until operations are complete.

WARNING: If drums or cylinders show signs of swelling or bulging, do not move or sample them until the pressure can be relieved safely. If possible, relieve any excess pressure prior to opening the drum by using a remotely controlled device, such as a pneumatic impact wrench or hydraulic penetration device. If pressure must be relieved manually, place explosion-resistant plastic barriers between the worker and the drums or cylinders.

10.3.2. USTs and Other Confined Spaces

For USTs and other confined spaces, the HASP should be followed to ensure worker safety.

WARNING: Personnel who enter a confined space should be accompanied by an on-site standby unit at all times.

The following steps should be detailed in the HASP prior to entry into a confined space:

1. Ventilate the area thoroughly prior to entry.
2. Disconnect connecting pipelines.
3. Take air samples to verify the absence of flammable or other hazardous vapors and demonstrate the presence of adequate oxygen levels.
4. Provide entry and standby teams with proper respiratory protection, protective clothing, safety harnesses, and ropes.
5. Establish lifeline signals (e.g., tugging on a rope) prior to entry so that field sampling personnel can communicate.
6. Maintain ladder(s) and other equipment in accordance with OSHA regulations.

10.3.3. Explosive Hazards

Due to the inherent dangers in sampling explosives (as well as potential or suspected explosives), only those individuals who have been trained and certified in the proper handling of these materials should participate in sampling activities. See OPNAVINST 8023.24B for qualifications and certification requirements. Special considerations are required when sampling explosive wastes that may be susceptible to shock, friction, electromagnetic radiation (EMR), electrostatic discharge, sparks, flames, elevated or freezing temperatures, moisture, or sunlight. Failure to handle explosives correctly could result in damage to property, injury, or loss of life.

General safety considerations include wearing PPE such as flameproof clothing, caps, safety goggles or face shields, conductive shoes, and respirators, if applicable. Only non-sparking tools should be used. Electrical grounding may be necessary in some cases. In addition, field sampling personnel should collect the smallest amount of sample necessary for the intended testing and analysis.

WARNING: Only trained and certified explosives personnel should handle, sample, or test explosives or suspected explosive materials.

10.4. Preparation

If the nature of the hazardous waste is unknown (e.g., at an abandoned disposal site), sampling personnel should take additional precautions to protect themselves from direct contact with waste materials. To characterize waste materials for RCRA or to verify the contents in drums, cylinders, tanks, or transformers, it is important that representative samples be collected and analyzed.

10.4.1. Preparation for UST Sampling

Before starting UST sampling, follow the hazard and safety precautions specified in Section 10.3. Prior to UST sampling, field personnel should ensure there is no leakage of product from the UST or related piping. If it is necessary to enter into a tank or vault for sampling, strict procedures for confined space entry should be followed by qualified and experienced personnel.

10.4.2. Preparation for PCB Sampling

The toxic nature and degree of hazards posed by PCBs require a high level of caution to be taken during sampling. Appropriate protective gear and clothing should be worn by sampling and support personnel during sampling events. Proper gloves should be used during sampling. Spill prevention and control should be planned in advance if transformer sampling is to be performed. Plastic pads and sorbent materials should be available.

10.4.3. Preparation for Drum Sampling

Prior to initiation of a sampling event, all drums should be inventoried. All available information concerning each drum should be recorded in the FLB/FN, including the following:

- Type of drum
- Contents
- Total capacity estimate
- Markings
- Labels
- Color
- Origin
- Condition.

Each drum should be marked with a unique identification number that corresponds to the sample container for present and future reference. Enamel spray paint is suitable for this purpose. Photographs of the numbered drum are useful for documenting the condition of the drum and providing a permanent record.

The opening of closed drums prior to sampling entails considerable risk if not performed with the proper techniques, tools, and safety equipment. Prior to sampling, all drums should be staged in easy-access areas. Any standing water or other materials should be removed from the top of the container so that:

1. The representative nature of the sample is not compromised when the container is opened.
2. Water cannot enter drums containing water-reactive compounds.

Manual and remote drum sampling techniques are discussed below.

WARNING: Before opening any drum, ensure that the drum is in an area that has secondary containment.

10.4.3.1. Manual Drum Opening

Two tools, discussed below, are typically used to open drums manually, bung wrenches and drum deheaders.

10.4.3.1.1. Bung Wrench

The most common method for manually opening drums is with a universal bung wrench. These wrenches have fittings to remove nearly all commonly encountered bungs and are constructed usually of cast iron, brass, or a bronze-beryllium non-sparking alloy formulated to reduce the likelihood of sparks. Use of a non-sparking wrench is highly recommended. However, use of a non-sparking wrench does not completely eliminate the possibility of producing sparks.

The wrench fitting matching the bung is inserted into the bung, and the tool is turned counter-clockwise to remove the bung. Proper protection and safety is necessary while opening drums.

WARNING: If drums or cylinders show signs of swelling or bulging, do not move or sample them until the pressure can be relieved safely.

10.4.3.1.2. Drum Deheader

A drum deheader can be used to open a drum manually when the bung is not removable with a bung wrench. Drum deheaders are constructed of forged steel with an alloy steel blade designed to cut the lid off (or partway off) with a scissor-like cutting action.

Drums are opened with a drum deheader by first positioning the cutting edge just inside the top chime and then tightening the adjustment screw so that the header is held against the side of the drum. The handle of the deheader is then moved up and down while sliding the deheader along the chime. If a drum has been damaged or badly dented, it may not be possible to cut the entire top of the drum. Because it is possible that the drum is under pressure, field personnel should cut the drum a small amount to release any pressure before cutting the whole lid from the drum. Proper health and safety procedures should be followed when using a drum deheader.

10.4.3.2. Remote Opening

Two devices, discussed below, are typically used to open drums remotely, hydraulic devices and pneumatic devices.

10.4.3.2.1. Hydraulic Devices

Remotely operated hydraulic devices use hydraulic pressure to pierce the wall of the drum. These devices consist of a manually operated pump that pressurizes oil through a length of hydraulic line. The metal-pointed piercing device is attached to the end of this line and pushed into the drum by hydraulic pressure.

The piercing device attaches to the drum so that a sampling hole is made in either the side of the head or the lid. Some hollow or tube-like piercers are designed to be left in place as a permanent tap or sampling port. Piercers are designed to establish a tight seal upon penetrating the container.

10.4.3.2.2. Pneumatic Devices

Pneumatic devices use compressed air to remove drum bungs remotely. A pneumatic bung remover consists of a compressed air supply that is controlled by a heavy-duty, two-stage regulator.

A high-pressure air line delivers compressed air to a pneumatic drill, which turns the selected bung removal fitting. An adjustable bracketing system positions and aligns the pneumatic drill over the bung. The bracketing system must be attached to the drum before the drill can be operated.

10.4.4. Preparation for Cylinder Sampling

Compressed gas cylinder sampling and identification of unknown products pose great environmental and personal risks and should be performed only by persons with appropriate training and experience. A local safety authority should be contacted prior to sampling. A compressed gas supplier may also be contacted for input.

Prior to initiation of a sampling event, all cylinders should be inventoried. The following information concerning each cylinder should be recorded in the FLB/FN:

- Type of cylinder
- Contents
- Total capacity estimate
- Markings
- Labels
- Color
- Origin
- Condition.

Each cylinder should be marked with a unique identification number that corresponds to the sample container for present and future reference. Photographs of the numbered cylinders are useful for documenting the condition of the cylinder and providing a permanent record.

10.4.5. Preparation for Storage Tank, Vacuum Truck, Process Vessel, and Similar Large Container Sampling

Prior to initiation of a sampling event, all containers should be inventoried. The following information concerning each container should be recorded in the FLB/FN:

- Type of container
- Total capacity estimate
- Actual capacity (if container is open)
- Markings
- Labels
- Color
- Origin
- Condition
- Existence and condition of ladders and catwalks.

Each container should be marked with a unique identification number that corresponds to the sample container for present and future reference. Enamel spray paint is suitable for this purpose. Photographs of the numbered vessels are useful for documenting the condition of the containers and providing a permanent record.

The procedure for opening a large containment vessel will vary with different containers. Ideally, large tanks and pressure/vacuum containers should be vented and opened for sampling by the tank operator familiar with tank access processes.

Most large tanks and vacuum trucks have valves near the bottom of the tank and hatches near the top. It is preferable to collect samples from the top of a tank for several reasons. First, the integrity of valves near the bottom of the tank cannot be assured; the valve may be immobile, break, or become jammed in the open position, resulting in an uncontrolled release of the tank contents. Second, the contents of a large vessel may become stratified, and collecting a sample from the bottom will not permit the sampling of each strata. The preferred method is to access the tank from the top to obtain a cross-sectional sample of its contents.

While opening and sampling larger containment vessels, precautions should be taken to ensure personal health and safety. Accessing storage tanks requires a great deal of manual dexterity. Such sampling usually requires climbing to the top of the tank through a narrow vertical or spiral stairway while wearing protective gear and carrying sampling equipment. At least two persons should perform the sampling: one to open the hatch and collect the samples and the other to stand back (usually at the head of the stairway) and observe, ready to assist or call for help.

Prior to opening the hatch, sampling personnel should check the tank for a pressure gauge. Large tanks and pressure/vacuum containers should be opened for sampling by the tank operator familiar with tank access procedures. However, if necessary, the release valve should be opened slowly to bring the tank to atmospheric pressure. If no release valve exists, field personnel should slowly loosen hatch cover bolts to relieve the pressure in the tank. Personnel should stop immediately if the pressure is too great or if a release occurs. Hatch cover bolts should not be removed until the tank is at atmospheric pressure.

If the tank pressure is too great or venting releases gases or vapors, field personnel should discontinue venting immediately. Sampling may need to be postponed until the proper equipment is available to control the release. Any atmospheric releases should be measured with portable field instrumentation and recorded in the FLB/FN.

10.5. Sample Collection Procedures

10.5.1. Large Tanks

Prior to sample collection, ensure that tanks are stabilized, proper safety precautions are taken, and backup personnel are in place. If the contents of the tank are stratified, each stratum should be sampled discretely. At a minimum, top, middle, and bottom samples should be collected. If the container has separate compartments, each should be sampled separately at varying depths. Upon retrieval of the sample, field personnel should immediately transfer the sample into the sample container.

Depending on the objective of the sampling event (e.g., characterization for disposal), samples may be composited in the laboratory on a weight/weight or volume/volume basis prior to analysis. Knowledge of the tank-filling process will guide the decision of whether or not to composite. Hot spots and separation of materials in compartments may reduce disposal costs if only a portion of the tank is contaminated. Compositing samples may result in low reported laboratory concentrations that are not representative of overall concentration. A well-designed sampling plan will ensure sampling accuracy and provide the data necessary for decision making.

10.5.2. Secondary Containment Sampling

Secondary containment helps prevent serious environmental problems by containing storage container releases. While the storage container itself is vital to minimize the potential for leaks, secondary containment is another important safeguard. The sampling of two types of secondary containment devices, barriers and double-walled tanks, is discussed below.

10.5.2.1. Barriers

Barriers or dikes are used to contain releases from storage containers and process units. The storage containers are typically placed on an impermeable barrier such as a continuous concrete slab, lined concrete slab, or geosynthetic clay liner. For sampling inside this type of secondary containment, use one of the surficial sampling techniques discussed below.

10.5.2.2. Double-Walled Tanks and Interstitial Spaces

Double-walled tanks are another common type of secondary containment. In general, double-walled tanks do not require barriers or dykes. For USTs storing petroleum products, regulations require monitoring of interstitial spaces to determine when primary containment has failed. For USTs, liquids generally are not allowed to accumulate if systems are properly monitored. The interstitial spaces of above-ground, double-walled storage tanks often are not monitored; however, tank integrity is checked regularly. Over time, small leaks may allow liquids to accumulate in interstitial spaces. For sampling interstitial spaces, use one of the containerized liquid sampling techniques discussed in Section 10.5.5. Depending on container construction, there may be limited access to interstitial spaces for sampling.

10.5.3. Surficial Sampling

Surficial sampling is used to assess the existence or extent of contamination on surfaces rather than in a soil, liquid, or air matrix. For example, the interior of a building may be assessed by collecting wipe samples from process vessels and inte-

riors of ventilation ducts. Though wipe, chip, sweep, and rinsate sampling have similar purposes, they are intended to assess different types of surface areas.

This recommended protocol outlines procedures and equipment for the collection of representative wipe, chip, sweep, and rinsate samples.

10.5.3.1. Wipe Samples

Wipe sampling is intended to monitor surficial contamination of non-volatile species of analytes (e.g., PCBs, metals, tetrachlorodibenzo-p-dioxin (TCDD), and tetrachlorodibenzofuran (TCDF) on non-porous surfaces, such as metal or glass. Sampling points should be chosen carefully and based on site history, manufacturing processes, personnel practices, obvious contamination, migration pathways, and available surface area. Suggested sampling points include process vessels, ventilation ducts and fans, exposed beams, and window panes. The sampling area should be large enough to provide a sufficient amount of sample for analysis (smaller sample amounts result in higher detection limits).

To collect a wipe sample, the following equipment is needed:

- Ruler or measuring tape to measure out the area being wiped
- 3-inch by 3-inch gauze pad inside a precleaned container
- Sample container
- Appropriate collection solvent
- Surgical gloves, changed prior to handling clean gauze, the sample container, or solvent.

The use of filter paper for wipe sampling is not recommended because it tends to rip and crumble on rough surfaces. If filter paper is used, it should be 4-inch-diameter heavy gauge paper, such as Whatman #4 filter paper.

Once the sample location is determined, sample collection can begin. For each sample, a new pair of surgical gloves should be worn to avoid cross contamination of the collected samples. The following procedure should be used for taking wipe samples:

1. Premeasure the area to allow for easier calculation of final results. If premeasuring is not feasible, measurements may be taken after the area is wiped.
2. Wearing a new pair of surgical gloves, remove the gauze pad from its sterile wrapping container and soak the gauze pad with the appropriate solvent.
3. Applying moderate pressure, wipe the entire sample area once in the horizontal direction and once in the vertical direction.
4. Wipe the entire sample area so that all sample material is picked up.
5. Place the gauze pad in the sample container.

A field blank should be collected for every lot of wipe material or solvent used. In some cases, blanks may be collected every 10 wipes to provide additional data for interpretation. Field blanks help identify potential contaminants from the pad, solvent, sample container, or ambient air. To perform a wipe blank, start by wearing new gloves, then wet a gauze pad with the solvent or water (for each collection parameter) and place the pad directly into the sample container.

In some cases, the laboratory should be told to rinse each sample container with an appropriate extraction or digestion solvent (depending on the analysis being performed) when transferring a sample to the extraction glassware. This procedure will ensure that the entire sample is removed from the container.

10.5.3.2. Chip Samples

Chip sampling is intended to monitor surficial contamination of non-volatile species of analytes (e.g., metals, PCBs, TCDD, and TCDF) on porous surfaces (e.g., cement, brick, and wood). Sampling points should be chosen carefully based on site history, manufacturing processes, personnel practices, obvious contamination, and available surface area. Suggested sampling points include floors near process vessels and storage tanks and loading dock areas. The sampling area should be large enough to provide a sufficient amount of sample for analysis (smaller sample amounts result in higher detection limits). To

facilitate the calculations once the analytical data is received, the sample area should be measured.

To collect a chip sample, the following equipment is needed:

- Ruler or measuring tape to measure the area to be sampled
- Surgical gloves, changed prior to collecting each sample
- Decontaminated chisel of borosilicate construction and a manual or electric hammer
- Natural bristle brush and a dustpan lined with aluminum foil or one that is dedicated, decontaminated, and constructed of a pre-approved material that will not interfere with the contaminants of concern
- Sample container.

Once the sample location has been determined and marked off, sample collection can begin. The following procedure should be used for collecting chip samples:

1. Measure the sample area (for calculation of final results).
2. Break up the sample surface using a decontaminated chisel and hammer. Avoid scattering pieces beyond the sampling boundary. Any pieces that fall outside the sampling area should not be used. Chip depth should be less than ¼ inch (preferably ⅛ inch).
3. Record chip depth in the FLB/FN.
4. Collect the chipped pieces using a dedicated, decontaminated dustpan and natural bristle brush, and transfer the sample directly into the sample container.

10.5.3.3. Sweep Samples

Sweep sampling is intended to monitor surficial contamination of non-volatile species of analytes (e.g., metals, PCBs, TCDD, and TCDF) in residue found on porous (e.g., asphalt) or non-porous (e.g., metal) surfaces. Sweep sampling collects dust and residue samples that may help determine and delineate contaminants. Sampling points should be based on site history, manufacturing processes, personnel practices, obvious contamination, migration pathways, and available surface area.

Suggested sampling points include areas in ventilation systems where dust can collect, floor surfaces near process vessels and storage tanks (e.g., linoleum floors where a solvent cannot be used or too much residue exists for a wipe sample to be easily collected), and street gutters where contaminated sediments may have migrated and accumulated. The sample area should be large enough to provide a sufficient amount of sample for analysis.

To collect a sweep sample, the following equipment is needed:

- Natural bristle brush
- Decontaminated stainless steel spatula and/or a dustpan lined with aluminum foil or one that is dedicated, decontaminated, and constructed of a pre-approved material that will not interfere with the contaminants of concern
- Surgical gloves, changed prior to collecting each sample
- Sample container.

Once the sample location is determined, sample collection can begin. Wearing a new pair of surgical gloves, sweep all residues in the sample area onto the dustpan or directly into the sample container. A dedicated, decontaminated spatula may be used to aid in transferring the sample into the sample container.

10.5.3.4. Rinsate Samples

Rinsate sampling is intended to determine if surfaces contain hazardous waste residue after being cleaned. This type of surficial sampling is associated normally with drum storage pads, floors of buildings, and the interior walls of waste tanks.

Rinsate samples are performed by collecting water from the last rinse step during the cleaning of a tank or surface area. The water is analyzed for known chemical contaminants and compared against a blank sample of the same type of water.

10.5.4. Transformers

The many peculiarities associated with transformers warrant that they be considered separately from drums and tanks. Because transformers often are located in secured, out-of-the-way locations, access may be a problem. A power-operated scissor lift or cherry picker may be needed to access pole-mounted transformers. In other cases, the transformer may be in an underground cell.

Special precautions should be taken due to the toxic nature and hazards posed by PCBs, which may be present in a transformer. Appropriate protection should be worn by sampling and support personnel. To aid in spill prevention and control, make sure to use plastic sheeting and absorbent pads

WARNING: Prior to sampling, transformers must be certified as "off line" and de-energized by an electrician or other authorized person. Internal pressure should be relieved before opening the transformer.

Once power to the transformer is cut and spill control measures are in place (plastic sheeting on ground or floor surface of lift), the cover of the transformer can be removed with hand tools. A sample of the dielectric fluid can be obtained with a disposable glass composite liquid waste sampler (COLIWASA); see Section 10.5.5.2.

The following procedure should be used to obtain a representative sample from the transformer:

1. Lower the COLIWASA at a rate that allows fluid levels on both the inside and the outside of the sampler to equalize.
2. Close the COLIWASA when it reaches the bottom of the transformer and, as the COLIWASA is retrieved, wipe it with a disposable absorbent pad.
3. Transfer the sample directly into the sample container. If a disposable sampling device is used, and if the transformer is out of service, it may be possible to leave the used sampler in the sampled material; however, this should be done only after consultation with responsible authorities. Otherwise, the sampler should be drummed along with protective clothing, sheeting, and absorbent pads, and disposed of at a predetermined approved location.

Note: Never use the transformer drain valve for sample collection for the following reasons:

1. The integrity of these valves cannot be assured; the valve may be rusty, may break, or may become jammed in the open position, resulting in the uncontrolled release of transformer contents.
2. Transformer contents may be stratified. Because PCBs are heavier than other insulating oils, the resulting stratification may prevent collection of representative samples. Samples obtained from the valve near the bottom of the transformer might indicate higher PCB concentrations than the true concentration of the total dielectric fluid.

10.5.5. Containerized Liquids

Liquids stored in a container are some of the most difficult to sample. Several factors determine which method to use for sampling containerized liquids, including container location, size and location of the container opening, and type of equipment available for sampling. The health and safety of sampling personnel also plays a key role in determining sampling methodology.

No matter what type of sampler is chosen, it should allow for the collection of all phases present in the container. Containers rarely hold a homogeneous mixture of material.

Sampling devices and their procedures for use with containerized liquids are presented below. Other appropriate sampling devices include the Bacon bomb sampler, Kemmerer sampler, and weighted bottle sampler (see Chapter 6).

Sampling containerized liquids presents unique obstacles to sampling personnel. Procedures for container staging, identification, and opening should be well planned. Health and safety precautions associated with sampling containerized materials are generally more stringent. QA/QC guidelines for waste samples, as opposed to environmental samples, are unique; therefore, each site should be considered individually. If high levels of contaminants are expected, trip and field blanks may be needed. However, if

residual or low-level waste or chemicals are expected in the sampled material, trip and field blanks may not be needed. If VOCs analyses are being conducted, trip and field blanks are required.

All containers should be inventoried prior to the initiation of the sampling event. The following information concerning each container should be recorded in the FLB/FN:

- Type of container
- Estimated total capacity of individual container
- Actual container capacity
- Markings, labels, color, origin, condition, etc.
- Photographs may also be taken to provide a permanent record.

Depending on the container location and position, it may be necessary to upright and/or relocate containers prior to sampling. Containers that can be moved should be positioned so that the opening, or bung, is upright, if the integrity of the container will allow. Containers should not be stacked.

WARNING: Drums containing liquid waste can be under pressure or vacuum. A bulging drum should not be moved or sampled until the pressure can be relieved safely.

The sampling of tanks, containers, and drums presents unique problems. Waste containers have various access ports including small access ports, manways, or hatches on the larger vessels or taps and bungs on smaller drums. The physical size, shape, construction material, and access location of each vessel will limit the types of equipment and methods that can be used for sample collection.

When liquids are contained in sealed vessels, gas vapor pressures build up, sludge settles out, and density layering develops. The potential for explosive reactions or the release of noxious gases when containers are opened requires considerable safeguards. The vessels should be opened with extreme caution. Certain situations may warrant preliminary sampling of headspace gasses. At a minimum, a preliminary check with an explosimeter or an organic vapor analyzer will help determine levels of personnel protection and may aid in selecting a sampling method.

In most cases, it is impossible to observe the contents of sealed or partially-sealed vessels. Since some layering or stratification is likely in any undisturbed solution, a sample should be taken that represents the entire depth of the vessel.

Agitation of vessel contents to disrupt the layers and rehomogenize the sample is physically difficult and almost always undesirable. In vessels greater than 1 meter in depth, the preferred sampling method involves slowly, and in known increments of length, lowering the suction line from a peristaltic pump. Discrete samples can be collected at various depths and combined or analyzed separately. If the specific depth of the sample is important, a discrete sampling device, such as the Kemmerer type, may be required. In situations where the reactive nature of the contents is known, a small submersible pump may be used.

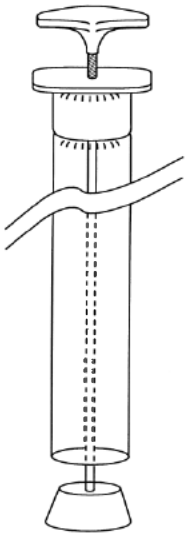
When sampling a previously sealed vessel, a check should be made for the presence of bottom sludge by measuring the depth to the apparent bottom and then comparing it to the known interior vessel depth.

Liquid samples from containers such as 55-gallon drums may be collected using lengths of glass tubing known as drum thieves. These tubes are normally 122 centimeters in length with a 6- to 16-millimeter inside diameter. Larger diameter tubes may be used for viscous fluids if sampling with the small diameter tube is not adequate. Sampling using the drum thief requires a two-person sampling team (minimum) and proper protective gear. Use of a drum thief is simple, relatively inexpensive, quick, and does not require equipment decontamination; however, this method does have serious drawbacks. Most low-density fluids do not hold well in the glass tubes. A significant amount of the potential sample flows out of the bottom of the tube as it is raised from the drum, thereby reducing the representativeness of collected material. Many

variations to this technique have been reported, including the incorporation of a small suction device (e.g., a pipette bulb) to the top of the tube, as well as the use of various tube sizes. Some success has been reported with tubes that have been heated at one end and then drawn to form a smaller orifice. This technique allows for the use of larger diameter tubing, which collects a larger sample volume per attempt, while reducing material loss from the bottom of the tube.

The COLIWASA is a sampler designed for representative sampling of multiphase wastes from drums and other containers. The COLIWASA is commercially available or can be fabricated from a variety of materials, including PVC, glass, or Teflon®. A COLIWASA usually consists of a 152-centimeter by 4-centimeter (inside diameter) tube with a neoprene stopper at one end, attached by a rod running the length of the tube to a locking mechanism at the other end. Manipulation of the locking mechanism opens and closes the sampler by lowering and raising the neoprene stopper. A recommended model of the COLIWASA is shown in Figure 10-1. However, the design can be modified or adapted to meet the needs of the sampling event.

Figure 10-1. COLIWASA Sampler



The COLIWASA is used primarily to sample containerized liquids. The PVC COLIWASA can sample most containerized liquid wastes except for those containing solvents. A glass COLIWASA is suitable for wastes that are unsuitable for the plastic unit, except for strong alkali and hydrofluoric acid solutions. Due to the unknown nature of most containerized wastes, samplers composed of glass or Teflon® are preferred in lieu of samplers containing PVC.

To identify stratified drum content and sample stratified samples, lower a glass COLIWASA into a drum all the way to the bottom slowly to allow the sample in the COLIWASA to equalize with the material in the drum, and then visually examine the withdrawn sample for stratified layers and depths. The stratified layers in the CALIWASA may be individually transferred to sample containers, or another COLIWASA may be used to collect stratified samples at the specific depths.

The major drawbacks associated with using a COLIWASA involve potential decontamination requirements and higher costs.

Specific procedures for using the drum thief and COLIWASA are provided below.

10.5.5.1. Procedures for Drum Sampling Using Glass Tubes (Drum Thieves)

The following method is recommended for using glass tubes.

1. Record the drum identification number or label for later confirmation, sampling, or disposal.
2. Open the drum.
3. Remove the cover from the sample container.
4. Lower the glass tubing until it almost touches the bottom of the container. Keep at least 30 centimeters of tubing above the top of the container.
5. Allow the sample in the tube to equalize with the material in the drum.
6. Cap the top of the tube with a safety-gloved thumb or a rubber stopper.
7. Carefully remove the capped tube from the drum, and insert the uncapped end into the sample container.

8. Release the thumb or stopper covering the tube, and fill the sample container to approximately 90% capacity or until no headspace remains for volatiles.
9. Repeat steps 2 – 7 if more volume is needed to fill the sample container.
10. Remove the tube from the sample container, and replace the tube in the drum.
11. Cap the sample container tightly with a Teflon®-lined cap, and attach the sample identification tag.
12. Replace the bung, or place plastic over the drum.
13. Place the sample container in a resealable plastic bag (one per bag). Place the bag in a clean paint can for transport.
14. Mark the sample identification number on the outside of each paint can, and complete the COC record and the FLB/FN.

The following optional method is recommended if a sample of the bottom sludge is desired:

1. Remove the covers from the container opening and the sample container.
2. Lower the glass tubing until it almost touches the bottom of the container. Keep at least 30 centimeters of tubing above the top of the container.
3. Allow the sample in the tube to equalize with the material in the drum.
4. Gently push the tube toward the bottom of the drum into the sludge layer. Do not force it.
5. Cap the top of the tube with a safety-gloved thumb or rubber stopper.
6. Carefully remove the capped tube from the drum, and insert the uncapped end into the sample container.
7. Release the thumb or stopper covering the tube, and allow the sample container to fill to approximately 90% capacity or until no headspace remains for volatiles. If necessary, the sludge plug in the bottom of the tube can be dislodged with the aid of a stainless steel laboratory spatula.
8. Repeat steps 2 – 7 if more volume is needed to fill the sample container, and recap the tube.
9. Proceed as in steps 10 – 13 above.

Note: If a reaction (e.g., violent agitation, smoke, and/or light) is observed when the glass tube is inserted, field sampling personnel should evacuate the area immediately. If the glass tube becomes cloudy or smoky after insertion into the drum, then hydrofluoric acid might be present. Therefore, a comparable length of rigid plastic tubing should be used to collect the sample. When a solid is encountered in a drum (either in a layer or as bottom sludge), the method described above for sampling bottom sludge may be used to collect a core of the material. The material may also be collected with a disposable scoop attached to a wooden or plastic rod.

10.5.5.2. COLIWASA Use Procedures

The following procedures can be adapted for use with other versions of COLIWASA samplers:

1. Select the COLIWASA material, assemble the sampler, and ensure the sampler is clean.
2. Check to make sure the sampler is functioning properly. If necessary, adjust the locking mechanism so the neoprene rubber stopper provides a tight closure.
3. Wear the necessary PPE, and observe required sampling precautions.
4. Open the sampler by placing the stopper rod handle in the T-position and pushing the rod down until the handle sits against the sampler's locking block.
5. Slowly lower the sampler into the liquid waste at a rate that permits the levels of the liquid inside and outside of the sampler tube to equalize. If the liquid level in the sample tube is lower than the liquid level outside the sampler, the sampling rate is too fast and will result in a non-representative sample.
6. When the sampler stopper hits the bottom of the waste container, push the sampler tube downward against the stopper to close the sampler. Lock the sampler in the closed posi-

tion by turning the T-handle upright and resting one end tightly on the locking block.

7. Slowly withdraw the sample from the waste container with one hand while wiping the sampler tube with a disposable cloth or rag with the other hand.
8. Carefully discharge the sample into a suitable sample container by slowly pulling the lower end of the T-handle away from the locking block with the lower end of the sampler positioned in the sample container.
9. Cap the sample container with a Teflon®-lined cap, label the container, and complete the COC record and the FLB/FN.
10. Unscrew the T-handle of the sampler, and disengage the locking block. Clean the sampler on site, or store the contaminated parts of the sampler in a plastic storage tube for subsequent cleaning. Store used rags in plastic bags for subsequent disposal.

10.5.6. Waste Pile Sampling

The protocol discussed below outlines general procedures for collecting samples from waste piles and other waste materials, equipment necessary for sampling, and adequate representation of the material. This section also discusses factors to consider when formulating a sampling plan. Due to the many variables associated with waste material sampling, exact procedures cannot be outlined for every sampling situation. These variables include the following: shape and size of piles; size, compactness, and structure of the waste material; and make-up. To determine the correct sampling methodology, the chemical and physical properties of a sample, the purpose of the sampling event, analysis procedures, and the intended use for the analyzed data should all be considered when planning the sampling event.

10.5.6.1. Considerations for the Sampling Plan

The physical and chemical make-up of the waste pile and the purpose for sampling should be considered when planning the sampling event. Considerations for creating a waste pile sampling plan are presented below.

10.5.6.2. Shape and Size

The shape and size of waste material and waste piles can vary greatly. Piles may be cone-shaped, long and rectangular, square, oval, or irregularly shaped. State and federal regulations often require a specific number of samples per volume of waste; therefore, size and shape may be used to calculate volume and plan for the correct number of samples. Shape also should be considered when planning physical access to the sampling point and selecting the type of equipment necessary to safely and successfully collect the sample at that location.

10.5.6.3. Sampling Procedures

Waste pile samples can be collected at the surface or at depth. These samples generally are collected using one of the following samplers: trowel or scoop, waste pile sampler, sampling trier, soil auger, grain sampler, split-spoon sampler, or soil coring device. Surface samples can be collected most efficiently with a trowel or a scoop. For samples at depth, augers may be used. For a sample core, waste pile samplers or grain samplers may be used.

For surface sampling, clear surface debris and use a trowel or scoop to collect a sample at a depth of 0 – 6 inches. The depth of surface samples may be determined by federal, state, or local regulations. Typically, the top 6-inch soils should not be analyzed for VOCs due to evaporation and loss. For surface core sampling, use a waste pile sampler, trier, or similar sampling device. Transfer the sample directly into the sample container with a decontaminated trowel or spatula (if necessary). A wide mouth bottle is preferred because it requires less disturbance of the sample when it is transferred into the sample container. If homogenization will be performed in the field, it should be performed prior to transferring the material to sample containers.

When sampling at depth, clear away the initial top layer of material prior to taking samples, and advance the hole to the desired sampling depth with a decontaminated bucket auger or power auger. Use a separate decontaminated sampler to collect the sample, and, if necessary, a deconta-

minated spatula to transfer the sample into the sample container.

Sampling devices most commonly used for small waste piles include thieves, triers, and shovels. Evacuation equipment, such as backhoes, can be useful for sampling larger waste piles.

A thief consists of two slotted concentric tubes, usually made of stainless steel or brass (see Figure 10-2). The outer tube has a conical pointed tip that permits the sampler to penetrate the waste pile. The inner tube is rotated to open and close the sampler. A thief is used to sample dry granules or powdered wastes, where particle diameter is less than one-third the width of the slots.

Figure 10-2. Thief Sampler

The following procedure is used to collect samples using a thief sampler:

1. While the sampler is in the closed position, insert it into the sample material from a point near a top edge or corner, through the center, and to a point diagonally opposite to the point of entry.
2. Rotate the inner tube of the sampler into the open position.
3. Wiggle the sampler a few times to allow materials to enter the open slots.
4. Place the sampler in the closed position, and withdraw it from the material being sampled.
5. Place the sampler in a horizontal position with the slots facing upward.
6. Rotate and slide the outer tube from the inner tube.
7. Transfer the sample into a laboratory-cleaned sample container, label the container, and complete the COC record and the FLB/FN.
8. Clean the sampler on site, or store the contaminated parts of the sampler in a plastic storage tube for subsequent cleaning. Store used rags in plastic bags for subsequent disposal.

A trier consists of a tube cut in half lengthwise with a sharpened tip that allows the sampler to cut into sticky solids and to loosen soil (see Figure 10-3). A trier samples moist or sticky solids with a particle diameter less than one-half of its diameter. Triers are available from 61 – 100 centimeters in length and from 1.27 – 2.54 centimeters in diameter. Larger triers can be fabricated.

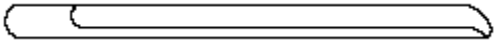
Figure 10-3. Sampling Trier

The following procedure is used to collect samples using a sampling trier:

1. Insert the trier into the material to be sampled at a 0- to 45-degree angle from horizontal. This orientation minimizes spillage of sample.
2. Rotate the trier once or twice to cut a core of material.
3. Slowly withdraw the trier, making sure that the slot is facing upward.
4. Transfer the sample into a laboratory-cleaned sample container using a spatula. Record applicable data in the FLB/FN, and complete the sample analysis request sheet and COC record.
5. Clean the sampler on site, or store the contaminated parts of the sampler in a plastic storage tube for subsequent cleaning. Store used rags in plastic bags for subsequent disposal.

Waste pile samplers are used for sampling wastes in larger heaps with cross-sectional diameters of greater than 1 meter (see Figure 10-4). They also can be used for sampling granular or powdered wastes, materials in large bins or barges, or soils where the grain sampler or sampling trier is not long enough. The waste pile sampler essentially is a large sampling trier. It is commercially available or easily fabricated from sheet metal or plastic pipe. Procedures for using the waste pile sampler essentially are identical to the sampling trier.

Figure 10-4. Waste Pile Sampler



10.5.6.4. Characteristics of the Material

Materials to be sampled may be homogeneous or heterogeneous. Homogeneous material, such as sand blast abrasive, may not require an extensive sampling protocol. The DQOs of a sampling event will determine whether grab or composite sampling is required. If a positive identification is made in analyzing a composite sample, then the discrete samples should be analyzed individually to determine the true distribution of contaminant throughout each component of the composite. A thief or trier sampler (if practical for the particular application) would provide a more representative sample compared with a shovel.

If the waste pile is composed of heterogeneous material, try to determine the source, nature, and extent of the deposited waste. If possible, sample the waste sources contributing to the pile to determine the characteristics of the waste pile. If any of the waste within a heterogeneous waste pile is hazardous, the entire waste pile should be managed as hazardous waste, unless the waste pile can be separated into hazardous and non-hazardous components.

Waste materials may be affected by their inherent chemical stability. Weathering and leaching over time may cause older material to differ in chemical composition from newly deposited material in the same pile. Heterogeneous material may undergo chemical reactions resulting in pockets or layers of different compounds.

Waste piles containing unknown waste can be sampled using a three-dimensional random sampling strategy. This strategy involves dividing the pile into a three-dimensional grid system and numbering each grid section and sampling point using random-number tables or random-number generators. This strategy should be used only if all points within the pile can be accessed.

10.5.6.5. Composite Samples

Compositing a number of individually collected field samples may help reduce analytical costs. The disadvantage of sample compositing is a loss of concentration variance data, whereas the advantage is a more representative sample from the population that is being sampled. Compositing is especially useful if the waste pile is homogeneous. Compositing requires that equal amounts of material from each sample be combined, and ground, sieved, and/or sufficiently mixed so that an aliquot sample can be removed for laboratory analysis. To improve the quality of the composite sample, follow the compositing considerations offered in ASTM D6051, *Standard Guide for Composite Sampling and Field Subsampling for Environmental Waste Management Activities*.

If the concentration of a regulated material exceeds regulated levels, the entire waste pile should be managed as regulated waste, or additional sampling and analyses should be performed to define regulated and non-regulated material.

To avoid having to resample, field sampling personnel should collect enough volume to provide for a different compositing scheme or additional individual analyses. This precaution requires initial field samples to be retained until the laboratory results on the composited sample become available.

When a waste pile is believed to be heterogeneous, individual random sampling is the preferred sampling technique.

10.5.7. Containerized Solids

Sampling containerized solid materials (e.g., sludge, granulars, and powders) is accomplished generally with one of the following samplers:

- Scoop or trowel
- Waste pile sampler
- Grain sampler.

Each sample should be taken discretely. Depending on the objective of the sampling event (e.g., characterization for disposal), compositing samples in the field or laboratory on a weight/weight basis prior to analysis may be permissible. The procedure to collect samples using a waste pile sampler is discussed in the previous section.

Use the following procedure to collect samples using a scoop or trowel:

1. Open the container to be sampled.

2. At specified intervals, take small, equal portions of sample from the surface and immediately below the surface.
3. Transfer the sample into a laboratory-cleaned sample container, label the container, and complete the COC record and the FLB/FN.
4. Clean the sampler on site, or store the contaminated sampler in a plastic storage tube for subsequent cleaning. Store used rags in plastic bags for subsequent disposal.

A grain sampler consists of two slotted telescoping tubes, usually made of brass, stainless steel, or high-density polyethylene. The outer tube has a conical, pointed tip on one end that permits the sampler to penetrate the material being sampled. The sampler is opened and closed by rotating the inner tube. Grain samplers are generally 61 – 100 centimeters long by 1.27 – 2.54 centimeters in diameter. The following procedure is used to collect samples using a grain sampler:

1. Open the container to be sampled.
2. While the sampler is in the closed position, insert it into granular or powdered material or waste being sampled from a point near a top edge or corner, through the center, and to a point diagonally opposite the point of entry.
3. Rotate the inner tube of the sampler into the open position.
4. Wiggle the sampler a few times to allow materials to enter the open slots.
5. Place the sampler in the closed position and withdraw from the material being sampled.
6. Place the sampler in a horizontal position with the slots facing upward.
7. Rotate and slide out the outer tube from the inner tube.
8. Transfer the sample into a laboratory-cleaned sample container, label the container, and complete the COC record and the FLB/FN.
9. Clean the sampler on site, or store the contaminated sampler in a plastic storage tube for subsequent cleaning. Store used rags in plastic bags for subsequent disposal.

10.5.8. Sampling for Lead in Paint

X-ray fluorescence spectrometry and direct laboratory testing may be used to determine the lead content of paint. However, X-ray fluorescence spectrometry is generally used only as a screening test to detect the presence of lead, because certain interferences can make it unreliable for determining exact concentration. Laboratory testing should be used to determine the actual concentration of lead in solid materials.

To collect a paint sample suitable for lead determination, use a sharp knife to cut through the paint. Remove the paint with a clean putty knife, and place the sample in a clean resealable plastic bag or appropriate container. Label the plastic bag or container and record pertinent sample collection information in the FLB/FN.

A sample of about 2 inches by 2 inches is required for a determination of lead content. Be sure to take a sample of all layers of paint, because only the lower layer may contain lead. Avoid including any of the underlying wood, plaster, metal, or brick in the sample. Wipe the sampled surface and any paint dust with a wet cloth or paper towel, and discard the cloth or towel.

If it is determined that a painted surface is homogeneous throughout the building and the same paint was applied at the same general time throughout, the number of samples can be reduced. At a minimum, three or five samples each from doors, windows, and walls for each floor of a building should be collected.

The U.S. Department of Housing and Urban Development recommends that action be taken to reduce exposure to lead in paint when the lead content is greater than 0.5% by laboratory testing or greater than 1.0 mg/cm^2 by X-ray fluorescence spectrometry. When the lead content of a door, window, or wall sample exceeds the recommended action level, all similar areas should be inspected. Action is especially important when paint is deteriorating or when infants, children, or pregnant women are present. Generally, buildings constructed after 1980 are not expected to contain paint with elevated lead concentrations.

Lead-contaminated waste generated by public, commercial, and industrial buildings is subject to hazardous waste regulations. Analysis of the waste using the Toxic Characteristic Leaching Procedure (TCLP) may be required. Lead-contaminated wastes with TCLP levels at or above 5 ppm are defined as hazardous and should be handled and disposed of in conformance with hazardous waste laws and regulations.

When lead-based paint is an integral part of demolition debris, the appropriate way to collect samples is by coring a representative portion of the material to be disposed to include both paint and wood. Because a relatively small amount of lead is present in the paint film, these wastes may not fail TCLP, and many can be disposed of as solid waste. If the waste is lead-based paint chips or blasting wastes, TCLP should be used on the waste to determine if it is hazardous. Due to the more concentrated nature of these wastes, they will often fail TCLP and require management as a hazardous waste.

10.5.9. Ashore Oil Spill Sampling

This section discusses methods for collecting surface ashore samples whenever an oil spill has occurred from a site or a vessel. A suction device can be used to collect samples. However, the statistical design of the sampling program should be the same no matter what devices are used to collect samples. Ashore oil spill samples can be collected by inverting a 4-fluid-ounce jar and collecting the liquid oil sample and store the sample at ≤6°C. Tarballs should be collected in an appropriately sized sample container and stored at ≤6°C. Shallow pollution samples can be collected by using one of the following methods.

10.5.9.1. Soil Punch Sampling

A soil punch is a thin-walled tube, 15 – 20 centimeters long, used to extract short cores from contaminated locations at beaches. The following steps are used to collect samples with a soil punch:

1. Drive the tube into the potentially contaminated location with a wooden mallet.
2. Extract the tube and core.
3. Push the collected materials into a mixing bowl, place the sample in a labeled container with a Teflon®-lined cap, and store the sample at 0 – 6°C.
4. Complete the COC record and the FLB/FN.
5. Clean the sampler on site, or store the contaminated parts of the sampler in a plastic storage tube for subsequent cleaning. Store used rags in plastic bags for subsequent disposal.

10.5.9.2. Scoop or Shovel Sampling

Surface samples following an ashore oil spill are collected with a scoop and shovel. A small plastic disposable scoop can be used to collect representative samples. Proper QA/QC procedures should be followed to ensure cross-contamination cannot occur during sampling events. Larger representative samples can be collected using a shovel.

10.5.9.3. Hand Auger Sampling

Shallow surface ashore oil spill samples can be collected with a hand auger. Samples should not be used for the examination of a core sample, because soil is mixed when the auger is pushed into the ground. The following procedure is used to collect a sample with a hand auger:

1. Place the hand auger at the location where the sample is to be collected.
2. Twist or screw the auger, extract the sample, and pull the auger.
3. Push collected materials into a mixing bowl, place the sample into a labeled container with a Teflon®-lined cap, and store the sample at ≤6°C.
4. Complete the COC record and the FLB/FN.
5. Clean the sampler on site or store the contaminated parts of the sampler in a plastic storage tube for subsequent cleaning. Store used rags in plastic bags for subsequent disposal.

Note: Power augers can be used to collect samples. The procedure is the same as for the hand auger.

10.6. QA/QC

See Chapter 3 of this handbook for information on establishing an appropriate QA/QC protocol.

A QA/QC plan involves the establishment of a sampling protocol, which is designed to minimize sources of error in each stage of the process, from sample collection to analysis and reporting of analytical data. See Chapter 2 for information on creating a SAP. Key elements of a SAP for waste sampling are as follows:

- Development of a statistically sound sampling plan for spatial and temporal characterization of the drums, waste pile, and tanks
- Installation of a vertical and horizontal sampling network to allow for the collection of subsurface samples
- Use of a sampling device that minimizes disturbance to the chemistry of the media formation
- Use of field decontamination procedures to minimize cross-contamination during sampling
- Collection of QA/QC samples and adherence to COC procedures.

10.7. Sampling Equipment List

Section 3.8 provides a generic sampling equipment list applicable to most sampling events. The following list provides additional equipment applicable to waste sampling. In most cases, only a portion of the equipment listed below would be required for a given sampling event.

- Manual Drum Opening
  - Bung wrench
  - Drum deheader
- Remote Opening
  - Hydraulic device
  - Pneumatic device
- Ashore Oil Spill Sampling
  - 4-ounce jar
- Shallow pollution sampling
  - Soil punch
  - Scoop or shovel
  - Hand augers or power auger
- Wipe Sampling
  - Ruler or measuring tape
  - Gauze pad inside a pre-cleaned container and/or 4-inch diameter heavy gauge paper, such as Whatman #4 filter paper
- Chip Sampling
  - Ruler or measuring tape
  - Decontaminated chisel of borosilicate construction
  - Manual or electric hammer
  - Natural bristle brush
  - Dust pan lined with aluminum foil or one that is dedicated, decontaminated, and constructed of a pre-approved material that will not interfere with the contaminants of concern
  - Aluminum foil
- Sweep Sampling
  - Natural bristle brush
  - Decontaminated stainless steel spatula and/or a dust pan lined with aluminum foil, or one that is dedicated, decontaminated, and constructed of a pre-approved material that will not interfere with the contaminants of concern
  - Aluminum foil
- Transformer Sampling
  - Disposable glass COLIWASA
- Containerized Liquids/Drum Sampling
  - Bacon bomb, Kemmerer sampler, weighted bottle sampler, drum thief (glass tubes), and/or COLIWASA
  - Disposable scoop attached to a length of wooden or plastic rod
- Waste Pile Sampling
  - Thieves, triers, or shovels
- Containerized Solids Sampling
  - Scoop or trowel, waste pile sampler, or grain sampler
- Sampling for Lead in Paint
  - X-ray fluorescence spectrometer
  - Sharp knife to cut through the paint
  - Clean putty knife
  - Resealable plastic bag or appropriate container.

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Chapter 11. Air Sampling

11.1. Purpose

This chapter provides supporting background information and general procedures for air sampling related to environmental restoration and compliance issues.

11.2. Scope

Because the requirements and methods for air sampling are often very complex, this information is intended only to provide an overview of methods, equipment, and instrumentation. For specific applications, the established regulatory or literature reference procedures should be consulted.

11.3. Background

Air sampling is conducted to monitor levels of air contaminants. Air is the most transient environmental medium and subject to extreme spatial and temporal heterogeneity. Representative air sampling presents unique and difficult challenges. Also, the contaminants of interest may be present at very low concentrations.

11.3.1. Air Matrices

Air sampling matrices include:

- Ambient (outdoor) air
- Indoor air
- Point sources (stacks, exhausts, and other emission sources)
- Fugitive emissions (sources of air pollutants other than stacks or vents)
- Soil gas, particularly over and around landfill waste sites, or groundwater plumes (soil gas sampling is addressed in Chapter 4, Soil Sampling).

In general, ambient or outside air will contain the smallest concentration of detectable air pollutants, and indoor air will contain an increased concentration range of pollutants. Pollutant concentrations from point sources such as stacks and vents, and fugitive emissions can vary from ppb levels to almost 100% pollutant.

11.3.2. Objectives of Air Sampling and Monitoring

Air sampling and monitoring may be performed to**:**

- Determine background levels of contaminants
- Provide continuous monitoring of atmospheric or industrial process conditions
- Measure acute or periodic releases of contaminants
- Provide data for computerized dispersion modeling to evaluate contaminant patterns and trends
- Vapor intrusion (VI) investigations. See the *DoD Vapor Intrusion Handbook* for more information on conducting VI investigations
- Monitor and evaluate remediation processes (e.g., air stripping, soil vapor extraction, and excavation). See US Army Corps of Engineer's EP-200-1-24, *Air Pathway Analysis for the Design of Remedial Action Projects,* and Chapter 11 of this Handbook and for more information.

The basic objective of air monitoring is to representatively measure in situ, or transfer all of the contaminant from a measured quantity of air into an analytical instrument that will respond proportionally to the amount of contaminant present. In practice this includes:

- Taking a portable instrument to the contaminated air location
- Taking a measured volume of the contaminated air to an instrument in the laboratory or in the field
- Extracting the contaminant from a measured volume of air and measuring its concentration in the laboratory or in the field.

Accurate measurements are often difficult to achieve, because many factors affect air sample representativeness, quantitation, and minimization of artifacts. Artifacts are contaminants originating from sources other than the intended sample. Common sources of artifacts are:

- Contaminated sampling equipment
- Improper sampling procedures

- Undesired physical or chemical reactions of the sample with the sampling container or collection media
- Thermal effects
- Contamination from adjacent sites or sources not representative of the site (e.g., indoor sources during a vapor intrusion investigation)
- Emissions from surrounding activities.

In addition, artifacts and poor quantitation are common problems with air analyses because the concentrations of contaminants are often very low with respect to the surface areas of the containers and sampling media used for their collection. Many different methods have been developed for measuring air contamination. The choice of method for a particular task depends on the anticipated use of the data, required detection/quantitation limits, data turnaround needs, data quality objectives, and regulatory requirements written into facility operating permits.

11.4. General Classification of Air Pollutants

Generally, air pollutants are broadly classified into two types – gases/vapors and particulates. Gases such as sulfur dioxide, nitrogen oxides, and carbon monoxide result primarily from industrial combustion processes. Hydrogen sulfide and halogens and their derivatives come mainly from industrial operations. Solvent vapors have numerous anthropogenic sources and can be present from primary or secondary sources (vadose zone and/or ground water contamination). Hydrocarbons and their oxidation products are primarily associated with gasoline fuel operations and incomplete combustion. Ozone results from photochemical reactions with nitrogen oxides, hydrocarbons, and other organic compounds. Particulates can be either droplets of liquid or solid particles. When particulate matter is suspended in air, it is called an aerosol. Aerosols most prevalent in pollution are in the 0.01 – 100 micron diameter particle size range. Aerosols can be formed by:

- Water vapor (e.g., fog or steam)
- Smoke and industrial fumes
- Reaction of species such as sulfur dioxide with water
- Growth of smaller entities such as salts into agglomerates (e.g., ammonium sulfate and nitrate)
- Organic liquid particulates from the distillation or vaporization of volatile materials
- Atomization of liquids through a small orifice.

Types of solid particulates include:

- Soot or carbon found in smoke from combustion processes of natural or man-made origins (particles are 0.01 – 1.0 micron diameter and very sticky)
- Fly ash consisting of non-combustible mineral solids formed from complete oxidation of coal or fuel oil, generally <200 micron diameter
- Dusts from natural or industrial disintegration processes, generally 1 – 1,000 micron diameter
- Fumes from condensation, calcination, or chemical reactions.

Liquid particulates include:

- Mists arising from vapor condensation, chemical reactions, or liquid atomization.

Many common types of pollutants are actually combinations of the general classifications:

- Smoke is a combination of gases and solid and liquid particulates
- Solid particulates frequently have organic and inorganic species adhered to their surfaces
- Liquid particulates may combine with gases and solid particulates
- Atmospheric aerosols are frequently mixtures of soluble and insoluble materials, with relative humidity determining the equilibrium of the two phases. They may be chemically complex with volatiles and several soluble aerosols co-dissolved. Figure 11-1 illustrates relative particle size ranges for aerosols, dusts, and fumes.

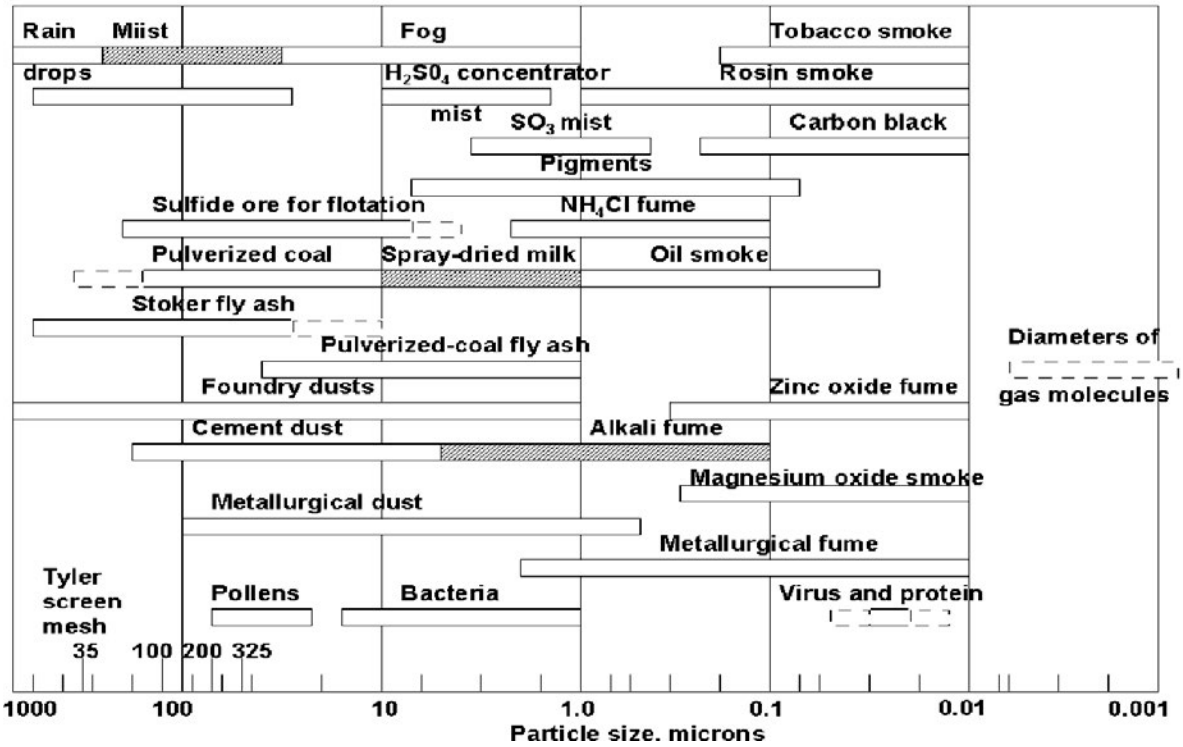

Figure 11-1 Particle Size Ranges for Aerosols, Dusts, and Fumes
Source: Faith, W. L. and Atkinson, A. A., Jr

11.5. Factors Affecting Ambient Air Sampling and Monitoring

11.5.1. Meteorological

11.5.1.1. Meteorological Parameters

Primary meteorological parameters to be considered in ambient air sampling are:

- Wind direction
- Wind speed
- Temperature
- Atmospheric stability
- Atmospheric pressure
- Precipitation.

Wind direction is most critical and must be monitored and documented constantly during air sampling events. Large variations in samples can result from even momentary shifts in wind direction. Changes in wind speed alter the volatilization rates of liquid contaminants and concentrations of contaminants downwind of the source. Generally, increased wind speed increases volatilization of liquids at the source and may conversely decrease the concentration of volatile downwind of the source. Increased wind speed may have the opposite effect on non-volatiles by increasing the amounts adsorbed by particulates such as soil and dust. Increased wind speed facilitates transfer of a greater number of large particulates from the source.

Higher temperature also increases volatilization. Both air temperature and solar radiation are factors, with solar radiation usually most critical, particularly for compounds with high vapor pressures.

Atmospheric stability refers to vertical motions of the air. When atmospheric conditions are unstable, pollutants become more dispersed in the various vertical layers. Under stable conditions, downwind concentrations are generally higher.

When monitoring sources such as landfills, atmospheric pressure is a significant factor, affecting the migration of gases through and out of the source. Low atmospheric pressures favor increased volatilization rates. Precipitation decreases overall airborne contaminants. The highest concentrations of contaminants generally occur in the initial precipitation samples. This is a result of particulate matter with its precipitate and gaseous contaminants being physically scrubbed from the air by the precipitation. Precipitation resulting in 100% relative humidity also significantly decreases particle transport by wind and volatilization rates.

11.5.1.2. Meteorological Measurements

For many air dispersion modeling applications, meteorological parameters can be obtained from the National Weather Service, the National Oceanic and Atmospheric Administration (NOAA), National Climatic Data Center, and the Federal Aviation Administration (FAA). These may be hourly observations, or may be readings taken every 5 – 15 minutes and calculated to an hourly average. For certain applications, it may be necessary to set up a custom on-site monitoring program. This is important if real-time analysis is needed or if wind flow is significantly affected by the terrain.

11.5.1.3. Wind Measurements

Wind direction and speed are critical parameters in predicting contaminant path of travel, air concentration, and deposition rates. Frequently, wind measurements are made at a height of 10 meters above ground or equal to the height of the stack or source being measured. It is very important that the structure supporting the monitoring equipment does not in any way interfere with the wind measurement, nor should any other structure or topographical factors be close enough to interfere with accurate measurements. The sensors are generally mounted on a thin mast above the tower at a height three times the lateral tower dimension.

Either prop vane or rotating cup anemometers can be used to measure wind speed. The cup anemometer has the advantage of being independent of direction, and can be calibrated to within 1% accuracy. Slowing of wind speed with this type sensor can lead to 5 – 10% error if the sensor continues to rotate. Vane type sensors must be damped to prevent over rotation, which results in an artificially high directional variation.

11.5.1.4. Temperature and Humidity

For the purposes of most modeling, temperature and humidity measurements that are representative of hourly periods can be used. The sensors can be located at the height of the shelter or about 1.5 meters. For plumes, temperature is used to calculate the plume rise from buoyant sources. If the contaminants of interest are also hygroscopic, a humidity measurement is also required. Sensors should be protected from direct solar radiation and the buildup of heated air within the shielded area. This can often be done by aspirating the air flow over the sensors.

Sometimes it is desirable to measure the temperature at two levels, usually between 2 and 10 meters, and use the temperature difference to determine the degree of atmospheric stability or surface inversion.

For dry deposition measurements, it is often necessary to know air humidity, surface wetness, amount and type of precipitation, and the chemistry of the precipitation.

11.5.2. Topographical Factors

Mountains, hills, valleys, lakes, and seas can significantly affect wind direction and the dispersion patterns of air pollutants. Wind generally flows along the axis of valleys with bi-directional distribution. At night, colder air flows down the slope into the valley creating thermal inversion of the air. The result is increased pollutant concentrations in the valley due to decreased vertical air dispersion. During the daytime hours, the effect is reversed but to a lesser degree.

Near oceans and large lakes, the differences in daytime and nighttime temperatures result in bi-directional wind changes. During the day, the wind generally moves from the cooler body of water toward the land in an upward motion. At night as the land mass cools, the effect is reversed producing "land breezes", which are not as strong.

11.5.3. Extraneous Contaminant Sources

Extraneous background contamination can come from many sources. Incidental atmospheric contaminants such as automobile exhaust or exhaust from a gasoline powered generator can render samples useless. Incidental contaminants on the large surfaces of containers and sorbents used to collect or concentrate samples can also pose significant problems. Because inadvertent contamination can affect analytical results, it is imperative that all sampling equipment be scrupulously clean and many types of blanks run.

11.5.4. Response Time of Sensors

Response time is the time required for a real-time sensor, recording in situ measurements, to respond to an incremental change in contaminant concentration and settle to a final value within a margin of error of the correct contaminant concentration. This is an important criterion to consider when selecting monitoring equipment for a specific application.

11.5.5. Placement of Samplers and Monitors

Placement requirements for sampling devices and monitors vary greatly depending on the type of source, type of monitoring, data quality objectives, and duration of the sampling or monitoring event. In general, care should be taken to maximize the representativeness of the data and minimize artifacts and effects resulting from poor collector or sensor placement.

When collecting air samples to determine the effect of an operation or facility on air quality, there must be at least one upwind sample taken to determine background ambient air conditions. The arrangement of downwind samples should vary depending on site conditions and project objectives.

Since the movement of airborne contaminants depends on weather conditions, the weather must be monitored during sampling. If there is a significant change in wind direction, samplers must be moved to maintain the proper upwind-downwind arrangement.

Because sampling equipment is often exposed to the elements, and operates for extended periods of time, it should be checked frequently to ensure proper operation. It should also be placed in a secured area when possible.

11.6. General Terms

11.6.1. Whole Air versus Component Samplers

Whole air samples are collected in various types of plastic bags, glass globes, or metal canisters with polished inside surfaces. Component samples are collected by passing the air stream through a filter device, a trapping liquid, or a solid sorbent medium.

11.6.2. Real Time versus Integrated or Composite Samplers

Field or "real-time" sampling refers to a variety of methods, using specific detectors, which can quickly survey an area of interest. Often these measurements are used to determine the placement of time integrated samplers, or other samplers for analysis in a laboratory. A grab sample may also be referred to as a real-time sample since the duration of collection is usually under a minute.

Composite or time-integrated samplers collect a sample or data over a specified time period, either continuously or periodically and give a representation of air contaminants over a much longer period of time than a real-time or grab sample.

11.6.3. Active Versus Passive Samplers

Samples may be collected in either an active or passive mode. Active air samplers use a pump or vacuum to pull ambient air through the monitor or collection media. Passive samplers allow ambient conditions to diffuse the sample through the monitor or the solid adsorbent material, which may be covered with a membrane or plastic film. The samples diffuse through the membrane and are adsorbed onto the solid media.

11.7. Strategies for Assessment of Air Pollution Emissions

Several approaches exist for evaluating emission of air pollutants. The method of choice depends on the end use of the data, data quality objectives, availability of sampling equipment, accessibility of sources, and recommendations of the regulatory agencies. EPA has published a four volume series for air pathway analysis (APA). These documents, *Air/Superfund National Technical Guidance Study Series, Vols. 1 – 4* are recommended for details on the various sampling methods. *Sampling and Analysis of Airborne Pollutants*, edited by Eric D. Winegar and Lawrence H. Keith, also provides guidance in this area.

11.7.1. Direct Assessment

Generally, it is preferable to measure emission rates directly rather than determine downwind mass/volume concentrations, the reason being that the data has more versatility for use in various modeling applications, where changes in parameters such as meteorological conditions can be evaluated. Direct measurements are also more useful for determining long-term effects, determining National Priority List (NPL) status for pollutants, and meeting permitting requirements. They are most useful for volatile contaminants. The preferred EPA method for these measurements is to set up an isolation flux chamber or enclosure over a small surface area of the emission site. This method is recommended for:

- Land surfaces
- Non-aerated, non-mixed liquid surfaces
- Aerated, mixed liquid surfaces
- Fugitive emissions from processes including leaks in seams, valves, ports, and controllers.

Advantages include:

- Cost effective
- Simple equipment requirements
- Direct measurements
- No models or estimates required
- Generally better quality data
- No upwind contamination and fewer meteorological interferences.

Disadvantages include:

- Not always possible
- Primarily used for volatiles materials
- Must exercise caution in data extrapolation.

11.7.2. Indirect Assessment

The indirect assessment approach uses a variety of samples from different ambient locations relatively close to the source to estimate concentrations via dispersion modeling equations. There are many models available, some developed for stack emissions, and others for area sources. The type of model determines the placement of sam-

plers and weighting of sample data. The models are designed to determine parameters such as downwind concentrations (sometimes at different heights), concentrations directly over the source, and general area concentrations.
Advantages include:
- Can be done where direct measurements are not feasible or possible
- Virtually any volatile or particulate species can be evaluated
- Not dependent on emission measurements
- Analyte measurements depend on analysis technique and sampling media.

Disadvantages include:
- Meteorological conditions play a major role and must be relatively stable for valid data collection
- Possibility of upwind contamination
- Lower concentrations of analytes due to mixing and dispersion forces
- Possibility of air flow interferences by topographical features
- Can be costly to perform
- Complexity of sampling devices
- Long term sampling may be difficult due to changing meteorological and atmospheric conditions
- Labor and analysis intensive
- Much more difficult to evaluate specific areas within a site.

11.7.3. Air Monitoring and Dispersion Modeling

In this method, measurements are generally made further downwind of the source and the data are used in a customized site-specific model to estimate overall site concentrations. For this type of determination to be accurate, meteorological and topographical factors must be accurately evaluated in the model. Modeling guidance can be found in the *EPA Superfund Exposure Assessment Manual, Appendix J,* which gives a brief description of EPA and other air pollution models. After a model is chosen, an estimate is made of source emission and downwind concentrations. The predicted and actual downwind concentration data are compared and source concentration is iteratively varied within the modeling equations until the data fit the equations for source and downwind concentrations. From the iterative process, the actual source emission concentration is thus estimated.
Advantages include:
- Can be done at greater distance from the source
- Exact data on source emission not required.

Disadvantages include:
- Dispersive forces result in concentrations being lower further from source
- The fit of the model to the actual conditions is critical
- Because the process is iterative, the uncertainty may be large.

11.7.4. Predictive Modeling

This method is based on choosing an emission model for a specific source type. Data for these models are usually obtained from literature, estimated, or calculated. For better accuracy, some data may need to be determined experimentally. The method is useful when used for screening or when an assessment does not require a high degree of confidence.
Advantages include:
- Fast
- Inexpensive
- Requires fewer or no field measurement
- Useful screening tool.

Disadvantages include:
- Provides estimate only
- Fit of site source and model critical
- Can be very inaccurate.

11.8. Field Measurement Instruments

Instruments have been developed for field operations to allow real-time measurement of air quality. Most instruments are meters, which measure analyte concentrations by passing a stream of air through the detector for a finite time interval. Other instruments monitor continuously and sound an alarm when a pre-set concentration level is exceeded, or monitor over a given time period and determine a time weighted average exposure. Before using any field instruments, the following factors must be considered:

- Limitations based on functional design or manufacturer quality control
- Safety must always be considered to ensure that the chosen instrument is compatible with the potential hazard. For example, some instruments are capable of detecting explosive hazards, but not all are safe for operations under these conditions. If the atmospheric concentration is potentially greater than 25% of the lower explosive limit, the meter itself must be certified safe for operation. Agencies certifying equipment safety include Factory Mutual (FM), Underwriters Laboratory (UL), and Mine Safety and Health Administration (MSHA)
- Although equipment accuracy may be certified within set limits by the manufacturer or the National Institute of Occupational Safety and Health (NIOSH), whenever possible, equipment should be calibrated before and after use. For some instruments calibration in the laboratory may be acceptable and will save time and inconvenience in the field
- Operators should be thoroughly familiar with the instrument and operating instructions before use. Always read or review the manual prior to using an instrument in the field.

Advantages include:

- Immediate readout
- Portability.

Disadvantages include:

- Response usually is not specific to a single chemical
- Detection limits are generally in the range of acute health effects (i.e., field instruments may not have the sensitivity needed to measure low concentrations of pollutants)
- Relatively expensive compared with sample collection equipment
- Quality control can be difficult because it is hard to run blanks and calibration samples in the field
- Changes in temperature and humidity may affect the sensitivity and accuracy of the instruments.

Field monitoring instruments are widely used for air monitoring in emergency situations where it is important to know whether the air is safe to breathe or whether a respirator will have to be worn. They are also widely used for screening to determine approximate concentration levels and the number and placement of other types of samplers. The following sections describe the common types of instruments used to monitor various air contaminants.

11.8.1. Detection of Volatile Organic Chemicals (VOCs)

VOCs include components of natural gas, gasoline, and solvents. These chemicals can evaporate to form an explosive mixture in air and may be toxic at lower concentrations. The following analytical instruments have been developed as portable devices, which can be taken into the field for air monitoring. Each instrument is calibrated by determining the response of the detector to clean (unpolluted) air and to air containing a known concentration of a VOC. When the instrument is used to monitor polluted air, instrument calibration should depend on the type and concentration of VOCs present.

11.8.1.1. Photo Ionization Detector (PID)

A PID contains a miniature lamp, which emits a very short wavelength ultraviolet radiation. Inside the instrument, a small air pump continuously draws ambient air through a tiny chamber, which is flooded with ultraviolet light (See Figure 11-2). If the radiated energy is higher than the ionization potential of a particular organic chemical in the sample, the chemical will be ionized. The chamber also contains two electrodes charged to a high voltage and attached to a sensitive current measuring device. When ions are formed, electric current flows between the electrodes in proportion to the number of ions in the air. The instrument display generally has units of parts-per-million (ppm). This concentration should be interpreted as the equivalent response to the calibration gas, not the ppm of unknown VOCs in the air, as different chemicals have different responses to the instrument.

Advantages include:

- Stable, calibration remains fairly constant
- Easier to ship, no flammable gas is required

- Sensitive to commonly encountered VOCs
- Not affected by presence of methane in air.

Disadvantages include:

- Sensitive to high humidity
- Can have problems when used in below freezing temperatures
- Bulb must be cleaned occasionally
- Response to various chemicals depends on the photoionization potential of the chemical and type of bulb used
- Detection limit generally 2 or 3 ppm VOCs (higher for VOCs not easily ionized by UV light)
- Not specific to a single chemical.

11.8.1.2. Flame Ionization Detector (FID)

A FID works by burning contaminated air in a hydrogen flame within the instrument. The residue of most burned organic vapors contains positively charged carbon-containing ions, which are attracted to the negative collecting electrode in the chamber. As the ions are collected, a current is generated, which corresponds to the concentration of vapor present. The amount of current is shown on the instrument display.

Advantages include:

- Response is more consistent for differing chemicals than with the PID
- Less sensitive to moisture than the PID

Disadvantages include:

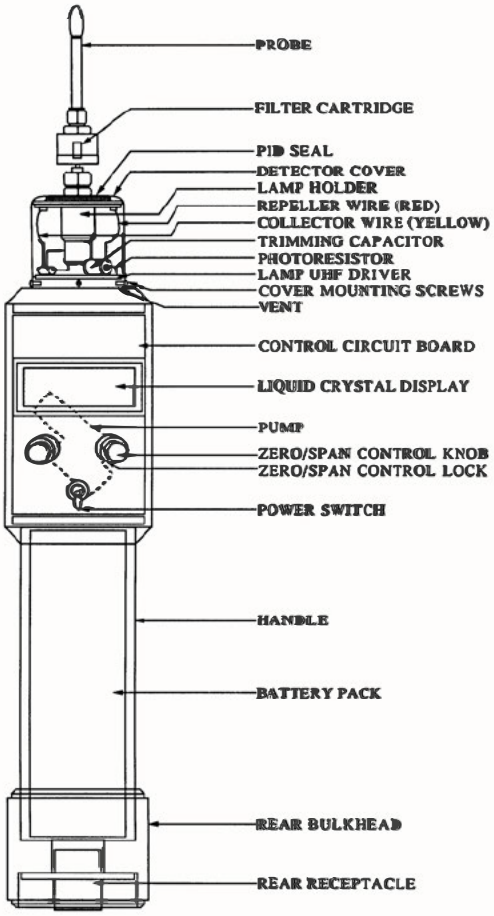

Figure 11-2 Photo Ionization Detector

- Need hydrogen for flame
- Sensitive to methane, which can mask the presence of toxic VOCs. Special methane filters are available
- Detection limit generally 2 or 3 ppm VOCs in air

11.8.1.3. Portable Gas Chromatograph (GC) and Gas Chromatograph/Mass Spectrometer (GC/MS)

A portable GC adds the benefit of separating mixtures of chemicals in an air sample. The air to be analyzed can be collected as either a whole air sample or in some instruments contaminants can be adsorbed on collection media and then desorbed to the instrument. Contaminants travel through a chromatography column and are separated based on their physicochemical properties, finally reaching a detector that outputs a signal that is proportional to the concentration of the

contaminant. Common GC detectors utilize the same technology as the PID and FID.
A GC/MS utilizes a mass selective detector that provides structural information on the detected contaminant (mass spectrum).
Advantages include:

- Selectivity, contaminants are separated and can be identified by both the time they spend traveling through the chromatography column and by their mass spectrum
- Sensitivity, these instruments are generally more sensitive than a PID or FID

Disadvantages include:

- Powering the instruments may necessitate a portable generator or large batteries
- GC and GC/MS can be more difficult to operate and require more extensive training than the handheld instruments.

11.8.1.4. Infrared Radiation Absorbance Detector

Although VOC vapors are transparent to visible light, they will absorb infrared radiation. This detector passes a beam of infrared radiation through air. The extent to which the different wavelengths of infrared radiation are absorbed depends on the chemical present and its concentration. Because different chemicals have different absorbance spectra, the infrared radiation detector can be used to selectively measure specific chemicals. Some analyzers contain a library of calibration data for common gases and vapors, and have the capability to store data for multi user-calibrated gases.
Advantages include:

- Specific for particular chemicals, since different VOCs have different infrared radiation absorbance characteristics.

Disadvantages include:

- Detection limits are generally greater than those for the PID or FID.

11.8.1.5. Indicator Tubes

Indicator tubes are small glass tubes filled with a porous material coated with a reagent. When air is drawn through the tube, the chemical of interest reacts with the reagent, resulting in a color change. The length of filler that changes color depends on the concentration of the chemical of interest. Indicator tubes are available for both volatile organic and inorganic chemicals such as ammonia, hydrogen sulfide, sulfur dioxide, nitrogen dioxide, etc. Indicator tubes are available for use with hand-operated pumps (which draw the required amount of air through the tube in a minute or less), battery-operated pumps (which draw the required amount of air through the tube over an 8 hour period to provide a measurement of average air concentration), and diffusion tubes (which depend on the diffusion of the chemical into the tube over an 8 hour period).
Advantages include:

- Inexpensive
- Direct readout.

Disadvantages include:

- Sensitivity limited to concentrations of chemicals that cause acute symptoms, hence not sensitive enough for environmental sampling where chronic effects are important
- Limited accuracy (±20 – 50%)
- Not completely selective: Although tubes are designed to detect single chemicals, other chemicals present in the air may affect readings
- Wet (foggy) weather and low temperatures can affect reading accuracy
- Limited shelf life: Each sampling tube must be used within a few months to a year of purchase, depending on tube type.

11.8.2. Explosimeter

Explosimeters operate by passing an electric current through a platinum wire, causing it to heat up and glow. As air is passed over the hot wire, any VOCs in the air are oxidized on the surface of the wire. Oxidation increases the temperature and electrical resistance of the wire, resulting in a decrease in the current.
Advantages include:

- Rugged
- Sensitivity to VOCs is in the percent range, which is relevant to explosive mixtures.

Disadvantages include:

- Does not work if the concentration of oxygen in the air is abnormal; most explosimeters in-

clude an oxygen meter to assure that oxygen is present at proper level
- Does not work if hydrogen sulfide (H_2S) in air greatly reduces the meter sensitivity; most explosimeters also include a H_2S meter
- Not sensitive to the presence of VOCs at low levels that may still present toxicity hazards.

11.8.3. Detection of Hydrogen Sulfide (H_2S)

H_2S is a toxic volatile gas with a permissible exposure limit of 10 ppm in air. Though hydrogen sulfide has a strong odor of rotten eggs, exposure to it for more than a few minutes desensitizes the nose, so the odor cannot be used as a reliable indicator of the presence of hazardous concentrations. A portable H_2S meter has an electrochemical detector designed specifically to react to the gas. The meter is calibrated by using air containing a known concentration of H_2S.

11.8.4. Detection of Carbon Monoxide (CO)

CO is a colorless and odorless toxic gas. Portable CO detectors have an electro-chemical cell, which reacts specifically to CO. Combination meters with sensors for explosive gas mixtures, oxygen, hydrogen sulfide, and CO are available. Such meters are commonly used to check air quality in confined spaces prior to entry. CO can also be measured by non-dispersive infrared spectroscopy.

11.8.5. Particulates

The Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for particulates not otherwise regulated (3.5 - 100 µm in diameter) is 15 mg/m^3. Portable meters are available that work by passing a stream of air through a light beam and measuring the amount of light bouncing off particles present. The resulting measurement indicates the concentration of particles in the air.

Advantages include:
- Real time data
- Portable

Disadvantages include:
- Sensitive to fog and other aerosols
- Not size specific for dust particles
- Not easily calibrated in the field

11.8.6. Mercury Vapor

Mercury vapor detectors are used primarily to provide guidance on whether respirators are needed in areas where mercury has been spilled. Detectors work by exposing a gold foil to a flow of contaminated air. Mercury vapor present in the air is absorbed by the foil, changing its electrical resistance. Approximately 40 ten-second samples containing 100 µg Hg/m^3 may be taken before the sensor reaches saturation. At that point, a ten-minute heating cycle is manually activated to clear the accumulated mercury from the foil.

Advantages include:
- Specific to mercury
- Portable
- Real-time data (response time one to ten seconds)
- Detection limits adequate for work place monitoring (one to ten $\mu g/m^3$).

Disadvantages include:
- Not easily calibrated
- Quality control samples such as a blanks and spikes are difficult in the field
- Detects only atomic mercury fumes, not organic mercury compounds, which are even more toxic.

11.9. Collecting Samples for Laboratory Analysis

Air sampling procedures have been developed to enable representative samples of air or contaminant(s) of interest to be delivered to the laboratory for analysis.

11.9.1. Whole Air Samples

Collection of whole air samples is the simplest sampling technique. For this method, a sample of air is collected in a bag, jar, or canister, and the container is delivered to the laboratory.

A major concern with this type of air sample is the loss of the chemical of interest due to adsorption on or permeation through the container walls. Chemical reactions with the container walls and photochemical reactions induced by sunlight are also a concern for some compounds. It is important that the holding times be minimized and that

the samples be analyzed as soon as possible. For very reactive or low concentration components this is not a suitable method.
At very high concentrations (e.g., several ppm), condensation may be a problem. Due to these limitations, this method should be used only for very stable volatile and semi-volatile organic chemicals such as hydrocarbons and chlorinated hydrocarbons with boiling points less than 150° C.
The following sections describe procedures, which may be used to collect whole air samples.

11.9.1.1. Bag Samples

Flexible bags for the collection of whole air samples are available in several different plastic materials including Tedlar®, Teflon®, Mylar®, and Saran®. Bag sampling is very useful in emergency situations where light weight and simplicity are an advantage and where the holding time will be very short.
Advantages include:

- Light weight
- Easily transportable
- Inexpensive.

Disadvantages include:

- Short holding times: Leakage and/or permeation of chemicals into and out of the bag can be a problem. Therefore, flexible bags should not be used for sampling for very low levels of air pollutants. Flexible bags are generally used to collect grab air samples to be analyzed within a few hours
- Cleanliness: Even new bags can be a source of contamination. Their cleanliness should be verified by blank analysis prior to use. Bags to be reused must be thoroughly cleaned by multiple evacuations and fillings with clean air. Cleanliness of each bag should then be verified before use. Cleanliness requirements depend on the concentration of the chemical to be measured and the analytical method. Reuse of flexible bags is not recommended when sampling for very low concentrations of organics
- Complicated field procedures: Additional equipment is required to fill flexible bags, including a vacuum pump and a hard-sided sampling box. An empty bag is put into the box and the inlet of the bag is attached to the sampling port of the box. The valve on the bag is then opened and the box is sealed. The vacuum pump is used to pull air out of the box, which reduces the pressure around the bag, causing it to fill with ambient air. The box is then opened and the valve on the bag is closed. The bag is then removed from the box, labeled, and delivered to the laboratory
- Transparent: Exposure to sunlight may cause photo-induced reactions of the chemicals in the air. Must store in darkness (e.g., wrap in black plastic bags)
- Reactivity: Some polymeric bag materials are reactive with certain compounds.

11.9.1.2. Glass Globe Samplers

Evacuated glass bulbs have been used extensively to collect whole air samples.
Advantages include:

- Ease: Simple to use when collecting grab samples; just open the valve to let air into the globe, close the valve, and deliver globe to the laboratory
- Cleanliness: Easily cleaned in the laboratory; should remain clean in storage
- Holding times: Neither absorption nor leakage is a significant problem, so holding times are longer than with flexible plastic bags.

Disadvantages include:

- Weight: Heavier than plastic bags
- Fragile: Subject to breakage in use and transportation
- Transparent: Exposure to sunlight may cause photo-induced reactions of the chemicals in the air; must store in darkness (e.g., wrap in black plastic bags)
- Reactivity: Surfaces can be reactive to some compounds.

11.9.1.3. Metal Canister Samplers

Stainless steel canisters, made less reactive by depositing a pure chrome-nickel oxide on the interior surface (Summa® polishing process), offer many advantages for collecting whole air samples. In general, a canister is evacuated to a

vacuum of approximately 30 inches of Hg. When opened to ambient air, the differential pressure causes air to flow into the canister. This technique may be used to collect grab samples (duration of 10 to 30 seconds) or time-integrated samples (duration of 12 to 24 hours) taken through a flow-restrictive inlet. A mass flow controller can maintain a constant flow rate from full vacuum to within about five inches of Hg below ambient pressure. With a critical orifice flow restrictor, a decrease in the flow rate occurs as atmospheric pressure approaches.

Advantages include:

- Holding time: Canisters are not subject to sample permeation or photo-induced chemical effects. (Sample integrity of trace level organic compounds stored in Summa® polished canisters has been demonstrated for many chemicals for up to 30 days.)
- Reusable: Can be reused after cleanup
- Cleanliness: Generally, does not absorb contaminants, so it is relatively easily cleaned. However, canisters used for high concentration samples should not be reused for very low concentration sampling. New canisters should be checked for cleanliness before use
- Rugged: Not readily breakable
- Sampling period: Can be used to collect either grab samples or samples over a 24 hour period
- Available in larger sizes than glass globes.

Disadvantages include:

- Heavy
- Expensive.

11.9.2. Air Component Samples

Another method of sampling air is to selectively remove the chemicals of interest from a measured volume of air and submit the concentrated sample to the laboratory for analysis. When obtaining any sample by selectively removing and concentrating the components of interest from a large volume of air, it is extremely important to remember that other undesirable things may also be concentrated such as background artifacts and water vapor. Because these undesirables may make subsequent analyses difficult or impossible, every effort should be made at the sampling stage to eliminate or minimize their inclusion. The following sections describe some of the sample concentration methods commonly used. The following section explains some methods used to collect and concentrate organic components from ambient air.

11.9.2.1. Passive Sampling Badges

A passive sampling badge consists of a solid adsorbent material covered with a membrane or plastic film. The chemicals of interest diffuse through the membrane and are adsorbed by the material inside the badge. The sampling badge is then put into a non-permeable (foil lined) pouch or plastic container and sent to a laboratory for analysis. At the laboratory, the adsorbing material is treated with solvents or heat to release the absorbed chemicals of interest.

Advantages include:

- Simple: no pumps, hoses, or batteries required
- Portable: can be attached to a worker's collar to measure the actual air breathed
- Several types of badges are available for different chemicals:
  - Volatile organic chemicals
  - Formaldehyde – 0.1 to 5 ppm
  - Glutaraldehyde – 0.2 to 5 ppm
  - Mercury vapor – detection limit < 0.05 mg/m^3.

Disadvantages include:

- High detection threshold: Suitable for work place exposure studies where the decision criteria are based on acute health effects. (Not suitable for most ambient air sampling)
- Accuracy: ±25%
- Requires 8 hour sampling period
- Not suitable for sampling for semi-volatile organic chemicals.

11.9.2.2. Active Air Samplers

These samplers use a pump to pull ambient air through the collection media. Sampling pumps are classified as high flow (500 – 3,000 cm^3/min) or low flow (50 – 200 cm^3/min). Flow rates

should be maintained within ±5% of set rate.
Pump features may include:

- Diaphragm or piston-type of pumping action
- Flow regulator
- Rotameter or strokes counter to measure flow rate or sample volume
- Pulse dampener to smooth flow rate
- Timing mechanisms
- Safety features for use in flammable or explosive atmospheres.

Various collection techniques are used to sample the chemicals of interest from the air.
Advantages include:

- Chemicals of interest are concentrated, resulting in improved detection limits
- Standard methods have been defined and validated
- Samples are collected over long periods to obtain data on average contaminant levels.

Disadvantages include:

- Air flow may change over time – need wind speed and direction data throughout sampling period
- Complex equipment is used, which increases the likelihood of sampling errors
- A source of power may be required for the air sampling pumps.

11.9.2.3. Solid Sorbents

Solid sorbents are the primary collection means used to sample volatile and semi-volatile organic chemical vapors from air. Typically, large volumes of air are passed through a series of cartridges containing an inert adsorbing material. The organic chemicals are adsorbed from the air onto the surface of the adsorbent material. The laboratory extracts the adsorbed chemicals by using solvents or heat.
Unfortunately, solid sorbents are not selective for individual chemicals. Since broad classes of chemicals are adsorbed, the material may become saturated before the end of the sampling period and fail to adsorb all of the chemicals of interest from the air. This potential problem is controlled by using several sorbent cartridges in series. If the analysis of the last cartridge does not find any of the chemical of interest, it was either not present in the air or completely adsorbed by the material in the preceding cartridges.
A wide variety of solid sorbent materials have been developed for air sampling.

11.9.2.3.1. Organic Polymers

- **Tenax®**. Tenax® resin (2,6-diphenylene oxide polymer) is used in air sampling for volatile organic chemicals with boiling points between 35° and 100° C (molecular weights ranging up to several hundred AMU). Use of Tenax® is specified in EPA Method TO-1 and in stack sampling Method 0030. Tenax® must be specially processed before use to remove interfering chemicals. The processing procedure is specified in Methods 0030 and 0031.
- **Amberlite® XAD-2**. XAD-2, used in air sampling for polynuclear aromatic hydrocarbons (PAHs), is specified in the following EPA sampling methods:
  - Method TO-13
  - Method 0010 (Modified Method 5 Sampling Train) for stack samples
  - Method 0020 for stack samples

  XAD-2 resin, as supplied by the manufacturer, is impregnated with a bicarbonate salt solution to inhibit microbial growth during storage. Both the salt solution and any residual extractable monomer and polymer species must be removed before the resin is used. Appendix A to EPA Method 0010 gives detailed procedures for preparing XAD-2 sorbent resin.
- **Thermosorb/N**. Thermosorb/N is used to sample for N-nitrosodimethylamine.
- **Polyurethane foam**. Polyurethane is used to sample semi-volatile chemicals such as pesticides, PCBs, and dioxins from large volumes of air, achieving a very low detection limit.

11.9.2.3.2. Inorganic Powders

Includes **silica gel, Porasil®, Florisil®, alumina, and inorganic molecular sieves.** These materials are considerably more polar than organic polymeric sorbents and thus capture polar compounds. However, the inorganic powders can become deactivated by adsorbing water moisture from the air. Silica gel will adsorb compounds

such as alcohols and phenols and other oxygen-containing compounds such as esters, aldehydes, and ketones. Florisil® can be used to collect chlorinated pesticides and PCBs from air.

11.9.2.3.3. Carbon Adsorbents

Carbon materials are a much stronger adsorbent than organic polymers and therefore allow efficient collection of highly volatile organic contaminants such as vinyl chloride, benzene, and toluene. However, the strong adsorption of carbon adsorbents can be a disadvantage in cases where recovery by thermal desorption of less volatile is desired because of the high temperatures required (e.g., 400° C).

There are a variety of carbon based adsorbents available with widely varying adsorption properties. The commonly available classes of carbon adsorbents include:

- **Carbon Molecular Sieves**. Sold under trade names such as **Spherocarb®**, **Carbosphere®**, **Carbosieve®**, and **Ambersorb® XE-347**, these materials have been used to sample air for very volatile organic chemicals such as vinyl chloride, ethylene dichloride, and methylene chloride.
- **Carbonaceous polymeric adsorbents** are available under trade names **Ambersorb® XE-340, XE-347**, and **XE-348**. XE-340 appears to be useful for volatile compounds in the C_4 to C_6 boiling point range, a volatility range not covered by organic polymeric adsorbents such as Tenax®.
- **Activated carbon**. Conventional activated carbons have a porous structure, which leads to difficulty in recovering adsorbed materials. Therefore, this material is rarely used as a sampling media.

11.9.2.4. Chemical Derivitization Techniques

Ambient air can be exposed to a chemical reagent that reacts with the volatile organic chemical of interest, forming a non-volatile product trapped in the sampling device. Integrated sample collection and derivitization of carbonyls with 2,4-dinitrophenyl hydrazine (DNPH) is a particularly good example of the utility of concentration and derivitization methodology.

The reagent can be in solution in a liquid impinger or "bubbler" or can be adsorbed on the surface of a porous solid. Liquid impingers require considerable glassware that must be specially cleaned, and the liquids must be handled in the field under difficult conditions. In addition, the impinger may have to be immersed in a bath of ice water to prevent the evaporation of the reagent-containing liquid.

Cartridges of solid sorbents coated with derivitizing reagent can provide much higher collection efficiencies than a liquid impinger. A variety of sorbent media can be used including: silica gel, glass beads, glass fiber filters, Amberlite® XAD-2 resin, Florisil®, Chromosorb P®, Carbopak B®, and C18 coated silica. Although the solid phase method is much superior to the impinger method, the sampling is not without problems such as:

- incomplete collection
- reactivity of carbonyls
- surface adsorption of carbonyls
- artifact and interfering compound formation
- blank contamination
- variable rates of formation of derivatives for various compounds
- interference of ozone and sulfur dioxide

11.9.2.5. Nebulization/Reflux Concentration

This method is a modification of the bubbler/impinger methodology. In this case, instead of bubbling air sample through a liquid scrubbing solution, the liquid is nebulized to a fine mist inside a glass bulb. Air is introduced through a small orifice located in close proximity to the nebulization tip and analytes of interest in the air flowing through the mist are transferred to the mist droplets. In the fine mist state, the surface area for analyte contact is greatly increased, resulting in significantly improved collection efficiencies. A non-wettable filter (usually Teflon®) collects and coalesces the mist back into the bulb while passing scrubbed air out. The liquid scrubber solution can either dissolve the analytes of interest or chemically derivatize them.

Table 11-1 lists the EPA standard methods for sampling ambient air and their respective collection media.

Table 11-1 EPA Standard Air Contaminant Sampling Methods for Toxic Organic Compounds

Method	Description	Types of Compounds Determined
TO-1	Tenax® GC adsorption and Gas Chromatography/Mass Spectrometry (GC/MS) analysis	Volatile, nonpolar organics (e.g., aromatic hydrocarbons, chlorinated hydrocarbons having boiling points in the range of 80° to 200° C
TO-2	Carbon molecular sieve adsorption and GC/MS analysis	Highly volatile, nonpolar organics (e.g., vinyl chloride, vinylidene chloride, benzene, toluene) having boiling points in the range of -15° to +120° C
TO-3	Cryogenic trapping and GC/FID or ECD analysis	Volatile, nonpolar organics having boiling points in the range of 10° to 200° C
TO-4	High volume PUF sampling and GC/ECD analysis	Organochlorine Pesticides and PCBs
TO-5	Dinitrophenylhydrazine (DNPH) liquid impinger sampling and HPLC/UV analysis	Aldehydes and Ketones
TO-6	Aniline liquid impinger with High Performance Liquid Chromatography (HPLC)	Phosgene
TO-7	Thermosorb/N adsorption	N-Nitrosodimethylamine
TO-8	Sodium hydroxide liquid impinger with High Performance Liquid Chromatography (HPLC)	Cresol, Phenol
TO-9	High volume Polyurethane Foam (PUF) sampling with High Resolution Gas Chromatography/High Resolution Mass Spectrometry (HRGC/HRMS)	Dioxins (polychlorinated dibenzo-p-dioxins), Furans (polychlorinated dibenzofurans)
TO-10	Low volume Polyurethane Foam (PUF) sampling with Gas Chromatography/Electron Capture Detector (GC/ECD)	Pesticides
TO-11	DNPH coated adsorbent cartridge followed by High Performance Liquid Chromatography (HPLC) detection	Formaldehyde
TO-12	Cryogenic Preconcentration and Direct Flame Ionization Detection (PDFID)	Non-Methane Organic Compounds (NMOC)
TO-13	PUF/XAD-2 adsorption with GC and HPLC detection	Polynuclear Aromatic Hydrocarbons (PAHs)
TO-14	Summa Canister collection with GC Analysis	Volatile Organic Compounds
TO-15	Summa Canister collection with GC/MS Analysis	Volatile Organic Compounds

11.10. Particulates

Many toxic chemicals present in ambient air are associated with solid particulates or aerosols. Organic chemicals, such as semi-volatile organics and polar compounds, may adsorb to particulates or condense to varying degrees and exist in a complex dynamic solid-vapor equilibrium with particulate matter. Volatile metals, such as cadmium and lead, in stack gases may condense on the surface of particulates. Some toxic compounds such as asbestos are present in ambient air only as particulates. Air sampling for particulates uses filtration, centrifugation, or impaction to remove particles from the air (See Figure 11-3 for an example of a typical particulate sampler). Certain adsorbed chemicals may evaporate off the surface of the particles during the capture process. Therefore, there is often the need for a gas phase collection device (e.g., adsorbent) downstream from the particulate capturing device. Analysis of both collection media would be necessary to determine the total amount of chemical present in the ambient air, but the results may not describe the actual phase distribution of the chemical in the air.

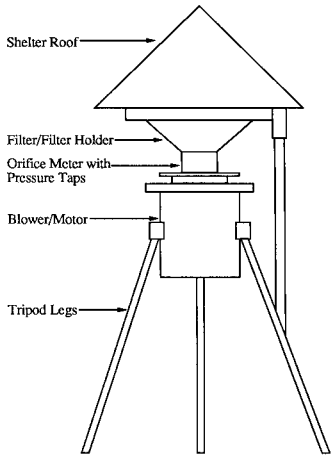

Figure 11-3 Particulate Sampler

11.10.1. Filtration

The most common method for collecting particulates is filtration. Many filter media with different filtration characteristics are available. The most commonly used media are:

- **Cellulose fiber filters** (e.g., Whatman No. 41 filter paper)
- **Glass or quartz fiber filters** withstand higher temperatures, are less affected by moisture in the air, and have higher collection efficiencies than cellulose filters. However, they have less strength and are more expensive than cellulose filters.
- **Membrane filters** (cellulose esters, Teflon®, nylon, etc.) have a well-defined pore size, but are limited to low flow-rate sampling. Many membrane filters will dissolve in solvents. This may be an advantage or disadvantage depending on the chemicals of interest.
- **Nucleopore filters** have well-defined pore sizes but are expensive and are limited to low volume sampling.

A variation on fiber filters is the thimble filter, which uses a filter paper thimble filled with fluffed cotton. For high temperature gases, an aluminum thimble replaces the paper thimble.

11.10.2. Centrifugal Collection and Impaction

EPA ambient air standards for particulates are based on the concentration of particles 10 µm in diameter or smaller. Methods for collecting size-fractionated particulate samples generally use cyclones (centrifugal collectors) or impactors. Both of these devices collect particles of a specific size range based on the design of the apparatus. Cyclones tend to have a rather broad size cut; impactors have a much sharper size cut.

- **Cyclone Collectors.** The cyclone is one of the most common types of solid particle collectors. It is an inertial, centrifugal separation, which separates particles by whirling them in a cyclonic motion in a conical shaped collection device. Particulates strike the wall of the collector and are collected at the bottom of the collection device.
- **Impactors/Impingers.** Impactor-type collectors function based on the different momentum of gases and particulates in a flowing stream. The separation is achieved by forcing the stream onto a solid surface where a specific size fraction of the aerosol is deposited. The solid surfaces may be a

baffled chamber, slotted plate, channels, or other obstructive arrangement.

11.11. Stationary Source Emission Samples

Stack, vent, and duct samples are collected to evaluate the concentration of hazardous chemicals and particulates emitted into the air. Emission testing may be done to:

- Comply with a set of regulatory requirements
- Provide emission test data for a regulatory request
- Collect information for control equipment design specifications
- Determine control equipment efficiencies
- Acquire emission inventory data for historical, contaminant reduction, or process control purposes.

Sources may range from large stacks to small vents. Sources can include:

- Process gas streams
- Control device inlet ducts
- Area ventilation sources
- Storage tank vents
- Material handling systems
- Surface impoundments and landfills
- Pumps, valves, flanges, and other devices with seals.

Basic sample collection principles are the same as those used for ambient air. However, the high velocity and high temperature of stack gases and some other stationary emission sources requires that special procedures be used to obtain representative samples.

Many stationary emission sources can now be monitored continuously rather that by discrete samples. **Continuous Emission Monitoring Systems (CEMS)** can collect more data than discrete samples, and digitized dataloggers can provide a variety of sampling time intervals. For any stationary source monitoring program, end use of data, data quality objectives, and QC requirements must be considered. Frequently, a screening test may be needed to determine the long range testing plan. All monitoring and measuring equipment must be kept in good working order and must be calibrated to traceable standards where applicable.

11.11.1. Special Problems with Stack Vent and Duct Sampling

Collecting samples from stack emissions requires procedures to address the following problems:

- **Non-Uniform Conditions Across Stack Vent or Duct.** One cannot assume that the stack gas is the same in the center of the stack, vent, or duct as it is near its walls. Therefore, the gas must be collected at various locations across the source to ensure the sample is representative of the average conditions in the source.
- **Velocity Effects at Sampling Orifice.** The tip of the sampling probe or nozzle can cause turbulence in the stack, vent, or duct gas that can deflect particles away from the probe, resulting in an invalid sample. It is important that the flow rate and flow direction of the sampled gas passing through the probe nozzle tip opening be the same as those in the source in order to minimize the turbulence caused by changes in gas flow at the tip of the probe. The gas flow rate and flow direction through the sampling probe or nozzle tip should be equal to gas flow rate and flow direction of gas passing through the source (i.e., isokinetic).
- **Condensation in Sampling Probe.** High temperature gas in a stack, vent, or duct may contain concentrations of water and chemicals that could condense out before reaching the sampling equipment if the gas is allowed to cool in the sampling probe. Therefore, precautions must be taken to maintain the temperature of the gas in the probe, while cooling the gas and condensing out the moisture as necessary in the sampling equipment to ensure sampling effectiveness. Temperature in the sampling line must be held above the dew point of the normally gaseous components.
- **Corrosivity of Stack Gases.** Since stack gases are frequently corrosive, sampling devices must be made of non-corrosive materials.
- **Collector Efficiency.** Generally, collectors should be at least 95% efficient unless the

reproducibility of samples is very high and representative of the gas stream.

- **Sample Collector Orientation.** The long axis of the sampling head must be parallel to the direction of gas flow.
- **Total Gas Flow.** For accurate quantitation, the total gas flow must be determined. Volume of gas flow is usually determined by traversing the cross section of the stack, vent, or duct using a Pitot tube to obtain gas velocity. Velocities calculated from the Pitot tube readings are averaged and multiplied by the cross sectional area of the source to obtain the gas volume.

11.11.2. Specified Procedures

In order to ensure the accuracy of reported stack, vent, or duct sampling data, the EPA specifies the sampling procedures in great detail. The sampling equipment is available from a number of commercial suppliers, and the methods should be followed precisely. The following sections summarize stack sampling methods that the EPA has developed for hazardous waste incinerators.

11.11.2.1. Method 0010 – Modified Method 5 Sampling Train

Gaseous and particulate pollutants are withdrawn from an emission source at an isokinetic sampling rate and are collected in a multicomponent sampling train. Principal components of the train include a high efficiency glass or quartz fiber filter and a packed bed of porous polymeric adsorbent resin **(XAD-2)**. The filter is used to collect organic-laden particulate materials and the porous polymeric resin to adsorb semi-volatile organic species. Commercial models of this equipment are available.

11.11.2.2. Method 0020 – Source Assessment Sampling System (SASS)

Particulate and semi-volatile organic materials are extracted from a source at a constant rate near isokinetic conditions and are collected in a multi-component sampling train. Three heated cyclones and a heated high-efficiency fiber filter remove and collect the particulate material from the sample and a cartridge containing 150 grams of XAD-2 resin.

11.11.2.3. Method 0030 – Volatile Organic Sampling Train (VOST)

This method collects a 20-liter sample of stack gas containing volatile principle organic hazardous compounds (POHCs). The stack gas is collected at a flow rate of 1 liter per minute using a glass-lined probe and a VOST. The gas stream is cooled to 20° C by passage through a water-cooled condenser. Volatile POHCs are collected on a pair of sorbent resin traps. Liquid condensate is collected in an impinger placed between the two resin traps. The first resin trap (front trap) contains approximately 1.6 grams of Tenax® and the second trap (back trap) contains approximately 1 gram each of Tenax® and petroleum-based charcoal, 3:1 by volume. The VOST is designed to be operated at 1 liter per minute with traps being replaced every 20 minutes for a total sampling time of two hours. Traps may be analyzed separately or combined into one trap to improve the detection limit. Recent experience has shown that when less than maximum detection ability is required, it is acceptable and probably preferable to operate the VOST at 0.5 liters per minute for a total of three 40 minute periods. This preserves the two hour sampling period, but reduces the number of cartridge changes in the field as well as the number of analyses required.

11.12. Measurement of Air Volume Sampled

To obtain the proper results, the total volume of air sampled must be known. The flow rate of air through the sampling media shall be measured at both the beginning and end of the sampling period because the resistance of air through the sampling media may increase as it is exposed to contaminated air, resulting in a decreased flow rate. The sampling device should also be checked periodically to make sure that the sampling pump is working. The air flow rate is the average of the beginning and end flow rates. If the sampling pump is connected to line power and does not contain a timer, a clock should be connected to the same outlet to measure the duration of sampling if the power is interrupted. The total amount of air that is sampled is calculated from the measured air flow rates and the sampling duration:

Total Volume = Average Flow Rate × Time

11.12.1. Low Flow Rate Samples

The most common type of air flow measuring device for low flow rate air samples is the soap film calibrator. This device is placed between the sampling device and the air pump, and a soap film is created across the end of the straight glass tube. This film acts as a frictionless piston, and moves up the tube as air is drawn through the calibrator. The time required to move the film past two points on the tube is either measured with a stop watch or is detected by photoelectric cells in the device.

Although this device is accurate, it is rather fragile and requires some practice to generate the soap films and to make the time measurements. The photoelectric cell detectors may not function in bright sunlight, so this type of device might have to be shaded with a dark cloth or plastic bag during use. After the air flow rate measurement is completed, the calibrator is disconnected from the pump and the sample collection device and the pump are connected directly to the sampling device.

The sample media used for low flow rate samples may consist of glass tubes that contain solid adsorbent media, midget impingers, or filter cassettes. The air is drawn through the collection media using a portable air sampling pump.

11.12.2. High Flow Rate Samples

Most high flow rate air sampling devices are equipped with a manometer or other flow rate indicator. The flow rate must be measured at the beginning and end of each sampling period and should be checked periodically during the sampling period. The total volume sampled is calculated by multiplying the average flow rate by the sampling time.

11.13. Hazard and Safety Precautions

The safety plan or Health and Safety Plan (HASP), as appropriate to the scope of the project, should address all anticipated hazards for each task. The following is a short list of more common (and commonly overlooked) hazards associated with air sampling activities.

11.13.1. Environmental Hazards

Safety precautions include a review of possible environmental hazards before entering the site and the use of proper clothing and equipment. Workers performing stack sampling and air monitoring during emergency situations may be exposed to hazardous levels of air pollutants. Therefore, the safety plan or HASP, as appropriate to the scope of the project, must specify what kind of real-time air monitoring will be performed, the action levels for the use of respirators, and the types of respirators to be worn if action levels are exceeded. If there is a chance sampling personnel may be exposed to hazardous air, planning should include:

- Staffing requirements for real-time air monitoring and personal protective equipment (PPE) support personnel
- Use and availability of real-time air monitoring equipment, including calibration standards
- Assignment of sampling personnel trained in the use of PPE and real-time air monitoring procedures, and medically approved for work in respirators.

11.13.2. Stack, Vent, and Duct Sampling Safety

Safety concerns are of critical importance in performing stack sampling due to the possibility of fume exposure, falling, dropping equipment on workers below, contact with hot surfaces, shock, and weather related hazards such as ice, snow, and rain.

Procedures developed for each sampling task should carefully address all relevant safety issues, such as criteria for use of PPE, fall protection lanyards, and heat resistant (Nomex®) coveralls and gloves.

11.13.3. Instrument Hazards

Gases used to calibrate and operate some instruments come in pressurized cylinders and many are flammable. Proper care should be taken when handling these materials. Light sources from some instruments can cause eye damage when viewed directly.

11.14. Preparation for Sampling

11.14.1. Role of the Sampler

The role of sampling personnel is critical to the overall conduct of an air sampling program. The role of sampling personnel is to:

- Prepare or review Sampling and Analysis Plan (SAP)
- Be familiar with all required sampling protocols
- Assemble and verify cleanliness and operational status of all required equipment
- Calibrate, standardize, and operate air quality monitors
- Collect air data
- Collect samples for specific emission activities
- Ensure samples are properly preserved and transported to laboratory within holding times
- Document and record all pertinent information

11.14.2. Guidelines for Air Sampling

The SAP should specify when, where, and how air samples are to be collected. Careful and complete planning is required to ensure needed equipment and trained personnel are available to perform the method of sampling needed to collect the desired data. The following procedures should be followed when mobilizing for an air sampling program:

1. Review SAP and the safety plan or HASP. Identify special equipment and associated security requirements.
2. Identify sampling locations and determine whether each presents a problem for access, security, or availability of required utilities.
3. Prepare a staffing plan, which includes a description of the responsibilities and required training for each of the sampling personnel. For air samples collected over a long duration (8 to 24 hours), determine how many sampling personnel are needed to monitor air flows and equipment performance and how many security personnel are needed to ensure that the sampling equipment is not tampered with while operating.
4. Coordinate planning and scheduling with facility personnel to ensure access to sampling locations and availability of security personnel, utilities, respirator support personnel, and emergency support services.
5. Coordinate with the laboratory to ensure availability of its services within holding time tolerances. The laboratory may be able to provide significant support in preparing or furnishing sampling equipment and shipping containers.
6. Procure required sampling equipment, including:
   - Any required calibration standards
   - Additional sampling devices as required for blanks and duplicates and to allow for field breakage
   - Check sampling canisters to ensure vacuum has been maintained
   - Check all battery powered pumps to ensure batteries are charged and will hold a charge
   - Check air flow measuring equipment to ensure operability.
7. Procure all required PPE, including respirators and correct cartridges, real-time air monitoring equipment, and fall protection equipment (for stack sampling).
8. Check availability of weather data. It may be necessary to install a portable weather station at the sampling site to obtain a record of wind speed and direction, temperature, humidity, air pressure, and precipitation events.
9. Ensure provisions are in place to monitor and record events that occur at the sampling location, which might affect samples. This includes any activities operating in close proximity, which may affect sample integrity. It is important that all unusual releases occurring while sampling be thoroughly documented as to time, location, duration, and types and quantity of chemicals released to the atmosphere. Releases can include spills and an unusual amount of dust from facility operations or construction activities.
10. Check the Field Sampling Forms to be sure that unique sample numbers have been assigned to each sample.
11. Obtain a Field Log Book/Field Notes. Keep air-monitoring field notes neat and legible in a

legally defensible form. When sampling begins, document the start time, flow rate, weather conditions (ambient temperature, barometric pressure, humidity, etc.), locations of sampling equipment, and other pertinent information in the Field Log Book/Field Notes. During sampling, check the weather conditions frequently and enter them in the Log Book. Check the sampling equipment periodically. Enter findings (e.g., sampler off, knocked over, etc.) in the Log Book. If, at any time, the sampling equipment must be moved, note the time of the movement, the new locations, and the reasons for movement. When sampling is completed, record the time and ending flow rate. When using a multiple part form, place part of the form in the Log Book per the SAP or SOPs. Include calculations (such as the volume of air sampled, average flow rates, etc.) and pertinent observations.

12. Ensure that all materials required for sampling are available in sufficient quantities for the planned work.

13. Shipping: Sample jars and cartridges must be packed with bubble wrap, styrofoam, or other cushioning material to prevent breakage during shipment to and from the site. Vermiculite contains asbestos and shall not be used.

The validity of air samples depends on care taken to comply with the detailed sampling procedures, which includes equipment calibration, air flow measurements, and the collection of weather data. Variables such as the types of chemicals present in the air, on-site conditions and activities, and weather conditions can greatly affect sampling performance.

If the SAP specifies a standard EPA procedure, a complete copy of the procedure should be obtained and reviewed to ensure necessary equipment is available.

Specified steps of the EPA procedure should be followed as closely as possible. Any deviations from the procedure should be noted in detail in the Field Log Book/Field Notes

Chapter 12. Process Sampling

12.1. Purpose

This chapter discusses the need and provides strategies for sampling associated with remediation technologies.

12.2. Scope

Sampling of water (and vapors) is commonly conducted in groundwater treatment plants to support decisions regarding compliance with discharge permits and for making operational decisions at the plant. Sampling may occur for plant influent and effluent and intermediate samples may be taken before and after specific processes in the treatment train to:

- Assess adequacy of performance
- Tailor the addition of chemical amendments
- Monitor equipment operation.

For example, the need to replace reactive media (such as granular activated carbon (GAC)) is based on the above-described process monitoring. Sampling is usually a simple matter of collecting the necessary volume directly in the sample container from a valved sample tap. Purging is usually not required. Analysis of samples is typically conducted by off-site fixed laboratories, although at a few sites frequent sampling may justify an on-site laboratory, particularly during the early phases of plant start-up and operation. Few plants need on-site labs following the first year or two. In some cases, particularly where the compliance with standards is critical, auto-sampler or in-line sensor devices are used to automate the sampling and analysis process and to provide near-real-time data for process control, including plant shut down. In-line sensors are commonly used to monitor pH, and to control chemical feed pumps for pH adjustment. Auto-samplers are often used for collection of composite samples (e.g., 24-hour composite). Composite sampling, in conjunction with off-site analysis, is often required for effluent monitoring of contaminant levels, and for effluent toxicity testing. Composite sampling is generally not applicable for VOCs. All sampling should be conducted in accordance with the project SAP, or applicable permit.

A brief discussion of process sampling considerations is shown below for only the most common treatment technologies for remediation of contaminated groundwater and soils. The discussion is limited to the following treatment technologies.

12.3. Ex situ Groundwater Treatment

12.3.1. Liquid-Phase Granular Activated Carbon

Sampling is usually performed at the influent and effluent of the vessels containing the liquid phase GAC. Usually there will be a set of two vessels, operated in series (i.e., lead / lag configuration). Typically, samples are collected from the influent of the lead vessel, from a port between the lead and lag vessels, and from the effluent of the lag vessel. The need to replace adsorptive media, such as liquid phase GAC, is based on the above-described process monitoring.

Sampling is usually a simple matter of collecting the necessary volume directly in the sample container from a valved sample tap. Purging is usually not required. Analysis of samples is typically conducted by off-site fixed laboratories, although at a few sites frequent sampling may justify an on-site laboratory, particularly during the early phases of plant start-up and operation. Please see the following references for additional information:

- USACE DG 1110-1-2 for additional discussion of sampling approaches
- UFGS 43 31 13.14 (11225), Downflow Liquid Activated Carbon Adsorption Units.

12.3.2. Air Stripping

Because air stripping results in some of the contaminants (i.e., VOCs) being transferred into the vapor phase, monitoring of both water and air is often required. The performance (i.e., removal efficiency) of the air stripper is monitored by

collecting water samples from ports positioned before and after the air stripper.

During air stripping, VOCs are transferred from the liquid to the vapor phase. A sample port on the air-discharge line of the air stripper is usually available for collecting air samples to determine the concentration of contaminants being discharged into the air. If the air is being discharged directly to the atmosphere, then monitoring of the air discharge line may be required to demonstrate that regulatory air-discharge criteria are not being exceeded. In some instances, the air discharge from the air stripper must be treated before it can be released to the atmosphere. The most common treatment technology for removing VOCs from the air discharge from air strippers is vapor-phase GAC.

Because the air discharge from air strippers will be laden with moisture, it will typically have to be routed through an air-water separator (i.e., knock-out tank) before vapor-phase GAC treatment. The purpose of the air-water separator is to remove entrained water from the air stream. The air-water separator will usually include a tank for collection of water. The water that accumulates in the air-water separator constitutes another waste stream, which may require sampling. In some cases the water that accumulates in the air-water separator can be blended back into the untreated water stream (upstream from the air stripper influent), in which case sampling may not be required.

Use of in-line sensors for continuous monitoring of parameters such as pH is relatively common for groundwater treatment plants. An important side-effect of air stripping is that it often results in an increase in the pH of the water, after it passes through the air stripper. The pH may increase due to removal of dissolved carbon dioxide, and a shift in the equilibrium between carbon dioxide, carbonic acid, bicarbonate, and carbonate ion. If the pH becomes elevated, this often results in an increased propensity for precipitation of minerals (e.g., calcium carbonate). Mineral precipitation can lead to rapid fouling of the air stripper and coating of surfaces downstream from the air stripper. Chemical feed systems are often used to prevent, or slow the rate of fouling. Acids or sequestrants are often introduced upstream from the air stripper to control mineral precipitation. Acid-feed systems are usually equipped with in-line pH meters to control the rate of acid addition.

Please see the following references for additional information:

- USACE DG 1110-1-3 for additional discussion of sampling approaches
- UFGS 43 13 13.13 (11226), Vapor Phase Activated Carbon Adsorption Units.

12.4. In situ Groundwater Treatment

All of the processes described below represent alternatives for groundwater remediation. All of these processes rely on conventional groundwater monitoring methods, using monitoring wells. The primary parameters that require monitoring are the contaminant levels, and contaminant breakdown products (when applicable). The primary basis for monitoring the effectiveness of these treatment processes is demonstrating that contaminant levels (and breakdown products, if applicable), are decreasing (in response to treatment), at an acceptable rate, over time.

In addition to monitoring contaminant levels there are a host of other "indicator parameters" that may need to be included as monitoring parameters. The suite of indicator parameters is technology-specific, and will vary depending on the specific compounds that are being introduced into groundwater as part of the treatment process. Since the monitoring for in situ treatment will typically involve sampling of existing monitoring wells, and such sampling is covered elsewhere in the document, the focus in this section is on the typical analytical requirements for the various in situ technologies. A brief description of the technologies also are included.

12.4.1. Monitored Natural Attenuation (MNA)

For MNA, the primary parameters that require monitoring are the contaminant levels and contaminant breakdown products. The primary basis for monitoring the effectiveness of MNA is demonstrating that contaminant levels (and

breakdown products, if applicable), are decreasing, at an acceptable rate, over time.

Measurements of organic carbon levels in groundwater (e.g., total organic carbon) are often used to help determine if naturally occurring, or anthropogenic, electron donors are present.

Groundwater samples are also commonly tested for levels of electron acceptors to determine if depletion of electron acceptors is occurring, and whether or not reductive dechlorination is contributing to attenuation of contaminants. In some cases, a relatively large suite of parameters may be necessary to provide the necessary lines-of-evidence to demonstrate the extent to which MNA is occurring, and to assess if attenuation processes are proceeding at a sufficient rate. Usually, the number of monitoring parameters and the frequency of monitoring can be reduced after a record of several years of groundwater monitoring data has been acquired and the trend in each of the parameters has been established. Refer to the references below for additional information on monitoring parameters and sampling approaches:

- Interstate Technology and Regulatory Cooperation (ITRC) Natural Attenuation of Chlorinated Solvents in Groundwater: Principles and Practices (September 1999)
- Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater, EPA 600-R-98-128, 1998.

12.4.2. Enhanced Anaerobic Bioremediation (EAB)

EAB usually involves injection of electron donor formulations into groundwater in order to stimulate anaerobic conditions, and to promote reductive dechlorination of chlorinated solvents. Electron donor formulations can include: corn syrup, molasses, emulsified oils, whey, chitin, etc. Introduction of electron donor results in depletion of electron acceptors. Microorganisms consume the most energetically favorable electron acceptors first (i.e., usually DO and nitrate), followed by less favorable electron acceptors such as sulfate. Chloroethenes, such as TCE, become available as electron acceptors after the more favorable electron acceptors have been largely depleted. In some instances, it may also be necessary to inject cultures of dechlorinating microorganisms (i.e., bioaugmentation), to promote reductive dechlorination.

The primary parameters that require monitoring are the contaminant levels and contaminant breakdown products. The primary basis for monitoring the effectiveness of these treatment processes is demonstrating that contaminant levels (and breakdown products, if applicable), are decreasing (in response to treatment), at an acceptable rate, over time.

Measurements of organic carbon levels in groundwater (e.g., total organic carbon) are often used to help determine the adequacy of delivery and distribution of electron donor. Groundwater samples are also commonly tested for levels of electron acceptors to determine if depletion of electron acceptors is occurring. Most of the same parameters that are used for MNA are also included as parameters for EAB. Refer to the below references for additional information on monitoring parameters and sampling approaches:

- Protocol for In Situ Bioremediation of Chlorinated Solvents Using Edible Oil (http://www.clu-in.org/download/remed/Final-Edible-Oil-Protocol-October-2007.pdf)
- Principles and Practices of Enhanced Anaerobic Bioremediation of Chlorinated Solvents.(http://costperformance.org/remediation/pdf/principles_and_practices_bioremediation.pdf)

Testing for the presence of genetic material from dechlorinating microorganisms (i.e., 16S ribosomal RNA (rRNA) from Dehalococcoides (DHC) organisms) and specific DHC reductive dehalogenase (RDase) genes is often performed to assess the microbial capacity for reductive dechlorination in groundwater. These gene-targeted molecular tools are used to assess the extent to which naturally-occurring DHC are present, or to assess how well the bioaugmentation culture has been distributed in groundwater. The number of copies of 16S rRNA DHC genes, and RDase genes can be determined via quantitative real-time polymerase chain reaction (qPCR)

analysis. This testing is available thru commercially laboratories such as SiREM and Microbial Insights.

For more information on qPCR testing see the following reference:

- Kirsti M. Ritalahti, Benjamin K. Amos, Youlboong Sung, Qingzhong Wu, Stephen S. Koenigsberg, and Frank E. Löffler; Quantitative PCR Targeting 16S rRNA and Reductive Dehalogenase Genes Simultaneously Monitors Multiple Dehalococcoides Strains**;** Appl. Envir. Microbiol., April 2006; 72: 2765 – 2774.9.2.2 Chemical Oxidation.

This technology involves the injection or placement of some type of chemical oxidant into the subsurface. The reagents often include permanganate, stabilized hydrogen peroxide, persulfate, and ozone. The primary considerations will be verifying the efficacy of the distribution of the reagents to assure adequate contact with the contaminants. The analytical requirements would normally include monitoring of oxidation/reduction potential, preferably using in situ measurement with downhole instruments. There would also be monitoring of the reagents themselves or reaction products. Permanganate addition creates a purplish hue to groundwater so colorimetric analysis may be possible to assess distribution of that reagent. Monitoring of target contaminant in standard groundwater samples would be an integral part of the sampling and analysis program.

For additional information, please refer to the following reference:

- Technical and Regulatory Guidance for In Situ Chemical Oxidation of Contaminated Soil and Groundwater, Second Edition (January 2005).

For oxidation of contaminants using ozone, the monitoring of residual ozone may be required for safety reasons.

12.4.3. Aerobic Biodegradation via Oxygen-Releasing Chemicals

A number of products are commercially available that rely on chemicals for slow-release of oxygen into groundwater. These chemicals are used to supply DO to support aerobic biodegradation of hydrocarbons, such as benzene, toluene, ethylbenzene, and xylene (BTEX), in groundwater. The chemicals usually contain either magnesium- or calcium-peroxide based formulations that, when hydrated, gradually release DO into groundwater. Oxygen-release chemicals can be applied in a number of different ways. In dry form, the chemicals can be packed into "socks" that are suspended below the water table, in wells. The dry powder can also be spread across the surface at the bottom of excavated areas for treatment of residual dissolved-phase hydrocarbon contamination; wetting of the area may be accomplished by applying water during backfilling. Alternatively, the dry chemicals can be mixed with water to form a slurry. The slurried material can then be delivered to groundwater via injection into existing wells or by DPT. Injection of the slurry under pressure usually results in distribution over a greater area around the injection point (i.e., greater radius of influence) relative to passive delivery techniques such as the suspended "sock" method.

Hydrogen peroxide has also been used to supply DO, and promote aerobic biodegradation of organic contaminants. A solution of hydrogen peroxide can be mixed into water that is being injected, or the hydrogen peroxide solution can be slowly metered into a well to provide a steady supply of DO. The hydrogen peroxide will kill microorganisms in the immediate vicinity of the injection well, but it breaks down rapidly, and releases oxygen as the main byproduct. The concentration and flow rate of the hydrogen peroxide solution must be carefully controlled to limit inhibition of microbial activity to the immediate vicinity of the injection points.

The analytical requirements would include the monitoring of DO and oxidation-reduction potential in groundwater as an indication of the extent of chemical distribution. Such measurements are best made downhole using suitable probes or low-flow sampling techniques. Monitoring of target contaminants in standard groundwater samples would be an integral part of the sampling and analysis program.

12.4.4. Air Sparging

This technology involves the injection of air under pressure below the water table using drilled or pushed wells. The goal is to provide adequate air distribution to allow the volatilization of VOCs from groundwater and, in some cases, the dissolution of oxygen into the groundwater. Vapors are often collected with a soil vapor extraction system.

The analytical requirements would include the monitoring of DO and oxidation-reduction potential in groundwater as an indirect indication of nearby air-flow paths. Such measurements are best made downhole using suitable probes or low-flow sampling techniques. For some projects, tracers such as helium or sulfur hexafluoride may be added to the injected air and monitored for in vapors or possibly in groundwater samples. Monitoring of target contaminant in standard groundwater samples would be an integral part of the sampling and analysis program.

12.4.5. In situ Thermal Remediation

In situ thermal remediation is an aggressive soil and groundwater treatment technology that involves heating of the subsurface. The heating can be achieved through:

- The introduction of electric currents with resultant resistive heating of the soil
- The injection of steam, or
- The placement of high temperature electric conductive heaters into the subsurface.

The heating raises the vapor pressure of contaminants, speeds diffusion, reduces viscosity and possibly interfacial tension for non-aqueous phase liquids, and possibly increases contaminant solubility. All of these effects increase the rate of contaminant mass removal from the subsurface. The remediation methods use vapor extraction and, in the case of steam injection, liquid extraction to remove mass from the subsurface. Steam and vapors are typically condensed as part of the above-ground treatment. The analytical program includes the monitoring of contaminant concentrations in both the collected vapors and groundwater (if heating is conducted below the water table). Sampling, analysis, and data collection would include the measurement of contaminant concentrations, collection of temperature data (usually from subsurface thermocouples), and sampling from above-ground treatment equipment, including analysis of condensed liquids and non-condensable gases.

The analytical program must be prepared for handling of high contaminant concentrations in the media of interest as mass removal rates are often very high. The sampling program, both for groundwater monitoring and process monitoring, must deal with sampling of media at high temperatures. To assure safe sampling and to avoid excessive losses of contaminants, sampled groundwater must be cooled before transfer to sample containers. Refer to USACE Engineer Manual EM 1110-1-4015 for additional discussion of sampling approaches.

12.5. Ex situ Soil Treatment

Rapid treatment processes such as solidification/stabilization (S/S) and low-temperature thermal desorption, rely primarily on pre- and post-treatment sampling and analysis of soil to confirm treatment criteria have been achieved. Relatively slow treatment processes, such as landfarming, usually require periodic monitoring to assess the progress of treatment over long periods. For landfarming and thermal desorption, post-treatment sampling must demonstrate that an adequate degree of contaminant reduction has occurred. S/S does not entail contaminant destruction, but sampling and analysis is usually still required to demonstrate that the leachability of contaminants has been adequately reduced.

12.5.1. Off-Site Disposal

Prior to off-site disposal of contaminated soil, sampling and analysis is usually required to demonstrate that the contaminated soil meets acceptance criteria for the landfill or other TSDF. Sampling and analysis may also be necessary to comply with transportation regulations. After excavation, the soil is typically placed in a covered stockpile, or in a roll-off container, while it is being staged for off-site transportation. Sampling is typically performed using hand tools (e.g., trowel, hand auger, etc.),

and the soil samples are usually sent to an off-site laboratory. Incremental sampling of the soil as it is placed in the container or stockpile will yield more representative concentrations.

12.5.2. Landfarming

Landfarming (sometimes referred to as land treatment) typically involves placement of contaminated soil onto a lined cell where it is periodically irrigated and tilled to promote biodegradation of organic contaminants. Landfarming is a relatively slow treatment process that requires periodic monitoring to assess the progress of treatment. The length of the treatment period depends on what types of contaminants are present, concentrations of contaminants, and on the local climate. Treatment periods can range from a few months to two or more years. In cold climates, treatment operations are usually suspended during the winter and not resumed until spring. The contaminants of concern represent the primary monitoring parameters. In some instances, it may be possible to correlate contaminant levels to a surrogate parameter such as total petroleum hydrocarbons (TPH). There are commercially available field analysis kits for parameters such as TPH, and PAHs. The field analysis kits can often be used to monitor the progress of treatment, and to determine when to collect confirmatory soil samples for laboratory analysis. Other important monitoring parameters include: soil moisture content, soil pH, and soil nutrient levels (e.g., nitrogen and phosphorous). Sampling is typically performed using hand tools (e.g., trowel), and the confirmatory soil samples are usually sent to an off-site laboratory. For more information, refer to the following:

- UFGS 02 54 20 (02190), Bioremediation of Soils Using Landfarming Systems.

12.5.3. Solidification/Stabilization

Solidification/Stabilization (S/S) typically involves blending contaminated soil with portland cement and/or other additives, in order to reduce the leachability of metals. A pug-mill is often used to bend the soil and the cement. S/S does not entail contaminant destruction, but sampling and analysis is required to demonstrate that the leachability of contaminants has been adequately reduced. The contaminants of concern (usually metals) represent the primary monitoring parameters. Sampling can usually be performed using hand tools, and the soil samples are usually sent to an off-site laboratory.

For more information, please refer to:

- UFGS 02 55 00 (02160), Solidification/Stabilization (S/S) of Contaminated Material (04-2006); and ETL 1110-1-158, *Treatability Studies for Solidification/Stabilization of Contaminated Material.*

12.5.4. Low-Temperature Thermal Desorption

Low-temperature thermal desorption (LTTD) is a process that involves heating soil to rapidly achieve stringent cleanup criteria for organic contaminants. During the heating process, the contaminants are volatilized from the soil, and then condensed out and recovered for off-site disposal. A limited degree of contaminant destruction may occur for some of the more thermally labile contaminants, which may have escaped as heated vapor. LTTD systems include complex cooling and vapor treatment systems. The heated vapor that is drawn off of the soil must be cooled, has to pass through particulate filtration systems, and usually through vapor-phase GAC adsorption vessels.

During operation of LTTD units, continuous emissions monitoring (CEM) is usually required. Stack gas CEM monitoring parameters usually include: oxygen, carbon monoxide, total hydrocarbons, and nitrogen oxides. Testing for particulate matter (e.g., PM_{10}) in the stack gas is also usually required. During the proof of performance (POP) test, testing of the stack gas for contaminants of concern is usually required.

The contaminants of concern represent the primary monitoring parameters. Soil samples are usually collected at a designated point of the conveyor system for feeding the soil into the LTTD unit, and from the treated soil stockpile. Sampling can usually be performed using hand tools, and the soil samples are usually sent to an off-site laboratory. For more information, please refer to:

- ETL 1110-1-173, *Thermal Desorption,* 31 May 1996.

12.6. In situ Soil Treatment

12.6.1. Soil Vapor Extraction (SVE)

Soil vapor extraction is a technology used to remediate soils above the water table and involves the application of a vacuum to wells screened above the water table and extraction of VOC vapors. Monitoring largely consists of the sampling and analysis of soil gas concentrations and measurement of vacuum distribution using sensitive vacuum gauges (down to a few millimeters of water column). Soil gas sampling is conducted from monitoring probes, from individual extraction wells, and from combined vapor flow at the above-ground treatment plant. Sampling of soil gas from subsurface probes can be conducted using Summa™ canisters, vacuum boxes, and Tedlar™ bags, or through direct-reading instruments (e.g., a PID) that can create vacuums greater than observed in the probes. Sampling of vapors being withdrawn from individual extraction wells or combined influent at the treatment facility usually involves the use of a vacuum box, sample pump, or Summa™ canisters, as the applied vacuums may be more than a half atmosphere. Any sampling pump used to collect the samples and transfer vapors to a container such as a Tedlar™ bag must not introduce potential contaminants such as oils.

12.6.2. Bioventing

Bioventing generally involves injection of atmospheric air into the soil above the water table to promote aerobic biodegradation of contaminants (where ambient conditions are oxygen limited), particularly petroleum hydrocarbons. The injection of gases other than, or in addition to atmospheric air can promote aerobic cometabolic degradation or anaerobic degradation of some chlorinated hydrocarbons. Tracer gases such as helium or sulfur hexafluoride are occasionally injected to assess the flow paths and diffusive and dispersive losses. Sampling in support of bioventing design and operation normally involves the collection of soil gas samples. Active soil gas sampling would be conducted in sampling ports at different locations and depths to assess distribution of oxygen, contaminant vapors, or other injected gases. Carbon dioxide, methane, or other gases may also be of interest to assess the degradation processes. Analysis for oxygen, carbon dioxide, and methane would typically be conducted in the field using multi-gas testing instruments.

Contaminant vapor concentrations are also determined to assess progress and the potential displacement of hazardous vapors to possible exposure points. Contaminant vapors may be analyzed in the field using non-specific analytical equipment (e.g., PID) or samples may be taken in Tedlar™ bags or Summa™ canisters for fixed or mobile lab analysis. Soil sampling for fixed or mobile lab analysis may be necessary to determine attainment of treatment goals.

12.6.3. In situ Thermal Remediation.

The requirements are similar to those for in situ thermal remediation for groundwater. Please refer to Section 12.4.5.

12.7. Chemical and Physical Parameters for Remediation Processes

Early site characterization up through and including the Remedial Investigation (RI) or RCRA facility Investigation (RFI) often focuses on obtaining data strictly relating to the contamination at a site. These investigations concentrate on gathering information such as concentration, extent of the contamination, potential sources, exposure scenarios, etc. Physical and chemical data of the medium relevant to remedy implementation are often overlooked. For example, if air stripping or carbon adsorption is being considered for removal of VOCs from the groundwater, it is important to know the concentration of iron and calcium in the groundwater, because these chemicals can cause fouling and plugging problems, which increase the cost of operations and maintenance (O&M). Site history and other information gathered during early phases of site characterization should provide ideas as to the contamination and the possible remedial processes that will be considered. Generally, cost savings can be achieved by collecting process characterization samples during initial field sampling events.

The number of process samples taken for analysis during the initial field sampling events should be kept to a minimum to save time and costs. Parameters that can be used as estimates for other parameters should be used. For example, the humic content of the soil or the COD may be required for the final design of a selected process. However, TOC is often recommended in the earlier stage of investigation instead of these parameters, as it is fairly easy to obtain and should provide an estimate of these parameters for the initial data analysis. For metals, consider having a laboratory to analyze for all the metals (approximately 30), as it may not cost any more than analyzing for a selected few. Analyzing for some parameters in the field may provide immediate information as to additional samples to take to eliminate the need for an additional trip to the field. It is recommended that the following water parameters be routinely analyzed during an early field sampling event: temperature, pH, conductivity, turbidity, DO, and oxidation-reduction potentials. These parameters can provide much information on the water and are easily measured with probes or other simple field instruments. It is also recommended that soil samples be collected for sieve analysis during the initial sampling event. Sieve analysis can provide a rough estimate of the following parameters: plasticity, field capacity, bulk density, particle density, permeability, porosity, and soil classification.

ASTM D 7294 lists physical and chemical treatment processes design data needed to evaluate, select, and design treatment processes for remediation at contaminated sites. It is recommended that these data are collected prior to evaluating remedies for large return/savings by investing very little time and money up front. This additional information will allow the decision makers to screen out technologies that are not applicable (e.g., SVE in tight soil) or cost effective, determine more accurate cost estimates, and save time and money by not having to re-mobilize to collect data during the design phase.

The analytical costs and time of obtaining these samples will be less than that for obtaining contaminant samples, because screening-level quality data is often sufficient, many tests are simple and can be performed in the field, and a minimal number of samples are needed to provide the design data required. Additionally, if off-site process parameters are expected to be the same as on-site parameters, samples can be taken from uncontaminated areas of the site and do not need to be handled as hazardous waste.

ASTM D 7294 identifies the most important parameters for a particular media and technology. Use the tables in ASTM D 7294 as a guide in conjunction with the Treatment Technology Profiles in the Remediation Technologies Screening Matrix and Reference Guide at http://www.frtr.gov/matrix2/section1/toc.html to quickly search and screen technologies that may be evaluated for site remediation later. The process data needed to further evaluate these technologies can then be obtained from ASTM D 7294 and can then be easily collected in the field at the same time as the contaminant data collection.

The laboratory methods listed in ASTM D 7294 are well defined and consist primarily of Standard Methods, SW-846, and EPA 600 methods. The field methods are not as well defined, and the table gives general information on field methods and their time and cost. Manufacturer's literature, the Internet and other information should be used to select the field kits that best meet the analytical and cost needs for that site.

For further information, see:

- ASTM D 5463 (Standard Guide for Use of Test Kits to Measure Inorganic Constituents in Water).

12.8. References

- Technical and Regulatory Guidance for In Situ Chemical Oxidation of Contaminated Soil and Groundwater, Second Edition (January 2005).
- DG 1110-1-2, Adsorption Design Guide, 1 March 2001.
- DG 1110-1-3, Engineering and Design-Air Stripping, 31 October 2001.

- ETL 1110-1-158, Treatability Studies for Solidification/Stabilization of Contaminated Material, 28 February 1995. http://www.cement.org/waste/pdfs/USACETreatabilityGuide.pdf
- ETL 1110-1-160, Landfill Off-Gas Collection and Treatment Systems, 17 April 1995.
- UFGS 02 53 16 (02181), Remediation of Contaminated Soils by Thermal Desorption (02-2010).
- UFGS 02 54 20 (02190), Bioremediation of Soils Using Landfarming Systems (02-2007).
- UFGS 02 55 00 (02160), Solidification/Stabilization (S/S) of Contaminated Material (02-2010).
- UFGS 43 13 13.13 (11226), Vapor Phase Activated Carbon Adsorption Units (10-2007).
- UFGS 43 31 13.14 (11225), Downflow Liquid Activated Carbon Adsorption Units (10-2007).
- Soil Vapor Extraction: USACE Soil Vapor Extraction and Bioventing Engineer Manual EM 1110-1-4001, 2002.
- ETL 1110-1-173, Thermal Desorption, 31 May 1996.
- UFGS 02 01 50 (01830), Operation, Maintenance and Process Monitoring for Soil Vapor Extraction (SVE) Systems (05-2010).
- Multi-Phase Extraction: USACE Multi-Phase Extraction Engineer Manual EM 1110-1-4010, 1999.
- Bioventing: USACE Soil Vapor Extraction and Bioventing Engineer Manual EM 1110-1-4001, 2002.
- US Air Force and US EPA Principles and Practice of Bioventing, Volume 1 and Volume 2, September 1995.
- In situ Thermal Treatment: USACE In situ Thermal Remediation Engineer Manual EM 1110-1-4010.
- In situ Chemical Oxidation: ITRC Technical Regulatory Guidance Document, In situ Chemical Oxidation of Contaminated Soil and Groundwater, 2nd Edition, January 2005.

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Chapter 13. Field Testing

13.1. Purpose

This chapter provides procedures for performing field testing to accurately characterize site conditions.

13.2. Scope

The scope of this chapter includes a discussion of field screening and field testing, and gives examples of SOPs for several analyses that are required by various regulations to be performed in the field. Other analyses that are not required for regulatory compliance also may be performed in the field. Field testing procedures and strategies should be specified in the project SAP.

13.3. Background

A sampling event is conducted to collect sample material for analysis of specific parameters to determine site conditions. Some of these parameters can influence the characteristics of the contaminants that need to be investigated and, therefore, must be accurately measured at the time of the sampling event. Certain parameters require analysis in the field because of the potential for sample deterioration during transport to a laboratory. Some parameters must be analyzed in the field because they can fluctuate rapidly with time and sample conditions. Parameters that may require measurement in the field include pH, temperature, residual chlorine, specific conductance, oxidizer/cyanide test, and DO.

13.4. Training

Personnel who will be performing any field testing must be trained in sample collection, preparation, and field testing methods, and demonstrate proficiency in the SOP for the test to be completed. Training and proficiency must be documented in accordance with the SAP. Navy personnel should also document their training following the Uniform Standards for Sampling, OPNAVINST 5090.1C, Environmental and Natural Resources Program Manual, Chapter 29.

13.5. Field Screening

Field screening procedures are typically qualitative or semi-quantitative in nature and are performed using special screening equipment or techniques, such as probes or portable hand-held instruments and meters. Some field screening is performed using field testing methods, and special kits that are designed for use in a field environment. Field screening is used to provide a quick determination of the presence, magnitude, or absence of an analyte of concern. Field screening provides preliminary results with minimized costs on a real-time or near-real-time basis. Because the quality control and analytical sophistication of field screening is not as controlled as it is for laboratory testing, a representative set of split or duplicate samples should be submitted to a laboratory for comparison of the results.

Examples of field screening SOPs are located in Section 13.7 and are summarized in Table 13-1.

Table 13-1. Field Screening Methods

Field Test	Matrix	Test Event
Specific Conductance	Water	CERCLA and drinking water assessment
Total Residual Chlorine	Water	Drinking water and wastewater assessment
pH	Water, aqueous wastes	Waste profiling and wastewater assessment
Oxidizer/ Cyanide	Wastewater, aqueous wastes	Waste profiling and wastewater assessment
Temperature	Water	All water sampling events
PID	Water, soil, waste	Preliminary screening for unknown volatile organic contaminants

There is a wide variety of field screening tests available, and the list is growing, but the analyst must be very cautious and clearly define and control the use of any data generated. The chance for false positives and false negatives must be known, and adequate quality control must be demonstrated to ensure approval of the screening procedures for use by the regulatory authority. Positive and negative measurements usually are acceptable as long as the Limit of Detection (see DoD Quality Systems Manual) associated with non-detects is below the action level or regulatory threshold limit. The best results for field screening methods are obtained when the contaminant is known and the technique is acceptable for use under the environmental conditions at the site.

13.6. Field Operations

Field operations that include field screening or field testing should consider the following:

- QAPP
- Test methods
- Calibration procedures
- Reference standards
- Materials and material preparation
- Sample storage
- Sample handling
- Sample traceability
- QC samples
- Control charts
- Data quality criteria
- Detection limits
- Recordkeeping
- Data reporting procedures
- Environmental conditions
- Facility conditions and control
- Personnel qualifications
- Disposal
- Safety.

13.7. Sample SOPs

The remainder of this chapter provides sample SOPs for the following.

- **Figure 13-1:** Specific Conductance (Field Testing)
- **Figure 13-2:** Field Determination of Total Residual Chlorine
- **Figure 13-3:** Field pH Measurements Using pH Paper
- **Figure 13-4:** Field pH of Aqueous Samples by Electrometric Measurement
- **Figure 13-5:** Oxidizer Field Testing for Cyanide Samples
- **Figure 13-6:** Field Temperature Determination
- **Figure 13-7:** Calibration & Maintenance of a Photovac PID.

These SOPs are written for specific instruments. If using a different instrument, the procedure may differ. Consult the Instrument Manual, and any appropriate regulatory guidance.

Figure 13-1. Sample SOP for Specific Conductance (Field Testing)

DoD Environmental Sampling and Field Testing Procedure

Standard Operating Procedure

Specific Conductance
(Field Testing)

Prep By:
Approved By:
Effective Date:

CAUTION

This Standard Operating Procedure has been prepared as an example for this handbook and may not be specifically applicable to all activities or organizations. Any mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Figure 13-1. Sample SOP for Specific Conductance (Field Testing) (continued)

1.0 Title: Standard Operating Procedure for Performing Specific Conductance Testing (Field Testing).

2.0 Scope and Application

2.1 This procedure is applicable to drinking, ground, surface, and saline waters; and domestic and industrial waste. This procedure is for field testing where needed; however, some regulations do allow this test to be performed in the laboratory. RCRA and CERCLA require analyses to be performed immediately upon sample collection. Drinking water programs allow a 28-day holding time until analysis. See these regulations for sample preservation requirements.

3.0 Summary of Method

3.1 The determination of specific conductance gives a measure of the ability of an aqueous solution to carry an electric current, which is related to the ions present in the aqueous solution.

3.2 The specific conductance of a sample is measured using a self-contained conductivity meter (Wheatstone Bridge-type or equivalent).

3.3 Whenever possible, samples are analyzed at 25°C. If samples are analyzed at different temperatures, corrections must be made and results reported at 25°C.

4.0 Interferences

4.1 Platinum electrodes can degrade and cause erratic results. When this happens, as evidenced by erratic results or flaking of the platinum black, the electrode should be replaced.

4.2 The specific conductance cell can become coated with oil and other materials. It is essential that the cell be thoroughly rinsed and cleaned between samples.

5.0 Equipment List

5.1 Conductivity Bridge (self-contained, Wheatstone Bridge-type or equivalent. Range 1–1,000 µS/cm) with Conductivity Cell (cell constant of 1.0, YSI #3403 or equivalent). Current METCAL calibration is required. Annual verification of cell constant is required.

5.2 Sample container (glass or plastic) able to submerge cell probe completely.

5.3 Thermometer - calibrated and able to read ± 0.1 degrees. (At a minimum, mercury in glass thermometers and dial-type thermometers shall be checked annually against a National Institute of Standards and Technology (NIST)-traceable thermometer.)

5.4 FLB/FN

5.5 Conductivity meter calibration log book

5.6 Sample collection device (e.g., bailer, scoop).

6.0 Reagents and Materials

6.1 Potassium chloride (KCL) solution; 0.01M: Dissolve 0.7456 gram of predried (2 hours at 105°C) KCL (reagent grade) in distilled water, and dilute to 1 liter at 25°C. Conductivity of this solution is 1,413 µS/cm at 25°C. Laboratory personnel can prepare this solution, or an equivalent NIST-traceable reference standard may be purchased.

6.2 Distilled water. If doing RCRA Method 9050, deionized distilled water is required with conductivity of less than 1 µmho/cm.

Figure 13-1. Sample SOP for Specific Conductance (Field Testing) (continued)

7.0 Hazards and Safety Precautions

7.1 Refer to the MSDS for details on chemical hazards and personal protection.

7.2 Minimum PPE, (i.e., chemical safety goggles and appropriately selected protective gloves) should be worn. Other PPE (e.g., safety shoes, hard hat, respirator) will be dictated by the specific hazards of the sampling site.

7.3 Emergency eyewash/shower must be present, as appropriate.

8.0 Preparation

8.1 Turn instrument on, and allow to warm up.

8.2 Ensure conductivity cell is correctly attached to conductivity meter.

8.3 Follow the directions of the manufacturer for the operation of the instrument.

9.0 Calibration and Standardization

Note: This procedure to be performed only by properly trained sampling personnel.

9.1 Prior to sampling, conduct the following:

9.1.1 Verify conductivity meter has current METCAL calibration.

9.1.2 Calibrate conductivity meter prior to use, using KCl solution (see paragraph 6.1) at 25°C and the table below to check the accuracy of the cell constant and conductivity bridge:

Conductivity 0.01M KCl	
°C	**µS/cm**
21	1305
22	1332
23	1359
24	1386
25	1413
26	1441
27	1468
28	1496

9.1.3 Enter the following calibration data in meter log book:

- Meter reading
- Temperature
- Reference material or calibration standard source
- True value/temperature of the calibration standard expected
- Signature and date
- Verified within manufacturer's tolerances

9.1.4 The number and concentration of the standards used for calibration should be based on the testing needs for the field activity. A single point check standard in the range of the sample concentrations to be measured may be used for field screening.

Figure 13-1. Sample SOP for Specific Conductance (Field Testing) (continued)

10.0 Procedure

10.1 Obtain sample according to the appropriate sampling SOP, and pour into sample container with a minimum of aeration.

10.2 Rinse cell with distilled water. Rinse probe with remaining sample water.

10.3 Place specific conductance cell in sample container.

10.4 Ensure sample level is above cell air vent hole.

10.5 Ensure all air is vented from cell.

10.6 Follow manufacturer's directions for operation of the conductivity meter.

10.7 Determine the temperature of samples. If the temperature of the samples is not 25°C, make temperature correction in accordance with the following guidelines:

- If temperature of the sample is below 25°C, add 2% of the reading per degree.
- If temperature is above 25°C, subtract 2% of the reading per degree.

The more the sample temperature of the measurement deviates from 25°C, the greater the uncertainty in applying the temperature correction.

10.8 Record results in the FLB/FN

- Sample ID
- Sample temperature, °C
- Meter reading, µmhos/cm
- Corrected meter reading, µmhos/cm at 25°C
- Signature and date
- SOP reference name/number.

10.9 Recheck calibration with the KCl solution (see paragraph 6.1), and enter into conductivity meter log book.

11.0 QA/QC

11.1 Conductivity cells must be kept clean.

11.2 Conductivity cell constant must be determined annually per Reference 12.2, Section 7.1.

11.3 Temperature variations and corrections represent the largest source of potential error.

11.4 Analyze calibration standards (see paragraph 6.1) after approximately every 15 samples, per RCRA method #9050A (paragraph 8.2).

11.5 Run one duplicate sample for every 10 samples, per RCRA method #9050A (paragraph 8.3).

12.0 References

12.1 EPA—Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020 Method 120.1 (Specific Conductance µmhos at 25°C) Editorial Rev., 1982. Applicable to drinking water and wastewater.

12.2 Test Methods for Evaluating Solid Wastes. SW-846, Method 9050A Specific Conductance. Applicable.

Figure 13-2. Sample SOP for Field Determination of Total Residual Chlorine

DoD Environmental Sampling and Field Testing Procedure

Standard Operating Procedure

Field Determination of
Total Residual Chlorine

Prep By:
Approved By:
Effective Date:

CAUTION

This Standard Operating Procedure has been prepared as an example for this handbook and may not be specifically applicable to all activities or organizations. Any mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Figure 13-2. Sample SOP for Field Determination of Total Residual Chlorine (continued)

1.0 Title: Standard Operating Procedure for Field Determination of Total Residual Chlorine.

2.0 Scope and Application

2.1 The HACH DR 100 Colorimeter is a portable battery-powered colorimeter designed for field testing. This instrument is utilized to measure the total residual chlorine content of samples. The DR100 conforms to the requirements of reference 11.1 using a 2.5-cm sample cell and DPD pillow-packed reagents for total residual chlorine determination. Reference 11.2 details operation and maintenance for the DR100.

2.2 This procedure is used to determine the level of residual chlorine for drinking and wastewater samples. Residual chlorine in drinking water must meet specified requirements. In wastewater analysis, residual chlorine can possibly interfere with some test procedures.

3.0 Summary of Method

3.1 Chlorine (hypochlorite ion, hypochlorous acid) and chloramines stoichiometrically liberate iodine from potassium iodide at pH 4 or less. The liberated iodine reacts with N,N-diethyl-p-phenylene diamine (DPH) to produce a red-colored solution. The solution is spectrophotometrically compared to a series of standards. The results are read in mg/l Cl.

4.0 Interferences

4.1 Interferences from oxidized manganese and copper are corrected by the addition of the DPD reagents. The method inhibits trace metal catalysts. High concentrations of monochloroamine (combined chlorine) will not interfere with the total residual chlorine test.

4.2 Turbidity and color will interfere with the colorimetric analysis.

5.0 Equipment

5.1 DR100 HACH Colorimeter with calibration curve.

5.2 Clippers.

5.3 2.5-cm sample cell.

5.4 1.0-cm cell holder.

5.5 1.0-cm sample cell.

5.6 Stopwatch or wrist watch.

5.7 Various appropriate pipettes.

5.8 100-mL volumetric flasks.

5.9 FLB/FN

6.0 Reagents and Materials

6.1 All reagents must be reagent-grade chemicals unless otherwise specified.

6.2 Stock Potassium Permanganate Solution (1000 ppm Equivalent–Chlorine Standard Solution). Place 0.891 gram $KMNO_4$ in a 1-liter volumetric flask, and dilute to 1 liter. Consult Reference 11.1 for preparation. This solution must be refrigerated and has a shelf life of 6 months. This reagent can be prepared by laboratory personnel or purchased from commercial sources.

6.3 DPD total chlorine reagent powder pillows. (Purchased from HACH)

Figure 13-2. Sample SOP for Field Determination of Total Residual Chlorine (continued)

6.4 Sodium Hydroxide, 0.1N. This reagent can be prepared by laboratory personnel or purchased from commercial sources.

6.5 Nitric Acid, 0.1N. This reagent can be prepared by laboratory personnel or purchased from commercial sources.

6.6 Reagent (deionized) water.

7.0 Hazards and Safety Precautions

7.1 Refer to the MSDS for details on chemical hazards and personal protection.

7.2 Minimum PPE is chemical safety glasses and appropriately selected gloves. Hazards associated with the sample or sampling site may require additional PPE.

7.3 An emergency eyewash/shower should be present, as appropriate.

8.0 Calibration and Standardization

8.1 Standard Preparation

8.1.1 Pipet 10.0 mL of the primary stock standardization solution potassium permanganate (paragraph 6.2) into a 100-mL volumetric flask. Fill volumetric flask to mark with reagent (ASTM Type I or II) water and mix. This is the secondary stock solution (equivalent 100 ppm chlorine).

8.1.2 Pipet 1.5 mL of secondary stock solution (paragraph 8.1.1) into a 100-mL volumetric flask. Fill flask to volume with reagent (ASTM Type I or II) water, and mix. This will produce an equivalent total chlorine standard with a concentration of 1.50 mg/L.

8.1.3 Pipet 1.0 mL of secondary stock solution (paragraph 8.1.1) into a 100-mL volumetric flask. Fill the flask to volume with reagent (ASTM Type I or II) water, and mix. This will produce an equivalent total chlorine standard with a concentration of 1.00 mg/L.

8.1.4 Pipet 50.0 mL of the 1.00 mg/L standard (paragraph 8.1.3) into a 100-mL volumetric flask. Fill the flask to volume with reagent (ASTM Type I or II) water, and mix. This will produce a total chlorine standard with a concentration of 0.50 mg/L.

8.1.5 Pipet 10.0 mL of the 1.00 mg/L chlorine standard (paragraph 8.1.3) into a 100-mL volumetric flask. Fill the flask to volume with reagent (ASTM Type I or II) water, and mix. This will produce a total chlorine standard with a concentration of 0.10 mg/L.

8.2 DR100 Calibration. This is completed by laboratory personnel.

8.2.1 Using the DR100 and the procedure in paragraph 8.3.3, STEPS (1) through (10), analyze a blank (0.00 mg/L ASTM Type I or II water) and the 0.10, 0.50, 1.00, and 1.50 mg/L standards. (8.1.2, 8.1.3, 8.1.4, 8.1.5).

8.2.2 After reading each standard, place the cell contents used for each reading in a flask, and titrate with standardized ferrous ammonium sulfate (FAS) titrant. Record these values as the true standard concentrations.

8.2.3 Plot a calibration curve of measured (meter) values versus true values. This chart shall be kept with the meter and updated annually, or when quality control data indicates potential errors.

8.3 Daily Standardization

Note: Prior to beginning this procedure, ensure reagents are not beyond expiration date.

8.3.1 Once the meter has been checked to ensure that it is in acceptable working condition, it is ready for daily standardization. The DR100 Colorimeter does not require a warm-up period. Both the mechanical zero and low battery indicator check should be made with the meter in the same general position that it will be in when the measurements are made. (See paragraph 10.3.3).

8.3.2 The DR100 Colorimeter shall be standardized prior to use each day at a minimum of 3 points that bracket the

Figure 13-2. Sample SOP for Field Determination of Total Residual Chlorine (continued)

expected sample value range. Normally, use the following standard concentrations: 0.00 mg/L (ASTM Type I or II water), 0.50 mg/L, and 1.00 mg/L. This standardization procedure shall be performed before the meter can be used in making field measurements. Entries are to be made in the FLB/FN indicating the standards used, the respective meter readings, and the corrected values. The corrected value is the value obtained from the calibration chart that corresponds to the meter reading. Each meter shall have an accompanying calibration chart for that meter.

8.3.3 Standardization Steps

STEP (1) Open the light shield, turn the right set knob fully clockwise, and place the 1-cm cell holder (without the 1-cm cell in the holder) in the left set position of the sample well. Close the light shield.

STEP (2) Hold the ON button down while adjusting the left set knob to align the meter needle with the arrow at the extreme left of the scale arc. Remove the cell holder.

STEP (3) Fill a clean 2.5-cm sample cell with reagent (ASTM Type I or II) water. Cap the cell and place it into the sample well. Press down firmly to seat the sample cell, and close the cell holder.

STEP (4) Hold the ON button down while adjusting the right set knob for a reading of 0.00 mg/L. Open the light shield, and remove the sample.

STEP (5) Remove the cap from the sample cell used in STEP (3) and add the contents of a DPD total chlorine powder pillow to the sample cell. Cap and shake it for 20 seconds. Allow at least 3 minutes but not more than 6 minutes for proper color development. (This is a "prepared standard" of 0.00 mg/L or "blank".)

Note: It is not necessary for all of the powder reagent particles to dissolve to obtain an accurate reading. Shaking the cell dissipates bubbles that may form on the cell wall and interfere with the test results.

STEP (6) Place the cell containing the prepared standard from STEP (5) into the sample well. Press down firmly to seat the sample cell, and close the light shield.

STEP (7) Hold the ON button down until the meter stabilizes.

STEP (8) Read the total chlorine concentration in mg/L from the upper (0.00–2.00) mg/L) scale. If the meter reading is 0.05 mg/L or less, then the meter is within the acceptable range and is to be reported as 0.00 mg/L.

STEP (9) Record this as a meter reading in the FLB/FN under the blank total chlorine concentration standard.

STEP (10) Remove the sample cell from the sample well, and rinse the inside of the sample cell and cap with reagent (ASTM Type I or II) water at least two times to remove any residue.

8.3.4 Repeat STEPS (3) through (10) using the 0.50 mg/L and the 1.00 mg/L standards (prepared in 8.1) in place of the ASTM Type I or II water. Record each meter reading in the FLB/FN. Refer to the calibration table to determine the true values associated with the meter readings, and record in the FLB/FN. Corrected values must be within the acceptable range of +0.05 units of the known standard concentration.

8.3.5 If the corrected value is outside of the acceptable range of +0.05 mg/L from the known standard concentration, then another standard solution shall be prepared and the standardization repeated. If the corrected value remains outside of this range, then it shall be assumed that the meter is malfunctioning. The Lab Director should be contacted for further instructions.

9.0 Procedure

9.1 Sample Collection, Preservation and Handling

9.1.1 Samples shall be collected in a clean glass or plastic container and tested on site within 15 minutes. No preservation is necessary for on-site testing

9.1.2 Samples should have a pH between 6 and 7 for this procedure to be used. If necessary, an appropriate amount of acid (0.1 N Nitric Acid) or base (0.1 N Sodium Hydroxide) that does not contain ammonium or chloride ions can be used to

Figure 13-2. Sample SOP for Field Determination of Total Residual Chlorine (continued)

adjust the pH to within this range.

9.1.3 Calibration curves shall be established for each meter (see paragraph 8.2) prior to initial use. Calibration curves should be updated annually.

9.1.4 Prior to daily use, standardize meter using standardization procedure (see paragraph 8.3).

9.2 Sample Analysis

9.2.1 Perform STEPS (3) through (10) of paragraph 8.3.3 for each set of samples and if the meter is physically relocated or disturbed during analysis of a sample set (any movement may offset the prism and invalidate the analyses). Analyze each sample following STEPS (1) through (10) of paragraph 8.3.3.

9.2.2 Once the meter value for each sample has been determined, that value shall be found in the calibration curve/table accompanying each meter. This gives the true total chlorine concentration. Record this true concentration in FLB/FN or appropriate data sheet.

9.2.3 If the sample temporarily turns yellow when adding the DPD Total Chlorine Reagent or reads above the highest scale division, the chlorine concentration is too high for the meter calibration. Any readings above 2.00 mg/L should be reported as >2.00 mg/L. Chlorine concentrations may be approximated by additional sampling, dilution, and further analysis. The sample also may be retained to determine if an interference exists or for reanalysis using a different test method.

10.0 Quality Assurance for Hach DR100

10.1 Ten percent of the samples shall be analyzed in duplicate (split samples). Ten percent of the samples shall have duplicate samples taken and analyzed (field duplicates). Record data in the FLB/FN or appropriate Data Sheet. Follow QAPP for reporting results.

10.2 A calibration curve is prepared at least annually. When any meter measurement is made, the value from the meter should be read to the nearest 0.05 units up to a meter reading of 1.50 mg/L. All values between 1.5 and 2.0 mg/L should be read to the nearest 0.1 unit on the meter scale. The meter value obtained in this procedure should then be found on the accompanying calibration curve to determine the true total residual chlorine concentration.

10.3 The HACH DR100 Colorimeter should have routine maintenance performed before it is standardized or used for field measurements. The following maintenance steps cover the internal components to ensure that the meter is functioning properly.

10.3.1 The DR100 Colorimeter uses four “AA” size batteries. These batteries should be replaced at least annually. The meter should be tagged to indicate the date of the last battery change. Do not use the instrument when the “Low Battery” indicator is lit. An indicator light that remains lit after batteries have been replaced may indicate that the internal lamp is burned out. In any event, if the light remains on after batteries have been changed, the meter is not functioning correctly and should not be used. The Lab Director should be contacted immediately.

10.3.2 While the meter is in the OFF position and as level as possible, the meter needle should align with the arrow at the far left of the meter scale. To reset the meter needle, use a screwdriver to adjust the mechanical zero screw in the center of the meter.

10.3.3 Other important considerations in obtaining accurate data are the condition of the sample cell holder and the sample cells. The exterior of the sample cell holder and sample cells should be cleaned with an absorbent tissue before placing them into the meter. Both the sample cell holder and the sample cell should be kept as clean and free of scratches as possible. After each test, the sample cells must be rinsed thoroughly with ASTM Type I or II water and dried. At no time should the sample cell be left in the meter after completion of a test. As with any analog output meter, the meter should be directly in front of the operator and as level as possible to eliminate errors when reading the meter scale.

11.0 References

11.1 Standard Methods for the Examination of Water and Wastewater, 21st Edition; Method 4500-C1.G, DPD Colorimetric Method.

Figure 13-2. Sample SOP for Field Determination of Total Residual Chlorine (continued)

11.2 DR100 HACH Colorimeter Total Chlorine Test Kit Instruction Manual.

Figure 13-2. Sample SOP for Field Determination of Total Residual Chlorine (continued)

Data Sheet
Total Residual Chlorine

Total Residual Chlorine DR100 S/N_____

Daily Standardization

Date:_____	*Meter Reading mg/L*	*Corrected Value, mg/L*
Blank Total Chlorine Conc.	_____	_____
1.00 mg/L Total Chlorine Std.	_____	_____
0.50 mg/L Total Chlorine Std.	_____	_____

Sample Analysis

Sample Description	*Meter (mg/L)*	*Corrected (mg/L)*	*Initials/Date/Time*
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

Figure 13-3. Sample SOP for Field pH Measurements Using pH Paper

DoD Environmental Sampling and Field Testing Procedure

Standard Operating Procedure

Field pH Measurements Using pH Paper

Prep By:
Approved By:
Effective Date:

CAUTION

This Standard Operating Procedure has been prepared as an example for this handbook and may not be specifically applicable to all activities or organizations. Any mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Figure 13-3. Sample SOP for Field pH Measurements Using pH Paper (continued)

1.0 Title: Standard Operating Procedure for pH Measurements Using pH Paper.

2.0 Scope and Application

2.1 The pH paper method is used as a pH-screening method for aqueous wastes or in cases where pH measurements using a meter are not possible.

2.2 This method is not applicable to wastes that contain components that may mask or alter the pH paper color change.

2.3 pH paper is not considered to be as accurate in measuring pH as a pH meter. Measurements taken using paper can be used to define waste as corrosive or non-corrosive (pH < 2 or > 12.5) only if the measured values differ from either threshold limit by a full pH unit. If readings within the ranges of either pH 1–3 or pH 11.5–13.5 are obtained using pH paper, then a pH meter should be used if possible to determine whether the waste is corrosive.

3.0 Summary of Method

3.1 The approximate pH of the waste is determined with wide-range pH paper.

3.2 A more accurate pH determination is made using "narrow-range" pH paper whose accuracy has been determined by using a series of buffers or by comparison with a calibrated pH meter.

4.0 Interferences

4.1 Certain waste may inhibit or mask changes in the pH paper. This interference can be determined by adding small amounts of acid or base to a small aliquot of the waste and observing whether the pH paper undergoes the appropriate changes.

4.2 Identification of Interferences

CAUTION: Addition of acid or base to samples may result in violent reactions or the generation of toxic fumes. Extreme caution must be exercised. Do not perform this test when cyanides (or other toxic fumes) may be present or generated. Perform this test in the field only with appropriate protective equipment and adequate ventilation.

4.2.1 Collect two samples of approximately 2 mL each.

4.2.2 Place pH paper (wide or narrow range) in each.

4.2.3 Add acid drop wise to the first sample until a pH change is observed by noting the color change.

4.2.4 Add base drop wise to the second sample until a pH change is observed by noting the color change.

4.2.5 The observation of the appropriate color change is a strong indication that no interferences have occurred. Record the results in the FLB/FN.

5.0 Equipment

5.1 PPE (see paragraph 7).

5.2 A sample collection device, if necessary.

5.3 Sample containers, if necessary.

5.4 FLB/FN.

6.0 Reagents and Materials

6.1 Wide range pH paper.

6.2 Narrow range pH paper (every 0.5 pH unit).

Figure 13-3. Sample SOP for Field pH Measurements Using pH Paper (continued)

6.3 Certified pH buffers.

6.4 Dilute acid (e.g., 1:4 HCl) for identification of interferences.

6.5 Dilute base (e.g., 0.1N NaOH) for identification of interferences.

6.6 Drum opening tools, if necessary.

7.0 Health and Safety Precautions

7.1 Corrosives damage skin/tissue and should not be touched or inhaled.

7.2 For known or suspected corrosives where pH meter readings are not possible, wear the following PPE:

7.2.1 Full body protection (Tyvek®).

7.2.2 Impervious rubber gloves.

7.2.3 Chemical safety glasses or face shield (preferable).

7.3 For known or suspected corrosives, an eyewash station and emergency shower should be located close to the work area, and a two-member crew is required.

7.4 For water matrices (e.g., groundwater, surface water), minimum PPE is safety glasses.

7.5 Consult the MSDS before performing work.

8.0 Preparation of Equipment

8.1 Verify each batch of pH paper versus certified pH buffers or a pH meter that has been calibrated with certified buffers.

8.2 Document verification in the FLB/FN.

9.0 Procedure

9.1 Drum inspection and opening

9.1.1 For drum sampling, particularly drums with unknown contents, examine the drum for its general condition. Note condition in the FLB/FN.

9.1.2 Look for rusting, leaking, bulging, improperly secured cover, and other abnormal conditions.

WARNING: Do not open bulging drums.

9.1.3 Open the drum.

9.1.4 Do not lean over the drum while measuring pH.

9.2 Sampling and Testing

9.2.1 Collect a representative sample.

9.2.2 pH measurements may or may not be taken directly from the source, depending on conditions.

9.2.3 Test the sample with wide range pH paper to determine the approximate pH. Record the results in the FLB/FN.

9.2.4 Select the appropriate narrow range pH paper.

9.2.5 Take two measurements using the narrow range pH paper. Record the results in the FLB/FN.

9.2.6 pH measurements can be used to define a waste as a corrosive or non-corrosive only if the measured values differ

Figure 13-3. Sample SOP for Field pH Measurements Using pH Paper (continued)

from either threshold limit (pH 2 or 12.5) by a full pH unit.

9.2.7 If readings in the ranges of either pH 1–3 or pH 11.5–13.5 are obtained, then the pH should be determined using a meter.

10.0 Quality Control

10.1 All pH determinations must be performed in duplicate.

10.2 Each batch of pH paper must be verified versus certified pH buffers or a pH meter that has been calibrated with certified pH buffers.

11.0 Reference

11.1 SW-846 Test Method for Evaluating Solid Wastes, Method 9041A.

Figure 13-4. Sample SOP for Field pH of Aqueous Samples by Electrometric Measurement

DoD Environmental Sampling and Field Testing Procedure

Standard Operating Procedure

Field pH of Aqueous Samples by Electrometric Measurement
(Orion Model 230A)

Prep By:
Approved By:
Effective Date:

CAUTION

This Standard Operating Procedure has been prepared as an example for this handbook and may not be specifically applicable to all activities or organizations. Any mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Figure 13-4. Sample SOP for Field pH of Aqueous Samples by Electrometric Measurement (continued)

1.0 Title: Standard Operating Procedure for Field pH of Aqueous Samples by Electronic Measurement.

2.0 Scope and Application

2.1 This method provides an SOP for field pH measurements and is applicable to aqueous samples and multiphasic waste where the aqueous phase constitutes at least 20% of the total volume of the waste. The pH reading of a sample is the logarithm of the reciprocal of the hydrogen ion concentration (hydrogen ion activity) in moles per liter.

3.0 Summary of Method

3.1 The pH of the sample is determined electrometrically using either a glass electrode in combination with a reference potential or a combination electrode. The measuring device is calibrated using a series of standard solutions of known pH.

4.0 Interference

4.1 The glass electrode, in general, is not subject to solution interferences from color, turbidity, colloidal matter, oxidants, reductants, or moderate salinity.

4.2 Coatings of oily material or particulate matter can impair electrode response. Remove oily or particulate film before measuring pH.

4.3 Temperature affects both the electrode output and the sample itself. Therefore, instrument calibration and sample analysis should be performed as near to 25°C as possible.

5.0 Equipment

5.1 Orion Research pH Meter Model 230A (or equivalent) or an appropriate portable pH meter with automatic temperature compensation.

5.2 Thermometer, centigrade — calibrated and able to read ± 1 degree.

5.3 ASTM Type I or II water wash bottle.

5.4 Clean wipes.

5.5 Sample collection containers.

5.6 FLB/FN.

6.0 Reagents and Materials

6.1 pH 4.0, 7.0, 10.0 (at 25°C) buffer solutions (buffer solutions to bracket expected sample values).

6.2 pH electrode filling solution (follow manufacturer’s instructions).

6.3 pH electrode storage solution (follow manufacturer’s instructions).

6.4 ASTM Type I or II water.

7.0 Health and Safety Precautions

7.1 Wear appropriate PPE (minimum of chemical safety glasses and appropriately selected gloves).

7.2 Respiratory protection is generally not required for routine samples.

7.3 An eyewash/safety shower should be present, when practical.

8.0 Calibration and Standardization

8.1 Fill the pH electrode with fill solution, and precondition electrodes per the manufacturer's specifications of reference

Figure 13-4. Sample SOP for Field pH of Aqueous Samples by Electrometric Measurement (continued)

11.2.

8.2 Remove the pH electrode from the storage solution, and thoroughly rinse with ASTM Type I or II water. Blot dry with a clean wipe.

8.3 Position the pH probe in a sample of ASTM Type I or II water, and ensure the porous junction of the probe is completely immersed.

8.4 Press the power key until the pH mode indicator is displayed. When the electrode is stable, the READY prompt will be displayed. The pH of the ASTM Type I or II water should be approximately six.

8.5 Remove electrode from ASTM Type I or II water sample, rinse electrode with ASTM Type I or II water, and blot dry.

8.6 Place the electrode in pH 7 buffer, and press the "cal" key. CALIBRATION will be displayed above the main readout, and P1 is displayed in the lower field.

8.7 Wait for a stable pH display, then press the "up arrow" or "down arrow" key and the first digit will start flashing. Scroll until the correct value appears in the first digit. Press "yes". The second digit will start flashing. Scroll until the correct value appears, then press "yes." Continue in this manner until all digits have been correctly entered.

8.8 The display will remain frozen for 2 seconds; then, P2 will be displayed in the lower field indicating the meter is ready for the next buffer (4 or 10 buffer).

8.9 Rinse the electrode with ASTM Type I or II water, and place the electrode into the second buffer. Wait for a stable pH display, then enter the correct value.

8.10 The electrode slope (in percent) is then displayed in the main field with SLP in the lower field. The meter automatically advances to MEASURE mode.

8.11 Record the slope in the FLB/FN. The slope shall be from 95% – 105%. If the slope is less than 95% or more than 105%, then recalibrate the pH meter.

8.12 Rinse the probe with ASTM Type I or II water, and place the electrode into the low range pH buffer solution. Record the pH buffer and temperature reading. If the pH is not within ± 0.05 units of the solution value, then recalibrate the pH meter.

8.13 Rinse the electrode with ASTM Type I or II water, and place the electrode into the high range pH buffer solution. Record the pH buffer and temperature reading. If the pH is not within ± 0.05 units of the solution, then recalibrate the pH meter.

8.14 Record calibration date and pH meter identification number in the appropriate FLB/FN.

Note: Press the power key to preserve power.

9.0 Procedure

9.1 Only calibrated equipment shall be used for sample analysis.

9.2 Agitate (without aeration) the sample, and decant an aliquot sufficient for analysis into a clean sample bottle.

9.3 Remove the pH electrode from the storage solution, thoroughly rinse the electrode with ASTM Type I or II water, and blot it dry with a soft tissue.

9.4 Position the electrode in the well-mixed sample solution.

9.5 Press the power key. When the electrode is stable, the READY prompt will be displayed and the temperature-corrected value for the sample will be displayed. Record the pH, sample identification, and sample time in the FLB/FN.

9.6 If elemental analytes are to be determined, then preserve the remainder of the sample by acidifying with nitric acid

Figure 13-4. Sample SOP for Field pH of Aqueous Samples by Electrometric Measurement (continued)

to a pH of ≤ 2.

10.0 Quality Control

10.1 The electrode shall be rinsed between samples.

10.2 Buffers shall be NIST traceable and shall have a current shelf life.

10.3 pH meters shall have a current METCAL (Navy Calibration) calibration sticker.

10.4 Calibration of mercury thermometers shall be checked at least annually against a NIST traceable certified thermometer.

10.5 The calibration of dial-type thermometers shall be checked at least quarterly against a NIST traceable thermometer.

11.0 References

11.1 Standard Methods for the Examination of Water and Wastewater, 21st Edition: Method 4500-H, pH Value.

11.2 Orion Research pH Meter Model 230A Instruction Manual.

11.3 SW-846, Method 9040C, pH Electrometric Measurement

Figure 13-4. Sample SOP for Field pH of Aqueous Samples by Electrometric Measurement (continued)

Data Sheet
pH Meter Standardization

Date of Standardization: _____

Time of standardization: _____

Analyst: _____

Instrument Model: _____

Instrument S/N: _____

Calibration Exp. Date: _____

Buffer Exp. Date: _____

Buffer Solution	*Temperature*	*Meter Reading*	*pH Corrected (to 25°C)*
7.0	_____	_____	_____
4.0	_____	_____	_____
10.0	_____	_____	_____

Slope _____

Analyst Signature and Date: _____

Figure 13-5. Sample SOP for Oxidizer Field Testing for Cyanide Samples

DoD Environmental Sampling and Field Testing Procedure

Standard Operating Procedure

Oxidizer Field Testing for Cyanide Samples

Prep By:
Approved By:
Effective Date:

CAUTION

This Standard Operating Procedure has been prepared as an example for this handbook and may not be specifically applicable to all activities or organizations. Any mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Figure 13-5. Sample SOP for Oxidizer Field Testing for Cyanide Samples (continued)

1.0 Title: Standard Operating Procedure for Oxidizer Field Testing for Cyanide Samples.

2.0 Scope and Application

2.1 This SOP covers the procedure needed to test for oxidizers in aqueous samples requiring cyanide analysis. Oxidizers are best removed at time of collection as they destroy/decompose most cyanides, causing a false low result.

3.0 Summary of Method

3.1 A few drops of sample are placed on potassium iodide-Starch test paper (KI starch paper). A "blue" color indicates the presence of oxidizing agents, which may destroy or decompose cyanides. The sample must then be treated with ascorbic acid to neutralize any oxidizing agents.

4.0 Interferences

4.1 None.

5.0 Equipment

5.1 Disposable droppers.

5.2 Sample containers.

5.3 FLB/FN.

6.0 Reagents and Materials

6.1 Potassium iodide -starch test paper (KI starch paper).

6.2 Standard oxidize -potassium dichromate 5%.

6.3 Ascorbic acid, solid.

7.0 Health and Safety Precautions

7.1 Minimum PPE shall be chemical safety goggles (cyanide solutions can be corrosive) and protective gloves. Other PPE will be dictated by the specific hazards of the sampling site (e.g., safety shoes, hard hats).

7.2 On returning from sampling, personnel will wash exposed skin with soap and water.

7.3 Emergency eyewash/safety shower must be present, as appropriate

8.0 Calibration and Standardization

8.1 Take a drop from the potassium dichromate solution (paragraph 6.2) and test the KI starch paper. The strip should turn blue.

9.0 Sampling and Testing

9.1 Collect a representative 1-liter sample.

9.2 With a disposable dropper, put a drop of sample on a strip of KI starch paper. A blue color on the strip indicates that the sample contains oxidizing agents (e.g., chlorine).

9.3 If a blue color is observed, add ascorbic acid, a few crystals at a time, until a drop of sample produces no color change to the KI starch paper.

9.4 Add an additional 0.6 grams of ascorbic acid for each liter of sample.

9.5 Preserve the sample according to the sample preservation guidelines.

Figure 13-5. Sample SOP for Oxidizer Field Testing for Cyanide Samples (continued)

9.6 Record in the FLB/FN that the sample was treated for oxidizer or that the oxidizer test was negative. Also, enter information on the appropriate data sheet.

10.0 Quality Control

10.1 KI starch strips are checked for functionality prior to use.

11.0 References

11.1 SW-846 Test Methods for Evaluating Solid Wastes, Method 9010A.

Figure 13-6. Sample SOP for Field Temperature Determination

DoD Environmental Sampling and Field Testing Procedure

Standard Operating Procedure

Field Temperature Determination

Prep By:
Approved By:
Effective Date:

CAUTION

This Standard Operating Procedure has been prepared as an example for this handbook and may not be specifically applicable to all activities or organizations. Any mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Figure 13-6. Sample SOP for Field Temperature Determination (continued)

1.0 Title: Standard Operating Procedure for Field Temperature Determination.

2.0 Scope and Application

2.1 This method is applicable to drinking, surface waters, domestic and industrial waste, and other various aqueous matrices.

3.0 Summary of Method

3.1 Temperature measurements may be made with any good grade of mercury - filled or dial type centigrade thermometer or thermistor.

4.0 Interferences

4.1 Temperature measurements must be made in the field because temperature is subject to change if there is a time delay in taking the reading.

4.2 Time must be allowed for temperature reading to reach equilibrium (no observed change for 30 seconds).

5.0 Equipment

5.1 Mercury, bimetallic, or electronic thermometers (thermometers should be readable in increments of 1 degree).

5.2 Rinse wastewater container.

5.3 ASTM Type I or II water squirt bottle.

5.4 Clean wipes.

5.5 Rubber gloves.

5.6 FLB/FN.

5.7 PPE.

5.8 Sample containers.

6.0 Reagents and Materials

6.1 ASTM Type I or II water.

7.0 Health and Safety Precautions

7.1 Wear appropriate PPE. As a minimum, safety glasses and protective gloves should be worn.

7.2 Respiratory protection is generally not required for routine samples. However, personnel performing this procedure should be aware of any potential volatile hazards that may require a respirator.

8.0 Procedure

8.1 Ensure thermometer has a current METCAL calibration sticker.

8.2 Immerse the sensor of the thermometer in the material to be tested.

8.3 Observe the temperature reading when equilibrium has been achieved (no change for 30 seconds).

8.4 Record the reading in the appropriate FLB/FN or other appropriate log.

8.5 Remove thermometer from sample.

8.6 Rinse the thermometer with water from the rinse water bottle, catching rinse in the waste container.

Figure 13-6. Sample SOP for Field Temperature Determination (continued)

8.7 Repeat procedure for additional temperature determination, or store thermometer.

9.0 Quality Control

9.1 Ensure thermometers have a current METCAL calibration.

9.2 The calibration of mercury thermometers shall be checked at least annually against a NIST-traceable certified thermometer.

9.3 The calibration of dial-type thermometers shall be checked at least quarterly against a NIST-traceable thermometer.

9.4 Do not use thermometers where the indicating fluid has become separated.

10.0 Reference

10.1 Standard Methods for Examination of Water and Wastewater, 21st Edition: Section 2550 B, Temperature.

Figure 13-6. Sample SOP for Field Temperature Determination (continued)

Field Temperature Data Sheet

Thermometer Control Number: _____

Calibration Expiration Date: _____

Analyst: _____

Remarks, Conditions: _____

_____

_____

_____

Temperature Log

Date/Time	Sample Location	Reading °F / °C	Analyst Initials	Remarks

Reviewed By: _____

Date: _____

Figure 13-7. Sample SOP for Calibration & Maintenance of a Photovac PID

DoD Environmental Sampling and Field Testing Procedure

Standard Operating Procedure

Calibration & Maintenance of a Photovac Photo Ionization Detector

Prep By:
Approved By:
Effective Date:

CAUTION

This Standard Operating Procedure has been prepared as an example for this handbook and may not be specifically applicable to all activities or organizations. Any mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Figure 13-7. Sample SOP for Calibration & Maintenance of a Photovac PID (continued)

1.0 Title: Calibration & Maintenance of a Photovac Photo Ionization Detector (PID)

2.0 Scope and Application

2.1 To calibrate and perform periodic maintenance on a PhotoVac PID Model No. XXXX.

2.2 Calibration is required at the start of each day, and after each time maintenance is performed on the instrument during the day (replacement of bulb or filter, etc.).

3.0 Summary of Method

3.1 Calibration — the measuring device is calibrated using a series of standard gases of known concentration.

3.2 Maintenance — requires the disassembly, replacement of minor components, and the reassembly of the instrument.

Note: Recalibration must be performed after each maintenance operation.

4.0 Equipment

4.1 PID with manufacturer's instructions.

4.2 Spare battery.

4.3 Battery charge.r

4.4 Spare bulb.

4.5 Spare particulate filter.

4.6 Wrenches, screwdrivers, as required, to disassemble the instrument for maintenance.

4.7 Cotton tipped swabs.

4.8 Clean/New sampling bags.

4.9 FLB/FN.

5.0 Reagents and Materials

5.1 Methanol.

5.2 Cylinder of pure air, or activated carbon filter to make pure air and a sampling pump to fill the sampling bag.

5.3 Cylinder of calibration gas.

6.0 Safety and Health Precautions

6.1 Serious eye damage can result from direct view of UV radiation.

6.2 Calibration gases are pressurized. Handle containers carefully.

6.3 Methanol is flammable.

7.0 Preparation of Equipment for Calibration

7.1 Carefully unpack the instrument and examine it for physical damage that could have occurred in transit.

7.2 The unit's battery should be charged for 16 hours before use, since the battery can lose its charge during storage.

7.3 Completely empty a flexible air sampling bag (Tedlar® or equivalent) using a vacuum (or sampling) pump.

Figure 13-7. Sample SOP for Calibration & Maintenance of a Photovac PID (continued)

8.0 Procedure for Calibration

8.1 Perform any maintenance operations prior to calibration since disassembly/reassembly requires recalibration.

8.2 Any deviations from the following procedures shall be per the manufacturer's instructions and noted in the FLB/FN.

8.3 Turn the power switch on to activate the unit. The pump should activate, making a continuous low humming sound.

8.4 Check the display for a "LOW BAT" indication (which means the battery should be replaced and/or recharged).

8.5 Allow the unit to operate for at least 2 minutes to come to equilibrium before calibrating.

8.6 Fill the bag with clean air (either "Zero Air" from a cylinder or air that has been passed through a tube of fresh activated charcoal).

8.7 Connect the sample bag to the sampling port of the TIP (inlet port of the instrument). Set the "SPAN" control to maximum, and adjust the "ZERO" knob until the display reads "0". Record the "ZERO" setting in the FLB/FN. Remove the sample bag.

8.8 Fill a sample bag with calibration gas. Record the cylinder manufacturer, lot number, and the label information on the chemicals present in the standard and their concentration in the FLB/FN.

8.9 Attach the sample bag to the sampling port of the TIP (inlet port of the instrument) and adjust the "SPAN" control so that the display reads the same as the concentration on the label of the cylinder. Record both the "SPAN" setting and the display in the FLB/FN. Remove the sample bag.

9.0 Procedure for Replacement of Filter

9.1 Any deviations from the following procedures shall be per the manufacturer's instructions and noted in the FLB/FN.

CAUTION: Certain maintenance procedures may be performed in the field, however, these require the instrument to be recalibrated. Maintenance procedures should be performed only by personnel who have been properly trained.

9.2 The TIP is fitted with a 15-µm cartridge-style filter designed to capture particles that might otherwise be drawn into the detector.

9.2.1 Never use instrument without the filter as the detector can be damaged.

9.2.2 Extended periods of operation in a dusty environment require frequent inspection of the filter for clogging and/or absorption of particles carrying volatile material.

9.2.3 When a filter is clogged, the sensitivity of the instrument decreases since the sample flow-through is decreased. On the other hand, when absorption of the volatile material occurs, a high background reading should be observed and consequently the need for an extreme zero resetting would be required.

9.2.4 The TIP response should be tested with and without the filter and the filter should be replaced if the response varies by more than 10%.

9.3 To access the filter, hold the filter housing firmly at the base with a 9/16-inch wrench and unscrew the 1/8-inch Swagelok® connection for the sample inlet at the top of the housing with another 9/16-inch wrench.

9.4 Replace the filter with the new one.

9.5 Screw the sample inlet connection firmly into place.

9.6 Recalibration (per paragraph 8) is required prior to use.

10.0 Procedure for Lamp Maintenance

10.1 Any deviations from the following procedures shall be per the manufacturer's instructions and noted in the FLB/FN.

Figure 13-7. Sample SOP for Calibration & Maintenance of a Photovac PID (continued)

CAUTION: Certain maintenance procedures may be performed in the field, however, these require the instrument to be recalibrated. Maintenance procedures should be performed only by personnel who have been properly trained.

10.2 The UV lamp should be cleaned if there is a significant loss of sensitivity not due to an obstructed filter.

10.3 Make sure that the unit is switched off before disassembling.

10.4 Refer to the manufacturer's instructions for disassembly and detailed cleaning procedures.

CAUTION: Do not touch the bulb with bare skin, as this can leave an oil film on the bulb, which may damage the equipment.

CAUTION: Under certain circumstances, water can be sucked into the detector. Provided that the water is relatively clean, this may not cause irreparable damage. Usually, the only corrective action needed is to have factory maintenance performed by disassembling and cleaning the unit as soon as possible after the occurrence. Delay will likely result in corrosion of internal parts.

10.5 Clean the lamp with a cotton swab dampened with methanol.

10.6 Be careful not to damage the screens.

10.7 When reassembling the instrument, be careful not to cross-thread the connections or damage the O ring seals.

10.8 After reassembly, perform an operational check of the unit.

10.8.1 If sensitivity is not recovered by cleaning or the lamp will not start, it is likely that a new lamp is required.

10.9 Recalibration per paragraph 8 is required prior to use.

11.0 Quality Control

11.1 Quality control is maintained by strict adherence to these procedures performed by personnel who are trained and familiar with the equipment.

11.2 Only certified calibration gases are used.

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Chapter 14. Guidelines for Requesting Laboratory Testing

14.1. Purpose

This chapter provides guidance for government, or contractors performing work for the government, on requesting laboratory testing and selecting laboratories for environmental sampling. Typically, formal quotes should be requested from multiple laboratories. In rough order of importance, laboratory selection should be based on the following:

- Accreditation/certification status
- Successful performance in related proficiency testing (PT) programs, where available
- Ability to meet project-specific QA/QC requirements
- Capacity to handle the specified number of samples within the required turnaround time
- Cost.

Once selected, communication with the laboratory prior to, during, and after sampling is essential to ensure that reported results will meet regulatory requirements and can be used as intended.

14.2. Scope

This chapter addresses the technical aspects of requesting laboratory testing services and selecting laboratories. Specifically, it contains guidance for preparing requests for quote (RFQ) or scopes of work (SOW). The RFQ or SOW must contain sufficient information to permit the laboratory to understand the requirement, provide a complete and responsive quote, and perform the tests and report the results in accordance with relevant requirements. In the case of projects for which a SAP has been prepared, the laboratory should be provided with a copy of the plan at the time the proposal or quote is solicited. The SOW and project planning documents should be included or referenced in the laboratory's contract.

14.3. Responsibilities

The regulated party (e.g., permit holder or effluent generator) ultimately is responsible for obtaining valid test data. This includes the development of appropriate sampling designs, the collection of representative samples, the performance of the appropriate methods or tests, and the implementation of required health and safety protective measures. Where sampling and testing are to be conducted by contractors, the regulated party is responsible for developing complete and accurate SOWs. The responsibilities of all parties involved in environmental sampling and testing must be clearly identified and agreed upon during project planning.

Typical Responsibilities for Sampling Personnel

- Selecting correct sample locations
- Collecting and preserving samples according to project-planning documents and the permit or regulation
- Labeling samples for proper identification by others
- Documenting any deviations from specified sampling procedures
- Recording all relevant field observations
- Initiating and maintaining sample COC records
- Notifying the laboratory of expected sample arrival dates and times
- Packing and shipping samples in a manner that preserves samples' integrity, maintains the chain of custody, complies with shipping regulations, and ensures timely delivery of the samples to the laboratory.

Typical Laboratory Responsibilities

- Providing prepared containers for sample collection if requested
- Checking samples immediately upon receipt for sample condition and proper preservation
- Notifying the DoD customer in a timely manner of any conditions that have potentially compromised sample integrity
- Properly segregating and storing samples
- Maintaining laboratory chain-of-custody
- Preparing and analyzing samples according to the SOW and project-planning documents

- Evaluating and reporting the results according to specifications
- Advising the customer in a timely manner of any problems, deviations from protocols, or control criteria performance issues
- Providing technical assistance, if requested, for data interpretation.

14.4. Hazards and Safety Precautions

See Chapter 3 for DOT requirements for shipping samples to the laboratory. Samples must be properly labeled, and the outside containers properly marked, so that all persons handling the samples are able to recognize the contents and observe all pertinent safety precautions during sample handling, transfer, storage, and analysis. The laboratory's hazard communication program must comply with 29 CFR 1910.1200.

14.5. Planning

Ideally, a DoD Chemist should be consulted during planning, to assist in developing the RFQ or SOW. At a minimum, the DoD Chemist should review the RFQ or SOW to ensure it is technically adequate. The following information should be determined during planning and included in the RFQ or SOW.

1. **Regulatory Requirements.** Describe the relevant regulation and purpose for testing (e.g., compliance monitoring under NPDES, drinking water testing, RCRA groundwater monitoring)
2. **Parameter(s) and Analytical Methods.** List all parameters to be analyzed and reported, and specific methods (e.g., sample cleanup, preparation, extraction, and analysis) to be used. For further guidance on this topic, see Section 14.6.
3. **Sample Descriptions and Sample Handling Requirements.** Provide a summary of the number and descriptions of sample matrices to be submitted for analysis (e.g., groundwater, soil, and wastewater). Describe any known or suspected toxic or hazardous samples. If the samples consist of multiple phases, this should be noted as well. Describe the number and type of sample bottles and sample preservation that will be used. Note whether the sampling team or the laboratory is to supply sample containers and preservatives.
4. **Laboratory Qualifications.** Describe all project-specific requirements for laboratory qualifications, including certification or accreditation requirements and participation in specific PT studies. Section 14.7 describes the minimum qualifications laboratories must meet in order to be eligible to perform testing for DoD.
5. **QA/QC.** Describe any project-specific quality assurance and quality control requirements and measurement performance criteria that differ from method QA/QC requirements. If applicable, include copies of the SAP or QAPP.
6. **Data Reporting Requirements.** Describe the content and format requirements for laboratory reports, including both hard-copy reports and electronic data deliverables (EDDs). For each parameter to be reported, list the required reporting units (e.g., percent, mg/L, ppm, ppb, dry weight/wet weight basis) and quantitation limits. Quantitation limits must be at or below compliance limits specified in the permit or regulation.
7. **Project Schedule.** Provide a schedule or timeline showing expected sampling dates, expected sample delivery dates, required sampling and analysis hold times, and required analytical turnaround time. For more guidance on this topic, see Section 14.10.

Roles for the DoD Chemist

A DoD Chemist should be consulted during project planning to assist in developing the RFQ or SOW. At a minimum, the chemist should review the RFQ or SOW to ensure it is technically adequate. A DoD Chemist also can:

- Develop or review project-specific performance standards and DQOs
- Verify the appropriateness of sampling and analytical methods

- Provide oversight for development and correct implementation of the SAP
- Notify the Contracting Officer of potential laboratory non-conformance issues, including prohibited practices
- Monitor corrective action, where necessary
- Perform data review.

14.6. Parameters and Analytical Methods

The permit or regulation typically prescribes the analytical parameters and methods to be used. The parameters tested and reported should be limited to those required in the scope of the regulation or permit. There are three primary criteria for method selection: 1) its use must be allowed under the permit or regulation, 2) it must be appropriate for the type of matrix being sampled, and 3) it must be capable of generating quantitative results with adequate data quality at or below the regulatory limit.

Once a facility has selected and begun using a specific method, it should exercise caution before changing either laboratories or methods, as this can affect the comparability of analytical results from one monitoring event to the next. To help evaluate data comparability between laboratories or methods, the permit holder may employ the analysis of split samples by two or more qualified laboratories.

In general, analytical methods used for regulatory compliance should be performed as written, and the laboratory must adhere to all method-specified quality control criteria. Modifications to methods specified in permits are allowed only if: 1) they are necessary to the successful analysis of regulated parameter in a particular sample matrix, and 2) the permit writer agrees to the change(s) prior to implementation. Care must be taken to ensure method modification does not alter the sample chemistry.

Most published methods accommodate some degree of flexibility, and in those cases, the laboratory may use discretion for specific steps in the method where allowed. In any case, the exact procedure used must be documented in the laboratory's SOP for that method.

The following paragraphs discuss the selection of parameters and methods for some common types of compliance monitoring.

Wastewater. Parameters controlled under the NPDES provisions of the CWA are listed in the NPDES permit application, Form 2C. Testing requirements including frequency, sample location, sampling method, and QC requirements, also are described in the permit.

The approved test methods for wastewater, along with sample holding times and preservation, are listed in 40 CFR Part 136. In March 2007, EPA proposed a number of new and revised analytical methods used under both the CWA and Drinking Water regulations. The proposed changes, found in the Federal Register, March 12, 2007 (Volume 72, Number 47), include the following:

- Additional new methods and updated versions of currently approved methods
- Revised method modification and analytical requirements
- Withdrawal of certain outdated methods
- Changes to sample collection, preservation, and holding time requirements.

Drinking Water. The water supplier's operating permit describes the test parameters, analytical methods, sampling methods, sampling frequency and compliance limits. The primary reference for drinking water methods is 40 CFR Part 141.21-142.30 and *Manual for the Certification of Laboratories Analyzing Drinking Water* (Fifth Edition, January 2005). As discussed above under Wastewater, the EPA Office of Water proposed a number of new and revised analytical methods (Federal Register, March 12, 2007 (Volume 72, Number 47)). Other standard methods may be acceptable, including Standard Methods for the Examination of Water and Wastewater and ASTM Water and Environmental Technology Methods.

Solid and Hazardous Waste. Under the RCRA regulations, the waste generator is responsible for

correctly characterizing its waste and may use knowledge of the waste in the process for selecting the test parameters. Solid wastes are classified as hazardous if they 1) are specifically listed in 40 CFR Part 261, 2) are deemed hazardous by the generator based on process knowledge, or 3) meet the characteristics of a hazardous waste specified in 40 CFR Part 261. Waste sampling is described in Chapter 10 of this handbook. The generator must understand and comply with all regulations found in 40 CFR Parts 260 to 261 before selecting methods for waste characterization. RCRA waste characterization methods are published in EPA SW-846 Test Methods for Evaluating Solid Waste, as updated.

Groundwater. The parameters and analytical methods for potable water testing are based on the drinking water regulations found in 40 CFR Part 141. For landfill monitoring, the landfill development permit specifies sampling methods, sampling frequency, whether to use filtered or unfiltered samples, purge methods, compliance limits, and test parameters. 40 CFR Part 265.90, Subpart F – Groundwater Monitoring contains regulations for groundwater monitoring at landfills. The regulations for landfill leachate monitoring are found in the solid waste landfill regulation in 40 CFR Part 258.

Underground Storage Tanks. The primary reference for selecting methods for analyzing the contents of USTs and leaking underground storage tanks (LUST) is 40 CFR Part 280. The methods for removal and additional monitoring are specified by state agencies for soil and groundwater monitoring. Additional information on sampling the contents of USTs is provided in Chapter 10 of this handbook.

Dredging Operations. Sampling and testing requirements for the purpose of obtaining dredging permits will vary based on past and future uses of the water body, regulatory requirements, and known contaminants. For the purpose of determining the proper handling of dredging spoils, sediment monitoring parameters can include RCRA hazardous waste characteristics, TSCA parameters (e.g., PCBs, dioxins and furans), and NPDES parameters. For the purpose of monitoring the impacts of dredging activities on water quality, dredging permits may require monitoring of surface water as well as sediments.

Note: When selecting or modifying methods, more extensive discussion is available in the EPA guidance document, Guidance on Evaluation, Resolution, and Documentation of Analytical Problems Associated with Compliance Monitoring, EPA 821-B-93-001, June 1993.

14.7. Laboratory Selection

Laboratories performing testing in support of the Defense Environmental Restoration Program must be accredited in accordance with the DoD ELAP.

Laboratories must possess any required state or host nation certification and/or be accredited for each applicable test method, by a nationally recognized laboratory accreditation body (e.g. the National Environmental Laboratory Accreditation Program or NELAP), compliant with International Organization for Standardization (ISO/IEC) 17011:2004. All laboratories must demonstrate the ability to generate acceptable results from the analysis of PT sample(s), subject to availability, using each applicable method in the specified matrix. Upon request, laboratories must make available to DoD the results of all PT samples analyzed by the laboratory during the period of performance. The laboratory shall make appropriate documentation available to the DoD Chemist/Quality Assurance Manager (QAM). All laboratories are subject to on-site assessments by authorized DoD representatives. The laboratory shall notify DoD in writing of any change in laboratory certification or accreditation status within 30 calendar days of the change. This written notification requirement applies, but is not limited to, suspension or revocation of DoD ELAP accreditation.

Laboratories shall have a documented program to prevent improper, unethical, or illegal actions and must not engage in any prohibited practices. The laboratory must have the appropriate accreditation for the testing to be performed. The laboratory must not commence testing until DoD has

accepted the laboratory's quality systems documentation.

14.8. QA/QC

Detailed information on QA/QC, including the systematic planning process, development of DQOs, and preparation of SAPs is provided in Chapter 2 of this handbook. Laboratories must follow all method-specified quality assurance and quality control procedures and observe method- or project-specified performance criteria.

14.9. Reporting

Laboratory reports must include a narrative describing the samples received, analyses, quality control exceedances, and any unusual observations made during analysis. The use of subcontractors must be identified in the primary laboratory's final report. The minimum recommended contents of laboratory reports for compliance sampling include the following:

In the absence of client specified reporting criteria, the reporting requirements outlined below shall be used for hard-copy data reports from the laboratory. They are divided into mandatory requirements for all printed data reports, and optional requirements. Optional reporting requirements are those that may be required by a specific project, depending upon the needs of the project. The following elements are required: cover sheet, table of contents, case narrative, analytical results, sample management records, and QA/QC information. Information for third-party review may be required depending on project-specific requirements or the method being used. The requirements below do not dictate what records the laboratory should maintain.

1. **Cover Sheet.** The cover sheet shall specify the following information:
   - Title of report (i.e., Test Report, Test Certificate)
   - Name and location of laboratory (to include a point of contact, phone and facsimile numbers)
   - Name and location of any subcontractor laboratories, and appropriate test method performed
   - Contract number
   - Unique identification of the report (such as serial number)
   - Client name and address
   - Project name and site location
   - Statement of data authenticity and official signature and title of person authorizing report
   - Amendments to previously released reports that clearly identify the serial number for the previous report and state the reason(s) for reissuance of the report
   - Total number of pages.
2. **Table of Contents.** Laboratory data packages should be organized in a format that allows for easy identification and retrieval of information. An index or table of contents shall be included for this purpose.
3. **Case Narrative.** A case narrative shall be included in each report. The purpose of the case narrative is to describe any abnormalities and deviations that may affect the analytical results. It is also used to summarize any issues in the data package that need to be highlighted for the data user to help them assess the usability of the data. The case narrative shall provide:
   - A table(s) summarizing samples received, providing a correlation between field sample numbers and laboratory sample numbers, and identifying which analytical methods were performed. If multiple laboratories performed analyses, the name and location of each laboratory should be associated with each sample.
   - A list of samples that were received but not analyzed
   - A description of extractions or analyses that are performed out of holding times
   - A definition of all data qualifiers or flags used

- Identification of deviations of any calibration standards or QC sample results from appropriate acceptance limits and a discussion of the associated corrective actions taken by the laboratory
- Identification of samples and analytes for which manual integration was necessary
- Appropriate notation of any other factors that could affect the sample results (e.g., air bubbles in VOC sample vials, excess headspace in soil VOC containers, the presence of multiple phases, sample temperature and sample pH excursions, container type or volume, etc.)
- Identification of numerical results outside of limits of quantitation.

4. **Analytical Results.** The results for each sample shall contain the following information at a minimum (information need not be repeated if noted elsewhere in the data package):
   - Project name and site location
   - Field sample ID number as written on custody form
   - Laboratory sample ID number
   - Matrix (soil, water, oil, etc.)
   - Date and time sample extracted or prepared
   - Date and time sample analyzed
   - Method numbers for all preparation, cleanup, and analysis procedures employed
   - Analyte or parameter
   - Method reporting limits and method limits of quantitation (at or above the low-level standard concentration) adjusted for sample-specific factors (e.g., aliquot size, dilution/concentration factors, moisture content)
   - All samples and analytes for which manual integration occurred, including the cause and justification
   - Limits of detection and/or method detection limits
   - Analytical results with correct number of significant figures
   - Any data qualifiers assigned
   - Concentration units
   - Dilution factors
   - Any dilutions or concentrations for all reported data, and if neat or less diluted results are available, recorded and reported data from both runs
   - Percent moisture or percent solids (all soils are to be reported on a dry weight basis).

The following information is optional but may be required site-specifically:

- Laboratory name and location (city and state)
- Sample description
- Sample preservation or condition at receipt
- Date and time sample collected
- Date sample received
- Sample aliquot analyzed
- Final extract volume
- Chemical Abstract Service (CAS) numbers
- Statements of the estimated uncertainty of test results.

5. **Sample Management Records.** These types of records include the documentation accompanying the samples, such as:
   - COC records
   - Shipping documents
   - Records generated by the laboratory which detail the condition of the samples upon receipt at the laboratory (e.g., sample cooler receipt forms)
   - Telephone conversation records associated with actions taken or quality issues
   - Description of the sampling procedures if the laboratory collected the sample.
6. **QA/QC Information.** The minimum internal QC data package must include the following:
   - MS recovery

- Relative percent difference (RPD) of required duplicates
- Laboratory Control Sample (LCS) recoveries
- In-house LCS control limits, if they exceed DoD limits
- Surrogate recoveries (organics)
- Tracer recoveries (radiochemical)
- Method blank results
- Preparation, analysis, and other batch numbers
- QC acceptance criteria for MS, LCS, surrogates, etc.
- Spike concentrations for MS, LCS, surrogates, etc.

7. **Information for Third-Party Review.** The information listed below is required if third-party (from outside the laboratory) data validation or verification is to be performed. This information is therefore optional and is provided only when the project-specific or regulatory requirements specify that a third-party review will occur.

   - Calibration data from the initial calibration curve
   - Initial calibration verification (ICV)
   - Continuing calibration verification(s) (CCV)
   - Performance standards analyzed in conjunction with the test method (e.g., tuning standards, degradation check standards, etc.)
   - Preparation, analysis, and other batch numbers
   - Raw data (e.g., chromatograms, mass spectrum results)
   - MS, if applicable (includes spike target concentration levels, measured spike concentration, and calculated recoveries)
   - RPD of required duplicates (e.g., MSD, LCS duplicate, matrix duplicates (MD), and field duplicates)
   - Method blank results
   - LCS recoveries[1]
   - Surrogate recoveries (organics)
   - Serial dilutions (SD) percent difference (metals)
   - Post-digestion spikes (PDS) recovery (metals)
   - Project action levels, DQOs, Measurement Quality Objectives (MQOs), and associated acceptance criteria
   - Supporting documentation (e.g., run logs, sample preparation logs, standard preparation logs).

In addition, the data package for third-party review may include summary forms from detection limit studies. The data validation guidelines for performance-based methods established in other DoD guidance on data review and data validation, EPA national functional guidelines, EPA regional functional guidelines, and project-specific guidelines for validation may all have distinct reporting formats. The appropriate validation guidelines should be consulted to determine what type of data package is required.

If compliance limits are exceeded or unusual data results are reported by the laboratory, further data review may be initiated.

It is recommended that at a minimum, the laboratory report be reviewed to make sure all samples were analyzed for the correct parameters, using the correct methods, within the specified holding times, and that the report conforms to specifications for content and format.

14.10. Project Schedule Considerations

The time from sample collection until the start of sample preparation is the holding time referred to in the regulations. In general, the time of sample collection time refers to the time when the sample first leaves its natural environment. EPA has established holding times to maintain sample integrity and stability and ensure representative analytical results. Samples must be preserved and packaged according to method specifications and received by the laboratory in time to permit the preparation and analysis within the required holding times.

Analytical turnaround time is the time between sample receipt and delivery of the final report to the customer. Table 14-1 lists the approximate minimum time needed to prepare and analyze certain types of samples. When estimating the minimum turnaround times possible for project planning purposes, add 1 day for sample receipt, preservation check, and sample log-in at the start of processing and 1 day at the end for data and QC review.

Table 14-1. Minimum Analytical Processing Time

Parameter	Preparation Time	Analysis Time
BOD	0.5 day	5 days
Solids	0.5 day	1 day
Wet chemistry	1 day	0.5 day
Metals, dissolved	0.5 day	0.5 day per method
Metals, total acid digestion	0.5 days water 1 day solids	0.5 day per method
Volatiles	0.5 day	1 day
Semi-volatile organics	2 days	1 day
Pesticides	1 day	1 day
TCLP-metals	2 days	0.5 day per method
TCLP-ZHE-volatiles	1 day	1 day
TCLP-semivolatiles	2 day	1 day
Radionuclides	2 days	1 to 15 days

Appendix A. Sampler/Sampling Recommendations and Strategies

Table A-1. Recommended Samplers for Various Types of Waste

(See Note 1 below)

Waste Type	Recommended Sampler	Limitations
Liquids, sludges, and slurries in drums, vacuum trucks, barrels and similar containers	COLIWASA, Open Tube (Thief), Stratified sample (Thief)	Not for containers greater than 1.5 m (5 ft) deep
	a) Plastic	Not for wastes containing ketones, nitrobenzene, dimethylformamide, mesityl oxide, or tetrahydrofuran
	b) Glass	Not for wastes containing hydrofluoric acid and concentrated alkali solutions
	c) Teflon®	None
Liquids, sludges, and slurries in drums, vacuum trucks, barrels, and similar containers	Peristaltic Pump	For containers more than 1.5 m (5 ft) deep
Liquids and sludges in ponds, pits, or lagoons	Pond sampler	Cannot be used to collect samples beyond 3.5 m (11.5 ft) Dip and retrieve sampler slowly to avoid bending the tubular aluminum handle
Powdered or granular in bags, drums, barrels, and similar containers	a) Grain sampler	Limited application for solids sampling moist and sticky solids with a diameter 0.6 cm ($^1/_4$ in)
	b) Sampling trier	May incur difficulty in retaining core sample of very dry granular materials during sampling
Dry wastes in shallow containers and surface soil	Trowel or scoop	Not applicable to sampling deeper than 8 cm (3 in) Difficult to obtain reproducible mass of samples
Waste piles	Waste pile sampler	Not applicable to sampling solid wastes with particle dimensions greater than half the diameter of the sampling tube
Solid deeper than 8 cm (3 in)	a) Soil auger	Does not collect undisturbed core samples
	b) Veihmeyer sampler	Difficult to use on stony, rocky, or very wet soil
Waste in storage tanks	a) Weighted bottle sampler	May be difficult to use on very viscous liquids
	b) Bacon Bomb sampler	Volume restriction 1 L maximum
	c) Kemmerer sampler	May need extra weight

Note 1: These are only recommendations. Consult the applicable regulations to confirm sampler selection recommendations.

Table A-2. General Sampling Strategies

(See Note 1 below)

Sample Source	Matrix	Sampling Strategy
Drum	Liquid or solid	Collect at least one sample from each drum through the bung on top. If contents are stratified, collect at least one sample from each stratum.
Vacuum truck, storage tank, process vessel	Liquid or solid	Collect at least one sample from each compartment in tank, through open hatch. If contents are stratified collect a sample from each stratum.
Barrel, fiberdrum, bucket, sack, bag	Solid (powder or granular)	Collect at least one sample from each container, through the top or fill opening. Withdraw samples through the center of each container to a point diagonally opposite the point of entry.
Soil	Soil	Random: Divide area into a grid. Grid size is determined based on statistical considerations. Collect at least one sample at each grid node or choose locations using a random numbers table. Depth of collection may vary depending on soil type, parameters and site history. Biased: collect stained soils or soils suspected to be contaminated. Obtain as many samples as necessary to characterize different areas of site. (Note 2)
Waste piles	Solid	Divide pile into a grid and collect sample at the nodes, obtaining a core of 1–2 feet in length at each node. The size of the piles will depend on the project's data quality objectives. (Note 2)
Pond, lagoon	Liquid or sludge	Divide surface into grid. Grid size is determined based on statistical considerations. Collect at least one sample at each node. If material is stratified, collect a sample from each stratum at each node.
Surface water [**Note:** Related to identifying the extent of spills or risk assessments. Not applicable to SDWA or CWA monitoring.]	Liquid	Pond or lake: Establish grid based on statistical considerations, collect samples at nodes. Depending upon objectives, samples may be obtained at the surface, mid-depth or bottom or any combination thereof. Sample should be collected at mid-depth in a channel. Additional samples may be required if multiple discharges and additional streams are present, or for delineation of contamination. (Note 3)
Sediment [**Note:** Related to identifying the extent of spills or risk assessments. Not applicable to SDWA, CWA or ecological monitoring.]	Solid	Pond or lake: Establish grid based on statistical considerations, collect samples at nodes. Stream or river: Collect at least three samples, one downstream, one upstream, and one adjacent to site or at a point of discharge. Additional samples may be required if multiple discharges and additional streams are present. For delineation of contamination, additional discrete downstream samples, transecting the stream and/or at various depths may be employed. (Note 4)

Note 1: These are only recommendations. Consult the applicable regulations to confirm strategy recommendations.
Note 2: Refer to *EPA QA/G5S* for guidance on designing statistically relevant sampling plans.

Note 3: Refer to the USGS's *National Field Manual for the Collection of Water-Quality Data* for additional guidance on collecting surface water samples.

Note 4: Refer to the USGS's *Guidelines for Collecting and Processing Samples of StreamBed Sediment for Analysis of Trace Elements and Organic Contaminants for the National Water Quality Assessment Program* for additional guidance on collecting surface water samples.

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Appendix B. Requirements for Sample Containers, Preservation, and Holding Times

Table B-1 below specifies the required sample containers, preservation, and holding times for test samples. Each column is organized by the terms defined below.

Note: The information provided in Table B-1 represents the sample handling requirements as they exist in the stated method. For the most up-to-date and accurate information, refer to the applicable reference document.

Note: A sampling plan is to be prepared and reviewed with the lab and, in some cases, the regulator prior to starting any sampling/testing operation. Local or state regulations may supersede these requirements.

Parameter. The testing parameters must be specified in the SAP.

Sample Containers. Collection of the size and number of sample containers specified in the following table will assure that the laboratory receives enough sample material to perform the required analyses. Additional sample containers may be required for laboratory QA tests; see Appendix C for details on QA/QC sample requirements.

Container cleaning procedures are found in the test method, laboratory quality program, or regulatory program guidance documents. References for container cleaning procedures and additional container information for RCRA sampling can be found in *U.S. EPA OSWER directive 9240.0-05, Specifications and Guidance for Contaminant-Free Containers, December 1992(http://www.epa.gov/region1/oeme/ATTACHD.pdf)* SDWA sampling containers and cleaning procedures can be found in the *Manual for the Certification of Drinking Water Laboratories, Fifth Edition January 2005*. The laboratory can furnish containers of the required size and cleanliness.

Note: VOA vials are to have Teflon®-faced silicone septum caps. All other jars and bottles are to have Teflon®-lined caps.

Preservation. Some samples must be preserved before shipment to the laboratory.

- Preserve samples immediately upon sample collection
- Cooling to ≤ 6°C can be accomplished by placing sample containers in an insulated plastic shipping cooler (Coleman picnic cooler or equal) along with plastic bags of ice
- Other preservation procedures must be specified completely in the SAP.

Filling Instructions. VOA vials with septum caps are to be filled completely with no headspace or air pockets. For all other containers, leave adequate headspace in containers to allow for thermal expansion of the sample material and mixing of sample.

Holding Time. Samples should be analyzed as soon as possible after collection. Many samples are not stable for lengthy periods following collection, so daily shipment to laboratories is very important. The holding times listed in the following table are the maximum amount of time that the samples may be held before analysis from time of collection and still be considered valid. Samples exceeding these holding times are not valid for compliance and must be retaken.

Table B-1. Requirements for Sample Containers, Preservation, and Holding Times

(See Note 1 below)

Parameter	Matrix	Sample Containers *(Note 2)*	Preservation	Filling Instructions	Holding Time	Method *(Note 3)*
Alkalinity	Drinking Water	200-mL glass or polyethylene bottles	Cool to ≤ 6°C.	Fill to neck of bottle.	14 days	SM2320
Alkalinity	Wastewater	200-mL glass or polyethylene bottles	Cool to ≤ 6°C.	Fill to neck of bottle.	14 days	EPA 310; SM2320
Ammonia as Nitrogen	Stormwater, Surface water, Wastewater	1-L glass or polyethylene bottles	H_2SO_4 to pH < 2; cool to ≤ 6°C.	Fill to neck of bottle.	28 days	EPA 350; SM4500-NH_3
Asbestos	Drinking Water	2x 1-L glass or polyethylene bottles	Cool to ≤ 6°C.	Leave ample air space in the bottle (at least 2.5 cm).	48 hours	EPA 100
Biochemical Oxygen Demand (BOD_5)	Stormwater, Surface water, Wastewater	1-L glass or polyethylene bottles	Cool to ≤ 6°C.	Fill to neck of bottle.	48 hours	SM5210
Bromide	Solid and Liquid Waste	100-mL glass or polyethylene bottles	None required.	Fill to neck of bottle.	As soon as possible	SW-846 Methods 6500, 9056, 9211
Bromide	Wastewater	100-mL glass or polyethylene bottles	None required.	Fill to neck of bottle.	28 days	EPA 300; SM4110
BTEX	Soils and Sludges	2x 40-mL vials *(Note 4)*	Per preparative method. See SW-846 Methods 5035, 5021, 5031, 5032.	Fill completely, no headspace.	14 days	Speciated results from VOC analysis: SW-846 Method 8260, 8015, 8021
BTEX	Wastewater	2x 40-mL vials *(Note 4)*	Cool to ≤ 6°C. If residual chlorine is present, add 0.008% $Na_2S_2O_3$. Adjust pH to 2 with HCl.	Fill completely, no headspace.	14 days	Speciated results from VOC analysis *(Note 6)*: EPA 602, 624, 1624
Carbonaceous Biochemical Oxygen Demand ($CBOD_5$)	Surface water, Wastewater	1-L glass or polyethylene bottles	Cool to ≤ 6°C.	Fill to neck of bottle.	48 hours	SM5210
Chemical Oxygen Demand (COD)	Stormwater, Surface water,	100-mL glass bottles	H_2SO_4 to pH < 2;	Fill to neck of bottle.	28 days	EPA 410; SM5220

Parameter	Matrix	Sample Containers *(Note 2)*	Preservation	Filling Instructions	Holding Time	Method *(Note 3)*
	Wastewater		Cool to ≤ 6°C.			
Chloride	Drinking Water	100-mL glass or polyethylene bottles	None required.	Fill to neck of bottle.	28 days	EPA 300; SM4110, SM4500-Cl^-
Chloride	Wastewater	100-mL glass or polyethylene bottles	None required.	Fill to neck of bottle.	28 days	EPA 300; SM4110; SM4500-Cl^-
Chloride	Groundwater, Other aqueous waste	100-mL glass or polyethylene bottles	Cool to ≤ 6°C.	Fill to neck of bottle.	28 days	SW-846 Methods 6500, 9056, 9212, 9250, 9251, 9253
Chlorinated Acids	Drinking Water	2x 1-L amber glass bottles fitted with screw caps lined with Teflon®	If chlorine is present, add 0.008% $Na_2S_2O_3$. Seal bottle and shake vigorously for 1 minute. Cool to ≤ 6°C, away from light.	Fill to neck of bottle.	Extract within 14 days; analyze within 28 days of extraction	EPA 515
Chlorinated Acids	Wastewater	2x 1-L amber glass bottles fitted with screw caps lined with TFE-fluorocarbon	If chlorine is present, add 0.008% $Na_2S_2O_3$. Cool to ≤ 6°C.	Fill to neck of bottle.	Extract within 7 days; analyze within 40 days of extraction	EPA 625, 604
Chlorine, Residual, Free	Drinking Water	500-mL glass or polyethylene bottles	NA; analyze immediately.	None.	15 minutes	SM4500-Cl^-
Chlorine, Residual, Total	Drinking Water	500-mL glass or polyethylene bottles	NA; analyze immediately.	None.	15 minutes	EPA 330; SM4500-Cl^-
Chlorine, Residual, Total	Wastewater	500-mL glass or polyethylene bottles	NA; analyze immediately.	None.	15 minutes	SM4500-Cl^-
Coliform, Fecal	Drinking Water	120-mL borosilicate glass or plastic bottles, pre-sterilized plastic bags	If residual chlorine is present, add 0.008% $Na_2S_2O_3$. Cool to < 10°C	Leave ample air space in the bottle (at least 2.5 cm).	6 hours	SM9221, 9222

Parameter	Matrix	Sample Containers *(Note 2)*	Preservation	Filling Instructions	Holding Time	Method *(Note 3)*
Coliform, Fecal	Surface water and Wastewater	120-mL glass or plastic bottles, pre-sterilized plastic bags	If residual chlorine is present, add 0.008% $Na_2S_2O_3$. Cool to < 10°C.	Leave ample air space in the bottle (at least 2.5 cm).	6 hours	SM9221, 9222
Coliform, Total	Drinking Water	120-mL glass or plastic bottles or pre-sterilized plastic bags	If residual chlorine is present, add 0.008% $Na_2S_2O_3$. Cool to ≤ 10°C.	Leave ample air space in the bottle (at least 2.5 cm).	6 hours	SM9221, 9222, 9223
Coliform, Total	Surface water, Storm water	120-mL glass or plastic bottles or pre-sterilized plastic bags	If residual chlorine is present, add 0.008% $Na_2S_2O_3$. Cool to < 10°C.	Leave ample air space in the bottle (at least 2.5 cm).	6 hours	SM9221, 9222
Conductivity (Specific Conductance)	Drinking Water	500-mL glass or polyethylene bottles	Cool to ≤ 6°C.	Fill to neck of bottle.	28 days	SM2510
Conductivity (Specific Conductance)	Groundwater	100-mL plastic and glass containers	None required.	None.	Analyze immediately	SW-846 Method 9050
Corrosivity	Solid and Liquid Waste	1-L polyethylene jar	None required.	Fill per sampling plan.	None listed	SW-846 Method 1110
Cyanide	Drinking Water	1-L glass or polyethylene bottles	NaOH to pH > 12. Cool to ≤ 6°C. If residual chlorine is present, add small amounts of $Na_2S_2O_3$ solution (0.02 g/L) until oxidizers are neutralized. If other oxidizing agents are suspected, refer to Method 9010C for preservation.	Fill to neck of bottle.	14 days	EPA 335; SM4500-CN^-

Parameter	Matrix	Sample Containers *(Note 2)*	Preservation	Filling Instructions	Holding Time	Method *(Note 3)*
Cyanide	Groundwater, Other aqueous waste	1-L glass or polyethylene bottles	50%NaOH to pH >12. If oxidizing agent is present, add 0.06 g ascorbic acid per L. Cool to ≤ 6°C.	Fill to neck of bottle.	14 days	SW-846 Method 9010, 9012, 9213
Cyanide	Solid and other non-aqueous	100 g in a glass jar	Cool to ≤ 6°C.	None.	14 days	SW-846 Method 9013
Cyanide	Storm water, Wastewater	1-L glass or polyethylene bottles	50% NaOH to pH >12. If an oxidant is present, add appropriate reducing agent as applicable to the method. Cool to ≤ 6°C. If other oxidizing agents are suspected, refer to Method 9010C for preservation.	Fill to neck of bottle.	14 days (48 hours if not treated for reducing agents)	EPA 335; SM4500-CN^-
Dioxins and Furans (PCDDs, PCDFs)	Groundwater	4 x 1-L amber glass bottles with Teflon®-lined lids	Cool to ≤ 6°C. Keep away from light. If chlorine is present, add 0.008% $Na_2S_2O_3$. If pH is greater than 9, adjust to pH 7-9 with sulfuric acid.	Fill to neck of bottle.	Extract within 30 days; analyze within 45 days of extraction	SW-846 Methods 8280, 8290
Dioxins and Furans (PCDDs, PCDFs)	Sediment, Soils, and Sludges	250-mL wide mouth glass containers with Teflon® lined lids	Cool to ≤ 6°C and keep in the dark.	Fill to neck of bottle.	Extract within 30 days; analyze within 45 days of extraction	SW-846 Methods 8280, 8290

Parameter	Matrix	Sample Containers *(Note 2)*	Preservation	Filling Instructions	Holding Time	Method *(Note 3)*
Dioxins and Furans (PCDDs, PCDFs)	Wastewater	4 x 1-L amber glass bottles with Teflon® lined lids	Cool to ≤ 6°C. Keep away from light. If chlorine is present, add 0.008% $Na_2S_2O_3$. If pH is greater than 9, adjust to pH 7-9 with H_2SO_4.	Fill to neck of bottle.	1 year	EPA 1613B
DBPs (Bromate)	Drinking Water	40-mL amber glass vials	EDA to produce 50 mg/L in sample. Store at ≤ 6°C in the dark.	Fill completely, no headspace.	28 days	EPA 300, 317, 326
DBPs (Chlorite)	Drinking Water	40-mL amber glass vials	EDA to produce 50 mg/L in sample. Store at ≤ 6°C in the dark.	Fill completely, no headspace.	14 days (must arrive at the laboratory w/in 48 hours of collection at 6°C or less)	EPA 300, 317, 326
DBPs (HAA5)	Drinking Water	120-mL amber glass vials with TFE-lined caps	Crystalline or aqueous NH_4Cl to produce 100 mg/L in sample. Store at 4°C in the dark.	Fill completely, no headspace.	28 days	EPA 552; SM6251
DBPs(Trihalomethanes)	Drinking Water	2x 60-mL glass vials with Teflon® faced silicone septum	Cool to ≤ 6°C. Samples must contain either 100 mg/L ammonium chloride or $Na_2S_2O_3$ as a dechlorinating agent. Refer to selected method for preservation requirements.	Fill completely, no headspace.	28 days	EPA 551, 502, 524
Dissolved Oxygen, Probe	Groundwater, Surface water and Wastewater	300-mL glass stoppered BOD bottles	None required.	Fill to neck of bottle with minimal aeration.	15 minutes	SM4500-O

Parameter	Matrix	Sample Containers *(Note 2)*	Preservation	Filling Instructions	Holding Time	Method *(Note 3)*
Fluoride	Drinking Water	100-mL polyethylene	None required.	Fill to neck of bottle.	28 days	EPA 300, SM4110, SM4500-F^-
Fluoride	Wastewater	100-mL polyethylene	None required.	Fill to neck of bottle.	28 days	EPA 300, SM4110, SM4500-F^-
Fluoride	Groundwater, Other aqueous waste	300-mL polyethylene	Cool to ≤ 6°C.	Fill to neck of bottle.	28 days	SW-846 Method 6500, 9056, 9214
Hardness	Drinking Water	100-mL glass or polyethy-lene bottles	HNO_3 or H_2SO_4 to pH < 2; Cool to ≤ 6°C.	Fill to neck of bottle.	6 months	EPA 130
Hardness	Wastewater, Surface water	100-mL glass or polyethy-lene bottles	HNO_3 or H_2SO_4 to pH < 2; Cool to ≤ 6°C.	Fill to neck of bottle.	6 months	EPA 130; SM2340
Herbicides	Sediment, Soils, and sludges, Other non-Aqueous, Solid Waste (concentrated)	250-mL wide mouth glass container with Teflon®-lined lid	Cool to ≤ 6°C.	Fill to neck of bottle.	Extract within 14 days; ana-lyze within 40 days of extraction	SW-846 Methods 8151, 8321
Herbicides	Groundwater, Other aqueous waste	4 x 1-L amber glass bottles with Tef-lon®- lined lids	Cool to ≤ 6°C. Keep away from light. If chlorine is present, add 3mL 10% $Na_2S_2O_3$ per gallon.	Fill to neck of bottle.	Extract within 7 days; ana-lyze within 40 days of extraction	SW-846 Methods 8151, 8321
Herbicides, TCLP extract *(Note 7)*	Solid Waste	Three 1-L wide mouth amber glass bottles with Teflon® - lined lids	Cool to ≤ 6°C. Keep away from light. If chlorine is present, add 3mL 10% $Na_2S_2O_3$ per gallon.	Fill to neck of bottle.	14 days from field collec-tion to TCLP extraction; 7 days from TCLP to preparative extraction; analyze within 40 days of preparative extraction	SW-846 Methods 1311, 8151, 8321

Parameter	Matrix	Sample Containers *(Note 2)*	Preservation	Filling Instructions	Holding Time	Method *(Note 3)*
Ignitability	Solid and Liquid Waste	250-mL amber wide mouth glass jar or wide mouth polyethylene bottle	None listed. Review sampling plan for non-aqueous wastes.	Fill with no headspace when volatiles are suspected. Check sampling plan.	Not established	SW-846 Method 1010, 1020, 1030; ASTM D-93-79, D-93-80, D3278-78
Metals (Lead and Copper)	Drinking Water	1-L certified metal-free glass or polyethylene bottles	HNO_3 to pH < 2.	Fill to neck of bottle.	6 months	EPA 200, SM3113
Metals (Lead and Copper)	Groundwater, Other aqueous waste	1-L certified metal-free glass or polyethylene bottles	HNO_3 to pH < 2.	Fill to neck of bottle.	6 months	SW-846 Methods 6010, 6020, 6200, 6800, 7000, 7010
Metals (Lead and Copper)	Solid waste	250-mL glass jar	None required.	Fill to neck of bottle.	6 months	SW-846 Methods 6010, 6020, 6200, 6800, 7000, 7010
Metals (Lead and Copper)	Wastewater	1-L certified metal-free glass or polyethylene bottles	HNO_3 to pH < 2.	Fill to neck of bottle.	6 months	SM3111; EPA 200; SM3113, SM3120
Metals, Calcium	Drinking Water	1-L certified metal-free glass or polyethylene bottles	HNO_3 to pH < 2.	Fill to neck of bottle.	6 months	EPA 200, SM3500-Ca, SM3111; SM3120
Metals, Calcium	Wastewater	1-L certified metal-free glass or polyethylene bottles	HNO_3 to pH < 2.	Fill to neck of bottle.	6 months	SM3111, SM3120, SM3500-Ca
Metals, Calcium	Groundwater, Other aqueous waste	1-L certified metal-free glass or polyethylene bottles	HNO_3 to pH < 2.	Fill to neck of bottle.	6 months	SW-846 Method 6010, 6020, 6200, 6800, 7000

Parameter	Matrix	Sample Containers *(Note 2)*	Preservation	Filling Instructions	Holding Time	Method *(Note 3)*
Metals, Calcium	Solid waste	250-mL certified metal-free glass or polyethylene bottles	None required.	Fill to neck of bottle.	6 months	SW-846 Method 6010, 6020, 6200, 6800, 7000
Metals, Dissolved	Groundwater	1-L certified metal-free glass or polyethylene bottles	Filter through 0.45-µm filter. HNO_3 to pH < 2.	Fill to neck of bottle.	6 months	SW-846 Method 6010, 6020, 7000, 7010
Metals, Dissolved	Stormwater and Wastewater	1-L certified metal-free glass or polyethylene bottles	Filter through 0.45-µm filter. HNO_3 to pH < 2.	Fill to neck of bottle.	6 months	EPA 200; SM3113, SM3120
Metals, Hexavalent Chromium (Cr^{+6})	Groundwater, Other aqueous waste	500-mL glass or polyethylene bottles	Cool to ≤ 6°C.	Fill to neck of bottle.	24 hours	SW-846 Methods 6800, 7195, 7196, 7197, 7198, 7199
Metals, Hexavalent Chromium (Cr^{+6})	Soils and Sludges	250-mL glass jar	Cool to ≤ 6°C.	Fill to neck of bottle.	30 days	SW-846 Methods 6800, 7195, 7196, 7197, 7198, 7199
Metals, Hexavalent Chromium (Cr^{+6})	Wastewater	1-L certified metal-free glass or polyethylene bottles	NaOH to pH of 9.3-9.7; Cool to ≤ 6°C.	Fill to neck of bottle.	28 days	EPA 218; SM3111C, SM3500-Cr
Metals, Mercury	Drinking Water	250-mL certified metal-free glass or polyethylene bottles	HNO_3 to pH < 2. Unpreserved samples may be sent to the laboratory within 2 weeks, then acid preserved and held 16 hours before analysis.	Fill to neck of bottle.	28 days	EPA 245; SM3112
Metals, Mercury	Groundwater, Other aqueous waste	500-mL glass or polyethylene bottles	HNO_3 to pH < 2.	Fill to neck of bottle.	28 days	SW-846 Method 7470

Parameter	Matrix	Sample Containers *(Note 2)*	Preservation	Filling Instructions	Holding Time	Method *(Note 3)*
Metals, Mercury	Sediment, Solid, Semi-solid waste	250-mL glass jar	Cool to ≤ 6°C	Fill to neck of bottle.	28 days	SW-846 Methods 7470, 7471, 7474
Metals, Mercury	Wastewater and Storm water	500-mL certified metal-free glass or polyethylene bottles	HNO_3 to pH < 2. Unpreserved samples may be sent to the laboratory within 2 weeks, then acid preserved and held 16 hours before analysis.	Fill to neck of bottle.	28 days	EPA 245; SM3112 (CVAA methods)
Metals, Primary (As, Sb, Ba, Be, Cd, Cr, Ni, Tl, Se)	Drinking Water	1-L certified metal-free glass or polyethylene bottles	HNO_3 to pH < 2. Unpreserved samples may be sent to the laboratory within 2 weeks, then acid preserved and held 16 hours before analysis.	Fill to neck of bottle.	6 months	EPA 200
Metals, Secondary (Al, Fe, Mn, Ag, Zn)	Drinking Water	1-L certified metal-free glass or polyethylene bottles	HNO_3 to pH < 2. Unpreserved samples may be sent to the laboratory within 2 weeks, then acid preserved and held 16 hours before analysis.	Fill to neck of bottle.	6 months	EPA 200; SM3120

Parameter	Matrix	Sample Containers *(Note 2)*	Preservation	Filling Instructions	Holding Time	Method *(Note 3)*
Metals, TCLP extract *(Note 7)*	Solid Waste	Three 1-L wide mouth glass bottles	Cool to ≤ 6°C. HNO_3 to pH < 2.	Fill to neck of bottle.	Metals: 6 months from field collection to TCLP extraction; 6 months from TCLP extraction to analysis: Mercury: 28 days from field collection to TCLP extraction; 28 days to analysis	SW-846 Method 1311, 6010, 6020
Metals, Total	Storm water, Surface water, and Wastewater	1-L certified metal-free glass or polyethylene bottles	HNO_3 to pH < 2.	Fill to neck of bottle.	6 months	EPA 200; SM3111; SM3113; SM3120
Metals, Total	Sediment, Soils and Sludges	250-mL wide mouth glass or polyethylene jar	None required.	Fill to neck of bottle.	6 months	SW-846 Methods 6010, 6020
Metals, Total	Groundwater, Other aqueous waste	1-L glass or polyethylene bottles	HNO_3 to pH < 2.	Fill to neck of bottle.	6 months	SW-846 Methods 6010, 6020
Nitrate	Drinking Water	100-mL glass or polyethylene	Cool to ≤6°C.	Fill to neck of bottle.	48 hours	EPA 300; SM4110, SM4500-NO_3^-
Nitrate	Wastewater, Surface water, Storm water	100-mL glass or polyethylene	Cool to ≤ 6°C.	Fill to neck of bottle.	48 hours	EPA 300; EPA 352; SM4110; SM4500-NO_3^-
Nitrate	Groundwater, Other aqueous waste	1-L Teflon®, plastic, glass	Cool to ≤ 6°C.	Fill to neck of bottle.	48 hours	SW-846 Method 6500, 9056, 9210
Nitrite	Drinking Water	100-mL glass or polyethylene	Cool to ≤ 6°C.	Fill to neck of bottle.	48 hours	EPA 300; SM4110, 4500-NO_2^-; SM4500-NO_3^-

Parameter	Matrix	Sample Containers *(Note 2)*	Preservation	Filling Instructions	Holding Time	Method *(Note 3)*
Nitrite	Wastewater	100-mL glass or polyethylene	Cool to ≤ 6°C.	Fill to neck of bottle.	48 hours	EPA 300; SM4110, SM4500-NO_2^-; SM4500-NO_3^-
Nitrite	Groundwater, Other aqueous waste	100-mL glass or polyethylene	Cool to ≤ 6°C.	Fill to neck of bottle.	48 hours	SW-846 Method 9056, 9216
Nitroaromatics and Nitrosamines (Explosives)	Wastewater	1-L amber or foil wrapped glass bottles with TFE lined cap	Cool to ≤ 6°C; if residual chlorine present add 0.008% $Na_2S_2O_3$. Store in dark	Fill to neck of bottle.	Extract within 7 days; analyze within 40 days of extraction	EPA 625, SM6410
Nitroaromatics and Nitrosamines (Explosives)	Groundwater	4 x 1-L amber glass bottles with Teflon lined screw cap	Cool to ≤ 6°C; if residual chlorine is present, add 0.008% $Na_2S_2O_3$. Store in dark.	Fill to neck of bottle.	Extract within 7 days; analyze within 40 days of extraction	SW-846 Methods 8270, 8330, 8091
Nitroaromatics and Nitrosamines (Explosives)	Concentrated Waste Samples, Soils, and Sediments	250-mL amber wide mouth glass with Teflon®-lined lid	Store in the dark at ≤6°C.	Fill to neck of bottle.	Extract within 14 days; analyze within 40 days of extraction	SW-846 Methods 8270, 8330, 8091
Oil and Grease as Hexane Extractable Material	Soils and Sludges	250-mL wide mouth glass container fitted with a TFE-lined screw cap	HCl to pH < 2 for samples with aqueous layers. Cool to ≤ 6°C.	Fill to neck of bottle.	28 days	SW-846 Method 9071
Oil and Grease as Hexane Extractable Material	Surface water, Storm water, Wastewater	1-L wide mouth glass container fitted with a Teflon®-lined cap	H_2SO_4 or HCl to pH < 2. Cool to ≤ 6°C.	Fill to neck of bottle.	28 days	SM5520, EPA 1664
Orthophosphate	Drinking Water	100-mL glass or polyethylene bottles	H_2SO_4 to pH < 2. Cool to ≤ 6°C.	Fill to neck of bottle.	28 days	EPA Method 365

Parameter	Matrix	Sample Containers *(Note 2)*	Preservation	Filling Instructions	Holding Time	Method *(Note 3)*
Orthophosphate	Drinking Water	100-mL glass or polyethylene bottles	Cool to ≤ 6°C.	Fill to neck of bottle.	Filter within 15 minutes. 48 hours	EPA Method 300; SM4110; SM4500-P
Orthophosphate	Surface water, Wastewater	100-mL glass or polyethylene bottles	Cool to ≤ 6°C.	Fill to neck of bottle.	Filter within 15 minutes. 48 hours	EPA 365, EPA 300; SM4110; SM4500-P
PCBs	Drinking Water	4 x 1-L amber glass bottles with Teflon®-lined lids	If chlorine is present, first add 50 mg/L of sodium sulfite. Adjust the sample to pH < 2 by adding 6N HCl. Cool to ≤ 6°C.	Fill to neck of bottle.	Extract within 1 year; analyze within 1 year of extraction	EPA 508, 525
PCBs	Groundwater, Other aqueous waste	4 x 1-L amber glass bottles with Teflon®-lined lids	Cool to ≤ 6°C. Keep away from light. If chlorine is present, add 3mL 10% $Na_2S_2O_3$ per gallon.	Fill to neck of bottle.	Extract within 1 year; analyze within 1 year of extraction	SW-846 Method 8082
PCBs	Sediment, Soils and Sludges, and other non-aqueous	250-mL wide-mouth glass container with Teflon®-lined lid	Cool to ≤ 6°C. Keep away from light.	Fill to neck of bottle.	Extract within 1 year; analyze within 1 year of extraction	SW-846 Method 8082
PCBs	Wipe Samples	250-mL wide-mouth glass container with Teflon®-lined lid	Cool to ≤ 6°C.	One wipe per jar.	Not established	SW-846 Method 3500, 3540, 3550, 8082
PCBs	Wastewater	1-L amber glass bottles fitted with Teflon®-lined screw cap	Cool to ≤ 6°C, if residual chlorine present add 0.008% $Na_2S_2O_3$.	Fill to neck of bottle.	Extract within 1 year; analyze within 1 year of extraction	EPA 608, 625, SM6410

Parameter	Matrix	Sample Containers *(Note 2)*	Preservation	Filling Instructions	Holding Time	Method *(Note 3)*
PCBs (screening)	Drinking Water	2 x 1-L amber glass bottles	$HgCl_2$ to 10 mg/L. If chlorine is present, add 0.008% $Na_2S_2O_3$. Seal bottle and shake vigo-rously for 1 minute. Cool to ≤ 6°C.	Fill to neck of bottle.	Extract within 1year; analyze within 1 year0 days of extraction	EPA 508
Pesticides (Organochloral)	Drinking Water	2x 1-L amber glass bottles	Residual chlorine in the sample should be reduced by adding 50 mg/L of sodium sulfite. Adjust the sample to pH < 2 by adding 6N HCl. Cool to ≤ 6°C.	Fill to neck of bottle.	Extract within 14 days; ana-lyze within 40 days of extraction	EPA 508
Pesticides (Organochloral)	Groundwater	Four 1-L amber glass bottles with Teflon®-lined lids	Cool to ≤ 6°C.	Fill to neck of bottle.	Extract within 7 days; ana-lyze within 40 days of extraction	SW-846 Method 8081, 8085
Pesticides (Organochloral)	Sediment, Soils and Sludges, Other Non-Aqueous	250-mL wide mouth glass container with Teflon®-lined lid	Cool to ≤ 6°C.	Fill to neck of bottle.	Extract within 14 days; ana-lyze within 40 days of extraction	SW-846 Method 8081, 8085
Pesticides (Organochloral)	Wastewater, Surface water, Storm water	1-L glass bottles with Teflon®-lined cap	NaOH or H_2SO_4 to pH 5-9; Cool to ≤ 6°C *(Note 5)*.	Fill to neck of bottle.	Extract within 7 days; ana-lyze within 40 days of extraction	SM6630; EPA 608

Parameter	Matrix	Sample Containers *(Note 2)*	Preservation	Filling Instructions	Holding Time	Method *(Note 3)*
Pesticides (Organophosphorus)	Drinking Water	1-L glass containers	If residual chlorine is present, add 0.008% $Na_2S_2O_3$. Seal bottle and shake for 1 min. Cool to ≤ 6°C. Keep away from light.	Fill to neck of bottle.	Extract within 14 days; analyze within 14 days of extraction	EPA 507
Pesticides (Organophosphorus)	Groundwater	Four 1-L amber glass bottles with Teflon®-lined lids	Cool to ≤ 6°C. Keep away from light. If chlorine is present, add 3mL 10% $Na_2S_2O_3$ per gallon.	Fill to neck of bottle.	Extract within 7 days; analyze within 40 days of extraction	SW-846 Method 8085, 8141
Pesticides, TCLP extract *(Note 7)*	Solid Waste	Three 1-L wide mouth amber glass bottles with Teflon®-lined lids	Cool to ≤ 6°C. Keep away from light. If chlorine is present, add 3mL 10% $Na_2S_2O_3$ per gallon.	Fill to neck of bottle.	14 days from field collection to TCLP extraction; 7 days from TCLP to preparative extraction; analyze within 40 days of preparative extraction	SW-846 Method 1311, 8141, 8085
pH	Drinking Water	Not applicable - field measurements	None required.	None.	Analyze in field	EPA 150, SM4500-H^+
pH	Groundwater, Other aqueous waste	50-mL glass or polyethylene bottles	None required.	None.	Analyze immediately	SW-846 Method 9040C, 9045
pH	Soils and Sludges	250-mL amber wide mouth glass jar or wide mouth polyethylene bottles	None required.	None.	Analyze immediately	SW-846 Method 9040, 9045
pH	Storm water, Surface water, Wastewater	50-mL glass or polyethylene bottles	None required.	None.	Analyze within 15 minutes	EPA 150; SM4500-H^+

Parameter	Matrix	Sample Containers *(Note 2)*	Preservation	Filling Instructions	Holding Time	Method *(Note 3)*
Phosphorus	Surface water, Storm water	100-mL glass or polyethylene bottles	H_2SO_4 to pH < 2. Cool to ≤ 6°C.	Fill to neck of bottle.	28 days	EPA 365; SM4500-P
Polynuclear Aromatic Hydrocarbons (PAHs)	Groundwater	4 x 1-L amber glass bottles with Teflon®-lined lids	Cool to ≤ 6°C. Keep away from light. If chlorine is present, add 3mL 10% $Na_2S_2O_3$ per gallon.	Fill to neck of bottle.	Extract within 7 days; analyze within 40 days of extraction	SW-846 Method 8100, 8270, 8410
Polynuclear Aromatic Hydrocarbons (PAHs)	Wastewater	4 x 1-L glass bottles, amber with TFE-lined cap	If residual chlorine is present, add 0.008% $Na_2S_2O_3$. Cool to ≤ 6°C.	Fill to neck of bottle.	Extract within 7 days; analyze within 40 days of extraction	EPA 610, 625, 1625; SM6410, 6440
Radiological Tests (alpha, beta, radium)	Groundwater	1-L glass or polyethylene bottles	HNO_3 to pH < 2.	Fill to neck of bottle.	6 months	SW-846 Methods 9310, 9315, 9320
Radiological Tests (alpha, beta, radium)	Drinking Water	1-L glass or polyethylene bottles	HNO_3 to pH < 2.	Fill to neck of bottle.	6 months	EPA 900 (gross alpha, beta); EPA 903 (radium-226), EPA 904 (radium-228)
Radiological Tests (alpha, beta, radium)	Drinking Water	1-L glass or polyethylene bottles	HNO_3 to pH < 2.	Fill to neck of bottle.	6 months	SM7110 (alpha, beta), C (gross alpha); SM7500-Ra B, C (radium-226), D (radium-228)
Reactivity (releasable cyanide) *(Note 6)*	Solid Waste	Two 250-mL amber wide mouth glass jars or wide mouth polyethylene bottles	50% NaOH to pH >12. Store at ≤ 6°C.	Fill with no headspace and per sampling plan.	Analyze as soon as possible	SW-846 Method 9010, 9012, 9013, 9014 for cyanide

Parameter	Matrix	Sample Containers *(Note 2)*	Preservation	Filling Instructions	Holding Time	Method *(Note 3)*
Reactivity (releasable sulfide) *(Note 6)*	Solid Waste	Two 250-mL amber wide mouth glass jars or wide mouth polyethylene bottles	Fill the surface of the solid with 2N zinc acetate until moistened. Store at ≤ 6°C.	Fill with no headspace and per sampling plan.	Analyze as soon as possible	SW-846 Method 9030, 9031, 9215 for sulfides
Salinity	Surface water	Not applicable - field measurements	None required.	None.	Analyze in field	EPA 430/9-86-004
Semivolatile Organics	Drinking Water	Two 1-L amber glass bottles	Residual chlorine should be reduced at the sampling site by addition of 40-50 mg of sodium sulfite. The sample pH is adjusted to < 2 with 6N HCl. Cool to ≤ 6°C.	Fill to neck of bottle.	Extract within 14 days; analyze within 30 days of extraction	EPA 525
Semivolatile Organics	Groundwater, Other aqueous waste	Four 1-L amber glass bottles sealed vials equipped with unpierced Teflon®-lined septa	Cool to ≤ 6°C. Keep away from light. If chlorine is present, add 3mL 10% $Na_2S_2O_3$ per gallon.	Fill to neck of bottle.	Extract within 7 days; analyze within 40 days of extraction	SW-846 Method 8270
Semivolatile Organics	Soils and Sludges, Sediment, and Other Non-Aqueous	250-mL wide mouth glass container with Teflon® lid	Cool to ≤ 6°C.	Fill to neck of bottle.	Extract within 14 days; analyze within 40 days of extraction	SW-846 Method 8270
Semivolatile Organics	Storm water	1-L amber glass bottles with Teflon®-lined caps	If chlorine is present, first add 0.008% $Na_2S_2O_3$. Cool to ≤ 6°C and keep in the dark.	Fill to neck of bottle.	Extract within 7 days; analyze within 40 days of extraction	EPA 625, 1625; SM6410
Semivolatile Organics	Concentrated Waste Samples	125-mL wide mouth glass container with Teflon® lid	None required.	Fill to neck of bottle.	Extract within 14 days; analyze within 40 days of extraction	SW-846 Method 8270

Parameter	Matrix	Sample Containers *(Note 2)*	Preservation	Filling Instructions	Holding Time	Method *(Note 3)*
Semivolatile Organics, TCLP extract *(Note 7)*	Solid Waste	Three 1-L wide mouth amber glass bottles with Teflon®-lined lids	Cool to ≤ 6°C. Keep away from light.	Fill to neck of bottle.	14 days from field collection to TCLP extraction; 7 days from TCLP to preparative extraction; analyze within 40 days of preparative extraction.	SW-846 Method 1311, 8270
Silica	Drinking Water	200-mL polyethylene	Cool to ≤ 6°C.	Fill to neck of bottle.	28 days	SM3120, SM4500-Si, SM4500 SiO_2
Silica	Wastewater	200-mL polyethylene	Cool to ≤ 6°C.	Fill to neck of bottle.	28 days	SM3120, SM4500-Si, SM4500 SiO_2
Sulfate	Drinking Water	100-mL glass or polyethylene bottles	Cool to ≤ 6°C.	Fill to neck of bottle.	28 days	EPA 300, 375; SM4110, SM4500-SO_4^{2-}
Sulfate	Aqueous Waste	100-mL glass or polyethylene bottles	Cool to ≤ 6°C.	Fill to neck of bottle.	28 days	SW-846 Method 6500, 9035, 9036, 9038, 9056
Sulfate	Wastewater	100-mL glass or polyethylene bottles	Cool to ≤ 6°C.	Fill to neck of bottle.	28 days	EPA 300, EPA 375; SM4110, SM4500-SO_4^{2-}
Sulfide	Drinking Water	500-mL glass or polyethylene bottles	None specified.	Fill to neck of bottle with minimal aeration.	Immediately	EPA 376
Sulfide	Solid Waste	500-mL glass or polyethylene bottles	Fill the surface of the solid with 2N zinc acetate until moistened. Store at ≤ 6°C.	Fill to neck of bottle with minimal aeration	7 days	SW-846 Method 9030, 9031, 9034, 9215

Parameter	Matrix	Sample Containers *(Note 2)*	Preservation	Filling Instructions	Holding Time	Method *(Note 3)*
Sulfide	Aqueous Waste	500-mL glass or polyethylene bottles	Use four drops of 2N zinc acetate solution per 100-mL of sample. Adjust the pH to greater than 9 with 6N NaOH solution. Store headspace free at ≤ 6°C.	Fill to neck of bottle with minimal aeration.	7 days	SW-846 Method 9030, 9031, 9034, 9215
Sulfide	Wastewater	100-mL glass or polyethylene bottles	Add 4 drops of 2N zinc acetate per 100-mL of sample; Add NaOH until pH > 9. Store at ≤ 6°C.	Fill to neck of bottle with minimal aeration.	7 days	SM4500 S^{2-}
Sulfite	Drinking Water	500-mL glass bottles	Sulfide may be removed by adding 0.5 g of zinc acetate. See method for additional steps to take for interferences.	Fill to neck of bottle.	Not specified	EPA 377
Sulfite	Wastewater	100-mL glass or polyethylene bottles	Analyze immediately or 1mL EDTA and cool to < 50°C.	Fill to neck of bottle.	Immediately (within 15 minutes)	SM4500-SO_3^{2-}
Temperature	Drinking Water, Storm water, Wastewater, Groundwater	Not applicable - field measurements	None required.	None.	Analyze immediately	SM2550
Total Kjeldahl Nitrogen	Surface water	500-mL glass or polyethylene bottles	H_2SO_4 to pH < 2; Cool to ≤ 6°C.	Fill to neck of bottle.	28 days	EPA 351; SM4500 NH_3, SM4500-N org
Total Organic Carbon (TOC)	Groundwater	1-L glass bottles with TFE-backed septa	H_2SO_4 to pH < 2; Cool to ≤ 6°C. Protect from sunlight.	Fill to neck of bottle.	28 days	SW-846 Method 9060

Parameter	Matrix	Sample Containers *(Note 2)*	Preservation	Filling Instructions	Holding Time	Method *(Note 3)*
TOC	Wastewater	100-mL glass bottles with TFE-backed septa	H_2SO_4 to pH < 2; Cool to ≤ 6°C. Protect from sunlight.	Fill to neck of bottle.	28 days	SM5310
Total Organic Halides (TOX)	Groundwater	250-mL amber Teflon Lined wide mouth glass jar	H_2SO_4 to pH < 2; Cool to ≤ 6°C.	Fill complete-ly, no head-space.	14 days	SW-846 Method 9020
TOX	Wastewater	Amber glass with Teflon-lined caps	H_2SO_4 to pH < 2; Cool to ≤ 6°C.	Fill complete-ly, no head-space.	14 days	EPA 450; SM5320
Total Petroleum Hydrocarbons (TPH)	Soils and Sludges	250-mL wide mouth glass container	Cool to ≤ 6°C.	Fill complete-ly, no head-space.	Per sampling plan and state or local requirements	SW-846 Methods 3560, 8440, 4030, and 9074
Total Petroleum Hydrocarbons as Diesel Range Organics (DRO)	Soils and Sludges	250-mL wide mouth glass container	Cool to ≤ 6°C. See method for specific pre-servation criteria.	Fill complete-ly, no head-space.	Extract within 14 days; ana-lyze within 40 days of extraction	SW-846, Method 8015
Total Petroleum Hydrocarbons as Gasoline Range Organics (GRO)	Soils and Sludges	250-mL wide mouth glass container	Cool to ≤ 6°C. See method for specific pre-servation criteria.	Fill complete-ly, no head-space.	14 days	SW-846, Method 8015
Total Solids	Surface water, Wastewater	100-mL glass or polyethy-lene bottles	Cool to ≤ 6°C.	Fill to neck of bottle.	7 days	SM2540
Total Suspended Solids	Storm water, Surface water, Wastewater	200-mL glass or polyethy-lene bottles	Cool to ≤ 6°C.	Fill to neck of bottle.	7 days	SM2540
Trihalomethanes (see DPBs)						
Turbidity	Drinking Water	1-L glass or polyethylene	Cool to ≤ 6°C.	Fill to neck of bottle.	48 hours	EPA 180; SM2130
Turbidity	Wastewater	100-mL glass or polyethy-lene	Cool to ≤ 6°C.	Fill to neck of bottle.	48 hours	EPA 180; SM2130

Parameter	Matrix	Sample Containers *(Note 2)*	Preservation	Filling Instructions	Holding Time	Method *(Note 3)*
Volatile Organic Compounds (VOCs)	Drinking Water	40-120-mL screw cap vials equipped with a Teflon® faced silicone septum– collect duplicates *(Note 4)*	HCl to pH < 2. Cool to ≤ 6°C. If chlorine is present, add 25mg ascorbic acid prior to HCl addition.	Fill completely, no headspace.	14 days	EPA 502 (GC), 524 (GC/MS), For specific volatile compounds review method requirements. By GC
VOCs	Groundwater	2 x 40-mL vials with Teflon® septum lined caps *(Note 4)*	HCl to pH < 2. Cool to ≤ 6°C. If chlorine is present, collect samples in 125-mL container with 4 drops of 10% $Na_2S_2O_3$ solution prior to HCl addition.	Fill completely, no headspace.	14 days	SW-846 Method 8260
VOCs	Wastewater and Storm water	40-mL glass VOA vial sealed with a septum *(Note 4)*	HCl or H_2SO_4 to pH < 2. Cool to ≤ 6°C. Presence of chlorine requires proper addition of $Na_2S_2O_3$ prior to adding acid.	Fill completely, no headspace.	14 days	EPA 624, 1624, 601; SM6200; SM6210, SM6230
VOCs	Concentrated Waste Samples	125-mL wide mouth glass container sealed with a septum *(Note 4)*	Cool to ≤ 6°C.	Fill completely, no headspace.	14 days	SW-846 Method 8260
VOCs, TCLP extract *(Note 7)*	Solid Waste	Two 40-mL glass vials *(Note 4)*	Cool to ≤ 6°C; adjust pH to < 2.	Fill completely, no headspace.	14 days from field collection to TCLP extraction; 14 days from TCLP extraction to analysis	SW-846 Method 1311, 8260

Notes:

Note 1. Check with the lab for container and preservative requirements and analytical method(s) to be used prior to sampling. Local or state regulations may supersede these requirements. In addition, sampling interferences, laborato-

ry methods, and known matrix effects may require specific project preservations to be developed. A sampling plan is to be prepared and reviewed with the sampling laboratory and, in some cases, the regulator prior to starting any sampling/testing operation.

Note 2. Additional sample quantities may need to be collected in order to allow for the preparation and analysis of QC samples, such as MS and duplicates.

Note 3. Methods are listed without revision numbers or letters. Test procedures are periodically revised. Check applicable regulations (e.g., 40 CFR Part 136 for Wastewater; Parts 141 and 143 for Drinking Water; Parts 122–270 for Wastes under RCRA, etc.) for updates. State or local regulations should also be reviewed for requirements.

Note 4. VOA vials are to have Teflon®-faced silicone septum caps. 125-mL wide mouth glass containers may be used for high concentration solid and semi-solid samples only. All other jars and bottles are to have Teflon lined caps.

Note 5. Wastewater Pesticides: When single chemical category analytes are to be measured, the table should be followed. When two or more chemical categories are to be measured, cool the sample to ≤6°C, reduce chlorine residual with 0.008% sodium thiosulfate, store in dark, adjust the pH to 6–9, and hold for 7 days before extraction and 40 days after extraction. Only use sodium thiosulfate when chlorine is present. When measuring for benzidine, if 1,2-diphenylhydrazine is suspected, adjust pH to 4.0 +/- 0.2. The pH adjustment may be performed upon receipt at the lab or may be omitted if samples are extracted within 72 hours of collection. For analysis of aldrin, add 0.008% sodium thiosulfate ($Na_2S_2O_3$).

Note 6. Reactivity: Total analysis for cyanide and sulfide may be substituted if allowed in sampling plan. Preservation for total cyanide and sulfide is per Groundwater, Other aqueous waste, Soils, Sludges and Solid Waste found above.

Note 7. TCLP extraction per SW-846 Method 1311; extraction and analysis per determinative method.

Appendix C. Requirements for Collection of Quality Control Samples

Table C-1 specifies the recommended frequency for submitting quality control samples to the laboratory for analysis. The exact number and types of quality control samples is dependent on permit, regulatory and project data requirements. Except for sample containers submitted for MS/MSD lab studies, the laboratory should not be informed which samples are for QC purposes.

Test Samples. Samples collected and analyzed to provide data on the presence of chemicals within a specified sample matrix. A single test sample may require that a number of sample containers be prepared as described in Appendix B.

Field Duplicates. Submitted and analyzed to determine the repeatability of data. Generally, one field duplicate is submitted for each 10 test samples or another frequency based on project statistical design.

Trip Blanks. Trip blanks are VOA vials of ultra-pure water that are prepared and furnished by the laboratory. In general, one trip blank consisting of two VOA vials is included in each shipping container used to ship VOA water samples to check on possible sample contamination during shipment.

Equipment Decontamination Blanks. Submitted to check on the adequacy of field measures used to decontaminate sampling equipment. In general, one equipment decontamination blank is submitted for each type of sampling equipment. In compliance cases, this blank may be collected after field decontamination is performed. This process validates the equipment is cleaned properly between sampling locations.

Field Blanks. Submitted to check on the cleanliness of sample bottles and reagents used to prepare and preserve samples in the field. For volatiles, one field blank is submitted for each day of sampling or one per cooler. In other nonvolatile analytical procedures field blanks may be collected per batch of sample containers and preservatives used.

MS/MSD Samples. MS/MSD samples are prepared and run by the laboratory to verify the effectiveness of sample preparation procedures in measuring the chemicals of interest from the matrix material. In general, one MS/MSD sample is prepared and run by the laboratory for each type of analysis and matrix at a rate of one MS/MSD pair per 20 test samples (minimum one pair per batch of samples). The required frequency of MS/MSD analyses should be specified in the SAP and requested to be the specific matrix sampled.

Water Samples. Additional sample containers of water must be submitted to the lab to provide sufficient sample material for these tests.

Other Sample Material. Generally, the test sample provides sufficient material for the preparation of MS/MSD samples, and no additional sample containers are required by the lab.

Table C-1. Requirements for Quality Control Samples

Drinking Water (SDWA)					
Parameters	**Field Duplicates**	**Trip Blanks**	**Equipment Decontam-ination Blanks**	**Field Blanks**	**MS/MSD Samples**
Residual chlorine, pH, temperature	N.A. – Field test				
Volatile Organic Compounds (VOCs)	None required *(Note 1)*	1 Trip Blank sample consisting of 2 lab filled VOA vials in each shipping container used to ship VOA water samples	*(Note 8)*	1 Field Blank sample consisting of 2 lab filled VOA vials exposed to the atmosphere where samples are collected. *Note 9* may be performed based on data needs	*(Note 4)*
Synthetic Organic Chemicals (Pesticides, Herbicides, PCBs)	None required *(Note 1)*	None	*(Note 8)*	*Note 9* may be performed based on data needs	*(Note 4)*
Metals (Sb, As, Ba, Be, Cd, Hg, Cr, Ni, Tl, Se)	None required *(Note 1)*	None	*(Note 8)*	*Note 9* may be performed based on data needs	*(Note 5)*
Lead and copper	None required *(Note 1)*	None	*(Note 8)*	*Note 9* may be performed based on data needs	*(Note 5)*
Fluoride	None required *(Note 1)*	None	*(Note 8)*	*Note 9* may be performed based on data needs	*(Note 5)*
Silica	None required *(Note 1)*	None	*(Note 8)*	*Note 9* may be performed based on data needs	*(Note 5)*
Orthophosphate	None	None	*(Note 8)*	*Note 9* may be	*(Note 5)*

Drinking Water (SDWA)					
Parameters	**Field Duplicates**	**Trip Blanks**	**Equipment Decontam-ination Blanks**	**Field Blanks**	**MS/MSD Samples**
	required *(Note 1)*			performed based on data needs	
Alkalinity	None required *(Note 1)*	None	*(Note 8)*	*Note 9* may be performed based on data needs	None
Hardness	None required *(Note 1)*	None	*(Note 8)*	*Note 9* may be performed based on data needs	None
Conductivity	None required *(Note 1)*	None	*(Note 8)*	*Note 9* may be performed based on data needs	None
Turbidity	None required *(Note 1)*	None	*(Note 8)*	*Note 9* may be performed based on data needs	None
Asbestos	None required *(Note 1)*	None	*(Note 8)*	*Note 9* may be performed based on data needs	None
Total Coliform	None required *(Note 1)*	None	*(Note 8)*	*Note 9* may be performed based on data needs	None
Nitrate	None required *(Note 1)*	None	*(Note 8)*	*Note 9* may be performed based on data needs	*(Note 5)*
Nitrite	None required *(Note 1)*	None	*(Note 8)*	*Note 9* may be performed based on data needs	*(Note 5)*
Radionuclides	None required *(Note 1)*	None	*(Note 8)*	*Note 9* may be performed based on data needs	None

Table C-1. Requirements for Quality Control Samples *(continued)*

Wastewater NPDES Permit Sampling (CWA) (Check state specific program for QC criteria)					
Parameters	**Field Duplicates**	**Trip Blanks**	**Equipment Decontam-ination Blanks**	**Field Blanks**	**MS/MSD Samples**
Dissolved oxygen	N.A. – Field Test				
Biochemical Oxygen Demand (BOD)	None required *(Note 1)*	None	None *(Note 8)*	*Note 9* may be performed based on data needs	None unless permit specified. One time demonstration of method performance per matrix.
Chemical Oxygen Demand (COD)	None required *(Note 1)*	None	None *(Note 8)*	*Note 9* may be performed based on data needs	None unless permit specified. One time demonstration of method performance per matrix.
Total Organic Carbon (TOC)	None required *(Note 1)*	None	None *(Note 8)*	*Note 9* may be performed based on data needs	None unless permit specified. One time demonstration of method performance per matrix.
Oil and grease	None required *(Note 1)*	None	None *(Note 8)*	*Note 9* may be performed based on data needs	None unless permit specified. One time demonstration of method performance per matrix.
Metals	None required *(Note 1)*	None	None *(Note 8)*	*Note 9* may be performed based on data needs	None unless permit specified. One time demonstration of method performance per matrix.

Table C-1. Requirements for Quality Control Samples *(continued)*

Wastewater NPDES Permit Sampling (CWA) (Check state specific program for QC criteria)					
Parameters	**Field Duplicates**	**Trip Blanks**	**Equipment Decontam-ination Blanks**	**Field Blanks**	**MS/MSD Samples**
Chromium, hexavalent (Cr^{+6})	None required *(Note 1)*	None	None *(Note 8)*	*Note 9* may be performed based on data needs	None unless permit specified. One time demonstration of method performance per matrix.
Pesticides	None required *(Note 1)*	None	None *(Note 8)*	*Note 9* may be performed based on data needs	None unless permit specified. One time demonstration of method performance per matrix.
PCBs	None required *(Note 1)*	None	None *(Note 8)*	*Note 9* may be performed based on data needs	None unless permit specified. One time demonstration of method performance per matrix.

Table C-1. Requirements for Quality Control Samples (continued)

Groundwater (RCRA; SW-846, July, 1992, Rev 1)					
Parameters	**Field Duplicates**	**Trip Blanks**	**Equipment Decontam-ination Blanks**	**Field Blanks**	**MS/MSD Samples**
pH, temperature, conductivity	N.A. – Field test				
Volatile Organics	1 per day per matrix type *(Note 1)*	1 Trip Blank sample consisting of 2 lab filled VOA vials in each shipping container used to ship VOA water samples	1 per day per matrix type *(Note 7)*	*(Note 9)*	1 in 20 *(Note 4)*
Semivolatile Organics	1 per day per matrix type *(Note 1)*	None	1 per day per matrix type *(Note 7)*	*(Note 9)*	1 in 20 *(Note 4)*
Pesticides/PCBs/Herbicides	1 per day per matrix type *(Note 1)*	None	1 per day per matrix type *(Note 7)*	*(Note 9)*	1 in 20 *(Note 4)*
Dioxins and Furans	1 per day per matrix type *(Note 1)*	None	1 per day per matrix type *(Note 7)*	*(Note 9)*	1 in 20 *(Note 4)*
Metals	1 per day per matrix type *(Note 1)*	None	1 per day per matrix type *(Note 7)*	*(Note 9)*	1 in 20 *(Note 5)*
Cyanide	1 per day per matrix type *(Note 1)*	None	None	*(Note 9)*	1 in 20 *(Note 5)*
Total Organic Halides (TOX)	1 per day per matrix type *(Note 1)*	None	None	*(Note 9)*	1 in 20 *(Note 5)*
Radiological Tests	1 per day per matrix type *(Note 1)*	None	None	*(Note 9)*	1 in 20 *(Note 5)*

Table C-1. Requirements for Quality Control Samples (continued)

Other Waters And Non-Aqueous Liquids (RCRA; SW-846, July 1992, Rev 1)					
Parameters	**Field Duplicates**	**Trip Blanks**	**Equipment Decontam-ination Blanks**	**Field Blanks**	**MS/MSD Samples**
Semivolatile Organics	1 per day per matrix type *(Note 1)*	None	1 per day per matrix type *(Note 7)*	*(Note 9)*	1 in 20 *(Note 4)*
Pesticides/PCBs/Herbicides	1 per day per matrix type *(Note 1)*	None	1 per day per matrix type *(Note 7)*	*(Note 9)*	1 in 20 *(Note 4)*
Volatiles Organics	1 per day per matrix type *(Note 1)*	1 Trip Blank Sample consisting of 2 lab filled VOA vials in each shipping container used to ship VOA water samples	1 per day per matrix type *(Note 7)*	*(Note 9)*	1 in 20 *(Note 4)*
Metals, Total	1 per day per matrix type *(Note 1)*	None	1 per day per matrix type *(Note 7)*	*(Note 9)*	1 in 20 *(Note 5)*
Cyanide	1 per day per matrix type *(Note 1)*	None	None	*(Note 9)*	1 in 20 *(Note 5)*
Mercury	1 per day per matrix type *(Note 1)*	None	1 per day per matrix type *(Note 7)*	*(Note 9)*	1 in 20 *(Note 5)*

Table C-1. Requirements for Quality Control Samples (continued)

Soils, Sludges, and Solid Waste (RCRA; SW-846, July 1992, Rev 1)					
Parameters	**Field Duplicates**	**Trip Blanks**	**Equipment Decontam-ination Blanks**	**Field Blanks**	**MS/MSD Samples**
Semivolatile Organics, Pesticides/PCBs/Herbicides	1 per day per matrix type *(Note 2)*	None	1 per day per matrix type *(Note 7)*	*(Note 9)*	1 in 20 *(Note 6)*
Volatile Organics	1 per day per matrix type *(Note 2)*	1 Trip Blank Sample consisting of 1 lab filled clean material per VOA vial in each shipping container used to ship VOA samples	1 per day per matrix type *(Note 7)*	*(Note 9)*	1 in 20 *(Note 6)*
Metals and cyanide	1 per day per matrix type *(Note 2)*	None	1 per day per matrix type *(Note 7)*	*(Note 9)*	1 in 20 *(Note 6)*
PCB Wipe Samples (TSCA)					
Parameters	**Field Duplicates**	**Trip Blanks**	**Equipment Decontam-ination Blanks**	**Field Blanks**	**MS/MSD Samples**
PCBs	Based on sampling design *(Note 3)*	None	1 in 20; minimum one per day.	One per lot of wipes and solvent. *(Note 9)*	1 per lab batch of samples: submit 2 sample containers, each containing an unused wipe sample pad. Specify method for preparing MS/MSD.

Notes:

Field Duplicates

Note 1 Water samples:
For some projects and methods, 1 water sample in 10 may be required.
Prepare a Field Duplicate Sample, minimum one per day per matrix type for RCRA.

Note 2 Soil, sludge and solid waste:
For some methods and projects, 1 sample in 10 of the same matrix type (sand, silt, clay, etc.), may be required.
Prepare a Field Duplicate Sample, minimum one per day per matrix type for RCRA.

Note 3 PCB wipe samples:
For some methods and projects, 1 wipe sample in 10, may be collected as a duplicate wipe sample from an adjacent location on same type of surface;
Minimum one per day per type of surface and lot of wipe material (wood, metal, concrete, etc.).

MS/MSD

Note 4 Water samples for organic analyses:
Collect an additional four sample containers for 1 sample in 20 for each matrix type per method.

Note 5 Water samples for inorganic analysis:
One additional sample container may be required
Test sample should include enough material for lab MS/MSD samples to be run at the rate of 1 per 20 test samples
(Minimum of one MS/MSD per matrix per method or one per batch of samples).

Note 6 Soil, sludge, non-aqueous liquids, solid waste:
One additional sample container may be required
Test Sample may include enough material for lab MS/MSD samples to be run at the rate of 1 per 20 test samples
(Minimum of one MS/MSD per matrix per method or one per batch of samples).

Equipment Decontamination Blanks

Note 7 Submit one per type of analysis for each type of sampling equipment used for each day of sampling and each matrix sampled.
Project specific requirements may eliminate or increase the frequency of equipment decontamination blanks.

Note 8 Not required if sample containers are filled directly from the tap, outfall or are collected with pre-cleaned dedicated sampling equipment.

Field Blanks

Note 9 Submit one per type of analysis for each batch of sample containers and preservatives used.

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Acronyms

40 CFR	Title 40 of the Code of Federal Regulations

A

AA	Atomic Absorption
AFI	Air Force Instruction
AL	Action Level
ANSI	American National Standard Institute
AR	Army Regulation
AR	Arsenic Rule
ARCS	Assessment and Remediation of Contaminated Sediments
ASQ	American Society for Quality
ASTM	American Society for Testing and Materials

B

BAT	Best Available Technology
BCT	Best Conventional Pollution Control Technology
BMP	Best Management Practices
BOD	Biochemical Oxygen Demand
BPT	Best Practicable Control Technology Currently Available
BSAF	Biota-Sediment Accumulation Factor
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene

C

C	Celsius
CAA	Clean Air Act
CAD	Computer Aided Design
CAS	Chemical Abstract Service
CCV	Continuing Calibration Verification
CEM	Continuous Emissions Monitoring
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations

CGP	Construction General Permit
COC	Chain-of-Custody
COD	Chemical Oxygen Demand
COLIWASA	Composite Liquid Waste Sampler
COPC	Contaminants of Potential Concern
COR	Contracting Officer's Representative
CPT	Cone Penetration Testing
CSM	Conceptual Site Model
CVAFS	Cold Vapor Atomic Fluorescence Spectrometry
CWA	Clean Water Act
CWS	Community Water System

D

DBP	Disinfection byproduct
DDBPR	Disinfectants and Disinfectant Byproducts Rule
DENIX	Defense Environmental Network and Information Exchange
DERP	Defense Environmental Restoration Program
DGT	Diffusion Gradients in Thin films
DHC	Dehalococcoides
DNAPL	Dense, Non-Aqueous Phase Liquid
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
DoD	Department of Defense
DODI	DoD Instruction
DON	Department of the Navy
DOT	Department of Transportation
DPD	Diethylphenylenediamine
DPT	Direct Push Technology
DQO	Data Quality Objectives
DTIC	Defense Technical Information Center
DTPA	Diethylenetriaminepentaacetic Acid
DU	Decision Unit

E

EA	Environmental Assessment
EAB	Enhanced Anaerobic Bioremediation
ECD	Electron Capture Detector
ECE	Environmental Compliance Evaluation
EDD	Electronic Data Deliverable
EDTA	Ethylenediaminetetraacetic Acid
EIS	Environmental Impact Statement
ELAP	Environmental Laboratory Accreditation Program
EMR	Electromagnetic Radiation
EMS	Environmental Management System
ENVCAP	Environmental Compliance Assistance Platform
EOD	Explosive Ordnance Disposal
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPTDS	Entry Point to the Distribution System
ESRI	Environmental Systems Research Institute
ESS	Explosives Safety Submission

F

FAA	Federal Aviation Administration
FAR	Federal Acquisitions Requirements
FAS	Ferrous Ammonium Sulfate
FFCA	Federal Facility Compliance Act
FID	Flame Ionization Detector
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FLB/FN	Field Log Book/Field Notes
FONSI	Finding of No Significant Impact
FSP	Field Sampling Plan
FWPCA	Federal Water Pollution Control Act

G

GAC	Granular Activated Carbon

GC	Gas Chromatography
GCP	General Construction Permits
GIS	Geographic Information System
GP	General Storm Water Permit
GPS	Global Positioning System
GWR	Ground Water Rule

H

HAA5	Haloacetic acids
HASP	Health and Safety Plan
HCL	Hydrochloric Acid
HDPE	High-Density Polyethylene
HIS	Hazard Information System
HMIS	Hazardous Materials Identification System
HSWA	Hazardous and Solid Waste Amendments

I

IATA	International Air Transport Association
IC	Ion Chromatograph
ICAO	International Civil Aviation Organization
ICP-AES	Inductively Coupled Plasma-atomic Emission Spectrometry
ICV	Initial Calibration Verification
IDLH	Immediately Dangerous to Life and Health
IDW	Investigation Derived Waste
IEC	International Electrotechnical Commission
IESWTR	Interim Enhanced Surface Water Treatment Rule
IMS	Immunomagnetic Separation
IR	Installation Restoration
ISM	Incremental Sampling Methodology
ISO	International Organization for Standardization
ITRC	Interstate Technology & Regulatory Council

K

KCL	Potassium Chloride

KI	Potassium Iodide
Kow	Octanol-Water Partition Coefficient

L

LCR	Lead and Copper Rule
LCS	Laboratory Control Sample
LNAPL	Light, Non-Aqueous Phase Liquid
LTTD	Low-Temperature Thermal Desorption
LUST	Leaking Underground Storage Tank

M

MARLAP	Multi-Agency Radiological Laboratory Analytical Protocols
MCA	Multichannel Analyzer
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MCO	Marine Corps Order
MCR	Manual Request Change
MDL	Method Detection Limit
METCAL	Metrology and Calibration
MGD	Million Gallons per Day
MIS	Multi-Increment Sampling
MNA	Monitored Natural Attenuation
MQO	Measurement Quality Objective
MS4	Municipal Separate Storm Sewer Systems
MS	Matrix Spike
MSD	Matrix Spike Duplicate
MSDS	Material Safety Data Sheet
MSGP	Multi-Sector General Permit

N

$NaBH_4$	Sodium Borohydride
NAVFAC	Navy Facilities Engineering Command
NAVOSH	Navy Occupational Safety and Health
NCP	National Oil and Hazardous Substances Pollution Contingency Plan

NCWS	Non-Community Water System
NEHC	Navy Environmental Health Center
NELAC	National Environmental Laboratory Accreditation Conference
NELAP	National Environmental Laboratory Accreditation Program
NEPA	National Environmental Policy Act
NFPA	National Fire Protection Association
NIPDWR	National Interim Primary Drinking Water Regulations
NMCPHC	Navy & Marine Corps Public Health Center
NOAA	National Oceanographic and Atmospheric Administration
NOEC	No-effect Concentration
NOI	Notice of Intent
NOS	Not Otherwise Specified
NOSSA	Naval Ordnance Safety and Security Activity
NOT	Notice of Termination
NPDES	National Pollution Discharge Elimination System
NPDWR	National Primary Drinking Water Regulation
NRC	National Research Council
NSDWR	National Secondary Drinking Water Regulation
NTNCWS	Non-Transient Non-Community Water System
NTU	Nephelometric Turbidity Units

O

O&G	Oil and Grease
O&M	Operations and Maintenance
OD	Outside Diameter
OSHA	Occupational Safety and Health Administration
OSH Act	Occupational Safety and Health Act

P

PA	Preliminary Assessment
PAH	Polycyclic Aromatic Hydrocarbons
PAL	Project Action Level
PCB	Polychlorinated Biphenyl

PDB	Passive Diffusion Bag
PDMS	Poly(dimethylsiloxane)
PDS	Post-digestion Spikes
PE	Performance Evaluation
PE	Polyethylene
PEL	Permissible Exposure Limit
PID	Photoionization Detector
PISCES	Passive In situ Concentration Extraction Sampler
PM	Preventative Maintenance
PMN	Premanufacturing Notice
POC	Point of Contact
POCIS	Polar Organic Chemical Integrative Sampler
POM	Polyoxymethylene
POX	Purgeable Organic Halogen
POP	Proof of Performance
PPB	Parts per Billion
PPE	Personal Protective Equipment
PPM	Parts per Million
PQO	Project Quality Objective
PT	Proficiency Test(ing)
PTFE	Polytetrafluoroethylene
PVC	Polyvinyl Chloride
PWS	Public Water System

Q

QA	Quality Assurance
QAM	Quality Assurance Manual
QAP	Quality Assurance Plan
QAPP	Quality Assurance Project Plan
QC	Quality Control
qPCR	Polymerase Chain Reaction

R

RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
Rdase	Reductive Dehalogenase
RESS	Required Explosives Safety Submission
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RFQ	Requests for Quote
RI	Remedial Investigation
ROD	Record of Decision
RPD	Relative Percent Difference
RPPM	Respiratory Protection Program Manager
RQ	Reportable Quantities

S

SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act of 1986
SD	Serial Dilution
SDWA	Safe Drinking Water Act
SI	Site Inspection
SIC	Standard Industrial Classification
SLP	Slope
SOC	Synthetic Organic Chemical
SOH	Safety and Occupational Health
SOP	Standard Operating Procedure
SOW	Scope of Work
SPCC	Spill Prevention Control and Countermeasure
SPMD	Semipermeable Membrane Device
SPME	Semipermeable Microextraction Device
SPP	Systematic Planning Process
SQuiRT	Screening Quick Reference Table
S/S	Solidification/Stabilization
SVE	Soil Vapor Extraction
SVOC	Semivolatile Organic Chemical

SWDA	Solid Waste Disposal Act
SWPPP	Storm Water Pollution Prevention Plan
SWTR	Surface Water Treatment Rule

T

TCDD	Tetrachlorodibenzo-p-dioxin
TCDF	Tetrachlorodibenzofuran
TCE	Trichloroethylene
TCLP	Toxic Characteristic Leaching Procedure
TCR	Total Coliform Rule
TDS	Total Dissolved Solids
THM	Trihalomethane
TMDL	Total Maximum Daily Loads
TNCWS	Transient Non-Community Water System
TOC	Total Organic Carbon
TOX	Total Organic Halogen
TPH	Total Petroleum Hydrocarbons
TRI	Toxic Release Inventory
TSA	Technical Systems Audit
TSCA	Toxic Substances Control Act
TSDF	Treatment, Storage, and Disposal Facility
TSS	Total Suspended Solids
TTHM	Total Trihalomethane

U

UA	Urbanized Area
UCMR	Unregulated Contaminants Monitoring Rule
UFP-QAPP	Uniform Federal Policy for Quality Assurance Project Plans
UIC	Underground Injection Control
USACE	United States Army Corps of Engineers
USGS	U.S. Geological Survey
UST	Underground Storage Tank

V

VOA	Volatile Organic Analysis
VOA	Volatile Organic Analytes
VOCs	Volatile Organic Chemicals
VSP	Visual Sample Plan

Glossary of Terms

A

Absorption	Assimilation of molecules or other substances into the physical structure of a gas, liquid, or solid without chemical reaction. The penetration of one substance into the inner structure of another.
Accuracy	The degree of agreement between a measured value and the true value. The combination of bias and precision of an analytical procedure, which reflects the closeness of a measured value to a true value.
Accreditation	A formal recognition that an organization (e.g., laboratory) is competent to carry out specific tasks (e.g., tests) or specific types of tasks.
Acetone	Volatile organic solvent, soluble in water. A listed hazardous waste in RCRA. Other names include: dimethylketone; 2-propanone
Acidity	The quantitative capacity of aqueous media to react with hydroxyl ions at a designated pH.
Action Level (AL)	Concentration that determines the need for evaluation of treatment requirements.
Active Sampler	In air monitoring context, a sampling device that uses a pump or vacuum to pull ambient air through the monitor or collection media.
Actual Lapse Rate	The rate of temperature change as an air mass rises or falls when factors of temperature gradients, humidity, etc. are taken into account.
Acute Exposure	An exposure to a toxic substance that results in severe biological harm or death in a short period of time.
Adsorption	Physical adhesion of molecules or colloids to the surfaces of solids without chemical reaction. One substance is attracted to and held on the surface of another. Adherence of the atoms, ions, or molecules of a gas or liquid to the surface of another substance.
Aerosol	Particulates of either liquid droplets or solids suspended in air. Aerosols most important in air pollution are in the 0.01–100 µm particle size range.
Amberlite®	Brand name for an XAD-2 resin; a polymeric material used for collection of polynuclear aromatic hydrocarbons from air.
Ambient	An encompassing state or naturally occurring environment.

Ambient Water	Waters in their natural state in the natural environment (e.g., rivers, lakes, streams, estuaries, and other receiving waters), as opposed to effluent discharges.
Analyte	The element, compound, or substance to be measured by chemical analysis.
Anemometer	An instrument used to measure wind speed.
Apparatus	The equipment used to collect samples, prepare samples, or measure analytes, such as: sample containers and other containers, filters, filter holders, labware, tubing, pipets, and other materials and devices that will contact samples, blanks, or analytical standards.
Aquifer	A layer of porous rock or soil that is saturated with water.
Artesian Well	A well made by boring into the earth until water is reached, and because of internal pressure, flows up like a fountain.
Artifacts	Substances produced during sampling or analysis that are not part of the desired sample. They may arise from equipment or environmental contamination, chemical interactions, or thermal effects.
Asbestos	Any material containing more than one (1) percent of mineral fibers from minerals such as chrysotile, amosite, crocidolite, or tremolite. A group of impure magnesium silicate minerals that occur in fibrous form.
Asphyxiant	A vapor or gas which can cause unconsciousness or death by suffocation (lack of oxygen). Simple asphyxiants are non-reactive gases such as nitrogen, carbon dioxide, and freon.
Atmospheric Stability	Refers to the vertical motions of the atmosphere that affect pollutant dispersion in the various atmospheric layers.
Atmospheric Turbulence	Swirls of motion of various air masses in the atmosphere (eddies or eddy currents).
Atomic Absorption (AA)	A technique for analyzing metals. The substance to be measured is converted to an atomic vapor by spraying a solution into a flame. An elemental light beam is directed through the flame, into a monochromator, and then to a detector that measures the amount of light absorbed by the atomized element in the flame. The absorbance at the selected wavelength is measured and compared with that of a reference substance. The absorbance is proportional to the concentration. This technique usually measures one element at a time.
	B
Background Samples	Samples that define the concentration of various chemicals in normal uncontaminated site material. Background samples are used to compare site conditions to the surrounding environment.

	Background samples are collected and handled in the same manner as all other samples.
Bailer	A long, cylindrical sampling device lowered into a well on a rope or cable and filled with a ground water sample.
Biased Sample	Samples that are collected at locations that are chosen based on historical information, behavior of contaminants, and knowledge about the physical system's matrix or the physical system's effect on the contaminant's transport or fate.
Biocide	A preservative (usually acid, to lower the pH) added to the sample to prevent microbial degradation.
Biodegradation	The process of decaying caused by living organisms.
Biota	Living creatures such as plants, animals, insects, fungi, bacteria.
Blank (sample)	Sample that does not contain the analyte of interest but in other respects has, as far as possible, the same composition as the actual sample.
Blind Samples	A quality control sample in which the laboratory performing the analysis is unaware of the sample origin. This sample may be collected as a duplicate during field operations or may be prepared from a known reference material containing the constituent of interest.
Borosilicate	A type of acid-resistant glass.
Boundary Layer	Layer of atmosphere influenced by ground conditions.
Buddy System	System of organizing employees into work groups in such a manner that each employee of the work group is designated to be observed by at least one other employee in the work group. The purpose of the Buddy System is to provide rapid assistance to employees in the event of an emergency.
Buoyant Turbulence	In air monitoring context, the air circulation that results from warm air rising from the earth's surface and being replaced by cooler downward moving air.

C

° C	Degrees Centigrade (Celsius). Water freezes at 0° C and boils at 100° C at normal pressure.
Calibration	The set of operations, which establish, under specified conditions, the relationship between values indicated by a measuring instrument, measuring system, or values represented by a material measure, and the corresponding known values of a measure.
Carcinogen	A substance capable of causing cancer.

Certification	Procedure by which a regulatory agency or third party gives written assurance that a product, process, or service conforms to specified requirements.
Chain-of-Custody Record	A document or documents that record the time and date of persons responsible for the security of samples from the time the samples are collected until the samples are consumed in testing or discarded.
Chemical Derivatization	Technique used for analysis of specific pollutants or compounds by chemically reacting or modifying the compound with a chemical reagent (derivatization reagent) to form a compound that is detectable and readily identified.
Chlorofluorocarbons (CFCs)	A class of chemicals that contain both chlorine and fluorine. CFCs are used as refrigerants, cleaning solvents and aerosol propellants.
Chlorinated Solvents	Organic chemicals that contain chlorine and that are liquids at normal temperatures and pressures.
Chromatogram	A plot displaying peaks that correspond to the constituents detected by a gas, liquid, or ion chromatograph.
Chronic Effect	Adverse health effects resulting from repeated doses of, or exposures to, a substance over a relatively prolonged period of time.
Cleanup Standard	The level of contamination that is acceptable in materials that remain after the cleanup of a contaminated site.
Coliform Bacteria	Bacteria used as indicator of pollution if found in water. Gram-negative, non-spore forming rods that ferment lactose within 48 hours at 35° C.
Collector Efficiency	The degree to which a sampling device is capable of collecting the desired analyte(s) without physically or chemically altering the analyte(s).
Co-located Samples	Two or more portions collected at the same point in time and space so as to be considered identical.
Colorimetric	Describes any technique by which an unknown color is visually evaluated in terms of standard colors. The concentration of a compound can be measured quantitatively from the shade or intensity of the test color or the length of the test color stain in a scaled vessel.
Combustible Gas Indicator (CGI)	Instrument used to determine the potential for combustion or explosion in an unknown atmosphere.
Combustible Liquid Class II (OSHA)	Class II liquids include those with flashpoints at or above 100° F. (37.8° C.), and below 140° F. (60° C.) except a mixture having components with flashpoints of 200° F. (93.3 C.) or higher,

	the volume of which make up 99 percent or more of the total volume of the mixture (Title 49 CFR 176.30).
Combustible Liquid (DOT Usage)	Flashpoint 100° F – 200° F.
Community Water System (CWS)	A public water system that serves at least 15 service connections used by year-round residents or regularly services at least 25 year-round residents.
Comparability	Degree with which data from one study may be compared to other similar studies.
Completeness	Measure of the amount of collected data compared to the amount of data expected or required under ideal conditions.
Component Air Sample	An air sample taken using a collection device that favors collection of either a specific pollutant or a class of pollutants.
Composite Sample	A sample prepared by physically combining two or more samples having the same specific relationship and processed to ensure homogeneity. For example, flow proportioned, time proportioned or equal mass samples.
Compressed Gas	Material packaged in a cylinder, tank or aerosol under pressure exceeding 40 psi at 70° F or other pressure parameters identified by DOT.
Condensible	Capable of forming a liquid from a vapor.
Confidence Interval	Range of values that can be declared with a specified degree of confidence to contain the correct or true value.
Confined Space	Any space that has restricted access and is not normally occupied. Includes tanks, vaults, and holes more than 4 feet deep, etc.
Contamination	Something inadvertently added to the sample during the sampling and analytical processing resulting in positive or negative effects.
Contamination Reduction Zone	At a remediation site, the transition zone between contaminated area (Exclusion Zone) and clean area. The zone is where personnel remove their personal protective equipment.
Continuous Sampler	Sampler that withdraws a sample constantly from a stream and accumulates the withdrawn volume for analysis at a later time.
Control Charts	A graph of some measurement plotted over time or sequence of sampling, together with control limit(s) and, usually, a central line or warning limit(s). Control charts may include a means chart for standards, matrix spikes, calibration check standards, laboratory control standards, a means chart for background or blank results, and a range chart for replicate analysis.
Control Sample	The sample against which results are compared or judged. The sample is identical in matrix whenever possible and prepared under the same conditions to determine the extent of variations.

	Control samples may include blanks, standards, check samples, or split samples, etc., which establish intralaboratory or analyst specific precision and bias, and to assess the performance of all or a portion of the measurement system, including sampling.
Conventional Pollutants	In the National Pollution Discharge Elimination System (NPDES) program, EPA Wastewater Discharge Information, Application Form 2C, the pollutants found in Part A.1. These are Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Organic Carbon (TOC), Total Suspended Solids (TSS), Ammonia, pH, and Temperature.
Coroliolis Force	A fictitious force used mathematically to describe the motion, as of aircraft, cloud formations and air masses, relative to a non-inertial, uniformly rotating frame of reference such as the Earth.
Corrosive	DOT Definition: A liquid or solid, excluding poisons, that causes visible destruction or irreversible alterations in human skin tissue at the site of contact, or has a severe corrosion rate on steel. See Title 49 CFR 173.240. In chemical terms, any solid, liquid, or gaseous substance that attacks materials and metals, or burns, irritates, or destructively attacks organic tissue. See 40 CFR Part 264 for definition of corrosivity under RCRA.
Cryogen	A substance for obtaining low temperatures (refrigerant). Cryogenic liquids such as liquid nitrogen are hazardous to handle.
Cyclone Collector	An inertial, centrifugal collection device for solid particles that separates particles by whirling them in a cyclonic motion inside a conical shaped collector.
	D
Data Quality	The totality of features and characteristics of data that bears on their ability to satisfy a given purpose; the sum of the degrees of excellence for factors related to data.
Data Quality Objectives (DQOs)	Qualitative and quantitative statements which specify the study objectives, domain, limitations, the most appropriate types of data to collect, and specifies the levels of decision error that will be acceptable for the project.
Decontamination	Removal of substances from skin, clothing, or equipment to the extent necessary to preclude the occurrence of foreseeable health effects, environmental effects, or sampling and testing effects.
Deionized Water	Water prepared by passing feedwater through a mixed-bed ion exchanger consisting of strong anion and strong cation resins mixed together. The resultant water has the characteristics of Type I or Type II water depending on the purification process. (See Distilled Water)

Denuders	Glass tubes (or sometimes glass tubes packed with glass beads) coated with an adsorbent chemical film for trapping specific gaseous analytes during air sampling.
Diethylphenylenediamine (DPD)	The reagent used in a colorimetric test to determine residual free chlorine (disinfectant) concentrations.
Direct Assessment of Air Pollution	Method of assessment where emission rates are measured directly rather than by determining downwind mass/volume concentrations.
Dispersion Modeling of Air Pollution	The use of meteorological, topographical, and specific pollutant concentration data to predict larger range effects of pollution. Method of iterative assessment using measurements made downwind of source combined with assessments of meteorological and topographical factors in a complex computer model.
Dissolved Matter	A substance that is dispersed in a material to give a single homogeneous phase.
Dissolved Oxygen	Oxygen dissolved in water.
Distilled Water	Water prepared by thermal distillation using a still of all-borosilicate glass, fused quartz, tin or titanium with the distillate meeting the following characteristics of Type I (Type II) water: Resistivity (megohm-cm @ 25° C) greater than 10 (> 1); Conductivity (µmhos/cm @ 25° C.) < 0.1 (= 1); Total oxidizable organic carbon (mg/liter) < 0.05 (< 0.2); Total solids (mg/liter) less than or equal to 0.1 (equal to 1); SiO2 (mg/liter) < 0.05 (< 0.1). These characteristics are from Standard Methods for the Examination of Water and Wastewater, 18th edition; other type waters may be specified in the work plan.
Dose	The amount of energy or substance absorbed in a unit volume of an organ or individual.
Dose Rate	The dose delivered per unit of time.
Dredge	A type of sampling equipment used to collect samples of sludge or sediments from the bottom of ponds, rivers, etc.
Duplicate (Sample)	Two samples taken from and representative of the same population and carried through all steps of the sampling and test procedure in an identical manner. Used to assess variance of the total method including sampling and analysis.
Dust	Solid particles generated by handling, crushing, grinding, rapid impact, detonation, and decrepitation of organic or inorganic materials, such as rock, ore, metal, coal, wood, and grain. Dusts do not tend to flocculate except under electrostatic forces; they do not diffuse in air but settle under the influence of gravity.

E

E. Coli	A member of the coliform group that can cause severe gastroenteritis, including diarrhea and vomiting (Escherichia coli).
Effluent	Liquid discharges from a piece of equipment or a site.
Effluent Limitations	Specific limits on the pollutants in the water discharged from a site.
Eijkelcamp Stony Soil Auger	A type of auger designed to make holes in stony soil.
Electrostatic Separator	An air sampler that uses high voltage to ionize aerosols then coalesce and collect them.
Entropy	A measure of a system's capacity to undergo change; a measure of the disorder in a system.
Entry Point	A place where water enters the distribution system of a drinking water supply system.
Environmental Samples	Samples of naturally occurring matrices such as soil, sediment, groundwater, surface water, and air.
Equipment Blank	An aliquot of reagent water that is subjected to all aspects of sample collection and analysis including contact with all sampling devices and apparatus. The purpose of the equipment blank is to determine if the sampling devices and apparatus for sample collection have been adequately cleaned.
Exclusion Zone	Designated zone at a hazardous waste site where contamination is known to or may occur. The exclusion zone may only be entered by trained personnel who are wearing appropriate personal protective equipment.
Exemption	A timely delay or release from compliance due to compelling factors (such as economics).
Explosimeter	Real time instrument that measures the concentration of organic chemicals in air as a fraction of the concentration required to cause an explosion
Explosion-proof Equipment	Apparatus enclosed in a case that is capable of withstanding an explosion of a specified gas or vapor and is capable of preventing the ignition of a specified gas or vapor surrounding the enclosure by sparks, flashes, or explosion of the gas or vapor within the case, and that operates at an external temperature such that a surrounding flammable atmosphere will not be ignited.
Explosive Division/Class 1.1	Mass-detonating material (high explosive).
Explosive Division/Class 1.2	Non-mass-detonating material; primarily fragmentation hazards.
Explosive Division/Class 1.3	Mass-deflagrating material (severe fire hazard).
Explosive Division/Class 1.4	Non-mass deflagrating material (fire hazard).

Explosive Limits	Some materials have a minimum and maximum concentration in air that can be detonated by spark, shock, fire, etc. The lowest concentration is known as the lower explosive limit (LEL). The highest concentration is known as the upper explosive limit (UEL).
Exposure	Subjection of a person to a toxic substance or harmful physical agent in the course of employment through any route of entry (e.g., inhalation, ingestion, skin contact, or absorption); includes past exposure and potential (e.g., accidental or possible) exposure, but does not include situations where the employer can demonstrate that the toxic substance or harmful physical agent is not used, handled, stored, generated, or present in the workplace in any manner different from typical non-occupational situations. An exposure to a substance or agent may or may not be an actual health hazard to the worker.
Extraction	Process where materials are separated using physical or chemical means.

F

° F	Degrees Fahrenheit. Water freezes at 32° F and boils at 212° F at normal pressure.
Fecal Coliforms	A group of coliform bacteria, associated with fecal matter of warm-blooded animals, whose presence in drinking water indicates the possible presence of disease-causing organisms and indicates the water is not safe for human consumption. Their confirmed presence is considered an acute violation of the Total Coliform Rule.
Field Blank	A quality control sample used to indicate potential sample contamination from sampling equipment or ambient air.
Field Duplicates (FD1 and FD2)	Two separate samples collected in separate sample bottles at the same time and place under identical circumstances and treated exactly the same throughout field and laboratory procedures, which may include filtration. Analyses of FD1 and FD2 give a measure of the precision associated with sample collection, preservation, and storage, as well as with laboratory procedures.
Field Sampling Plan	A document that describes exactly where and how samples are to be collected, preserved, packaged, and shipped to the laboratory. The Field Sampling Plan also describes all required field tests and the chain of custody procedures.
Field Standards	Samples of known concentrations that are used in the field for calibration and comparison with unknown samples or to verify field sampling or test procedures.
Filter Pack	An air sampling device consisting of a series of two or more stages of filters for collection of specific analytes. The filters

	are separated by inert o-rings and the filter housing is also inert, usually Teflon.
Fixed Matter	Residues from the ignition of particulate or dissolved matter, or both.
Flame Ionization Detector (FID)	A detector that uses hydrogen flame to measure the presence of volatile chemicals in air. An air monitoring instrument that uses an FID detector in measuring health and safety exposure based on the total relative levels of volatile organics in the environment compared to background levels or a standard mixture.
Flammable (DOT Usage)	Flashpoint < 100° F.
Flammable Aerosols	An aerosol which is required to be labeled "Flammable" under the United States Federal Hazardous Substances Labeling Act. For storage purposes, flammable aerosols are treated as Class IA liquids (NEPA 30, Flammable and Combustible Liquids Code).
Flammable Gas	Any compressed or liquefied gas, except an aerosol, is flammable if either a mixture of 13 percent or less (by volume) with air forms a flammable mixture or the flammable range with air is wider than 12 percent regardless of the lower limit (at normal temperature and pressure). (International Civil Aviation Organization (ICAO) Technical Instructions).
Flammable Limits	Flammable liquids produce (by evaporation) a minimum and maximum concentration of flammable gases in air that will support combustion. The lowest concentration is known as the lower flammable limit (LFL). The highest concentration is known as the upper flammable limit (UFL).
Flammable Solid (DOT Usage)	Any solid material, other than one classed as an explosive, that under conditions normally incident to storage is liable to cause fire through friction or retained heat from manufacturing or processing; or that can be ignited readily, and when ignited burns so vigorously and persistently as to create a serious storage hazard. Flammable solids, excluding Dangerous When Wet, are further defined in Title 49 CFR 173.150.
Flash Point	The lowest temperature at which a liquid gives off enough vapor to form an ignitable mixture with air and produce a flame when a source of ignition is present.
Flow Rate	The rate at which a stream of material passes by a point or through an orifice (e.g., cubic feet per minute of air, gallons per minute of water.)
Fly Ash	Non-combustible aerosol mineral solids formed from incomplete oxidation of coal or fuel oil, generally < 200 µm diameter.
Follow-up Monitoring	Testing defined in the SDWA after a PWS installs treatment. Follow-up monitoring is required for lead, copper, and other water quality parameters.

Fugitive Emission	A source of air pollution other than stacks or vents (i.e., connectors, gaskets, valves, etc.).
Full Protective Clothing	Personal protective equipment that completely protects a worker's skin from possible contact with toxic or corrosive gases, liquids or solids. This level of PPE is used where high chemical gas, vapor, or fume concentrations in air may have a corrosive effect on exposed skin, and/or where the chemical in the air may be readily absorbed through the skin to produce toxic effects. These suits are impervious to chemicals, offer full body protection, and include self-contained breathing apparatus (SCBA).
Fully Encapsulating Suits	Full chemical protective suits that are impervious to chemicals, offer full body protection from chemicals and their vapors/ fumes, and are used with SCBA.
Fume	Fume aerosol particulates from condensation of distillation vapors, calcination, or chemical reactions.
Fungicide	A chemical that prevents the growth of fungus and which is approved for use by the U.S. EPA.

G

Gas	A state of matter in which the material has very low density and viscosity; can expand and contract greatly in response to changes in temperature and pressure; easily diffuses into other gases; readily; and uniformly distributes itself throughout any container. A gas can be changed to the liquid or solid state by the combined effect of increased pressure and/or decreased temperature.
Gas Chromatograph (GC)	An instrument where the components of a mix are separated from one another by volatilizing the sample into a carrier gas stream and over a bed of packing with a solid support or through a long narrow capillary. Different components move through the packing at different rates and are detected separately by an appropriate detector. The different detectors can measure ionization, thermal conductivity changes, density differences, or other characteristics of the separated components.
Gas Chromatograph/ Mass Spectrometry (GC/MS)	A technique used in combination with a gas chromatograph in which a small amount of separated components from the GC travel into a mass spectrometer through a vacuum and are exposed to a beam of electrons which ionizes the molecules and the fragments of the molecules into characteristic ions. The ions are separated according to their mass using electromagnetic fields and then the characteristic ion patters are detected. A library of known identities or patterns is used to determine which fragments are present and identify the compound present in the sample.

Geostatistics	Statistical methods that are used to calculate the expected concentration of chemicals in soil between sampling points.
Giardia Lamblia	A parasitic protozoan species that infects the gastrointestinal tract.
Glass Globe Samplers	Evacuated glass bulbs used to collect whole air samples.
Grab Sample	A sample that is representative of one specific sample site location at a specific time. A single sample that is collected at one point in time and place.
Gradient Wind	Free blowing wind above the boundary layer of the atmosphere.
Graphic Furnace Atomic Absorption (GFAA)	A technique used for measuring metals. Graphite furnace atomic absorption (GFAA) or electrothermal atomic absorption spectroscopy is based on the same principle as atomic absorption. In GFAA, the flame is replaced with an electrically heated atomizer or graphite tube. A sample volume is dispensed in the tube and heated in three or more stages. The final stage heats the tube to atomize the element being determined. An elemental light beam is directed through the furnace, into a monochromator, and then to a detector that measures the amount of light absorbed by the atomized element. The absorbance at the selected wavelength is measured and compared with that of a reference substance. The absorbance is proportional to the concentration. This technique usually measures one element at a time.
Gram	A metric unit of weight equal to about 1/28 ounce. One cubic centimeter of pure water weighs one gram. There are 1,000 grams in a kilogram.
Groundwater	The portion of the water beneath the land surface that is within the zone of saturation (below the seasonally high water table) where all pore spaces of the geologic formation are filled with water.
Grouting	Filling a borehole or well with an impervious material such as bentonite clay or cement.

H

Handling Time	The time between collection of samples and their delivery to the laboratory. The maximum allowable handling time may be specified in the Field Sampling Plan.
Hardness	In water chemistry, hardness is a term originally referring to the soap-consuming power of water; current practice defines total hardness as the sum of the calcium and magnesium concentrations expressed as calcium carbonate in milligrams/liter; certain test techniques for hardness measure the polyvalent cations used to precipitate soap; as such it is also taken to include iron and manganese. "Permanent hardness" is the excess of hardness

	over alkalinity; "temporary hardness" is hardness equal to or less than the alkalinity. These are also referred to as "non-carbonate" or "carbonate" hardness, respectively.
Hazard Class	A category of hazard associated with a hazardous material or hazardous waste that has been determined to pose an unreasonable risk to health, safety, and property when transported (see Title 49 CFR 171.8). The hazard class is defined by the U.S. DOT and published in Title 49 CFR 172.101. The hazard classes used in the United States include Explosive (Division/Class 1.1, 1.3, 1.4); Flammable Liquid; Flammable Solid; Corrosive Material; Nonflammable Gas; -1, -B, -C, -D, and -E; Etiologic Agent; Irritation Material; Organic Peroxide; Combustible Liquid; Flammable Gas; and Blasting Agent.
Hazardous Air Pollutant	A pollutant to which no ambient air quality standard is applicable but that may cause or contribute to an increase in mortality or in serious illness. For example, asbestos, beryllium, and mercury have been declared hazardous air pollutants.
Hazardous Chemicals	Chemicals or materials used in the workplace that are regulated under the OSHA Hazard Communication Standard or the "right-to-know'' regulations in Title 29 CFR 1910.1200.
Hazardous Material	In a broad sense, a hazardous material is any substance or mixture of substances that can produce adverse effects on the health and safety of a human being or the environment. Legal definitions are found in individual regulations.
Hazardous Substances	Chemicals, mixtures of chemicals, or materials subject to the regulations contained in Title 40 CFR 116. For transportation purposes, a material, and its mixtures or solutions, identified by the letter "E" in column 2 of the Hazardous Material Table included in Title 49 CFR 172.101 when offered for transportation in one package, or in one transport vehicle if not packaged, and when the quantity of the material therein equals or exceeds the reportable quantity (RQ). For details, refer to Title 49 CFR 171.8 and Title 49 CFR 172.101.
Hazardous Waste	Any material listed as such in Title 40 CFR 261, Subpart D, that possesses any of the hazard characteristics of corrosivity, ignitability, reactivity, or toxicity as defined in Title 40 CFR 261, Subpart C, or that is contaminated by or mixed with any of the previously mentioned materials (See Title 40 CFR 261.3).
Hazardous Waste Landfill	An excavated or engineered area on which hazardous waste is deposited and covered; proper protection of the environment from the material to be deposited in the landfill requires careful site selection, good design, proper operation, leachate collection, and treatment through final closure.
Hazardous Waste Manifest	

(EPA Usage)	The shipping document, originated and signed by the waste generator or authorized representative that contains the information required by Title 40 CFR 262, Subpart B.
Health and Safety Plan (HASP)	A document that describes the hazards that may be encountered while collecting specified samples and specifies the required personal protective equipment and procedures that will minimize the risks. The contents of a Health and Safety Plan required for work at a hazardous waste site are specified by OSHA in Title 29 CFR 1910.120.
Holding Time	The time between the collection of environmental samples and the extraction or analysis of the samples. Maximum allowable holding times are specified by regulations for many analytes within each regulatory program.
Homogeneity	The degree of uniformity of structure or composition. The term is often used to describe a mixture, solution, or environmental sample comprised of substances that are uniformly dispersed. When discussing a sample, the degree to which each portion of the sample is representative of the whole sample.
Homogenization	Process whereby a sample is mixed until a consistent physical appearance is achieved.
Hydrogeology	The presence and movement of underground water as a function of the soil and rock layers that are present.

I

Ignitability (EPA Usage)	A liquid with a flashpoint less than 140° F.
Imhoff Cone	A cone shaped graduated vessel used to measure the volume of solids that will settle out of a liquid.
Immiscible	Two liquids that are not capable of mixing or blending; not mutually soluble.
Impactor	An instrument for collecting samples of suspended particles (as dust in air) by directing a stream of the suspension onto a surface or into a liquid.
Impermeable	Media through which substances cannot be diffused at any measurable rate.
Impinger	An air sampling collection device that collects gas forcibly against a surface. Both wet and dry impingement processes may be used.
In Situ	Within place; commonly used to refer to the location of activities (e.g., in situ soil vapor measurements).
Indirect Assessment	Method of assessment using a variety of samples from different Air Pollution ambient locations relatively close to the source to estimate concentrations via dispersion modeling equations.
Inductively Coupled Plasma	

(ICP, ICAP)	A technique used for metal analysis based on the principle of atomic emission. The high temperature of the plasma excites atomic ionization which results in ionic emission spectra. The efficient excitation results in low detection limits and large dynamic ranges of four to six orders of magnitude for many elements. This technique is especially useful for refractory metals and significantly reducing chemical interferences associated with flame atomic absorption. Instruments are capable of performing multi-element analysis.
Inductively Coupled Plasma/ Mass Spectrometer (ICP/MS)	A technique in which part of the ionic cloud from an ICP torch is introduced into a vacuum and bombarded with electrons. The ions are separated according to their mass using electromagnetic separation and then the characteristic ion patters are detected by a mass spectrometer. It can determine which fragments are present and therefore the identity of the metal analytes.
Inert	Exhibits no chemical reactivity.
Infiltration	The flow of fluid into a substance through pores or small openings. The word is commonly used to denote the flow of water into soil.
Ingestion	The process of taking substances into the body through the mouth, as in food, drink, medicine, etc.
Inhalation	The breathing in of a substance in the form of gas, vapor, fume, mist, or dust.
Injection Well	A well into which gas, air, oil, water, or waste is pumped.
Inorganic Chemical	Generally considered to embrace all chemical substances except hydrocarbons and their derivatives. In some cases inorganic and organic chemicals may not be easily distinguished such as organometallics, organic cyanides, etc.
Integrated Sample	In air monitoring context, refers to a sample collected over time.
Internal Standard	A material present in or added to samples in known amounts to serve as a reference measurement. The standard added to a test portion of a sample in a known amount and carried through the entire procedure as a reference for calibration and controlling the precision and bias of the applied analytical method.
Inversion	In air monitoring context, a very thermally stable atmospheric condition where a positive thermal gradient exists and the upper air is warmer than the lower air.
Irritant	Any material, liquid, or solid substance, that upon contact with fire or when exposed to air gives off dangerous or intensely irritating fumes, such as tear gas, but not including Poison Division/Class 2.3 or 6.1 material. Materials named as irritants are presented in Title 49 CFR 173.38.

Isokinetic Sampling	Sampling in which the linear velocity of the gas entering the sampling nozzle is equal to that of the undisturbed gas stream at the sample point.

K

Kilogram	A metric unit of weight, about 2.2 pounds.
Kilopascal (kPa)	A unit of measure for vapor pressure.

L

Lab Pack	A hazardous waste disposal container holding many other small volume containers of compatible chemicals from laboratory operations, packed with an inert filler, for shipping to an approved disposal operation.
Laboratory Decontaminated	The cleaning of sampling equipment and bottles in a controlled setting such as a laboratory or the cleaning of equipment and materials used in testing.
Lagoon	An artificial pond used for the storage or disposal of liquids.
Lanyard	A cord, thong, rope, or strap used for fastening.
Leachate	Liquid that seeps from the ground. In the laboratory test methods, liquid that has been exposed to a contaminated solid material for a defined period of time.
Leaching	Action whereby soluble constituents migrate through permeable media due to the vertical percolation/infiltration of a liquid.
Lead Solder	A solder containing 0.2 percent or more lead.
Leak or Leaking	A flaw, crack, or hole permitting accidental escape of fluid. Any instance in which an article, container, or equipment has any hazardous material (e.g., PCB) on any part of its external surface or has released this substance to the surrounding environment resulting in an environmental threat.
Liter	A metric unit of volume somewhat more than a quart. A liter of water weighs 1 kilogram or about 2.2 pounds
Lithology	Presence and location of different types of soil, bedrock, and groundwater.
Lower Explosive Limit (LEL)	Minimum concentration of a combustible gas in air that will explode when ignited.
Lower Flammable Limit (LFL)	The concentration of a chemical in air over a liquid that has been heated to its flash point

M

Matrix	Refers to the mixture of biological, chemical, and physical materials found in various types of environmental samples such as freshwater, seawater, sediment, and animal or plant tissues.

	The materials can interfere with the analyses and, if not compensated for, can lead to false and invalid data.
Matrix Spike/ Matrix Spike Duplicate (MS/MSD)	A quality control sample prepared by adding a known amount of analyte to the matrix sample. A known amount of analyte added to a second or duplicate matrix sample is the MSD. The matrix sample, MS, and MSD data are used to evaluate the recovery of the analyte from the matrix (bias) and evaluate the reproducibility of the analyte in the MS/MSD (precision). All samples are prepared and analyzed to determine the effect of the matrix on the procedures used for processing.
Maximum Contaminant Level (MCL)	Enforceable standard that specifies how much of a contaminant can be present in drinking water.
Maximum Contaminant Level Goal (MCLG)	Nonenforceable goal that specifies the level of contaminant at which there is no health concern.
Mechanical Turbulence	In air monitoring context, the effects of air masses flowing over rough or irregular surface elements.
Meteorological Parameter	Weather conditions such as wind direction and speed, temperature, atmospheric stability, atmospheric pressure, humidity, and precipitation that are very critical to air sampling and monitoring activities.
Method	A sampling or measurement process that has been officially specified by an organization as meeting its data quality requirements.
Method Blank	A quality control sample or blank processed simultaneously with and under the same conditions as the samples including all steps of the test procedure. The method blank may be reagent water, clean sand, or pure material known to be free of the analyte of interest and with a similar matrix as the samples being tested.
Method Detection Limit (MDL)	The minimum concentration of an analyte in a specific matrix and with a specific method, is measured and reported with a 99 percent confidence that the concentration of the analyte is greater than zero.
Microorganism	An organism of microscopic or ultramicroscopic size.
Milligram	A metric unit of weight. There are 1,000 milligrams in one gram of a substance.
Milliliter	A metric unit of volume equal to one cubic centimeter. A milliliter of pure water weighs one gram at 4° C and 760 mm mercury pressure.

Minimum Level (ML)	The lowest level at which the entire analytical system gives a recognizable signal and an acceptable calibration point.
Mist	Aerosol particulates arising from vapor condensation, chemical reactions, or liquid atomization.
Mixing Layer	In air monitoring context, the top of a neutral or unstable surface air layer. For stable surface air layers such as inversions, the mixing layer is undefined.
Mottles	Areas of different color or texture. Term often used in soil descriptions.

N

Nebulization/Reflux	A method of air sampling in which the air stream is passed through a nebulized mist of liquid which traps the pollutants of interest.
Nitrile	A type of synthetic rubber that is resistant to oil and is commonly used to make gloves used when handling hazardous chemicals.
Nephelometric Turbidity Unit (NTU)	A unit of measure for turbidity of water.
Nontransient Non-community Water System (NTNCWS)	A public water system that is not a community water system and that regularly serves at least 25 of the same persons over 6 months per year.

O

Olfactory	Of, relating to, or connected with the sense of smell.
Opacity	Extent to which a material absorbs or diffuses light.
Oxidizer	A chemical other than a blasting agent or explosive as defined in Title 29 CFR 1910.109(a), which initiates or promotes combustion in other materials thereby causing fire either of itself or through the release of oxygen or other gases.

P

Particulate Matter	Solid matter that is heterogeneously dispersed in water. In air monitoring, the particulate matter may be droplets of liquid or solid particles, suspended in air and referred to as aerosols.
Passivate	In air or gas monitoring, the chemicals of interest are allowed to diffuse through the membrane or plastic film and are absorbed on a solid absorbent material inside to trap the chemicals.
Passive Sampler	In air or gas monitoring, refers to a sampling device that allows ambient air conditions to diffuse the sample through the monitor or onto the adsorbent material.

PCB Transformer	Any transformer that contains a liquid in which PCBs are present at a concentration of 500 ppm PCB or greater. (Title 40 CFR 761.3).
Percolating	A liquid that is flowing down through a porous material such as soil.
Permissible Exposure Limit (PEL)	The maximum allowable 8-hour time-weighted average concentration of a chemical in air to which workers may be exposed.
Pesticide	A chemical that is toxic to pests (insects and rodents) and that is approved by EPA for use for this purpose.
pH	The negative logarithm of the hydrogen-ion activity in an aqueous solution or the logarithm of the reciprocal of the hydrogen-ion activity. pH is a measure of the acidity or alkalinity of a liquid on a scale from 1 to 14; acids have a pH lower than 7; alkalis have a pH above 7.
Phase I	The first phase of EPA's regulatory development approach to control air pollution. It covers the first eight VOCs to be regulated.
Phase II	The second phase of EPA's regulatory approach to control air pollution. Phase II covers additional VOCs, pesticides, and inorganic chemicals.
Phenolic Compounds	Aromatic organic chemicals that contain one or more hydroxyl groups bonded directly to the benzene ring.
Photo Ionization Detector (PID)	A detector that uses an ultraviolet light to measure the presence of volatile chemicals in air. An air monitoring instrument that uses the PID detector in measuring health and safety exposure based on the total relative levels of volatile organics in the environment.
Piezometer	A meter used to measure the pressure under earthen dams, foundations, boreholes and within aquifers.
Pitot Tube	Measuring device used to determine gas velocities in emission sources.
Plume	In air monitoring context, a feathery emission of gases, liquids and particulates from a point source such as a stack or vent.
PM2.5	Particles having an aerodynamic diameter $\leq$ 2.5 micrometers.
PM10	Particles having an aerodynamic diameter $\leq$ 10 micrometers.
Point Source	In air sampling, a fixed emission source such as a stack, vent, or discharge pipe.
Point Source (CWA Usage)	Any discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel or other floating craft from which pollutants are or may be dis-

	charged. This term does not include return flows from irrigated agriculture or agricultural storm water runoff.
Poison Division/Class 2.3	Poisonous gases or liquids of such a nature that a very small amount of the gas, or vapor of the liquid, mixed with air is dangerous to life (Title 49 CFR 173.326).
Poison Division/Class 6.1	Demonstrated an oral LD50 of up to and including 50 mg/kg, or in inhalation LC50 of up to and including 2 mg/liter, or a general LD50 of up to and including 200 mg/kg; or is either classed as Poison Class B per Title 49 CFR 173.343, or qualifies as a Category I Pesticide per Title 40 CFR Part 162 excluding the corrosivity criteria.
Pollutant (CWA Usage)	Dredged spoil, solid waste, incinerator residue, filter backwash, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials (except those regulated under the Atomic Energy Act), heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water. It does not mean: (a) sewage from vessels; or (b) water, gas, or other material which is injected into a well to facilitate production of oil or gas, or water. (See complete definition in 40 CFR 122.2).
Polychlorinated Biphenyl (PCB)	Any of 209 compounds or isomers of the biphenyl molecule that have been chlorinated to various degrees (includes monochlorinated compounds). PCBs are highly toxic to aquatic life, they persist in the environment for long periods of time, and they are biologically accumulative.
Precision	The degree of reproducibility of results, or the degree of mutual agreement among independent, similar, or repeated measurements.
Predictive Modeling of Air Pollution	Method of assessment based on choosing an emission model for a particular source type. Data are usually obtained from literature, estimation, or calculation. Generally used for screening.
Pressurized Sampling	A canister sampling procedure for collection of whole air samples. A metal bellows-type pump forces ambient air into an evacuated canister until the pressure reaches 15–30 psig.
Pretreatment Standards	
(CWA Usage)	Specific industrial operation or pollutant removal required prior to discharge of contaminated water to a municipal sewer.
Procedure	A set of systematic instructions for performing an operation.
Proficiency Testing	Determination of field or laboratory testing performance by means of inter-laboratory comparisons.
Protocol	Thorough, written description of the detailed steps and procedures involved in the collection of samples.

Public Water System (PWS)	A system for the provision to the public of piped water for human consumption, if such system has at least 15 service connections or regularly serves an average of at least 25 individuals daily at least 60 days of the year. Such term includes (1) any collection, treatment, storage, and distribution facilities under control of the operator of such system and used primarily in connection with such system, and (2) any collection or pretreatment storage facilities not under such control that are used primarily in connection with such system. A public water system is either a "community water system" or a "non-community water system" and may be "transient" or "non-transient."

Q

Qualitative	The identification, characterization, or description of materials.
Quality Assessment	The evaluation of data to determine if they meet the quality criteria required for a specific application.
Quality Assurance	An integrated system of activities involving planning, quality control, quality assessment, reporting, and quality improvement to ensure that sampling and testing meet defined standards of quality with a stated level of confidence.
Quality Assurance Plan	A written plan that describes the methods and procedures that are required to assure the validity of sampling and analytical data.
Quality Control	The activity whose purpose is to measure and control the quality of sampling and testing so that it meets the needs of users and provides assurance that the appropriate level of confidence is achieved.
Quantitative	A measurable number, quantity or percent composition of a mixture. A number or amount of anything, either specified or indefinite.

R

Radioactivity	Atomic emission resulting from natural or artificial nuclear transformation. The energy of the process is emitted in the form of alpha, beta, or gamma rays by the decaying of the nuclei of the atom.
Radionuclide	A radioactive species of atom characterized by the constitution of its nucleus and hence by the number of protons, the number of neutrons, and the energy content.
Range	Spread of values calculated by subtracting the lowest value from the highest value. The extent of variation.
Raw Data	Any worksheets, records, memoranda, notes, or exact copies thereof, that are the result of original observations, and or activities of a study and are necessary for the reconstruction and evaluation of the reports of that study. Raw data may include pho-

	tographs, microfilm or microfiche copies, computer printouts, magnetic media, including dictated observations, and recorded data from automated instruments.
Reagent	Any substance used in a reaction for the purpose of detecting, measuring, examining, or analyzing other substances.
Reagent Blank (Method Blank)	A clean sample that contains any reagents used in the sample preparation and analysis procedure and processed simultaneously with and under the same conditions as samples containing an analyte of interest through all steps of the procedure.
Reagent Water	Water demonstrated to be free from the analyte(s) of interest and potentially interfering substances at the MDL for that analyte in the reference method or additional method. Reagent water may be defined as to the quality of the water to be used for analysis (see Distilled Water).
Real-Time Sampling	In air monitoring context, refers to field measurements that can be made with various instruments to quickly survey the area. Grab samples taken in the field over very short collection periods may also be referred to as real-time samples.
Reportable Quantity	The quantity specified in column 2 of the Hazardous Materials Table in Title 49 CFR 172.101, for any material identified by the letter "E" in Column 1 (Title 49 CFR 171.8), or any material identified by EPA on Table 117.3, Reportable Quantities of Hazardous Substance in Title 40 CFR 173. The letter "E" in column 1 (Title 49 CFR 172.101) identifies this material as a potential hazardous substances.
Representativeness	Correspondence between an environmental sample and the actual material that is present in the environment. The degree to which the data collected accurately reflect the universe of data from which they are drawn, or the degree to which samples represent true systems.
Reproducibility	The extent to which a method, test, or experience yields the same or similar results when performed on subsamples of the same sample by different analysts or laboratories. Usually expressed in terms of precision and accuracy.
Residue	As related to Title 49 CFR 171.8, residue is the hazardous material remaining in a packaging after its contents have been emptied and before the packaging is refilled, or cleaned and purged of vapor to remove any potential hazard. Residue of a hazardous material, as applied to the contents of a tank car (other than DOT Specification 106 or 110 tank cars), is a quantity of material no greater than 3 percent of the car's marked volumetric capacity.

Retention Time	Period of time from the injection of a sample into a gas chromatography system until the point of maximum detector response for each substance.
Rodenticide	A chemical that is toxic to rodents such as mice and rats, and is approved by U.S. EPA for use for this purpose.

S

Salinity	A measure of the concentration of dissolved salts in a liquid.
Salvage Drum	A drum with a removable metal head that is used to store and transport damaged or leaking containers of hazardous materials (See Title 49 CFR 173.3.) (Also referred to as disposal or recovery drum.).
Sample Collection	The procedures involved in obtaining a representative portion of a material.
Samples	Portions of material such as soil, water, air, waste or contaminants extracted from the media that are representative of the material present in the environment.
Sampling	The techniques used for obtaining or extracting representative test samples from the environment.
Saranex®	A plastic fabric that is coated with polyethylene to resist penetration by water and chemicals. Used to make disposable coveralls that are used where there is the risk of splashes or exposure to liquids.
Secondary Maximum Contaminant Level (SMCL)	The maximum permissible level of a contaminant, defined in 40 CFR 143, in water that is delivered to the free flowing outlet of the ultimate user of a public water system.
Seep	A spot where a fluid (as water, oil, or gas) contained in the ground oozes slowly to the surface and often forms a pool.
Semivolatile Organic Chemicals (SVOCs)	Organic chemicals that have a vapor pressure range from 10-12-10-8 KPa. Chemicals that do not evaporate rapidly, but which will vaporize at temperatures below which they decompose.
Serial Dilution	Performing a series of dilutions on a substance to generate a calibration curve or to reduce the concentration of a substance to the measurable level.
Shelby Tubes	A type of sampling device used to obtain soil samples.
Sieve	A woven-like structure made of intersecting strands of wire or plastic, usually mounted in a steel frame. They are available in a wide range of sizes, weaves, and meshes from as coarse as 25 to as fine as 400.

Sludge	A water formed sedimentary deposit, usually a solid or semi-solid material that has settled out of a liquid.
Soil	The unconsolidated mineral and organic matter on the surface of the earth that has been subjected to and influenced by geologic and other environmental factors.
Soil Gas	Subsurface gas that may be generated by biological, chemical, and physical decomposition.
Soil Texture	A standardized description used to differentiate types of soil classes by geologists. Used to differentiate sand, sandy loam, loam, etc., relevant classifications can be found in the United Soil Classification Systems (USCS), Burmeister, and United States Department of Agriculture (USDA).
Soluble	Capable of being dissolved.
Solution	A spontaneously forming homogeneous mixture of two or more substances, retaining its constitution in subdivision to molecular volumes and having various possible proportions on the constituents.
Solvent	The component of a solution that is present in excess or that undergoes no change of state. A liquid capable of dissolving another substance.
Soot	Aerosol carbon particulates found in smoke from combustion processes of natural or manmade origin (0.01–1.0 µm diameter).
Sorbent	A solid material used to extract a chemical contaminant from a gas or a liquid.
Split Spoon Sampler	Soil sampling device used during drilling of boreholes to obtain soil samples at specific depths.
Standard Operating Procedure (SOP)	A written document that details an operation, analysis, or action whose mechanisms are thoroughly prescribed and that is commonly accepted for performing certain routine or repetitive tasks.
Steam Jenny	A piece of transportable equipment that generates low pressure steam; used for cleaning equipment such as drill rigs.
Storage	When used in connection with hazardous waste, means the containment of hazardous waste, either on a temporary basis or for a period of years, in such a manner as not to constitute disposal of such hazardous waste.
Storage Facility	Any facility used for the retention of hazardous waste prior to shipment or usage, except generator facilities (under Title 40 CFR) which is used to store wastes for less than 90 days, for subsequent transport.
Sub-Atmospheric Sampling	A canister sampling procedure for collection of whole air samples in which the canister is under vacuum. A grab sample can

	be collected by opening the inlet for 10 – 30 seconds, or a time-integrated sample can be collected over a period of up to 24 hours by using a flow-restrictive orifice.
Subsurface Soil	The soil more than a defined distance below grade and extending downward to the top of the seasonally high water table.
Summa Canisters	Metal canisters with a chrome-nickel oxide inside surface (Summa polishing process) used to collect whole air samples.
Support Zone	Uncontaminated area defined at a remediation site where administrative functions needed to keep site operations running smoothly are conducted.
Surface Soil	The soil extending from the surface to just above a defined distance below grade.
Surface Impoundment	Any natural depression or excavation and/or dike that is built into or upon the land, which is fixed, uncovered, and lined with soil or a synthetic material, and is used for treating, storing, or disposing wastes. Examples include holding ponds and aeration ponds.
Surveillance	Observation or supervision to gather information.
Swale	A natural or manmade low-lying or depressed and often wet stretch of land.
System Blank	A quality control sample or blank used to measure the background or baseline response in the absence of a sample.
Systematic Error	Error that usually results in a consistent deviation or bias in a final result.

T

Tedlar® Bag	Brand name for a collapsible container equipped with a resealable valve and used to collect and store gas samples.
Teflon®	Brand name for a type of plastic that is resistant to organic and most inorganic chemicals.
Tenax®	Brand name for a 2,6-diphenylene oxide polymer used as sampling media for volatile and semi-volatile organic chemicals.
Thermal Desorption	Use of heat to remove volatile and semi-volatile organic compounds from a solid sorbent.
Thermal Gradients	In air monitoring context, the result of uneven heating and cooling of the earth and surrounding air layers and the decrease of atmospheric pressure with vertical height.
Threshold	The level where the first effects occur; also the point at which a person just begins to notice an effect. (OSHA Usage).
Time Resolution of Sensors	Time required for a real-time sensor, recording in situ measurements, to reach 90 percent of the final response to an incremental change in contaminant concentration.

Topographical Factors	Natural surface features such as mountains, hills, valleys, lakes, and seas, and man-made features such as high-rise buildings, highways, and parking lots which influence the dispersion of air pollutants.
Topography	The geological or physical features of a particular place.
Total Matter	The sum of the particulate and dissolved matter.
Toxicity	The harmful effects of a chemical on some biological mechanism and the condition under which these effects occurs.
Toxicity Characteristic Leaching Procedure (TCLP)	Test procedure defined by EPA to determine whether a waste material placed in a landfill may contaminate groundwater.
Trace Analyte	The trace metal(s) or trace organic(s) which are to be determined in the sample of interest.
Trace Metals	Naturally occurring chemical elements that are everywhere in the environment and generally in very low concentrations (< 10 ppm). Examples include the 13 elements classified as priority pollutants by the EPA.
Trace Metal Grade	Reagents that have demonstrated to be free from the metal(s) of interest at the MDL of the analytical method to be used.
Trace Organics	Manmade (synthetic) or naturally occurring compounds composed of carbon, hydrogen, and oxygen that occur in low concentrations in the environment (<100 ppm). Examples are polyaromatic hydrocarbons from fossil fuel combustion, synthetic pesticides such as diazanon, and naturally occurring and manmade compounds such as dioxins and furans.
Traceability	The property of a sample or measurement whereby it can be related to appropriate international or national standards through an unbroken chain.
Transient Non-community Water Systems (TNCWS)	A non-community water system that does not regularly serve at least 25 of the same persons over 6 months per year.
Trip Blank	A quality control sample consisting of a clean sample matrix that is carried to the sampling site and transported to the laboratory for analysis without having been exposed to the sampling procedures. The purpose of the trip blank is to determine whether samples might have been contaminated during transport and storage.
Turbidity	Reduction in a liquid's transparency from the presence of particulate matter.
Turnaround Time	The amount of time in hours or days from sample receipt at the laboratory to delivery of final report.

Tyvek®	Brand name for a plastic fabric used to make disposable coveralls that help protect personnel from exposure.
	U
Upper Explosive Limit (UEL)	Maximum concentration of a combustible gas or vapor in air that will explode when ignited.
Upwind Sample	A sample taken in air monitoring upwind of the source to ensure that the actual sample is not being contaminated or biased by other sources of emissions in the sampling area.
	V
Vadose Zone	Groundwater located in the zone of aeration above the water table.
Vapor Pressure	The pressure characteristic at any given temperature of a vapor in equilibrium with its liquid or solid form. Higher values indicate higher volatility or evaporation rate.
Vapor Probe	That portion of an instrument that is used to collect a gas; the part of the instrument inserted into soil when conducting soil gas analysis.
Variance	Measure of the variability of a property or measurement. A statistical term describing the variation of values in a data set around some common value. Referred to as sample variance or population variance depending on the calculation procedure.
Verification	Confirmation by examination and provision of evidence that specified requirements have been met.
Vermiculite	Lightweight mineral made from expanded mica. May be used to pack sample containers for shipping.
Virus	An infectious agent composed almost entirely of protein and nucleic acids. Viruses can reproduce only within living cells.
Viscosity	Resistance to flow of a liquid or gas.
Visibility Measurement	Measurement of the greatest distance at which a dark object of reasonable size can be seen against the horizon sky. Measurement depends on degree of light transmission through the atmosphere and contrast of the object to the background. (Meteorological definition).
Volatile Organic Chemicals (VOCs)	Organic compounds that have a vapor pressure range >10–2kPa.
Volatilization	Process whereby solids and liquids pass into the vapor state at a given temperature.
	W
Waiver	A document that relinquishes the holder from a requirement.
Waste Samples	Portions of waste that are representative of the material.
Water Solubility	The extent to which a compound dissolves in water.

Water Table	The seasonally high level of the surface of an aquifer.
Well Purging	Process in which the standing water is removed from a well and the well is allowed to refill with groundwater before a sample is collected.
Wet Collectors	In air sampling context, a collection device that uses a finely dispersed liquid to increase the size of aerosol particles.
Wetland	Those areas that are inundated or saturated by surface or groundwater at a frequency or duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include lakes, swamps, marshes, bogs and similar areas such as sloughs, prairie potholes, wet meadows, prairie river overflows, mudflats, and natural ponds.
Whole Air Sample	An air sample taken without attempting to concentrate any specific pollutants.

EM 1110-1-4000

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	Engineering and Design MONITORING WELL DESIGN, INSTALLATION, AND DOCUMENTATION AT HAZARDOUS TOXIC, AND RADIOACTIVE WASTE SITES	
	Distribution Restriction Statement Approved for public release; distribution is unlimited.	

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US Army Corps
of Engineers

ENGINEERING AND DESIGN

Monitoring Well Design, Installation, and Documentation at Hazardous, Toxic, and Radioactive Waste Sites

This manual is approved for public release, distribution is unlimited.

ENGINEER MANUAL

AVAILABILITY

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DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
Washington, DC 20314-1000

EM 1110-1-4000

CEMP-RT
CECW-EG

Manual
No. 1110-1-4000

1 November 1998

Engineering and Design
MONITORING WELL DESIGN, INSTALLATION, AND DOCUMENTATION AT HAZARDOUS TOXIC, AND RADIOACTIVE WASTE SITES

1. Purpose. This Engineer Manual (EM) provides the minimum elements for consideration in the design, installation, and documentation of monitoring well placement (and other geotechnical activities) at projects known or suspected to contain chemically hazardous, toxic, and/or radioactive waste.

2. Applicability. This EM applies to all U.S. Army Corps of Engineers (USACE) commands having hazardous, toxic, and radioactive waste (HTRW) project responsibilities. For special considerations of radioactive, biological, or mixed (chemical and radioactive) waste components, contact the USACE Hazardous, Toxic, and Radioactive Waste (HTRW) Center of Expertise (CX) in Omaha, Nebraska.

3. References. References are provided in Appendix A.

4. Distribution Statement. Approved for public release, distribution is unlimited.

5. Discussion. The technical understanding and evaluation of HTRW studies involves an appreciation of the interactions between geology, hydrology, geotechnical engineering, and chemistry. This scenario is complicated by the trace (low parts per billion) levels of regulated chemical species that are detectable in the environment and when detected or suspected may trigger intricate and costly response actions. Slight deviations from prescribed drilling, well installation, sampling, or analytical procedures may bias or invalidate both the reported concentrations of these regulated species and the technical basis upon which the Corps makes decisions. These relationships are further complicated by the heterogeneous, anisotropic character of the natural environment itself. This situation requires environmental characterization based upon procedures that are standardized, documented, understood, and followed. This manual outlines that effort.

FOR THE COMMANDER:

2 Appendices
App A - References
App B - Abbreviations

This manual supersedes EM 1110-1-4000, dated 31 August 1994.

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U.S. Army Corps of Engineers
Washington, DC 20314-1000

EM 1110-1-4000

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Manual
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Engineering and Design
MONITORING WELL DESIGN, INSTALLATION, AND DOCUMENTATION AT HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE SITES

Table of Contents

Subject	Paragraph	Page
Chapter 1		
Introduction		
Purpose	1-1	1-1
Applicability	1-2	1-1
References	1-3	1-1
Terminology	1-4	1-1
Background	1-5	1-2
Chapter 2		
Boreholes and Wells: Site Reconnaissance, Locations, Quantities, and Designations		
Site Reconnaissance	2-1	2-1
Locations and Quantities	2-2	2-1
Designations	2-3	2-1
Chapter 3		
Drilling Operations		
Physical Security	3-1	3-1
Drilling Safety and Underground Utility Detection	3-2	3-1
Permits, Licenses, Professional Registration, and Rights-of-Entry	3-3	3-1
Site Geologist	3-4	3-1
Equipment	3-5	3-1
Drilling Methods	3-6	3-2
Recirculation Tanks and Sumps	3-7	3-8
Materials	3-8	3-8
Surface Runoff	3-9	3-14
Drilling Through Contaminated Zones	3-10	3-14
Soil Sampling	3-11	3-14
Rock Coring	3-12	3-17
Abandonment/Decommissioning	3-13	3-18
Work Area Restoration and Disposal of Drilling and Cleaning Residue	3-14	3-19
Chapter 4		
Borehole Logging		
General	4-1	4-1
Format	4-2	4-1
Submittal	4-3	4-1
Original Logs and Diagrams	4-4	4-1
Time of Recording	4-5	4-1
Routine Entries	4-6	4-1
Chapter 5		
Monitoring Well Installation		
General	5-1	5-1
Well Clusters	5-2	5-1
Well Screen Usage	5-3	5-1
Beginning Well Installation	5-4	5-1
Screens, Casings, and Fittings	5-5	5-5
Granular Filter Pack	5-6	5-5
Bentonite Seals	5-7	5-6
Grouting	5-8	5-6
Well Protection	5-9	5-7
Shallow Wells	5-10	5-8
Drilling Fluid Removal	5-11	5-11
Drilling Fluid Losses in Bedrock	5-12	5-11
Well Construction Diagrams	5-13	5-11

Subject	Paragraph	Page
Chapter 6		
Well Development		
General	6-1	6-1
Timing and Record Submittal	6-2	6-1
Development Methods	6-3	6-1
Development Criteria	6-4	6-3
Development-Sampling Break	6-5	6-4
Development Water Sample	6-6	6-4
Well Washing	6-7	6-4
Well Development Record	6-8	6-4
Potential Difficulties	6-9	6-5
Chapter 7		
Well and Boring Acceptance Criteria		
Well Criteria	7-1	7-1
Abandoned/Decommissioned Borings and Wells	7-2	7-1
Well and Boring Rejection	7-3	7-1
Chapter 8		
Water Levels		
Measurement Frequency and Coverage	8-1	8-1
Vertical Control	8-2	8-1
Reporting and Usage	8-3	8-1
Methods	8-4	8-1
Chapter 9		
Topographic Survey		
Licensing	9-1	9-1
Horizontal Control	9-2	9-1
Vertical Control	9-3	9-1
Field Data	9-4	9-1
Geospatial Data Systems	9-5	9-1
Chapter 10		
Borehole Geophysics		
Usage and Reporting	10-1	10-1
Methods	10-2	10-1
Chapter 11		
Vadose Zone Monitoring		
Usage and Reporting	11-1	11-1
Methods	11-2	11-1
Chapter 12		
Data Management System		
Benefits	12-1	12-1
Assistance Sources	12-2	12-1
Geospatial Data Systems	12-3	12-1
Appendix A		
References		
Appendix B		
Abbreviations		

List of Figures

Figure		Page
3-1.	Suggested format for use in obtaining water approval	3-11
3-2.	Suggested format for obtaining approval for filter pack	3-13
3-3.	Example materials summary	3-16
4-1	Boring log fomat	4-2
4-2.	HTRW Drilling Log	4-5
5-1.	Schematic construction of single-cased well with gravel blanket	5-2
5-2.	Schematic construction of multi-cased well with concrete pad	5-3
5-3.	Schematic construction diagram of monitoring well	5-4
5-4.	Post placement and gravel blanket layout around wells	5-9
5-5.	Schematic construction of flush-to-ground completion	5-10
5-6.	Well design parameters to minimize frost heave	5-11

List of Tables

Tables **Page**

3-1. Drilling Methods..... 3-3
4-1. Soil Parameters for Logging.. 4-7
4-2. Rock Core Parameters for Logging.... 4-8

Chapter 1
Introduction

1-1. Purpose

This Engineer Manual (EM) provides geotechnical and chemical guidelines for U.S. Army Corps of Engineers (USACE) elements in the planning, installing, and reporting of soil and/or bedrock borings, monitoring wells, and other geotechnical and geochemical devices at hazardous, toxic, and radioactive waste (HTRW) sites. These guidelines are a compilation of those procedures necessary for the acquisition of environmentally representative geotechnical data and samples, using conservative methods documented in a comprehensive manner.

1-2. Applicability

a. This EM applies to all USACE commands, elements and their contractors (including architect-engineers, [AE's]) having military and/or civil works hazardous, toxic and radioactive waste (HTRW) site responsibilities and/or engaged in programs within the Comprehensive Environmental Resource, Compensation, and Liability Act (CERCLA); the Resource Conservation and Recovery Act (RCRA); the Superfund Amendments and Reauthorization Act (SARA); the Defense Environmental Restoration Program (DERP); non-mission HTRW work for other (non-Corps) offices; work within host nation agreements; or any other Corps-managed HTRW activities.

b. Only HTRW work involving *chemical* issues are covered within this manual. Biological waste components of HTRW are not addressed. Supplemental instructions will be provided as appropriate procedures are identified. In the interim, any requests for assistance in those areas should be directed to the Hazardous, Toxic, and Radioactive Waste (HTRW) Center of Expertise (CX) within the U.S. Army Engineer District, Omaha (CENWO), Attention: HTRW - Center of Expertise, Geoenvironmental & Process Engineering Branch (CENWO-HX-G); or Headquarters, U.S. Army Corps of Engineers (HQUSACE), Attention: Directorate of Military Programs, Policy and Technology Branch (CEMP-RT).

c. The specific application of and adherence to these guidelines must be tailored to each project as a function of the contaminants of concern; local geohydrologic setting; geotechnical judgment; available resources; applicable regulatory requirements; policy and guidance; public concerns; and project mission.

1-3. References

Appendix A contains a list of those publications referenced by and relevant to this manual.

1-4. Terminology

a. General. As in any relatively new field using the principles, terminology, and personnel of several other fields, there is a certain lack of communication over the language used to express data and mechanisms within this new field. The situation is further compounded by alternative methods, both traditional and innovative, to complete actual projects. The additional requirements for permits, licenses, and other federal and state regulatory procedures, and the potential for litigation, add to the HTRW site complexities.

b. Corps situation.

(1) Within USACE, a given HTRW project may be performed totally in-house, partially in-house, or by one or more contractors/AE's (either independently reporting to the Corps or through a system of prime- and subcontracting). One Corps office may broker the work of another who in turn contracts the effort. In some cases, one Corps district may design a project and award the contract while a second district supervises construction.

(2) Providing program level technical guidance in this administrative situation requires the guidance to be specific, while allowing any field activity to adapt the guidance to its needs. The intent is to foster the defense of variances, not the defense of recommended methods and procedures. This approach is warranted to provide the Corps with compatibility and continuity of HTRW investigations while allowing functional flexibility. With this in mind, the following three terms are introduced: the *field activity* (FA); the *field drilling organization* (FDO); and the *drilling and well installation plan*. These terms are defined in paragraphs 1-4*c*(2), (3), and (1), respectively. Generically, these terms refer to a client-contractor-contract relationship. This relationship can be applied to both in-house and contracted efforts, thereby providing consistency for the geotechnical portion of the Corps HTRW involvements.

c. Definitions (alphabetically arranged). These definitions are intended to guide the reader through the use of this manual. While other terms with equivalent definitions may be familiar to some readers, the terminology as defined here provides a common basis for the **CONSISTENT** understanding by **ALL** readers.

(1) Field Sampling Plan (FSP). The FSP is contained within the Sampling and Analysis Plan (SAP), and describes the drilling and well installation plan. The SAP and FSP requirements are outlined in EM 200-1-3. The FSP is approved by the FA or FDO before field activities begin. The plan specifies the particulars of the field effort; for example: borehole/well/sample locations, depths, equipment, materials, procedures and alternatives, quality control measures, and other topics required by the responsible FA. Implementation is by the FDO.

(2) Field activity (FA). That Corps element minimally headed by a Commander or Director; e.g., district, laboratory, or agency, assigned or otherwise acquiring the responsibility to administer a contract, agreement, or in-house Corps procedure to research, investigate, design, and/or construct a project involving hazardous and/or toxic wastes.

(3) Field drilling organization (FDO). That office within the Corps or contracted by the Corps responsible for execution of the drilling plan. In a contracted arrangement, the prime contractor is regarded as the FDO. Subcontractors, even though they may physically perform the field work, are the responsibility of the prime contractor, whom the Corps holds contractually accountable.

(4) Geotechnical data quality management (GDQM). The development and application of those policies and procedures required to obtain and utilize accurate and representative geotechnical information throughout the entire HTRW project cycle, from predesign investigations to postconstruction monitoring.

(5) Hazardous, toxic, and radioactive waste (HTRW). A USACE idiom referring to substances which because of their properties, occurrence, or concentration, may potentially pose a threat to human health and welfare, or to the environment. This includes materials defined by federal regulations as hazardous waste, hazardous substances, and pollutants.

(6) Monitoring well. A monitoring well is a device designed and constructed for the acquisition of groundwater samples that are representative of the chemical quality of the aquifer adjacent to the screened interval, unbiased by the well materials and installation process; and which, if so designed, provides access to measure potentiometric head across the screened interval.

(7) Redevelopment/well rehabilitation. A procedure which restores the original or near original pumping capacity to an existing well by the removal of sediment, precipitation, flocculent, surface run-in, or other built-up materials from within that well.

(8) Screened interval. That portion of a well which is directly open to the host environment/aquifer by way of openings in the well screen.

(9) Site safety and health plan (SSHP). A project-unique document approved by the responsible FA for FDO compliance. The plan includes the identification of hazardous substances present, recommended action upon encountering those substances, project/site safety requirements, organizational safety responsibilities, and the identification of supporting health and safety activities.

(10) Well development. A procedure which locally improves or restores the aquifer's hydraulic conductivity, well capacity, and removes well drilling fluids, muds, cuttings, mobile particulates, and entrapped gases from within and adjacent to a newly installed well.

d. Acronyms. Appendix B contains a list of the abbreviations used in this manual.

1-5. Background

a. EM 1110-1-4000. As a GDQM mechanism, this manual provides guidance for collection and documentation of geotechnical information. Site-specific deviations should be described and supported in the drilling and well installation plan.

(1) Technical understanding and evaluation of HTRW studies involve an appreciation of the interactions among many fields including geology, hydrology, geotechnical engineering, and chemistry. This scenario is complicated by the trace (low parts per billion) levels of regulated chemical species that are detectable in the environment and which, when detected or suspected, trigger intricate and costly response actions. Slight deviations from prescribed drilling, well installation, sampling, or analytical procedures may bias or invalidate the reported concentrations. This sensitivity requires that procedures be relevant, standardized, documented, understood, and followed. Despite these procedures, the normal heterogeneity and anisotropy of natural field occurrences are, in themselves, frequently sufficient to confuse the appropriate interpretation of the

gathered field data.

(2) The specific content of this manual will be periodically updated based upon reader suggestions, lessons learned, technological advances, and Corps needs. Issues of significant concern will be disseminated Corpswide in a more expeditious manner.

(3) Not all geotechnical personnel will agree on every practice advocated herein. Any such variations should be over a matter of degree, not substance. If the reader perceives a technical difficulty in any of this manual's contents, the reader is requested to contact the proponent.

b. Proponency. The technical proponents for this manual are the Policy and Technology Branch, Environmental Division, Directorate of Military Programs (CEMP-R), and the Geotechnical and Materials Branch, Engineering Division, Directorate of Civil Works (CECW-EG), Headquarters, U.S. Army Corps of Engineers. All comments and suggestions should be directed to HQUSACE, CEMP-R, 20 Massachusetts Avenue, N.W., Washington, D.C. 20314-1000.

Chapter 2
Boreholes and Wells: Site Reconnaissance, Locations, Quantities, and Designations

2-1. Site Reconnaissance

Site visits are suggested for project geotechnical personnel as early as practical in the planning for any subsurface exploration. The purpose of this reconnaissance is to evaluate physical site conditions and logistical support availability. Particular items of interest would include geologic and geographic settings, site access, proximal utilities, service areas, sample shipment facilities, and potential hazards. Application of this knowledge will contribute to enhancing the technical approach and cost realism for subsequent project development.

2-2. Locations and Quantities

The locations and quantities of boreholes and wells should be selected to effectively ascertain desired geologic, hydrologic, and/or chemical parameters. The number of borings or wells specified in the drilling plan should not be altered without coordination with the FA. The drilling and well installation plan should permit relocations when necessitated by proximal utilities or drilling difficulties. The criteria for selection of the new location(s) should be included as a portion of the drilling plan and should indicate when coordination would be required with the FA.

2-3. Designations

Borehole and well designations (identification numbers) should not be unilaterally changed in the field or in a centralized computer database without prior approval of the installing Corps organization or non-Corps agency. After receiving approval, the requesting FA should physically renumber those sites where a designation is posted in the field. Temporary conversions not involving the alteration of either field markings or a centralized database may be done for reporting purposes without approval of the installing organization or agency. Such temporary changes may be necessary, for instance, if the data entry format of a given computer system is not compatible with the characters in the existing well designation. A conversion table should be included in the final report to document any permanent *or* temporary boring/well designation changes.

Chapter 3
Drilling Operations

3-1. Physical Security

The FDO should comply with all security policies at the project site. The FDO is responsible for securing its own equipment. The FDO should address any special situations in the drilling plan.

3-2. Drilling Safety and Underground Utility Detection

When drilling in areas of known or suspected hazardous materials, appropriate health and safety precautions should be implemented. Guidance adaptable for drilling activities is available in Occupational Safety and Health Administration (OSHA) documents (particularly, 29 CFR 1910.120 and 29 CFR 1926), ER 385-1-92, and EM 385-1-1. The FDO should determine all applicable regulations, requirements, and permits with regard to drilling safety and underground utility detection. These items should be included in the safety plan. The safety plan should be approved by the FA prior to any drilling.

3-3. Permits, Licenses, Professional Registration, and Rights-of-Entry

The FA should be responsible for identifying all applicable permits, licenses, professional registration, rights-of-entry, and applicable state and local regulatory procedures for drilling, well installation, well decommissioning/ abandonment, and topographic surveying (to include any requirements for the submission of well logs, samples, etc.). Acquisition and submission of these items to state or local authorities should be coordinated between the FA and FDO, with the responsibilities of each specified in the drilling plan. The need for any rights-of-entry should be specified in the drilling plan along with the organization(s) responsible for their acquisition.

3-4. Site Geologist

A "site geologist" (defined as an earth science or engineering professional with a college degree in geology, civil engineering, or related field; experienced in HTRW projects, soil and rock logging, and monitoring well installation), should be present at each operating drill rig. This geologist should be responsible for logging; acquisitioning (and possibly shipment) of samples; monitoring of drilling operations; recording of water losses/gains and groundwater data; preparing the boring logs and well diagrams; and recording the well installation and decommissioning procedures conducted with that rig. Each site geologist should be responsible for only one operating rig. The geologist should have onsite sufficient tools, forms, and professional equipment in operable condition to efficiently perform the duties as outlined in this manual and other relevant project documents. Items in the possession of each site geologist should include, as a minimum, a copy of this manual, a copy of the approved drilling and well installation plan, log forms, the approved safety plan, a 10-power (minimum) hand lens, and a measuring tape (weighted with stainless steel or chemically stable, nonmetallic material) long enough to measure the deepest boring/well within the project, heavy enough to reach that depth, and small enough to readily fit within the appropriate annulus or opening. Each site geologist should also have onsite a water-level measuring device (preferably electrical), pH and electric conductivity meters, a turbidimeter, a thermometer, an instrument for measuring dissolved oxygen, and materials necessary to prepare the samples for storage or shipment. At some sites, the geologist may be also responsible for monitoring gases during drilling. If so, the geologist should have the necessary instruments and be proficient in their use and calibration.

3-5. Equipment

a. Condition. All drilling, sampling, and supporting equipment brought to a site should be in operable condition and free of leaks in the hydraulic, lubrication, fuel, and other fluid systems where fluid leakage would or could be detrimental to the project effort. All switches (to include safety switches), gages, and other electrical, mechanical, pneumatic, and hydraulic systems should be in a safe and operable condition prior to arrival onsite.

b. Cleaning. All drilling equipment should be cleaned with steam or pressurized hot water before arriving at the project installation/site. After arrival but prior to project commencement, all drilling equipment including rigs, support vehicles, water tanks (inside and out), augers, drill casings, rods, samplers, tools, recirculation tanks, etc., should be cleaned with steam or pressurized hot water using approved water (see paragraph 3-9*b*) at the installation decontamination point. Guidance for decontamination of field equipment may be found in ASTM D 5088. Samplers and other equipment, such as water level indicators, oil/water interface probes, etc. may require additional decontamination steps. A similar cleaning should also occur between each boring/well site. After the onsite cleaning, only the equipment used or soiled at a particular boring or well should need to be recleaned between sites. Unless circumstances require otherwise, water tank interiors may not need to be cleaned between each boring/well at a given project. Prior to use, all casings, augers, recirculation and water tanks, etc., should be devoid both inside and out of any asphaltic, bituminous, or other encrusting or coating materials, grease, grout, soil, etc. Paint, applied by the equipment manufacturer, may not have to be removed from

drilling equipment, depending upon the paint composition and its contact with the environment and contaminants of concern. All equipment should be decontaminated before it is removed from the project site. If drilling requires telescoping casing because of differing levels of contamination in subsurface strata, then decontamination may be necessary before setting each string of smaller casing and before drilling beyond any casing. To the extent practical, all cleaning should be performed in a single remote area that is surficially crossgradient or downgradient from any site to be sampled. Waste solids and water from the cleaning/decontamination process should be properly collected and disposed. This may require that cleaning be conducted on a concrete pad or other surface from which the waste materials may be collected. Guidance for decontamination of field equipment used at low level radioactive waste sites may be found in ASTM D 5608.

3-6. Drilling Methods

a. Objective. The objective of selecting a drilling method for monitor well installation is to use that technique which

(1) Provides representative data and samples.

(2) Eliminates or minimizes the potential for subsurface contamination and/or cross-contamination.

(3) Minimizes drilling costs.

b. Methods. Table 3-1 presents types of drilling methods. Detailed descriptions of different drilling methods may be found in EPA/600/4-89/034, EPA/625/R-93/003a, USGS WRI Report 96-4233, USGS TWRI Book 2 Chapter F1, ASTM D 6286, Driscoll (1986), and U.S. Army FM 5-484. Where possible, ASTM drilling method-specific guides are referenced with the drilling methods listed below.

(1) Hollow stem augers. Method references: ASTM D 5784 and EPA/600/4-89/034.

(2) Cable tool/churn drill. Method reference: ASTM D 5875.

(3) Water/mud rotary. Method references: ASTM D 5781, D 5783, and D 5876.

(4) Air/pneumatic rotary methods. Method reference: D 5782.

(5) Sonic/vibratory. Method reference: EPA/625/R-94/003.

(6) Direct Push. Method references: ASTM Standard Guides D 6001 and D 6282, and EPA/510/B-97/001.

c. Special concerns.

(1) Dry methods.

(a) Hollow stem augers are technically advantageous in most situations because of their “dry” method of drilling. A dry drilling method is preferred for HTRW work. Dry methods advance a boring using purely mechanical means without the aid of an aqueous or pneumatic drilling “fluid” for cuttings removal, bit cooling, or borehole stabilization. In this way, the chemical interface with the subsurface is minimized, though not eliminated. Local aeration of the borehole wall, for example, may occur simply by the removal of compacted or confining soil or rock.

(b) Vibratory, or sonic drilling, employs the use of high-frequency mechanical vibration to take continuous core samples of overburden soils and most hard rock. A sonic drill rig uses an oscillator, or head, with eccentric weights driven by hydraulic motors, to generate high sinusoidal force in a rotating drill pipe. The frequency of vibration of the drill bit or core barrel can be varied to allow optimum penetration of subsurface materials. Sonic drilling penetrates a formation by displacement, shearing, or fracturing. Displacement occurs by fluidizing the soil particles (sands and light gravels) and causing them to move either into the formation or into the center of the drill pipe. Shearing occurs in dense silts, clays, and shales, if the axial oscillations of the drill pipe overcomes the elastic nature of the material. The penetration of cobbles, boulders, and rock is caused by fracturing of the material by the inertial moment of the drill bit. Although, rock drilling and sampling requires the addition of water or air to remove drill cuttings, the volume of drill cuttings generated during sonic drilling is usually much less than those generated from some other drilling methods. Drilling through unconsolidated material can be done in the dry, without the use of drilling fluids such as air or water-based fluids and additivies. Overall, the sonic drilling method can also offer the advantages of obtaining relatively undisturbed soil and rock samples at higher drilling rates than conventional methods, with high percentage of core recovery, and produces less investigation-derived waste.

TABLE 3-1
DRILLING METHODS

Method	Drilling Principle	Depth Limitation m (Ft.)	Advantages	Disadvantages
Direct-Push	Advancing a sampling device into the subsurface by applying static pressure, impacts, or vibration or any combination thereof to the above ground portion of the sampler extensions until the sampler has been advanced its full length into the desired soil strata.	30 (100)	Avoids use of drilling fluids and lubricants during drilling. Equipment highly mobile. Disturbance of geochemical conditions during installation is minimized. Drilling and well screen installation is fast, considerably less labor intensive. Does not produce drill cuttings, reduction of IDW.	Limited to fairly soft materials such as clay, silt, sand, and gravel. Compact, gravelly materials may be hard to penetrate. Small diameter well screen may be hard to develop. Screen may become clogged if thick clays are penetrated. The small diameter drive pipe generally precludes conventional borehole geophysical logging. The drive points yield relatively low rates of water.
Auger, Hollow- and Solid-Stem	Successive 1.5m (5-ft) flights of spiral-shaped drill stem are rotated into the ground to create a hole. Cuttings are brought to the surface by the turning action of the auger.	45 (150)	Fairly inexpensive. Fairly simple and moderately fast operation. Small rigs can get to difficult-to-reach areas. Quick setup time. Can quickly construct shallow wells in firm, noncavey materials. No drilling fluid or lubricants required. Use of hollow-stem augers greatly facilitates collection of split-spoon samples, continuous sampling possible. Small-diameter wells can be built inside hollow-stem flights when geologic materials are cavey.	Depth of penetration limited, especially in cavey materials. Cannot be used in rock or well-cemented formations. Difficult to drill in cobbles or boulders. Log of well is difficult to interpret without collection of split spoons due to the lag time for cuttings to reach ground surface. Soil samples returned by auger flight are disturbed making it difficult to determine the precise depth from which the sample came. Vertical leakage of water through borehole during drilling is likely to occur. Solid-stem limited to fine-grained, unconsolidated materials that will not collapse when unsupported. Borehole wall can be smeared by previosly-drilled clay. With hollow-stem flights, heaving sand can present a problem. May need to add water down-auger to control heaving or wash materials from auger before completing well.
Jetting	Washing action of water forced out of the bottom of the drill rod clears hole to allow penetration. Cuttings brought to surface by water flowing up the outside of the drill rod.	15 (50)	Relatively fast and inexpensive. Driller often not needed for shallow holes. In firm, noncavey deposits where hole will stand open, well construction fairly simple. Minimul equipment required. Equipment highly mobile.	Somewhat slow with increasing depth. Limited to drilling relatively shallow depth, small diameter boreholes. Extremely difficult to use in very coarse materials, i.e., cobbles and boulders. Large quantities of water required during drilling process. A water supply is needed that is under enough pressure to penetrate the geologic materials present. Use of water can affect groundwater quality in aquifer. Difficult-to-interpret sequence of geologic materials from cuttings. Presence of gravel or larger materials can limit drilling. Borehole can collapse before setting monitoring well if borehole uncased.

TABLE 3-1
DRILLING METHODS

Method	Drilling Principle	Depth Limitation m (Ft.)	Advantages	Disadvantages
Cable-tool (percussion)	Hole created by dropping a heavy "string" of drill tools into well bore, crushing materials at bottom. Cuttings are removed occasionally by bailer. Generally, casing is driven just ahead of the bottom of the hole; a hole greater than 6 inches in diameter is usually made.	300+ (1,000 +)	Can be used in rock formations as well as unconsolidated formations. Can drill through cobbles and boulders and highly cavernous or fractured rock. Fairly accurate logs can be prepared from cuttings if collected often enough. Driving a casing ahead of hole minimizes cross-contamination by vertical leakage of formation waters and maintains borehole stability. Recovery of borehole fluid samples excellent throughout the entire depth of the borehole. Excellent method for detecting thin water-bearing zones. Excellent method for estimating yield of water-bearing zones. Excellent method for drilling in soil and rock where lost circulation of drilling fluid is possible. Core samples can be easily obtained. Excellent for development of a well.	The potential for cross-contaminated samples is very high. Decontamination can be difficult. Heavy steel drive pipe used to keep hole open and drilling "tools" can limit accessibility. Cannot run some geophysical logs due to presence of drive pipe. Relatively slow drilling method. Heavier wall, larger diameter casing than that used for other drilling methods normally used. Temporary casing can cause problems with emplacement of effective filter pack and grout seal. Heaving of unconsolidated sediment into bottom of casing can be a problem.
Mud Rotary	Rotating bit breaks formation; cuttings are brought to the surface by a circulating fluid (mud). Mud is forced down the interior of the drill stem, out the bit, and up the annulus between the drill stem and hole wall. Cuttings are removed by settling in a "mud pit" at the ground surface and the mud is circulated back down the drill stem.	1,500+ (5,000 +)	Drilling is fairly quick in all types of geologic materials, hard and soft. Borehole will stay open from formation of a mud wall on sides of borehole by the circulating drilling mud. Eases geophysical logging and well construction. Geologic cores can be collected. Can use casing-advancement drilling method. Borehole can readily be gravel packed and grouted. Virtually unlimited depths possible.	Expensive, requires experienced driller and fair amount of peripheral equipment. Completed well may be difficult to develop, especially small diameter wells, because of mud or filter-cake on wall of borehole. Lubricants used during drilling can contaminate the borehole fluid and soil/rock samples. Geologic logging by visual inspection of cuttings is fair due to presence of drilling mud. Beds of sand, gravel, or clay may be missed. Location of water-bearing zones during drilling can be difficult to detect. Drilling fluid circulation is often lost or difficult to maintain in fractured rock, root zones, or in gravels and cobbles. Difficult drilling in boulders and cobbles. Presence of drilling mud can contaminate water samples, especially the organic, biodegradable muds. Overburden casing usually required. Circulation of drilling fluid through a contaminated zone can create a hazard at the ground surface with the mud pit and cross-contaminate clean zones during circulation.

TABLE 3-1
DRILLING METHODS

Method	Drilling Principle	Depth Limitation m (Ft.)	Advantages	Disadvantages
Reverse Rotary	Similar to hydraulic rotary method except the drilling fluid is circulated down the borehole outside the drill stem and is pumped up the inside, just the reverse of the normal rotary method. Water is used as the drilling fluid, rather than a mud, and the hole is kept open by the hydrostatic pressure of the water standing in the borehole.	1,500+ (5,000 +)	Drilling readily accomplished in soils and most hard rock. Drilling is relatively fast and for drilling large diameter boreholes. Borehole is accessible for geophysical logging prior to installation of well. Creates a very "clean" hole, not dirtied with drilling mud. Large diameter of borehole permits relatively easy installation of monitoring well. Can be used in all geologic formations. Very deep penetrations possible. Split-spoon sampling possible.	Drilling through cobbles and boulders may be difficult. Use of drilling fluids, polymeric additives, and lubricants can affect the borehole chemistry. A large water supply is needed to maintain hydrostatic pressure in deep holes and when highly conductive formations are encountered. Expensive--experienced driller and much peripheral equipment required. Hole diameters are usually large, commonly 18 inches or greater. Cross-contamination from circulating water likely. Geologic samples brought to surface are generally poor; circulating water will "wash" finer materials from sample.
Air Rotary	Very similar to hydraulic rotary, the main difference is that air is used as the primary drilling fluid as opposed to mud or water.	1,500+ (5,000 +)	Can be used in all geologic formations; most successful in highly fractured environments. Useful at most any depth. Drilling in rock and soil is relatively fast. Can use casing-advancement method. Drilling mud or water not required. Borehole is accessible for geophysical logging prior to monitoring well installation. Well development relatively easy.	Relatively expensive. Cross-contamination from vertical communication possible. Air will be mixed with the water in the hole and blown from the hole, potentially creating unwanted reactions with contaminants; may affect "representative" samples. Air, cuttings and water blown from the hole can pose a hazard to crew and surrounding environment if toxic compounds encountered. Compressor discharge air may contain hydrocarbons. Organic foam additives to aid cuttings removal may contaminate samples. Overburden casing usually required.
Sonic (vibratory)	Employs the use of high-frequency mechanical vibration to take continuous core samples of overburden soils and most hard rock.	150 (500)	Can obtain large diameter, continuous and relatively undisturbed cores of almost any soil material without the use of drilling fluids. Can drill through boulders, wood, concrete and other construction debris. Can drill and sample most softer rock with high percentage of core recovery. Drilling is faster than most other methods. Reduction of IDW.	Rock drilling requires the addition of water or air or both to remove drill cuttings. Extraction of casing can cause smearing of borehole wall with silt or clay. Extraction of casing can damage well screen. Equipment is not readily available and is expensive.

TABLE 3-1
DRILLING METHODS

Method	Drilling Principle	Depth Limitation m (Ft.)	Advantages	Disadvantages
Air-Percussion Rotary or Down-the-Hole (DTH) Hammer	Air rotary with a reciprocating hammer connected to the bit to fracture rock.	600 (2,000)	Very fast penetrations. Useful in all geologic formations. Only small amounts of water needed for dust and bit temperature control. Cross-contamination potential can be reduced by driving casing. Can use casing-advancement method. Well development relatively easy.	Relatively expensive. As with most hydraulic rotary methods, the rig is fairly heavy, limiting accessibility. Overburden casing usually required. Vertical mixing of water and air creates cross-contamination potential. Hazard posed to surface environment if toxic compounds encountered. DTH hammer drilling can cause hydraulic fracturing of borehole wall. The DTH hammer requires lubrication during drilling. Organic foam additives for cuttings removal may contaminate samples.

(c) Another dry method, known as the direct push method, involves sampling devices that are directly inserted into the soil to be sampled without drilling or borehole excavation. Direct push sampling also includes the use of the Site Characterization and Analysis Penetrometer System (SCAPS) which has contaminant screening capability in addition to indirect soil stratigraphy information (ASTM D 5778 and D 6067). Direct push sampling consists of advancing a sampling device into the subsurface by applying static pressure, impacts, or vibration or any combination thereof to the above ground portion of the sampler extensions until the sampler has been advanced its full length into the desired soil strata. Direct push methods may be used to collect both soil (ASTM D 6282) and water samples (ASTM D 6001). In some cases the method may combine water sampling and/or vapor sampling with soil sampling in the same investigation. The direct push sampling method is widely used as a preliminary site characterization tool for the initial field activity of a site investigation. Direct push sampling is an economical and efficient method for obtaining descrete soil and water samples without the expense of drilling and its related decontamination and waste cuttings disposal costs. This method may be especially advantageous at a radioactive site, where the reduction of IDW is of special importance. The equipment generally used in direct push sampling is small and relatively compact allowing for better mobility around the site and access to confined areas. The rapid sample gathering provided by direct push methods can be used to determine the chemical composition of the soils and ground water in the field in certain circumtances. This method may offer an immediate determination of the need for further monitoring points. It must be cautioned, however, that certain temporary well points installed by this method may not be allowed as permanent monitoring wells by some state and local regulations.

(2) Pneumatic methods. When air is used it should be detailed in the drilling plan, to include the following items:

(a) Situation favoring air usage.

(b) Air drilling method to be used.

(c) Expected subsurface contaminants, and how field personnel will be protected from any adverse effects caused by these contaminants in the returned air and particles blown from the borehole or well.

(d) The potential effects of air usage upon the chemical analyses of groundwater and soil (especially for volatile species) and the mitigation procedures to negate the detrimental aspects of these effects.

(e) The potential effects of air usage upon the physical, hydrological, and structural character of the surrounding soil and/or rock and the mitigation to address the negative aspects of these effects.

(f) Measures to be taken to reduce oil usage and to limit aquifer aeration.

(g) Specify the type of air compressor and compressor lubricating oil and require that sufficient samples of the initial reservoir (and any refill) oil be retained by the FDO, along with a record of oil loss (recorded on the boring log), for evaluation in the event of future problems. The oil sample(s) may be disposed of upon project completion.

(h) Require an air line oil filter and that the filter be changed per manufacturer's recommendation during operation with a record kept (on the boring log) of this maintenance. More frequent changes should be made if oil is visibly detected in the filtered air, as by an oil stain on clean, writing paper after directing the filtered air from a hose onto the paper “300 mm” (“a foot”) away for “15 seconds.” (While these numbers are arbitrary, they are provided as examples for FDO guidance and intra/interproject consistency.)

(i) Prohibit the use of any additive except approved water for dust control and cuttings removal.

(j) Detail the use of any downhole hammer/bit with emphasis upon those procedures to be taken to preclude residual groundwater sample contamination caused by the lubrication of the downhole equipment.

(k) Discuss the volume of air and pressure rating required for drilling and whether a downhole hammer, rotary bit, or both can be used. The air volume and pressure required should be adequate for the hole diameter, boring depth, available equipment, and site conditions.

(l) Detail the use of any bottled gas with emphasis on air composition, quality, quantity, method of bottling, and anticipated use.

(m) Air usage should be fully described in the boring log to include equipment description(s), manufacturer(s), model(s), air pressures used, frequency of oil filter change, and evaluation of the system performance, both design and actual.

(3) Aqueous methods.

(a) Aqueous drilling methods use a fluid, usually water, or a water and bentonite mix, for cuttings removal, bit cooling, and hole stabilization. For HTRW work, the use of these materials increases the potential to add a new contaminant or suite of contaminants to the subsurface environment adjacent to the boring. Even the removal of one or more volumes of water equal to that which was lost during drilling will not remove all of the lost fluid. In addition, the level of effort to be expended upon well development is directly tied to the amount of water loss during drilling: a minimum of three times the volume lost to be removed during development. Therefore, the less fluid loss, the less the development effort (time and cost).

(b) The situation is further complicated when bentonite is used. While bentonite tends to reduce the amount of drilling fluid loss, the residual bentonite remaining around the boring after development may provide sufficient sorptive material to modify local groundwater chemistry for some parameters (for example, metals).

3-7. Recirculation Tanks and Sumps

If possible, only portable recirculation tanks should be used for mud/water rotary operations and similar functions. The use of dug sumps or pits (lined) should be used only if necessary, as when the volume necessary to handle problem holes that encounter running sand or gravel is greater than can be handled by a portable tank. This is important in order to minimize cross-contamination and to enhance both personal safety and work area restoration.

3-8. Materials

a. Bentonite. Bentonite is the only drilling fluid additive that is typically allowed under normal circumstances. This includes any form of bentonite (powders, granules, or pellets) intended for drilling mud, grout, seals, etc. Organic additives should not be used. Exception might be made for some high yield bentonites, to which the manufacturer has added a small quantity of polymer. The use of any bentonite should be discussed in the drilling plan and approved by the FA. Bentonite should only be used if absolutely necessary to ensure that the borehole will not collapse or to improve cuttings removal. The following data should be included in the drilling plan and submitted along with a sample of the material for approval:

(1) Brand name(s).

(2) Manufacturer(s).

(3) Manufacturer's address and telephone number(s).

(4) Product description(s) from package label(s) or manufacturer's brochure(s), to include any polymer or other additives.

(5) Intended use(s) for this product.

(6) Potential effects on chemical analyses of subsequent samples.

b. Water.

(1) To the extent practical, the use of drilling water should be held to a minimum at HTRW sites. When water usage is deemed necessary, the source of any water used in drilling, grouting, sealing, filter placement, well installation, well decommissioning/abandonment, equipment washing, etc. should be approved by the FA prior to arrival of the drilling equipment onsite and specified in the drilling plan. Desirable characteristics for the source include:

(a) An uncontaminated aquifer origin;

(b) Wellhead upgradient of potential contaminant sources;

(c) Be free of survey-related contaminants by virtue of pretesting (sampling and analysis) by the FDO using a laboratory validated by USACE for those contaminants using methods within that validation, and knowledge of the water-chemistry is the most important factor in water approval;

(d) The water is untreated and unfiltered;

(e) The tap has accessibility and capacity compatible with project schedules and equipment; and

(f) Only one designated tap for access.

(2) Surface water bodies should not be used, if at all practical.

(3) If a suitable source exists onsite, that source should be used. If no onsite water is available, the FDO should both locate a potential source and submit the following data in writing to the FA for approval prior to the arrival of any drilling equipment onsite. A suggested format is given in Figure 3-1.

(a) Owner/address/telephone number.

(b) Location of tap/address.

(c) Type of source (well, pond, river, etc.). If a well, specify static water level (depth), date measured, well depth, and aquifer description.

(d) Type of any treatment and filtration prior to tap (e.g., none, chlorination, fluoridation, softening, etc.).

(e) Time of access (e.g., 24 hours per day, 7 days per week, etc.).

(f) Cost per liter (gallon) charged by owner/operator.

(g) Results and dates of all available chemical analyses over past 2 years. Include the name(s) and addresses of the analytical laboratory(s).

(h) Results and date(s) of chemical analysis for project contaminants by a laboratory validated by USACE for those contaminants.

(4) The FDO should have the responsibility to procure, transport, and store the water required for project needs in a manner to avoid the chemical contamination or degradation of the water once obtained. The FDO also should be responsible for any heating, thermal insulation, or agitation of the water to maintain the water as a fluid for its intended uses.

c. Grout.

(1) Cement. Cement grout, when used in monitoring well construction or borehole/well decommissioning, should be composed of Type I Portland cement (ASTM C 150), bentonite (2-5% dry bentonite per 42.6 kg (94 lb) sack of dry cement) and a maximum of 23 to 26 L (6-7 gal) of approved noncontaminated-water per sack of cement. The addition of bentonite to the cement admixture will aid in reducing shrinkage and provide plasticity. Note that the maximum amount of dry bentonite allowed here varies from the 10 percent allowable in ASTM D 5092. The amount of water per sack of cement required for a pumpable mix will vary with the amount of bentonite used. The amount of water used should be kept to a minimum. When a sulfate resistant grout is needed, Types II or V cement should be used instead of Type I. Neither additives nor borehole cuttings should be mixed with the grout. The use of air-entrained cement should be avoided to negate potential analytical interference in groundwater samples by the entraining additives.

(2) Bentonite. Bentonite grout is a specially designed product, which is differentiated from a drilling fluid by its high solids content, absence of cement and its pumpability. A typical high solids bentonite grout will have a solids content between 20 and 30 percent by weight of water and remain pumpable. By contrast, a typical low solids bentonite, as used in a drilling fluid, contains a solids content between 3 and 6 percent by weight of water. The advantages of using bentonite grout include (Oliver 1997) :

- Bentonite grouts, when hydrated, exert constant pressure against the walls of the annulus, leaving no room for contaminants to travel in the well.
- Bentonite grouts are more flexible and do not shrink and crack when hydrated, creating a low permeability seal.
- Placement using bentonite grouts is much easier because more time is allowed for setting.
- Bentonite high solids grouts require less material handling than cement.
- Bentonite grouts are chemically inert, which protects personal safety, equipment, and water quality.
- Bentonite grouts have no heat of hydration making them compatible with polyvinyl chloride (PVC) casing.
- Wells constructed with bentonite grouts can be easily reconstructed if necessary.
- Cleanup of bentonite grouts is much easier than with cement grouts.

Situations where bentonite grout should not be used are when additional structural strength is needed or when excessive chlorides or other contaminants such as alcohols or ketones are present. Under artesian conditions the bentonite does not have the solids content found in a cement-bentonite grout and will not settle where a strong uplift is present. Where structural support is needed, bentonite grout does not set up and harden

like a cement and will not supply the support a cement-bentonite grout will provide (Colangelo 1988).

(3) Equipment. All grout materials should be combined in an aboveground rigid container or mixer and mechanically (not manually) blended onsite to produce a thick, lump-free mixture throughout the mixing vessel. The mixed grout should be recirculated through the grout pump prior to placement. Grout should be placed using a grout pump and pipe/tremie. The grout pipe should be of rigid construction for vertical control of pipe placement. Drill rods, rigid polyvinyl chloride (PVC) or metal pipes are suggested stock for tremies. If hoses or flexible plastics must be used, they may have to be fitted with a length of steel pipe at the downhole end to keep the flexible material from curling and embedding itself into the borehole wall. This is especially true in cold weather when the coiled material resists straightening. Grout pipes should have **SIDE** discharge holes, **NOT** end discharge. The side discharge will help to maintain the integrity of the underlying material (especially the bentonite seal).

d. Granular filter pack.

(1) Proper design of hydraulically efficient monitoring wells can be accomplished by designing the well in such a way that either the natural coarse-grained formation materials or artificially introduced coarse-grained materials, in conjunction with appropriately sized intake openings, retain the fine materials outside the well while permitting water to enter. Thus, there are two types of wells and well intake designs for wells installed in unconsolidated or poorly-consolidated geologic materials: natural developed wells and wells with an artificially introduced filter pack. In both types of wells, the objective of a filter pack is to increase the effective diameter of the well and to surround the well intake with an envelope of relatively coarse material of greater permeability than the natural formation material (EPA/600/4-89/034). The decision to design the well using the natural formation as the filter pack should include consideration that the natural formation material may slough in high enough above the top of the well screen to leave insufficient room for the bentonite seal. All granular filters should be approved by the FA prior to drilling and should be discussed in the drilling plan. Discussions should include composition, source (natural formation or artificial), placement, and gradation. The FDO should either prescribe the gradation of the filter pack in the field sampling plan (FSP) or detail that it will be determined after a sieve analysis of the stratum in which the screen is to be set has been performed. If the actual gradation is to be determined during drilling, more than one filter pack gradation should be on hand so that well installation will not be unnecessarily delayed. A 0.5 L (one-pint) representative sample for visual familiarization of each proposed granular filter pack, accompanied by the data below, should be submitted by the FDO to the FA for approval prior to drilling. Each sample should be described, in writing (see Figure 3-2 for submittal format), in terms of:

(a) Lithology;

(b) Grain size distribution;

(c) Brand name, if any;

(d) Source, both manufacturing company and location of pit or quarry of origin for artificial filter packs;

(e) Processing method for artificial filter packs, e.g., pit run, screened and unwashed, screened and washed with water from well/river/pond, etc.; and

(f) Slot size of intended screen.

(2) Granular filter packs should be visually clean (as seen through a 10-power hand lens), free of material that would pass through a No. 200 (75 µm [0.0029 in.]) sieve, inert, siliceous, composed of rounded grains, and of appropriate size for the well screen and host environment. Organic matter, soft, friable, thin, or enlongated particles are not permissible. A chemical analysis, including analytes of project concern, may be advisable in some circumstances. However, the reproducibility of that result should be evaluated against the spatial and temporal variability of the aggregate source and processing methods. The filter material should be packaged in bags by the supplier and therein delivered to the site.

e. Well screens, casings, and fittings.

(1) Typically, only PVC, polytetrafluoroethylene (PTFE), and/or stainless steel should be used. All PVC screens, casings, and fittings should conform to National Sanitation Foundation (NSF) Standard 14 for potable water usage or ASTM Standard Specification F 480 and bear the appropriate rating logo. If the FDO uses a screen and/or casing manufacturer or supplier who removes or does not apply this logo, the FDO should

WATER APPROVAL

Project for Intended Use:

1. Water source:
   Owner:
   Address:
   Telephone Number:

2. Water tap location:
   Operator:
   Address:

3. Type of source:
   Aquifer:
   Well depth:
   Static water level from ground surface:
   Date measured;

4. Type of treatment prior to tap:

5. Type of access:

6. Cost per liter (gallon) charged by Owner/Operator:

7. Attach results and dates of chemical analyses for past 2 years. Include name(s) and address(s) of analytical laboratory(s).

8. Attach results and dates of chemical analyses for project analytes by the laboratory certified by, or in the process of being certified.

SUBMITTED BY:

Company:

Person:

Telephone Number:

Date:

FOA APPROVAL (A)/DISAPPROVAL (D)	(Check one)	
Project Officer:	A	D
Project Geologist/Date:	A	D

Figure 3-1. Suggested format for use in obtaining water approval

include in the drilling plan a written statement from the manufacturer/supplier (and endorsed by the FDO) that the screens and/or casing have been appropriately rated by NSF or ASTM. Specific materials should be specified in the drilling plan approved by the FA. All materials should be as chemically inert as technically practical with respect to the site environment.

(2) All well screens should be commercially fabricated, slotted or continuously wound, and have an inside diameter (ID) equal to or greater than the ID of the well casing. An exception may be needed in the case of continuously wound screens because their supporting rods may reduce the full ID. If the monitoring well is to be subject to aquifer testing (slug test or pump test), a continuous wound screen should be used. Stainless steel screens may be used with PVC or PTFE well casing. No fitting should restrict the ID of the joined casing and/or screen. All screens, casings, and fittings should be new.

(3) Couplings within the casing and between the casing and screen should be compatibly threaded. Thermal or solvent welded couplings on plastic pipe should not be used. This caution also applies to threaded or slip-joint couplings thermally welded to the casing by the manufacturer or in the field. Several thermally welded joints have been known to break during well installation on a single project. The avoidance should remain until the functional integrity of thermal welds has been substantiated.

(4) Pop rivets, or screws should not be used on monitor wells. Particular problems with their use include anomalous analytical results, restriction of the well ID, and a loss of well integrity at the point of application.

f. Well caps and centralizers.

(1) The tops of all well casings should be telescopically covered with a slip-joint-type cap. Each cap should be composed of PVC, PTFE, or stainless steel. Each cap should be constructed to preclude binding to the well casing due to tightness of fit, unclean surface, or frost, and secure enough to preclude debris and insects from entering the well. Caps and risers may be threaded. However, sufficient annular space should be allowed between the well and protective casing to enable one to thaw any frosted shut caps. Caps should be vented, or loose enough to allow equilibration between hydrostatic and atmospheric pressures. Special cap (and riser) designs should be provided by the FA or FDO for wells in floodplains and those instances where the top of the well may be below grade, e.g., in roadways and parking lots.

(2) The use of well centralizers should be considered for wells deeper than 6 m (20 ft). When used, they should be of PVC, PTFE, or stainless steel and attached to the casing at regular intervals by means of stainless steel fasteners or strapping. Centralizers should not be attached to any portion of the well screen or bentonite seal. Centralizers should be oriented to allow for the unrestricted passage of the tremie pipe(s) used for filter pack and grout placement.

g. Well protection materials. Elements of well protection are intended to protect the monitoring well from physical damage, to prevent erosion and/or ponding in the immediate vicinity of the monitoring well, and to enhance the validity of the water samples.

(1) The potential for physical damage is lessened by the installation of padlocked, protective iron/steel casing over the monitoring well and iron/steel posts around the well. The casing and posts should be new. The protective casing diameter or minimum dimension should be 100 mm (4 in.) greater than the nominal diameter of the monitor well, and the nominal length should be 1.5 m (5 ft). The protective posts should be at least 80 mm (3 in.) in diameter and the top modified to preclude the entry of water. If extra protection is necessary, the protective posts can be filled with concrete. Nominal length of the posts should be 1.8 m (6 ft). Special circumstances necessitating different materials should be addressed in the drilling plan.

(2) Erosion and/or ponding in the immediate vicinity of the monitoring well may be prevented by assuring that the ground surface slopes away from the monitoring well protective casing and by the spreading of a 150 mm (6-in.) thick, 2.4 m (8-ft) diameter blanket of 19- to -75-mm (3/4- to 3-in.) gravel around the monitoring well.

(3) The validity of the water samples is enhanced by a locking cover on the protective casing. The cover should be hinged or telescoped but not threaded. Lubricants on protective covers should be avoided. Threaded covers tend to rust and/or freeze shut. Lubricants applied to the threads to reduce this closure tend to adhere to sampling personnel and their equipment. All locks on these covers should be opened by a single key and, if possible, should match any locks previously installed at the site(s), and be made of noncorrosive matrial, such as brass.

h. Glues and solvents. The use of glues and solvents in monitoring well installation should be prohibited.

i. Tracers. Tracers or dyes should not be used or otherwise introduced into borings, wells, grout, backfill, groundwater, or surface water unless specifically approved in the drilling plan. The drilling plan should describe any

GRANULAR FILTER PACK APPROVAL

Project for Intended Use:

1. Filter Material Brand Name:
2. Lithology:
3. Grain Size Distribution:
4. Source:

    Company that made product:

    Location of pit/quarry of origin:

5. Processing Method:
6. Slot Size of Intended Screen:

Submitted by:

Company:

Person:

Telephone:

Date:

FOA APPROVAL (A)/DISAPPROVAL (D)	(Check one)	
Project Officer Name/Date:	A	D
Project Geologist Name/Date:	A	D

Figure 3-2. Suggested format for obtaining approval for filter pack

approved usage; chemical, radiological, and/or biological composition of the substances; and potential effects upon subsequent chemical, radiological, or biological analyses of the injected media. Discussion should also be provided of the expected, post-injection visual appearance of the media into which the substances are to be introduced. The discussion should also include relevant Federal and state regulations and those agencies' opinions relative to the approved usage.

j. Lubricants. If lubrication is needed on the threads or couplings of downhole drilling equipment, it should be biodegradable and nontoxic. Vegetable oil/shortening or PTFE tape may be used. Additives containing lead or copper should not be used. The only lubricant recommended for monitoring well joints is PTFE tape. The use and type of lubricants should be included in the drilling plan and boring logs/well construction diagrams.

k. Hydraulic fluids. Any hydraulic or other fluids in the drilling rig, pumps, transmissions, or other field equipment/vehicles should **NOT** contain any polychlorinated biphenyls (PCBs).

l. Antifreeze. The use of any antifreeze (either a commercially available automotive variety or a local derivation) to prevent overnight water line freezing should require FA approval. If antifreeze is added to any pump, hose, etc., where contact with drilling fluid is possible, this antifreeze should be completely purged with approved water prior to the equipment's use in drilling, mud mixing, or any other part of the overall drilling operation. A sample of the clean (approved) water that has been circulated through the equipment after antifreeze removal should be retained for laboratory analysis. Only antifreeze without rust inhibitors and/or sealants should be considered. Antifreeze usage should be noted on the boring log, including the dates, reasons, quantities, composition, and brand names of antifreeze used. Antifreeze usage should be a last resort option. No antifreeze should be used in the drilling operation. Overnight storage in a heated garage may be a better option than spending time purging antifreeze and getting frozen equipment ready to operate.

m. Agents and additives. The use of any materials or substances other than those recommended herein for drilling, well installation, or development should be prohibited. Included in this suggested prohibition are lead shot, lead wool, burlap, dispersing agents (e.g., phosphates), acids, explosives, disinfectants, organic based drilling additives, metallic based lubricants, chlorinated and petroleum based solvents, adhesives, etc.

n. Summary. A materials usage summary, or MSDS should be provided of any drilling/well construction materials which potentially could have a bearing on subsequent interpretation of the analytical results. An example summary is provided at Figure 3-3.

3-9. Surface Runoff

Surface runoff, e.g., precipitation, wasted or spilled drilling fluid, and miscellaneous spills and leaks, should not enter any boring or well either during or after construction. To help avoid such entry, the use of starter casing, recirculation tanks, berms around the borehole, surficial bentonite packs, etc., is recommended.

3-10. Drilling Through Contaminated Zones

a. Many borings and wells are drilled in areas that are clean relative to the deeper zones of interest. However, circumstances do arise that require drilling where the overlying soils or shallow aquifer may be contaminated relative to the underlying environment. This situation may be addressed by the placement of, at least, double casing: an outer permanent (or temporary) casing sealed in place and cleared of all previous drill fluids prior to proceeding into the deeper, "cleaner" environment. In this procedure, the outer drill casing is set and sealed within an "impermeable" layer or at a level below which the underlying environment is thought to be cleaner than the overlying environment. The drilling fluids used to reach this point are appropriately discarded, replaced by a new or fresh supply. This system can be repeated, resulting in telescopic drill casing through which the final well casing is placed. These situations should be addressed on a case-by-case basis in the drilling plan.

b. Caution should be exercised to prevent further migration of contaminants via boreholes, especially dense non-aqueous phase liquid (DNAPL) migration. A recommended investigation strategy is to drill in expected DNAPL zones only after subsurface conditions have been characterized by drilling in surrounding DNAPL-free areas (the "outside-in" strategy). In DNAPL zones, drilling should generally be minimized and should be suspended when a potential trapping layer is first encountered. Drilling through DNAPL zones into deeper strategraphic units should be avoided. Also non-invasive methods, such as geophysical or geochemical surveys, can be useful at some sites to roughly define subsurface geologic or contaminant conditions (USEPA OSWER Directive 9283.1-06).

3-11. Soil Sampling

a. *Intact samples.* Unless otherwise specified in the drilling plan, intact soil samples for physical descriptions, retention, and physical analyses should be taken continuously and retained for the first 3 m (10 ft) and every 1.5 m (5 ft) or at each change of material, whichever occurs first, thereafter. Soil samples should be collected at intervals that are consistent with the goals of the project. These samples should be representative of their host environment. Borehole cuttings do not usually provide the desired information and, therefore, are not usually satisfactory. Sampling procedures should be detailed in the drilling plan. Additional guidance on soil sampling can be found in EM 200-1-3, EM 1110-1-1906 and ASTM Standard Guide D 6169.

b. *Odors.* At the detection of any anomalous odors (or vapor readings) from the boring or intact samples, drilling should cease for an evaluation of the odors and to determine the crew's safety. After the field safety representative completes this evaluation and implements any appropriate safety precautions as may be required in the site safety and health plan (SSHP), drilling may only then resume. If the odors or vapor readings are judged by the field personnel to be contaminant-related, intact soil samples should be continuously taken until the odors/readings are within background ranges. These samples should be retained and preserved in appropriate screw-capped sample jars for possible chemical analysis. With the resumption of background readings,

routine sampling should resume. Specific procedures should be detailed in the FSP and SSHP.

c. Volume. Representative soil samples of sufficient volume for physical testing from each sampled interval should be retained for future reference or appropriate analysis. Upon boring completion, the number of samples retained from that boring may be reduced, retaining at least representative samples of major units, key samples, and those for testing requirements. Minimum information on each sample container should include the project, depth below surface, and boring and sample number. All samples known or suspected to contain contaminants of concern should be so marked on both the sample container and boring log. No geotechnical data should appear on the container that is not specified on the boring log. Containers should be kept from becoming frozen. Soil samples known or suspected of being contaminated may have to be handled, stored, tested, and/or disposed of as hazardous waste. Storage, packaging, and shiping instructions for soil samples for physical testing should be prescribed in the drilling plan. USEPA has published additional guidance concerning the management of investigation-derived wastes (IDW) for Superfund projects (USEPA, EPA/540/G-91/009 and USEPA, OSWER Publication 9345.3-03FS) that should be incorporated into the drilling plan, as appropriate.

d. Physical testing. Physical soil testing is a function of the project. The drilling plan should detail specific testing guidance and requirements. The appropriate number of field samples selected for physical soil testing as well as sample retrieval locations should be determined by the project geotechnical personnel. Procedures and equipment for soil testing are described in the current EM 1110-2-1906 (or ASTM Standard Test Method D 2487). Downhole geophysical logging may reduce the need for sampling. Tested samples should be representative of the range and frequency of soil types encountered in the project area and should specifically include the screened interval of each completed well. In addition, samples should be obtained from borings that cover the geographic and geologic range within the project area. The FDO should select the particular samples. Samples selected for physical testing that are suspected to be contaminated should be labeled as such. Tests should include moisture content and those tests necessary to determine the soil classification as described in D 2487. Laboratory and summary sheets should be submitted to the FA after final test completion. The drilling and safety plans should address any contaminant-related safety precautions for the physical analysis of these samples. The FDO is responsible for communicating these concerns to the laboratory performing the soil testing. The testing laboratory is responsible for taking all the necessary health and safety precautions adequate to protect the laboratory personnel. Samples for physical analysis which are known or suspected to be contaminated should be tested only in a soils laboratory equipped and managed to process contaminated samples.

e. Soil samples for chemical analysis.

(1) Samples should be extracted from an as intact, minimally disturbed condition as technically practical. Once at the surface, the sampler should be opened, sample extracted, and bottled in as short a time as possible. Samples for volatile analysis should be bottled, and capped within a **VERY** short time (about 15 seconds from the time of opening the sampler). Each soil sample for volatile analysis should have minimal head space for representative analytical results.

(2) All sampling equipment that will contact the sample should be thoroughly decontaminated between samples. This can be accomplished by the use of a hot-water pressure washer or as follows:

(a) Scrub equipment with a low-sudsing, nonphosphate detergent in approved water.

(b) Rinse with approved water.

(c) When sampling for metals, rinse with 0.1 N nitric acid (4.2 mL of concentrated nitric acid added to 1,000 mL (33 fl oz) of water). (**CAUTION**: Add acid to water, never add water to concentrated acid.) Continue rinsing the sampling equipment now with distilled or deionized water. If the sampling equipment being used is made of stainless steel, the use of 0.1 N hydrochloric acid (rather than 0.1 N nitric acid) is preferred to avoid oxidation (rusting) of the
stainless steel. The 0.1 N hydrochloric acid is prepared by adding 3.1 mL of concentrated hydrochloric acid to 1,000 mL (33 fl oz) of water. The same **CAUTION** applies: add the concentrated acid to the water, not the water to the acid.

(d) When sampling for organic volatiles, semivolatiles, or pesticides/PCBs, rinse with pesticide grade isopropanol followed by rinsing with distilled or deionized water. When using isopropanol to decontaminate a sampler, the sampler must be allowed to completely air dry prior to reassembly.

MATERIALS SUMMARY

PROJECT: GENERAL AAP

Date: Oct-Nov 1987

Brand/Description (Example Entries)	Material Source/Supplier (Example Entries*)	(Example Entries*)
PVC casing	4.0" ID, Schedule 40, flush threaded;	ABC Mfg; Aville, Minnesota 2" ID, Schedule 40, flush threaded
PVC screen	0.05" slot, 4.0" ID; Schedule 40,	ABC Mfg; Aville, Minnesota flush threaded, 0.02" slot, 2" ID; Schedule 40, flush threaded
Bentonite (drilling fluid and grout)	Tru-gel	A. O. Bentonite; Bville, Wyoming
Granular bentonite (seal)	Gran-Bent	White Mud, Cville, Montana
Bentonite pellets (seal)	(No brand name available)	PELBENT, Dville, Utah
Sand (filter pack)	8-12 silica sand	State Sand, Mville, Colorado; supplier: EFG Co., Eville, Utah
Cement (grout)	Portland Type II	A. Lumber Co., Eville, Utah
Drilling water	St. Peter Sandstone	Production Well #1, Tap at well house
Drilling rod lubricant	Slick Turn	Oil Products Co., Fville, Texas
Air compressor oil	Oil #40	Oil Products Co., Fville,

Figure 3-3. Example materials summary

(3) Additional acquisition, preservation, and handling criteria for the chemical analysis of soils are found in EM 200-1-3.

f. Liners. If sample liners are used, the following should apply:

(1) Use clear liners or take extra samples to ensure that the sample is of sufficient quantity and quality for the intended analyses;

(2) Liner seams and ends should be "airtight," i.e., "moisture impermeable";

(3) Borehole/drilling fluids should not be trapped within the liner;

(4) Liner or sealant interaction with the sample should not alter the sample's chemical composition; and

(5) Liners must be free of contamination and be decontaminated prior to use. Decontamination may not be necessary if the liners have been packaged by the manufacturer and has intact packaging up to the time of use.

g. Location. All soil samples, except those for physical and/or chemical analysis and reference should remain onsite, neatly stored at an FA-designated location. The disposition of these samples should be arranged by the FA. Samples from HTRW sites may have to be stored, and later disposed of, off site. Depending on the site and its accessibility to the public, it may be permissible (depending on state regulations) to stage the drums neatly on pallets immediately adjacent to the boring/monitoring well location. If the option exists to dispose of IDW by spreading it on the ground at the sampling location, it may not be cost-effective to stage the drums in a central location and then move them back to the boring/monitoring well location for disposal. Sample retention and disposal should be given detailed attention in the SAP.

3-12. Rock Coring

Bedrock should be cored unless the drilling plan specifies otherwise. Coring, using a diamond- or carbide-studded bit (ASTM D 2113) , produces a generally intact sample of the bedrock lithology, structure, and physical condition. The use of a gear-bit, tricone, etc., to penetrate bedrock should only be considered for the confirmation of the "top of rock" (where penetration is limited to a few meters [feet]), the enlargement of a previously cored hole, or the drilling of highly fractured intervals. Except as noted below, guidance for preserving, storing, photographing, marking, cataloging, and handling of rock core samples may be found in ASTM D 5079.

a. The coring of bedrock or any firm stratigraphic unit should be conducted in a manner to obtain maximum intact recovery. The physical character of the bedrock (i.e., fractures, poor cementation, weathering, or solution cavities) may lessen recovery, even with the best of drillers and equipment.

b. The minimum core size should be an "N" series, 50 mm (2 [plus]-in.) diameter. Larger bit (hence, core) diameters may be needed to enhance core recovery.

c. While drilling in bedrock, and especially while coring, drilling fluid pressures should be adjusted to minimize drilling fluid losses and hydraulic fracturing. All pumping pressures should be recorded.

d. Rock cores should be stored in covered core boxes to preserve their relative position by depth. Intervals of lost core should be noted in the core sequence. Boxes should be marked on the cover (both inside and outside) and on the ends to provide project name, boring number, cored interval, and box number in cases of multiple boxes. Any core box known or suspected to contain contaminated core should be appropriately marked on the log and on the box cover (inside and out), and on both ends. The weight of each fully loaded box should not exceed 34 kg (75 lb). No geotechnical or contaminant data should appear on or within the box that is not specified on the boring log. As a minimum, the estimated number of boxes required for a given boring should be on hand prior to coring that site.

e. The core within each completed box should be photographed after the core surface has been cleaned or peeled, as appropriate, and wetted. Each photo should be in sharp focus and contain a legible scale in centimeters (feet and tenths of feet). The core should be oriented so that the top of the core is at the top of the photo. Each photo should be annotated on the back with the project name, bore/well designation, box number, cored depths pictured, and date photographed. One set of glossy color prints should be sent to the FA after the last coring. In addition, all negatives should be delivered to the FA after the FA has received the prints. (See ER 1110-1-1803 for additional guidance on core management.)

f. All rock core, except that for analysis and reference, should be neatly stored at an FA-designated location. The disposition of these samples should be arranged by the FDO. Specific instructions for the storage or required packaging and method of shipment to the laboratory should be provided in the drilling plan.

g. Bedrock cores known or suspected of being contaminated may have to be handled, stored, tested, and/or disposed of as hazardous waste. Such a consideration and determination should be made prior to drilling plan approval. This determination may alter drilling methods, coring frequency, data quality, costs, etc. Geophysical downhole logging or borehole camera techniques could be considered as alternatives in some cases. The drilling plan should reflect the final decision and possible alternatives that retain viability.

3-13. Abandonment/Decommissioning

Abandonment (also termed decommissioning) is that procedure by which any boring or well is permanently closed. Abandonment/decommissioning procedures should preclude any current or subsequent fluid media from entering or migrating within the subsurface environment along the axis or from the endpoints of any boring or well penetrating that environment.

a. Planned abandonment requirements and procedures should be described in the FSP plan and incorporate USACE guidance and applicable state and/or Federal regulatory abandonment requirements.

b. The closure of any borings or wells not scheduled for abandonment per drilling plan should be approved by the FA prior to any casing removal, sealing, or back-filling. Abandonment requests should be submitted by the FDO to the FA with the following data, plus recommendation:

(1) Designation of boring/well in question;

(2) Current status (depth, contents of hole, stratigraphy, water level, etc.);

(3) Reason for closure; and

(4) Action taken, to include any replacement boring or well.

c. Each boring or well to be abandoned/decommissioned should be sealed by grouting from the bottom of the boring/well to the ground surface. This should be done by placing a tremie pipe to the bottom of the boring/well (i.e., to the maximum depth drilled/bottom of well screen) and pumping grout through this pipe until undiluted grout flows from the boring/well at ground surface. Any open or ungrouted portion of the annular space(s) between the innermost well casing and borehole (to include any casings in between) should be grouted in the same manner.

d. After 24 hours, the FDO should check the abandoned site for grout settlement. That day, any settlement depression should be filled with grout and rechecked 24 hours later. Additional grout should be added using a tremie pipe inserted to the top of the firm grout, unless the depth of the unfilled portion of the hole is less than 4.5 m (15 ft) and this portion is dry. This process should be repeated until firm grout remains at ground surface.

e. An abandoned well may be grouted with the well screen and casing in place. However, local regulations or a lack of data concerning well construction, condition, or other factors may require the removal of the well materials and a partial or total hole redrilling prior to sealing the well site. See ASTM Standard Guide D 5299 for a discussion of other decommissioning procedures.

f. For each abandoned boring/well, a record should be prepared to include the following as applicable.

(1) Project and boring/well designation.

(2) Location with respect to the replacement boring or well (if any); e.g., 6 m (20 ft) north and 6 m (20 ft) west of Well 14.

(3) Open depth of well/annulus/boring prior to grouting.

(4) Casing or items left in hole by depth, description, composition, and size.

(5) Copy of the boring log.

(6) Copy of construction diagram for abandoned well.

(7) Reason for abandonment.

(8) Description and total quantity of grout used initially.

(9) Description and daily quantities of grout used to compensate for settlement.

(10) Dates of grouting.

(11) Disposition of materials removed/displaced from decommissioned boring/well; e.g., objects, soil, and groundwater.

(12) Water or mud level (specify) prior to grouting and date measured.

(13) Remaining casing above ground surface: type (well, drill, protective), height above ground, size, and composition of each.

(14) Report all depths/heights from ground surface.

(15) The original record should be submitted to the FA.

g. Replacement well/borings (if any) should be offset at least 6 m (20 ft) from any abandoned site in a presumed up- or cross-gradient groundwater direction.

3-14. Work Area Restoration and Disposal of Drilling and Cleaning Residue

All work areas around the wells and/or borings should be restored to a condition essentially equivalent to that of preinstallation. This includes the disposal of borehole cuttings and rut removal. Borehole cuttings, discarded samples, drilling fluids, equipment cleaning residue, and water removed from a well during installation, development, and aquifer testing should be disposed of in a manner approved by the FA, host installation, and consistent with applicable state and federal regulations. These types of materials are considered investigation-derived wastes (IDW). (See USEPA EPA/540/G-91/009 for USEPA guidance on the management of these materials.) Whatever procedures are followed, the leaving of barrels containing drill cuttings, excess samples, and water at various unsecured locations around the site at the completion of well installation is not appropriate. All drums/barrels filled onsite should be permanently labeled (in a waterproof manner and resistant to fading) and inventoried as to their contents and source. Restoration and disposal procedures (to include disposal location(s)) should be discussed in the FSP. Depending on the site and its accessibility to the public, it may be permissible (depending on state regulations) to stage the drums neatly on pallets immediately adjacent to the boring/monitoring well location. If the option exists to dispose of IDW by spreading it on the ground at the sampling location, it may not be cost-effective to stage the drums in a central location and then move them back to the boring/monitoring well location for disposal.

Chapter 4
Borehole Logging

4-1. General

Each boring log should fully describe the subsurface environment and the procedures used to gain that description. Guidance on field logging of subsurface explorations of soil and rock may be found in ASTM Standard Guide D 5434.

4-2. Format

All borings should be recorded in the field on Engineer (ENG) Form 1836 and 1836-A, per EM 1110-1-1804 (Figure 4-1) or on ENG Form 5056-R and 5056A-R, developed for HTRW work (see Figure 4-2). This guidance applies to in-house and contracted activities. Suggested data for recording are discussed throughout this manual. Because of the large quantity of information routinely required on logs at HTRW sites, a scale of 25 mm (1 in.) on the log equaling 300 mm (1 ft) of boring is usually adequate.

4-3. Submittal

Each original boring log should be submitted directly from the field to the FA after each boring is completed. In those cases where a monitoring well or other instrument is to be inserted into the boring, both the log for that boring and the installation diagram may be submitted together.

4-4. Original Logs and Diagrams

Only the "original" boring log (and diagram) should be submitted from the field to the FA. Carbon, typed, or reproduced copies are not considered "original." The original should be of sufficient legibility and contrast to provide comparable quality in reproduction.

4-5. Time of Recording

Logs should be recorded directly in the field without transcribing from a field book or other document. This technique lessens the chance for errors of manual copying and allows the completed document to be field-reviewed closer to the time of drilling.

4-6. Routine Entries

In addition to the data desired by the FDO and uniquely required by the drilling plan, the information should include those items listed in ASTM Standard Guide D 5434, except items under section 6.1.4 in D 5434. The other exceptions would be weather conditions, and certain items concerning sample handling procedures in sections 6.1.6 and 6.1.7 in D 5434. Sample handling procedures are required to be entered in the field logbook that is described in EM 200-1-3. The following information should also be routinely entered on the boring log.

a. Each boring and well (active and abandoned) should be uniquely numbered and located on a sketch map as part of the log.

b. Depths/heights should be recorded in meters (feet) and decimal fractions thereof (millimeters or tenths of feet). English units are acceptable if typically used by the site geologist.

c. Field estimates of soil classifications shall be in accordance with ASTM Standard Practice D 2488 and shall be prepared in the field at the time of sampling by the geologist. Guidance on soil and rock classification may also be found in EM 1110-1-1906, Spigolon 1993, Murphy 1985 and U.S. Army FM 5-410.

d. Each soil sample taken should be fully described on the log. The descriptions of intact samples should include the parameters shown in Table 4-1.

e. In the field, visual numeric estimates should be made of secondary soil constituents; e.g., "silty sand with 20 percent fines" or "sandy gravel with 40 percent sand." If such terms as "trace," "some," "several," etc., are used, their quantitative meaning should be defined on each log.

f. When used to supplement other sampling techniques, disturbed samples (e.g., wash samples, cuttings, and auger flight samples) should be described in terms of the appropriate soil/rock parameters to the extent practical. "Classification" should be minimally described for these samples along with a description of drill action and water losses/gains for the corresponding depth. Notations should be made on the log that these descriptions are based on observations of disturbed material rather than intact samples.

g. Rock core should be fully described on the boring log. Typical rock core parameters are shown in Table 4-2.

h. For rock core, a scaled graphic sketch of the core should be provided on or with the log, denoting by depth, location, orientation, and nature (natural or coring-induced) of all core breaks. Also mark the breaks purposely made to fit the core into the core boxes. If fractures are too numerous to be individually shown, their location may be drawn as a zone and described on the log. Also note, by

HTRW DRILLING LOG

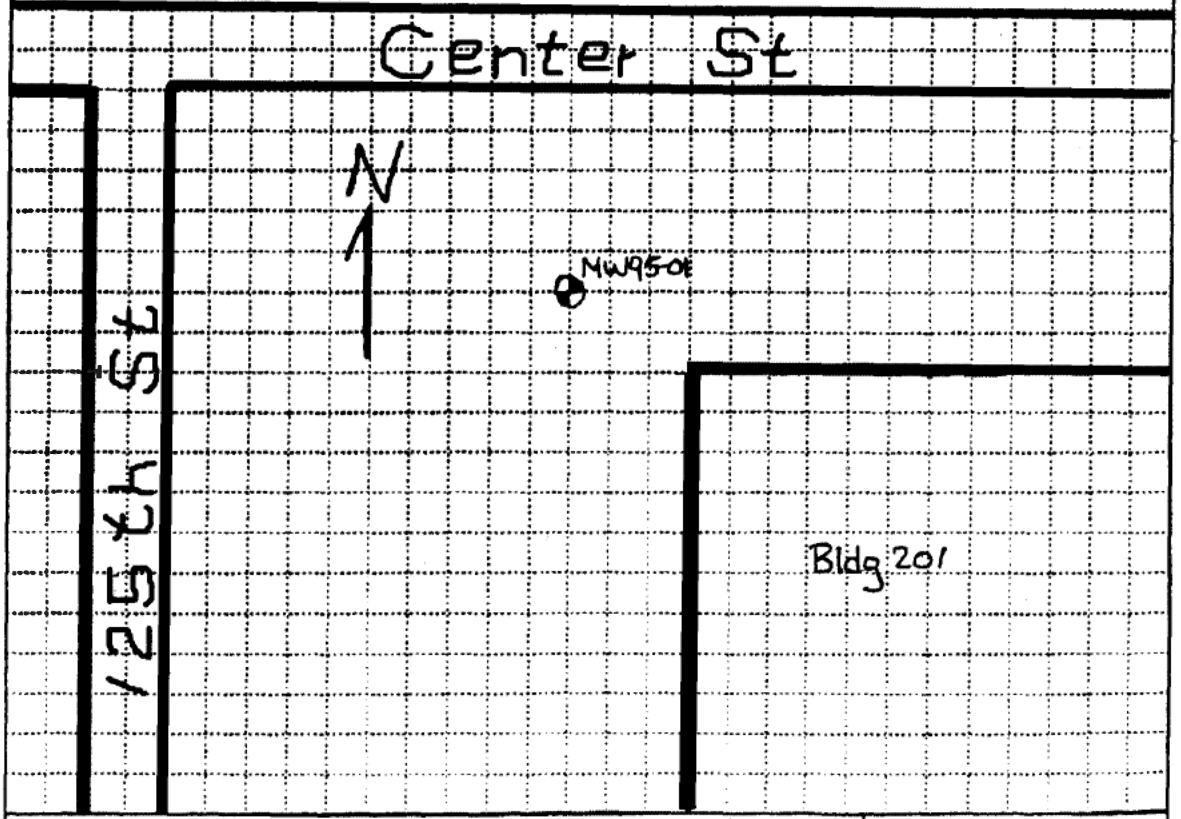
1. COMPANY NAME: CONTRACTING FIRM, INC.	2. DRILL SUBCONTRACTOR: SUBCONTRACT DRILLERS, INC	DISTRICT: OMAHA; HOLE NUMBER: MW95-01; SHEET 1 OF 3
3. PROJECT: BIG SUPERFUND SITE	4. LOCATION: Site A	
5. NAME OF DRILLER: JOE SUPER DRILLER	6. MANUFACTURER'S DESIGNATION OF DRILL: CME-75 Milwaukee Heavy Duty Drill Rig	
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: CME-75, using 4 1/4" hollow stem augers, 3" O.D. Stainless steel split-spoons (chemical and geotech), bullet bit (outer) drag bit (inner)	8. HOLE LOCATION: See Map Below	
	9. SURFACE ELEVATION: Not Yet Available	
	10. DATE STARTED: 8-6-95	11. DATE COMPLETED: 8-7-95
12. OVERBURDEN THICKNESS: 12.0'	15. DEPTH GROUNDWATER ENCOUNTERED: 5.0'	
13. DEPTH DRILLED INTO ROCK: ϕ	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED: 4.5' TOC ~72 hours (in well)	
14. TOTAL DEPTH OF HOLE: 12.0'	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)	

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
	ϕ	ϕ	ϕ

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY
			BTEX 4 x 40z	TRPH 2 x 8 oz	Lead 2 x 8 oz	ϕ %

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR
		8-6-92		Field Geologist

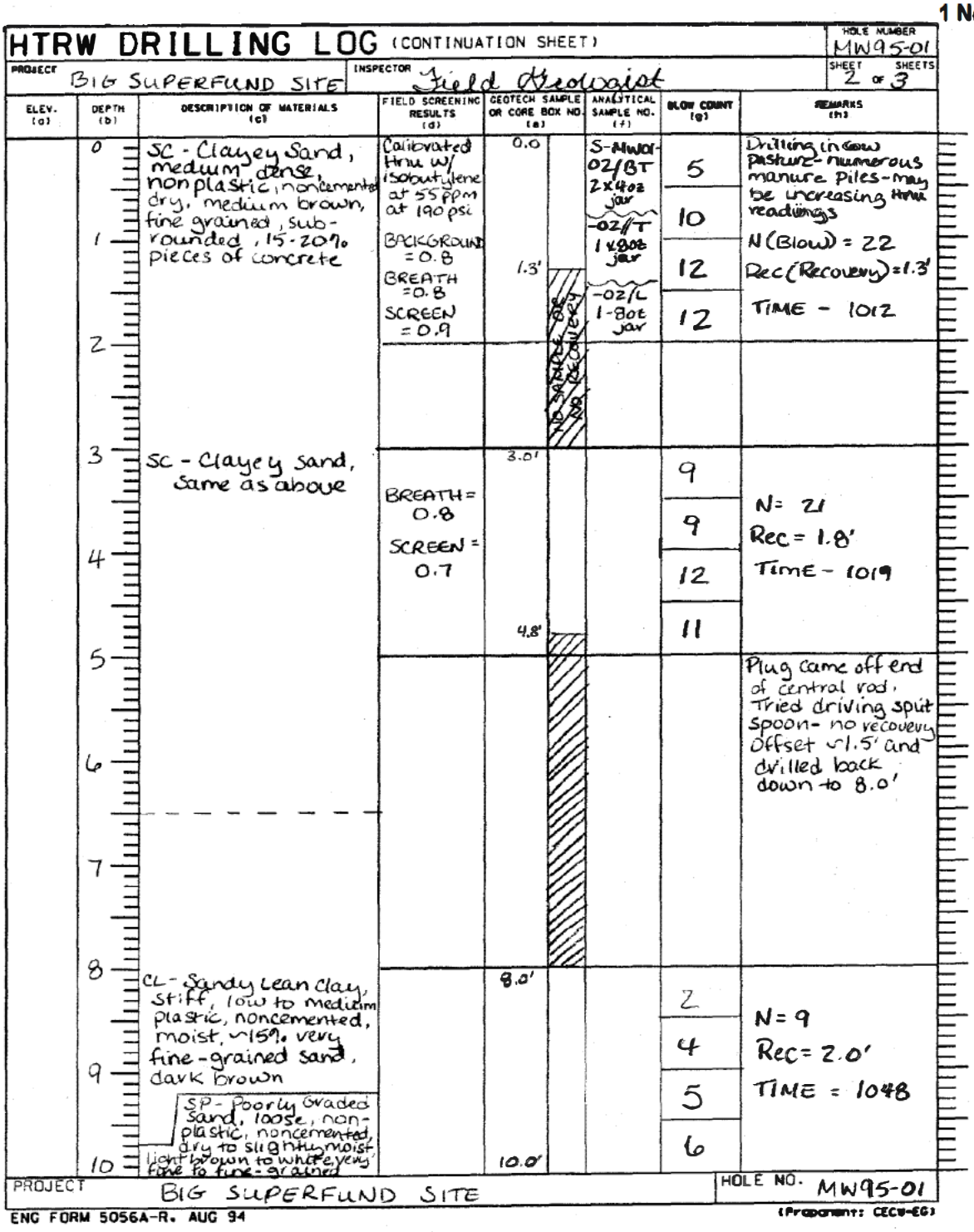
LOCATION SKETCH/COMMENTS — SCALE: 1" = 20'



PROJECT: BIG SUPERFUND SITE — HOLE NO.: MW95-01

ENG FORM 5056-R, AUG 94 (Proponent: CECW-EGI)

Figure 4-1. Boring log format (Sheet 1 of 3)



HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER MW95-01

PROJECT: BIG SUPERFUND SITE

INSPECTOR: Field Geologist

SHEET 2 OF 3 SHEETS

ELEV. (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO. (e)	ANALYTICAL SAMPLE NO. (f)	BLOW COUNT (g)	REMARKS (h)
	0	SC - Clayey Sand, medium dense, nonplastic, noncemented, dry, medium brown, fine grained, sub-rounded, 15-20% pieces of concrete	Calibrated Hnu w/ isobutylene at 55 ppm at 190 psi BACKGROUND = 0.8 BREATH = 0.8 SCREEN = 0.9	0.0 1.3'	S-MW01-02/BT 2x4oz jar -02/T 1x8oz jar -02/L 1-8oz jar	5 10 12 12	Drilling in cow pasture- numerous manure piles- may be increasing Hnu readings N (Blow) = 22 Rec (Recovery) = 1.3' TIME - 1012
	1						
	2						
	3	SC - Clayey Sand, same as above	BREATH = 0.8 SCREEN = 0.7	3.0' 4.8'		9 9 12 11	N = 21 Rec = 1.8' TIME - 1019
	4						
	5						Plug came off end of central rod. Tried driving split spoon - no recovery. Offset ~1.5' and drilled back down to 8.0'
	6						
	7						
	8	CL - Sandy Lean Clay, stiff, low to medium plastic, noncemented, moist, ~15% very fine-grained sand, dark brown		8.0'		2 4 5 6	N = 9 Rec = 2.0' TIME = 1048
	9						
	10	SP - Poorly Graded Sand, loose, nonplastic, noncemented, dry to slightly moist, light brown to white, very fine to fine-grained		10.0'			

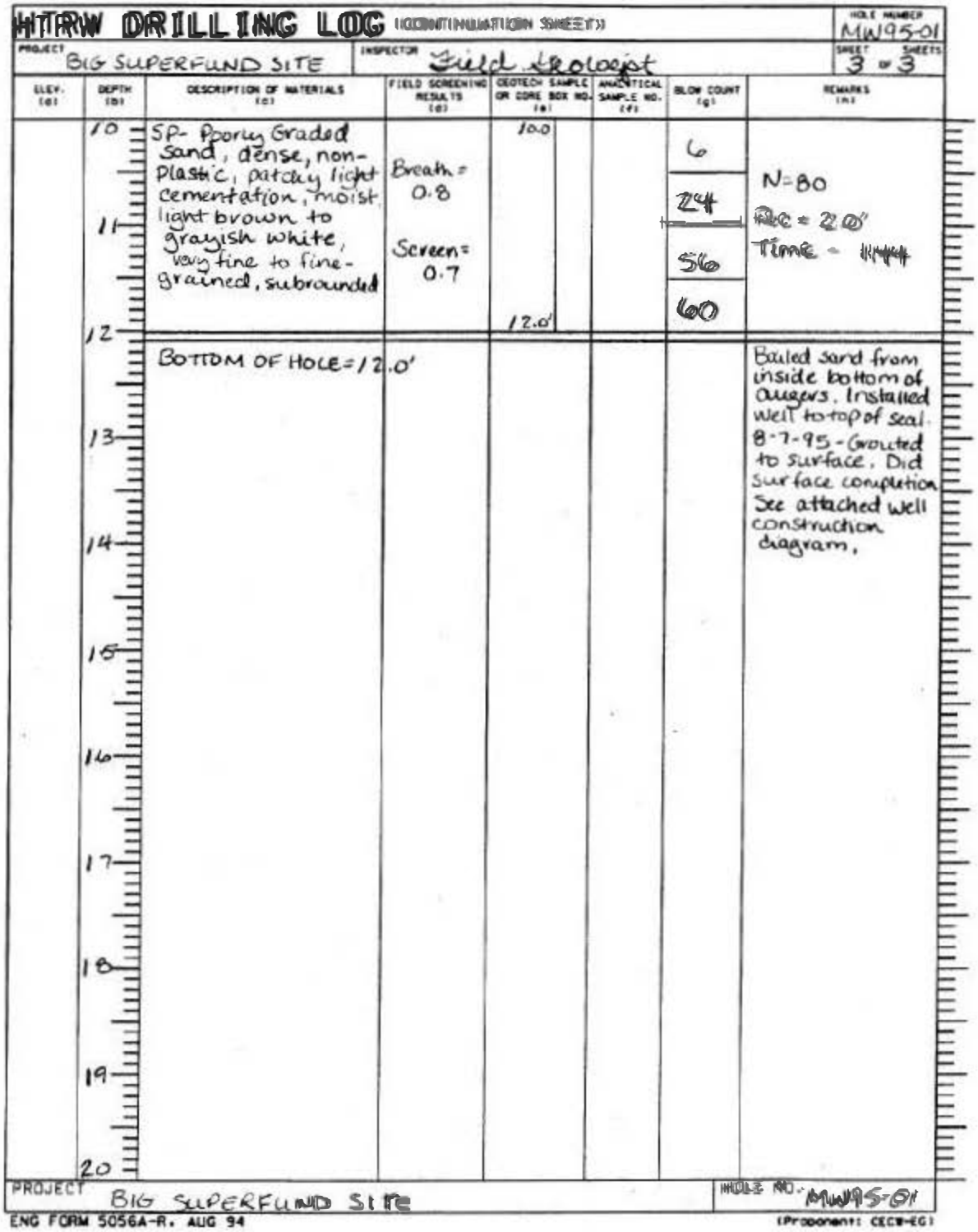
PROJECT: BIG SUPERFUND SITE

HOLE NO. MW95-01

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

Figure 4-1. (Continued) **(Sheet 2 of 3)**



HTRW DRILLING LOG (CONTINUATION SHEET)

HOLE NUMBER: MW95-01

PROJECT: BIG SUPERFUND SITE

INSPECTOR: Field Geologist

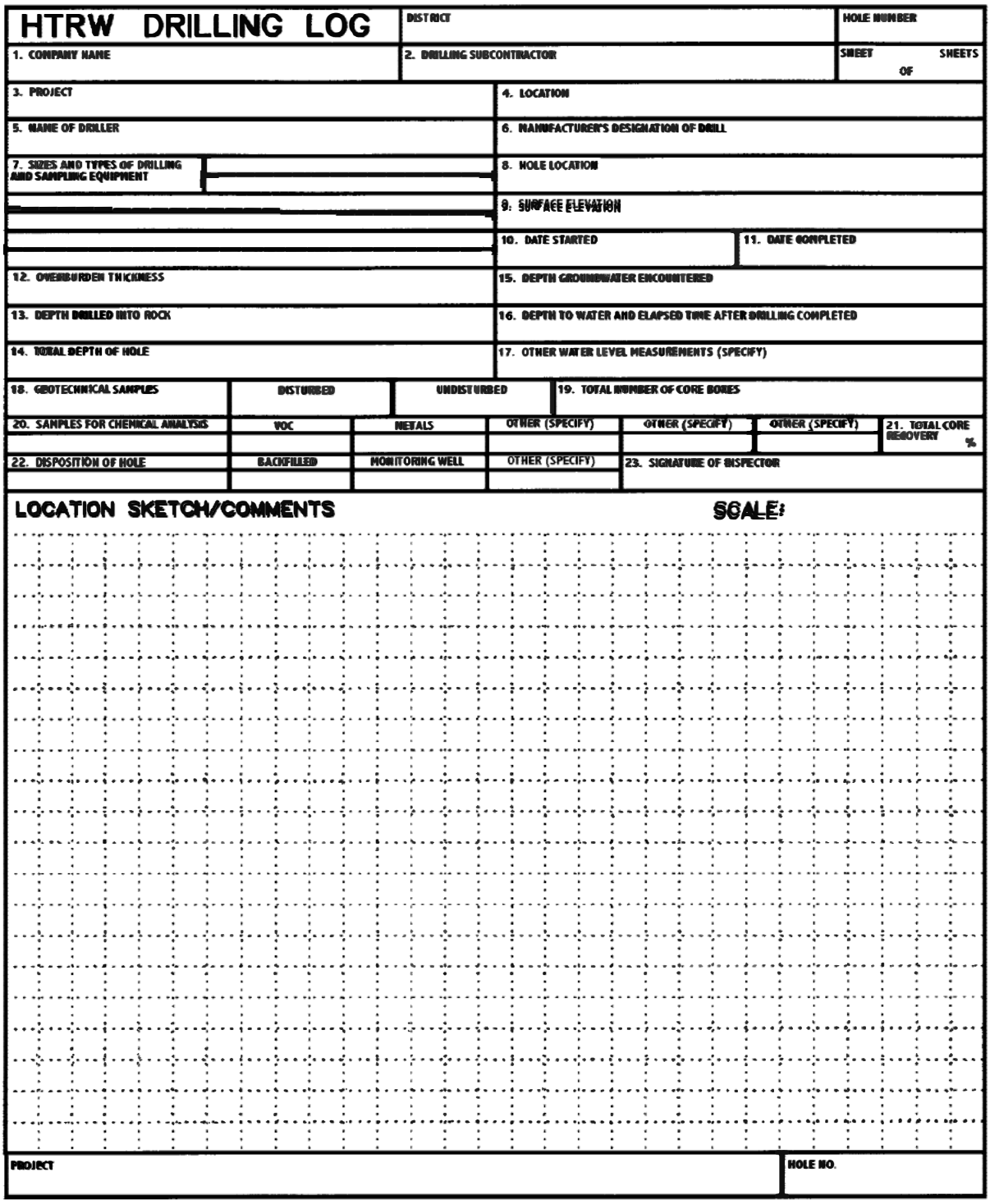
SHEET 3 OF 3 SHEETS

ELEV. (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO. (e)	ANALYTICAL SAMPLE NO. (f)	BLOW COUNT (g)	REMARKS (h)
	10	SP- Poorly Graded Sand, dense, non-plastic, patchy light cementation, moist, light brown to grayish white, very fine to fine-grained, subrounded	Breath = 0.8	10.0		6	N=80
	11		Screen = 0.7			24	REC = 2.0'
						56	TIME = 1444
	12			12.0'		60	
		BOTTOM OF HOLE = 12.0'					Bailed sand from inside bottom of augers. Installed well to top of seal. 8-7-95 - Grouted to surface. Did surface completion. See attached well construction diagram.
	13						
	14						
	15						
	16						
	17						
	18						
	19						
	20						

PROJECT: BIG SUPERFUND SITE — HOLE NO.: MW95-01

ENG FORM 5056A-R, AUG 94 (Proponent: CECW-EG)

Figure 4-1. (Concluded) **(Sheet 3 of 3)**



HTRW DRILLING LOG

DISTRICT		HOLE NUMBER
1. COMPANY NAME	2. DRILLING SUBCONTRACTOR	SHEET SHEETS OF
3. PROJECT	4. LOCATION	
5. NAME OF DRILLER	6. MANUFACTURER'S DESIGNATION OF DRILL	
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT	8. HOLE LOCATION	
	9. SURFACE ELEVATION	
	10. DATE STARTED	11. DATE COMPLETED
12. OVERBURDEN THICKNESS	15. DEPTH GROUNDWATER ENCOUNTERED	
13. DEPTH DRILLED INTO ROCK	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED	
14. TOTAL DEPTH OF HOLE	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)	

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES			
20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY %
22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR		

LOCATION SKETCH/COMMENTS SCALE:

PROJECT	HOLE NO.

Figure 4-2. HTRW Drilling Log

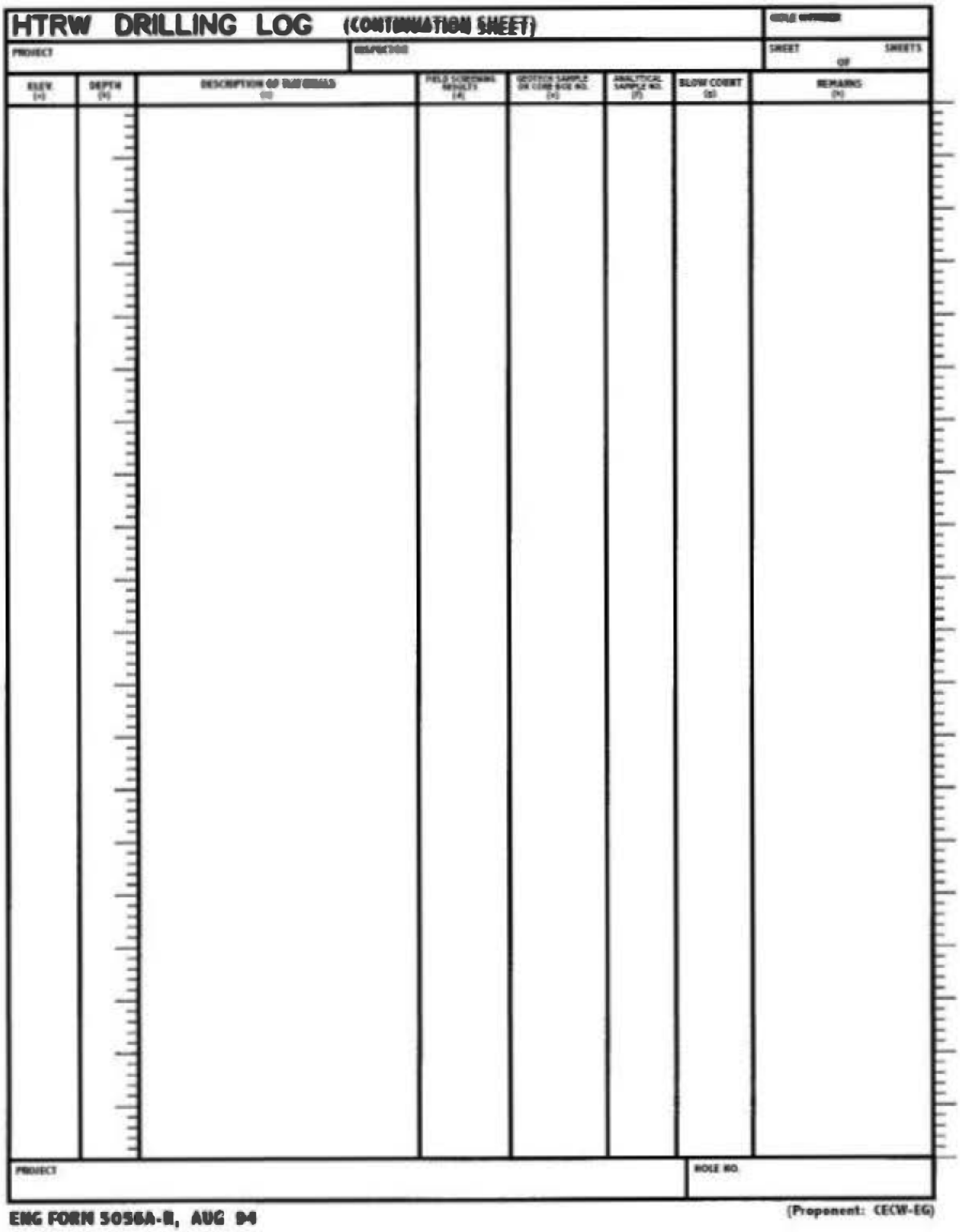


Figure 4-2 (Concluded)

Table 4-1
SOIL PARAMETERS FOR LOGGING

PARAMETER	EXAMPLE
Classification	Sandy clay
Depositional environment and formation, if known	Glacial till, Twin Cities Formation
ASTM D 2488 Group Symbol	CL (field estimate)
Secondary components and estimated percentages	Sand: 25 percent Fine sand 5 percent Coarse sand 20 percent
Color (Soil color charts such as Munsell Soil or the Geological Society of America (GSA) Rock Color Chart are helpful for describing the color of soil samples. If a color chart is used, give both narrative and numerical description and note which chart was used. Suggested standard colors can be found in Spigolon 1993)	Gray: (Gr) (7.5 YR 5.0 (Munsell))
Plasticity	Low plasticity
Consistency (cohesive soil)	Very soft, soft, medium stiff, very stiff, hard
Density (noncohesive soil)	Loose, medium loose, dense, very dense
Moisture content Use a relative term. Avoid a percentage unless a value has been measured.	Dry, moist, wet, saturated
Structure and orientation	No apparent bedding: numerous vertical, iron-stained, tight fractures
Grain angularity	Rounded

depth, the intervals of all lost core and hydrologically significant details. This sketch should be prepared at the time of core logging, concurrent with drilling.

i. A record of the brand name and amount of any bentonite used for each boring should be made on the log, along with the reason for and start (by depth) of this use. If measured, record mud viscosities and weight.

j. The drilling equipment used should be generally described on each log. Include such information as rod size, bit type, pump type, rig manufacturer, and model.

k. Each log should record the drilling sequence; e.g.:

(1) Opened hole with 8-in. auger to 9 ft;

(2) Set 8-in. casing to 10 ft;

(3) Cleaned out and advanced hole with 8-in. roller bit to 15 ft (clean water, no water loss);

(4) Drove 1-3/8-in. ID X 2-in. outside diameter (OD) sampler to 16.5 ft;

(5) Advanced with 8-in. roller bit to 30 ft, 15-gal water loss;

(6) Drove 1-3/8-in. ID X 2-in. OD sampler to 31.5 ft;

(7) Hole heaved to 20 ft; and

(8) Mixed 25 lb of ABC bentonite in 100 gal of water for hole stabilization and advanced with 8-in. roller bit to 45 ft, etc.

l. All special problems and their resolution should be recorded on the log; e.g., hole squeezing, recurring problems at a particular depth, sudden tool drops, excessive grout takes, drilling fluid losses, unrecovered tools in hole, lost casings, etc.

m. The dates and times for the start and completion of borings should be recorded on the log along with notation by depth for drill crew shifts and individual days.

n. Each sequential boundary between the various soils and individual lithologies should be noted on the log by depth. When depths are estimated, the estimated range

Table 4-2
ROCK CORE PARAMETERS FOR LOGGING

PARAMETER	EXAMPLE
Rock type	Limestone, sandstone, granite
Formation	Anytown Formation
Modifier denoting variety	Shaly, calcareous, siliceous, micaceous
Bedding/banding characteristics	Laminated, thin bedded, massive, cross bedded, foliated
Color (Color charts such as Munsell or the GSA Rock Color Chart are helpful for describing the color of rock samples. If a color chart is used give both narrative and numerical description and note which chart was used. Suggested standard colors can be found in Spigolon 1993).	Light brown: (lBr)
Hardness	Soft, very hard
Degree of cementation	Poorly cemented, well cemented
Texture	Dense, fine-, medium-, coarse-grained, glassy, porphyritic, crystalline
Structure and orientation	Horizontal bedding, dipping beds at 30 degrees, highly fractured, open vertical joints, healed fractures, slickensides at 45 degrees, fissile
Degree of weathering	Unweathered, slightly weathered, highly weathered
Solution or void conditions	Solid, cavernous, vuggy with partial infilling by clay
Primary and secondary permeability, include estimates and rationale	Low primary; well cemented High secondary: several open joints
Lost core interval and reason for loss	50-51 ft, noncemented sandstone likely

should be noted along the boundary.

o. The depth of first encountered free water should be indicated along with the method of determination; e.g., “37.6 ft from direct measurement after drilling to 40.0 ft”; “40.1 ft from direct measurement in 60-ft hole when boring left overnight, hole dry at end of previous shift”; or “25.0 ft based on saturated soil sample while sampling 24-26 ft.” Any other distinct water level(s) found below the first should also be described.

p. The interval by depth for each sample taken, classified, and/or retained should be noted on the log. Record the length of sampled interval, length of sample recovery, and the sampler type and size (diameter and length).

q. A record of the blow counts, hammer type and weight, and length of hammer fall for driven samplers should be made. For thin wall samplers, indicate whether the sampler was pushed or driven and the pressure/blow count per drive. Blow counts should be recorded in 150 mm (0.5 ft) foot increments when standard penetration (ASTM D 1586) samplers (35 mm [1-3/8 in.] ID X 50 mm [2 in.] OD) are used. For penetration less than a half foot, annotate the count with the distance over which the count was taken. Blow counts, in addition to their engineering significance, may be useful for stratigraphic correlation. (See Hsai-Wong Fang (1991) for interpretation of blow counts when 75-mm (3-in.) samplers are used).

r. When drilling fluid is used, a quantitative record should be maintained of fluid losses and/or gains and the interval over which they occur. Adjustment should be made for fluid losses due to spillage and intentional wasting (e.g., recirculation tank cleaning) to more closely estimate the amount of fluid lost to the subsurface environment.

s. Record the drilling fluid pressures typically used during all drilling operations (aqueous and pneumatic) and the driller's comments on drillability, drill speed, down pressure, rotation speed, etc.

t. Note the total depth of drilling and sampling on the log.

u. Record significant color changes in the drilling fluid return, even when intact soil samples or rock core are being obtained. Include the color change (from and to), depth at which change occurred, and a lithologic description of the cuttings before and after the change.

v. Soil gas readings, if taken, should be recorded on the log. Each notation should include interval sampled and reading. A general note on the log should indicate meter manufacturer, model, serial number, and calibration material. If several meters are used, key the individual readings to the specific meter.

w. Special abbreviations used on a log and/or well diagram should be defined in the log/diagram where used.

Chapter 5
Monitoring Well Installation

5-1. General

A monitoring well is a device designed for the acquisition of groundwater samples that represent the chemical quality of the aquifer adjacent to the screened interval, unbiased by the well materials and installation process, and which provides access to measure the potentiometric surface for that screened interval. The screened interval consists of that portion of the device that is directly open (e.g., horizontally adjacent) to the host aquifer by way of openings in the well casing (hereafter called the "screen") AND indirectly open (e.g., vertically adjacent) to the aquifer by way of the filter pack (or other permeable material) extending below and/or above the screen. While the maximum length of the screened interval is fixed for a given well (by the length of the filter pack), the effective or functional length may vary with water table fluctuations or sampling techniques. Additional guidance on monitoring well installation may be found in ASTM D 5092.

5-2. Well Clusters

Each monitoring well is a mechanism through which to obtain a representative sample of groundwater and, to measure the potentiometric surface in that well. To help ensure this representation in the case of well clusters, each well of a cluster should be installed in a separate boring. Multiple well placements in a single boring are too difficult for effective execution and evaluation to warrant single hole usage.

5-3. Well Screen Usage

Each overburden well should have a screen, as per Figure 5-1, 5-2, or 5-3 (or of a technically equivalent construction as in ASTM D 5092). Under normal conditions, the extra effort for screen installation in bedrock wells can be more than offset by the assurance of an unobstructed opening to the required depth during repeated usage. When conditions permit, and when allowed by state or local law, an open, unscreened well may be constructed in firm stable bedrock. However, well integrity and consistent access to the original sampled interval during prolonged monitoring must be maintained.

5-4. Beginning Well Installation

a. The installation of each monitoring well should begin within 12 hours of boring completion for holes uncased or partially cased with temporary drill casing. Installation should begin within 48 hours in holes fully cased with temporary drill casing. Once installation has begun, no breaks in the installation process should be made until the well has been grouted and drill casing removed. Anticipated exceptions should be requested in writing by the FDO to the FA prior to drilling. Data to include in this request are:

(1) Well(s) in question;

(2) Circumstances; and

(3) Recommendations and alternatives.

b. In cases of unscheduled delay such as personal injury, equipment breakdowns, or sudden inclement weather or scheduled delays such as borehole geophysics, no advance approval of delayed well installation should be needed. In those cases, resume installation as soon as practicable. However, partially completed borings should be properly secured during periods of drilling inactivity to preclude the entry of foreign materials or unauthorized personnel to the boring. In cases where a partially cased hole into bedrock is to be partially developed prior to well insertion, the well installation should begin within 12 hours after this initial development.

c. Temporary casing and hollow stem augers may be withdrawn from the boring prior to well installation if the potential for cross-contamination is not likely and if the borehole walls will not slough during the time required for well installation. This procedure is usually successful in firm clays and in bedrock that is not intensely fractured or highly weathered.

d. If the borehole will not remain stable long enough to complete placement of all necessary well materials in their proper position, it may be necessary to install some or all of the well materials prior to removal of the casing or hollow stem augers. In this situation, the hollow stem augers or casing should have an inside diameter sufficient to allow the installation of the prescribed diameter screen and casing plus annular space for a pipe through which to place the filter pack and grout.

e. Any materials, especially soils, blocking the bottom of the drill casing or hollow stem auger should be dislodged and removed from the casing prior to well insertion. This action both reduces the potential for cross--contamination and makes well installation easier.

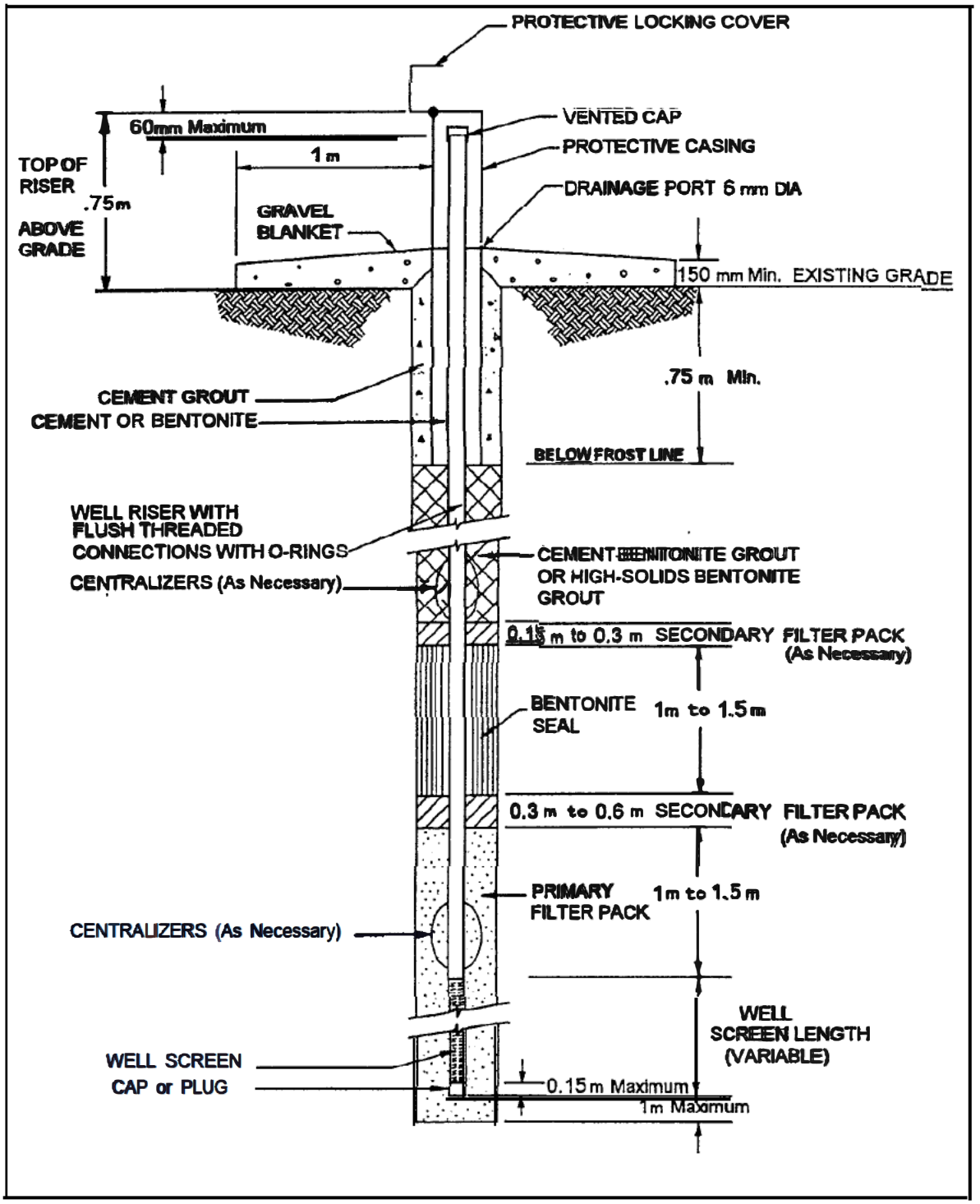


Figure 5-1. Schematic construction of single-cased well with gravel blanket

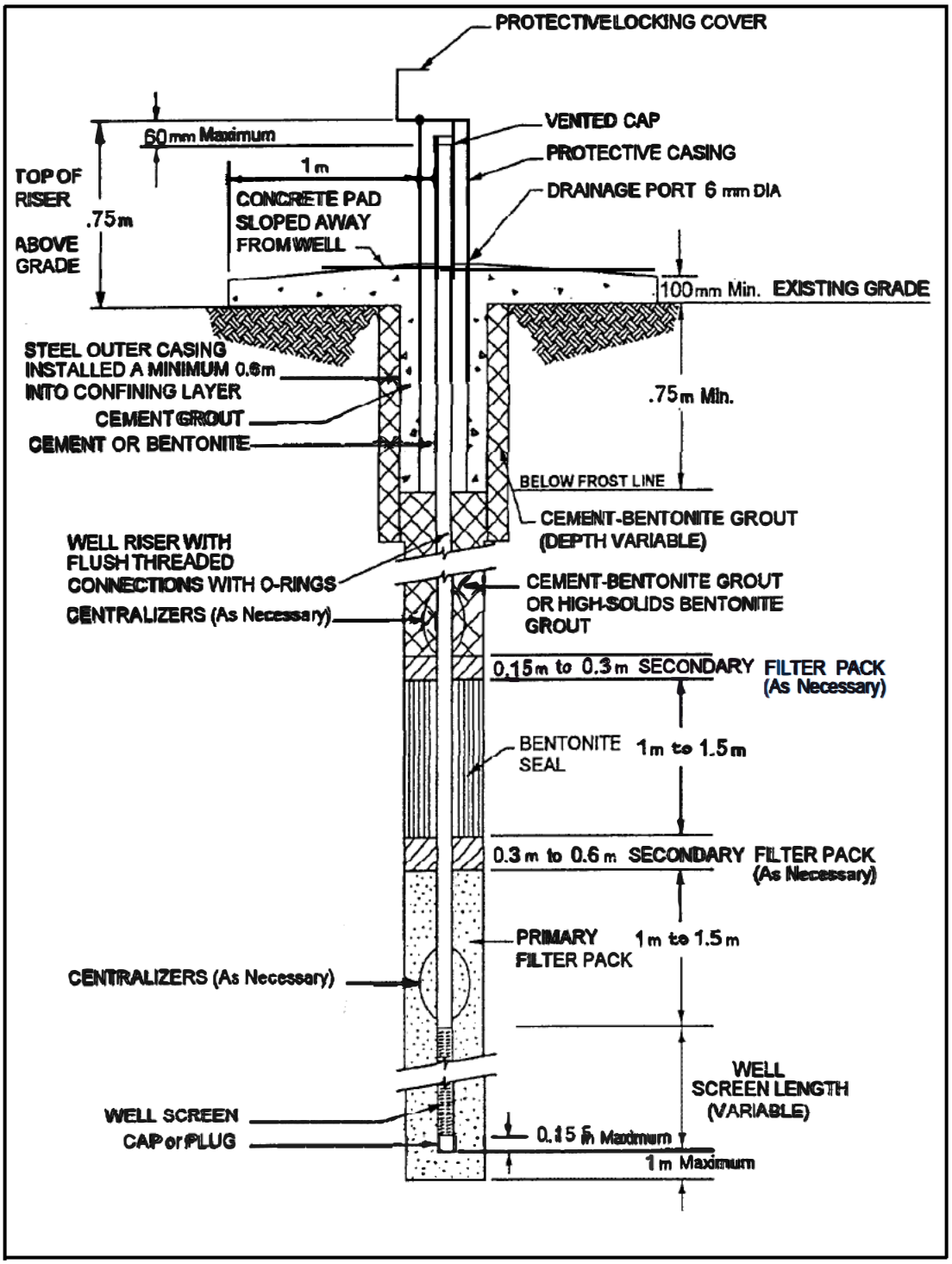


Figure 5-2. Schematic construction of multi-cased well with concrete pad

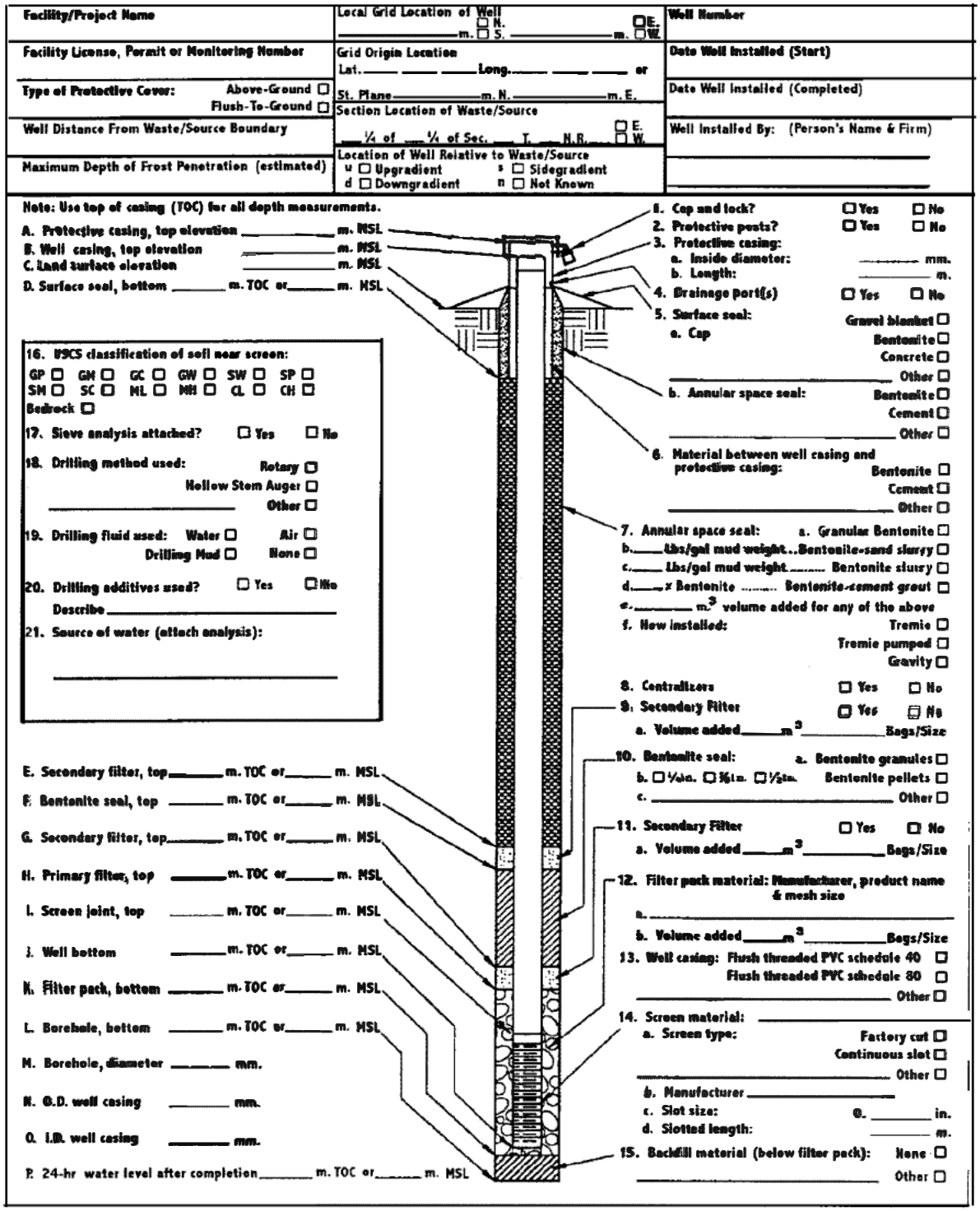


Figure 5-3. Schematic construction diagram of monitoring well

f. Once begun, well installation should not be interrupted due to the end of the driller's work shift, darkness, weekend, or holiday.

g. If possible, the FDO should ensure that all materials and equipment for drilling and installing a given well are available and onsite prior to drilling that well. The FDO should have all equipment and materials onsite prior to drilling and installing any well if the total well drilling and installation effort is scheduled to take 14 days or less. For longer schedules, the FDO should ensure that the above-mentioned materials needed for at least 14 days of operation are onsite prior to well drilling. The balance of materials should be in transit prior to well drilling. Any site-specific factors that preclude the availability of needed secure storage areas should be identified and resolved in the drilling plan.

5-5. Screens, Casings, and Fittings

a. All well screens and well casings should be free of foreign matter (e.g., adhesive tape, labels, soil, grease, etc.) and washed with approved water prior to use. Prewashing may not be necessary if the materials have been packaged by the manufacturer and have their packaging intact up to the time of installation. Pipe nomenclature stamped or stenciled directly on the well screen and/or blank casing within and below the bentonite seal should be removed by means of SANDING, unless removable in approved water. Solvents, except approved water, should NOT be used for removal of marking. Washed screens and casings should be stored in plastic sheeting until immediately prior to insertion into the borehole.

b. Bottoms of well screens should be placed no more than 1 m (3 ft) above the bottom of the drilled borehole. If significant overdrilling is required (as for determining stratigraphy), a pilot boring should be used. The intent here is to narrow the interval of aquifer being sampled, limit the potential for stagnant or no-flow areas near the screen, and preclude unwanted backfill materials (e.g., grout or bentonite) from entering or passing through the interval to be screened and sampled. The casing/screen should be suspended from the surface and should not rest on the bottom of the borehole during installation of the filter pack and annular seal.

c. All screen bottoms should be securely fitted with a threaded cap or plug of the same composition as the screen. This cap/plug should be within 150 mm (0.5 ft) of the open portion of the screen. No solvents or glues should be permitted for attachment.

d. Silt or sediment traps (also called cellars, tail pipes, or sumps) should NOT be used. A silt trap is a blank length of casing attached to and below the screen. Trap usage fosters a stagnant, turbid environment which could influence analytical results for trace concentrations.

e. The top of each well should be level such that the difference in elevation between the highest and lowest points on the top of the well casing or riser should be less than or equal to 6 mm (0.02 ft).

f. The borehole should be of sufficient diameter to permit at least 50 mm (2 in.) of annular space between the borehole wall and all sides of the well (centered riser and screen). When telescoping casings (one casing within another), the full 50 mm (2-in.) annulus may not be practical or functional. In this case, a smaller spacing may be acceptable, depending on site specifics.

g. Well screen lengths may be a function of hydrostratigraphy, temporal considerations, environmental setting, analytes of concern, and/or regulatory mandate. Screen lengths should be specified in the drilling plan.

h. The actual inside diameter of a nominally sized well is a function of screen construction and the wall thickness/schedule of both the screen and casing. In the case of continuously wound screens, their interior supporting rods may reduce the full inside diameter. This consideration is critical when planning the sizes for pumps, bailers, surge devices, etc.

i. When physical or biological screen clogging is anticipated, the larger open-area per unit length of continuously wound screens has an advantage over the slotted variety.

5-6. Granular Filter Pack

a. When artificial filter packs are used, a tremie pipe for filter pack placement is recommended, especially when the boring contains drilling fluid or mud. A record should be maintained of the amount of water used to place the filter pack, which should be added to the volume of water to be removed during well development.

b. The filter pack should extend from the bottom of the boring to 1 to 1.5 m (3 to 5 ft) above the top of the screen unless otherwise specified in the drilling plan. This extra filter allows for settlement (from infiltration and compaction) of the filter pack during development and repeated sampling events. The additional filter helps to

maintain a separation between the bentonite seal and well screen.

c. Sometimes, depending on the gradation of the primary filter pack and the potential for grout intrusion into the primary filter pack, a secondary filter pack may be installed above the primary filter pack to prevent the intrusion of the bentonite grout seal into the primary filter pack. To be effective, the secondary filter should extend 0.3 to 0.6 m (1 to 2 ft) above the primary filter pack.

d. The final depth to the top of the granular filter should be directly measured (by tape or rod) and recorded. Final depths should not be estimated, for example, as based on volumetric measurements of placed filter.

5-7. Bentonite Seals

a. Bentonite seals, especially those set in water, should typically be composed of commercially available pellets. Pellet seals should be 1 to 1.5 m (3 to 5 ft) thick as measured immediately after placement without allowance for swelling. Granular bentonite may be an alternate if the seal is set in a dry condition. Tremie pipes are not recommended.

6. Slurry seals can be used when the seal location is too far below water to allow for pellet or containerized-bentonite placement or within a narrow well-borehole annulus. Typically, the specific gravity of cement grout placed atop the slurry seal will be greater than that of the slurry. Therefore, the intent to use a slurry seal should be detailed in the drilling plan, and details should include a discussion of how the grout will be precluded from migrating through the slurry. Slurry seals should have a thick, batter-like (high viscosity) consistency with a placement thickness of 1 to 1.5 m (3 to 5 ft). Typically, only high-solids bentonite grouts are used that consist of a blend of powdered bentonite and fresh water mixed to a minimum 20 percent solids by weight of pumpable slurry with a density of 9.4 pounds per gallon or greater.

c. In wells designed to monitor possible contamination in firm bedrock, the bottom of the bentonite seal should be located at least 1 m (3 ft) below the top of firm bedrock, as determined by drilling. "Firm bedrock" refers to that portion of solid or relatively solid, moderately to unweathered bedrock where the frequency of loose and fractured rock is markedly less than in the overlying, highly weathered bedrock. Special designs will be needed to monitor contamination in fractured bedrock. Guidance on design of ground-water monitoring systems in karst and fractured-rock aquifers may be found in ASTM D 5717.

d. The final depth to the top of the bentonite seal should be directly measured (by tape or rod) and recorded. Final depths should not be estimated, as, for example, based on volumetric measurements of placed bentonite.

e. Numerous opinions have been expressed regarding bentonite hydration time, bentonite placement procedures under water versus in a dry condition, and the potential installation delays and other consequences caused by these factors. By not allowing sufficient time for the bentonite seal to hydrate and form a low permeable seal, grout material could infiltrate into the bentonite seal and possibly into the filter pack. It is recommended waiting a minimum of 3 to 4 hours for hydration of bentonite pellets, or tablets when cement grout is used above the bentonite seal. If bentonite chips are used, the minimum hydration time could be twice as long. Normally chips should only be used if it is necessary to install a seal in a deep water column. Because of their high moisture content and slow swelling tendencies, chips can be dropped through a water column more readily than a material with a low moisture content, such as pellets or tablets. Bentonite chips should not be placed in the vadose zone. A 1 m (3 ft) minimum bentonite pellet seal must be constructed to protect the screen and filter pack from downhole grout migration. When installing a bentonite seal in the vadose zone (the zone above the water table), water should be added to the bentonite for it to properly hydrate. The amount of water required is dependent on the formation. It is recommended that the bentonite seal be placed in 0.15 to 0.3 m (6 in to 1 ft) lifts, with each lift hydrated for a period of 30 minutes. This method will assure that the bentonite seal is well hydrated and accomplish its intended purpose. A 0.15 to 0.3 m (6 in. to 1 ft) layer of fine to medium sand (secondary filter pack) placed atop the bentonite seal may further enhance barrier resistance to downward grout migration.

5-8. Grouting

All prescribed portions of grout material should be combined in an aboveground rigid container and mechanically (not manually) blended to produce a thick, lump-free mixture throughout the mixing vessel. The mixed grout should be placed around the monitoring well as follows.

a. The grout should be placed from within a rigid side discharge grout pipe located just over the top of the seal. The grout or tremie pipe should be decontaminated prior to use.

b. Prior to exposing any portion of the borehole above the seal by removal of any drill casing (to include hollow-stem augers), the annulus between the drill casing and well

casing should be filled with sufficient grout to allow for planned drill casing removal. The grout should not penetrate the well screen or granular filter pack. Disturbance of the bentonite seal should be minimal.

(1) If all drill casing is to be removed in one operation, the grout should be pumped through the grout pipe until undiluted grout flows from the annulus at ground surface, forming a continuous grout column from the seal to ground surface. The drill casing should then be removed, making certain that borehole exposure to the atmosphere is minimal. During the removal of hollow stem augers, the grout pipe may have to be periodically reinserted for additional grouting to compensate for the larger annular space created by the augers' helical coil.

(2) If drill casing is to be incrementally removed with intermittent grout addition, the grout should be pumped through the grout pipe until it reaches a level that will permit at least 3 m (10 ft) of grout to remain in the well/drill casing annulus AFTER removing the selected length of drill casing. Using this method, at least 6 m (20 ft) of grout should be within the drill casing before removing 3 m (10 ft) of driven casing or considerably more than 6 m (20 ft) of grout for the removal of 3 m (10 ft) of hollow stem auger. With this method, the grout pipe needs only to be reinserted to the base of the casing yet to be removed before repeating the grout insertion process.

c. If the ungrouted portion of the hole is less than 4.5 m (15 ft) deep and without fluids after casing removal, the ungrouted portion may be filled by pouring grout from the surface without a pipe.

d. If drill casing (to include hollow-stem auger) was not used, grouting should proceed to surface in one continuous operation. Care should be taken, however, in deep wells when using cement grout around PVC casing. Extreme heat, commonly known as heat of hydration, can be generated by the cement during hydration and curing. The heat generated can be sufficient enough to soften or weaken PVC casing, resulting in collapse of the casing. Grouting in multiple lifts may be necessary in this situation.

e. Once begun, the grouting process should be continuous until all the drill casing has been removed and all annular spaces are grouted to the ground surface.

f. Protective casing should be installed on the same day as grouting begins.

g. The FDO should check the site for grout settlement and add more grout to fill any depression that day. Repeat this process until firm grout remains at ground surface. This process should be completed within 24 hours of the initial grout placement. Incremental quantities of grout added in this manner should be recorded on the well completion diagram to be submitted to the FA.

h. For grout placement in a dry and open hole less than 4.5 m (15 ft) deep, the grout may be manually mixed and poured in from the surface as long as seal integrity is maintained.

i. No grout should be placed or allowed to migrate below the bentonite seal and into the well screen.

5-9. Well Protection

a. Protective casing should be installed around each monitoring well the same day as initial grout placement. The annulus formed between the outside of the protective casing and borehole should be filled to the ground surface with grout. The annulus between the monitoring well and protective casing should be filled to a minimum of 150 mm (0.5 ft) above the ground surface with cement or bentonite as part of the overall grouting procedure. Specific details of well protection should be approved by the FA. These details and specific elements to be included in the well construction diagrams should be described in the drilling and well installation plan.

b. All protective casing should be steam or hot-water-pressure cleaned prior to placement; free of extraneous openings; and devoid of any asphaltic, bituminous, encrusting, and/or coating materials, except the black paint or primer applied by the manufacturer.

c. Recommended minimum elements of protection design include the following list.

(1) A 1.5 m (5-ft) minimum length new, black iron/steel pipe (protective casing) extending about 0.75 m (2.5 ft) above ground surface and set in grout (see Figures 5-1, 5-2, and 5-4). The bottom of the protective casing should extend below the frost line to preclude damage from frost heave.

(2) A protective casing inside diameter at least 100 mm (4 in.) greater than the nominal diameter of the well riser.

(3) A hinged cover or loose-fitting telescopic slip-joint cap to keep direct precipitation and cap runoff out of

the casing. Threaded covers should be avoided because of the tendency to rust or freeze shut.

(4) All protective casing covers/caps secured to the casing by means of a noncorrosive padlock from the date of protective casing installation. All manhole covers should also be lockable.

(5) If practical, have all padlocks at a given site opened by the same key. The FDO should provide four of these keys to an FA-designated representative at the project.

(6) No more than 60 mm (0.2 ft) from the top of the protective casing to the top of the well casing. This, or a smaller spacing, is needed for subsequent water-level determinations by some acoustical equipment which must rest upon the well casing in order to function.

(7) All painting of the protective casing must be done offsite, prior to installation. Only the outside of the casing should be painted. Each well should be identified by a number placed on the outside of the well casing. Various methods of identification have been successfully used such as painting the number on the protective casing with the help of a painting stencil, attaching a metal imprinted noncorrosive metal tag, or imprinting the number directly on the steel protective casing. The color of the casing, the well number and method of application should be specified by the design FA in the drilling and well installation plan, and should be in accordance with the requirements prescribed by the owner and state and local technical regulations. Painting should be completed and dry prior to initially sampling the well.

(8) The erection of protective posts should be considered when physical damage resulting from construction equipment or vehicles is likely. When necessary, steel posts should be erected with a minimum diameter of 80 mm (3 in.). Each post should be radially located a minimum of 1 m (3 ft) from the well and placed 0.6 to 1 m (2 to 3 ft) below ground surface, having 1 m (3 ft) minimally above ground surface. Posts are typically filled with concrete and set in post holes which are backfilled with concrete. The post should be painted orange using a brush. Installation should be completed prior to sampling the well. Flags or barrier markers in areas of high vegetation may be helpful.

(9) When posts are used in conjunction with concrete pads, the posts should be located **OUTSIDE** of the pad. Posts inside of a pad (especially near a comer or edge) may cause the pad to crack, either by normal stress relief or if severely struck as by a vehicle.

(10) The above-mentioned posts should be supplemented with three-strand barbed wire in livestock grazing areas. Post and wire installation should be installed prior to sampling.

(11) Place a 6 mm (l/4 in.) diameter hole (drainage port) in the protective casing centered, no more than 3 mm (l/8 in.) above the grout filled annulus between the monitoring well riser and the protective casing.

(12) The application of at least a 150 mm (0.5 ft) thick coarse gravel 19- to 75-mm (3/4- to 3-in.) particle size pad extending 1 m (3 ft) radially from the protective casing (see Figure 5-4 for layout and dimensions). Prior to placement of this gravel pad, any depression around the well should be backfilled to slightly above the level of the surrounding ground surface with uncontaminated cohesive soil. This will prevent a “bathtub” effect of water collecting in the gravel pad around the well casing. Construction of the gravel pad is suggested prior to development. Some long-term, heavy traffic, or high visibility locations may warrant a concrete pad specially designed for site conditions. Any concrete pad usage, especially in cold climates, should be designed to withstand frost heaving. Frost uplift may adversely affect well and pad integrity. A concrete pad should be at least 100 mm (4 in.) thick and 1 m (3 ft.) square. Round concrete pads are also acceptable.

(13) All elements of well protection should be detailed in the drilling plan. In addition, unique well protection requirements for floodplains, frost heaving, heavy traffic areas, parking lots, as well as wells finished at or below grade, and other special circumstances should also be covered on a case-by-case basis, in the drilling plan. As an example, a suggested well design to minimize the effects of frost heaving is shown in Figure 5-6. An example of a flush-to-ground completion is shown in Figure 5-5. Additional guidance on monitoring well protection may be found in ASTM Standard Practice D 5787.

5-10. Shallow Wells

Shallow, less than 4.5 m (15 ft), well construction may be more problematic than deep. Sufficient depth may not be available to utilize the full lengths of typical well components when the aquifer to be monitored is near the surface. The FA should tailor design criteria to the actual environment and project objectives for appropriate shallow well construction.

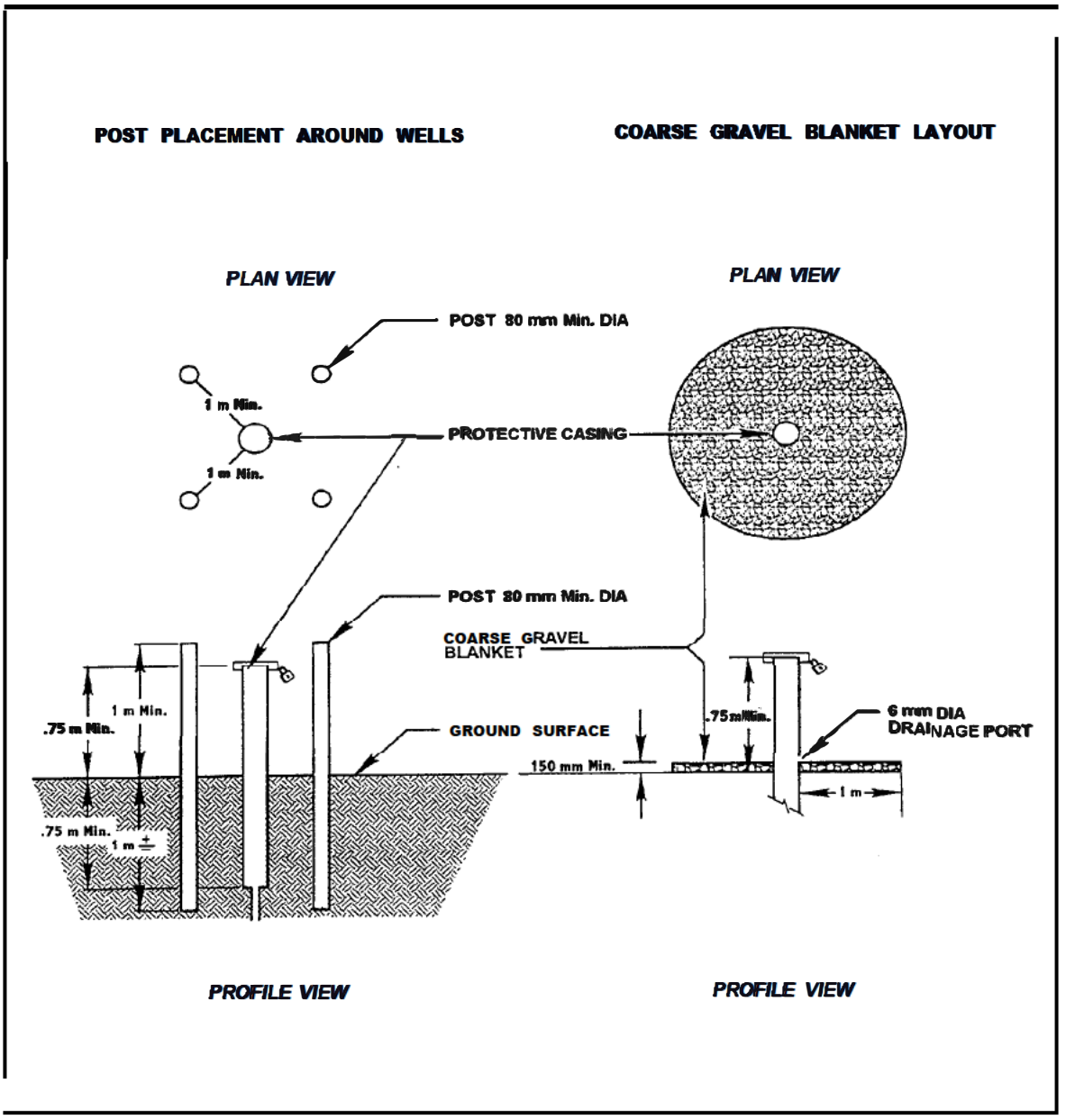


Figure 5-4. Post placement and gravel blanket layout around wells. (Adapted from a figure provided by International Technology Corporation)

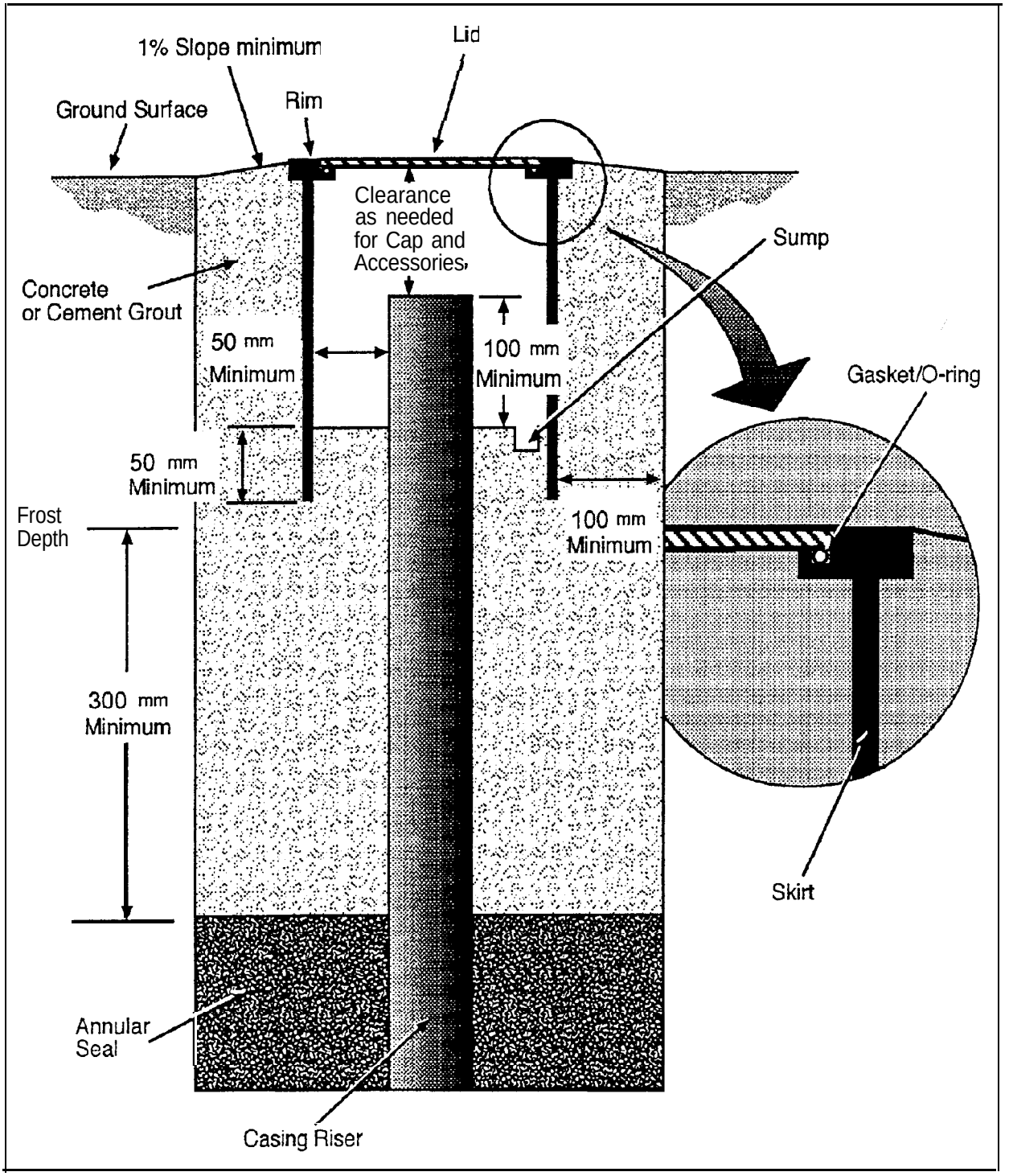


Figure 5-5. Schematic construction of flush-to-ground completion. (Figure provided by Ronald Schalla)

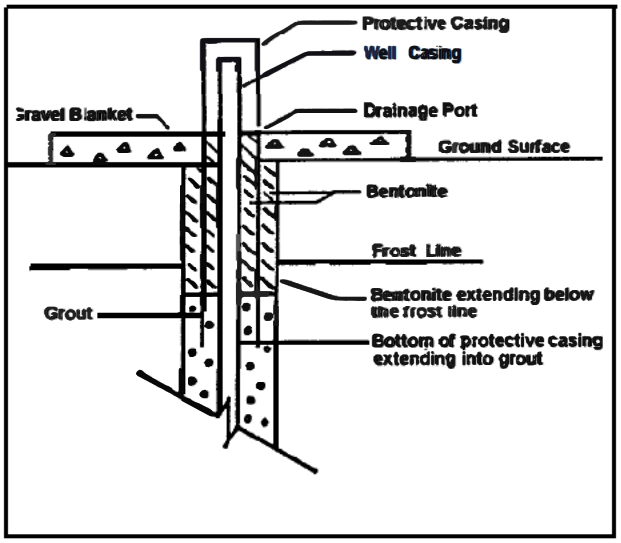


Figure 5-6. Well design parameters to minimize frost heave

5-11. Drilling Fluid Removal

When a borehole, made with or without the use of drilling fluid, contains an excessively thick, particulate-laden fluid that would preclude or hinder the specified well installation, the borehole fluid should be removed or displaced with approved water. This removal is intended to remove or dilute the thick fluid and thus facilitate the proper placement of casing, screen, granular filter, and seal. Fluid losses in this operation should be recorded on the well diagram or boring log and later on the well development record. Any fluid removal prior to well placement should be contingent upon the driller's and the geologist's evaluation of hole stability, e.g., long enough for the desired well and seal placement.

5-12. Drilling Fluid Losses in Bedrock

If large drilling fluid losses occur in bedrock and if the hole is cased to bedrock, the FDO should remove at least three times this volumetric loss prior to well insertion. The intent is to allow the placement of a larger pump in the borehole than otherwise possible in the well casing, thereby reducing subsequent development time and removing the lost water closer to the time of loss. Development of the completed well could then be reduced by a volume equal to that which was removed through the above procedure.

5-13. Well Construction Diagrams

a. Each installed well should be depicted in a well diagram. An example of a well diagram is shown in Figure 5-3. This diagram should be attached to the original bore log for that installation and graphically denote, by depth from ground surface.

(1) The bottom of the boring (that part of the boring most deeply penetrated by drilling and/or sampling) and boring diameter(s).

(2) Screen location.

(3) Joint locations.

(4) Granular filter pack.

(5) Seal.

(6) Grout.

(7) Cave-in.

(8) Centralizers.

(9) Height of riser (stickup) without cap/plug above ground surface.

(10) Protective casing detail.

(a) Height of protective casing without cap/cover, above ground surface.

(b) Bottom of protective casing below ground surface.

(c) Drainage port location and size.

(d) Gravel pad height and extent.

(e) Protective post configuration.

(11) Water level (ASTM D 4750) 24 hours after completion with date and time of measurement.

(12) Estimated maximum depth of frost penetration.

b. Describe the following on the diagram.

(1) The actual quantity and composition of the

grout, bentonite seals, and granular filter pack used for each well.

(2) The screen slot size in millimeters (inches), slot configuration, total open area per meter (foot) of screen, outside diameter, nominal inside diameter, schedule/thickness, composition, and manufacturer.

(3) The material between the bottom of the boring and the bottom of the screen.

(4) The outside diameter, nominal inside diameter, schedule/thickness, composition, and manufacturer of the well casing.

(5) The joint design and composition.

(6) The centralizer design and composition.

(7) The depth and description of any permanent pump or sampling device. For pumps include the voltage, phase requirements, and electrical plug configuration.

(8) The protective casing composition and nominal inside diameter.

(9) Special problems and their resolutions; e.g., grout in wells, lost casing and/or screens, bridging, casing repairs or adjustments, etc.

(10) The dates and times for the start and completion of well installation.

c. Each diagram should be attached to the original boring log and submitted from the field to the FA.

d. Only the original well diagram and boring log should be submitted to the FA. Carbon, typed, or reproduced copies should be retained by the FDO. A legible copy of the well diagram may be used as a base for the supplemental protection diagram.

e. Special abbreviations used on the well completion diagram should be defined on the diagram.

Chapter 6
Well Development

6-1. General

Well development is the procedure that locally improves or restores the aquifer's hydraulic conductivity and removes well drilling fluids, muds, cuttings, mobile particulates, and entrapped gases from within and adjacent to a newly installed well. The resulting inflow should be physically and chemically representative of that portion of the aquifer adjacent to the screened interval. The appropriate development method/procedure to use will vary according to the hydrologic characteristics of the aquifer, the geologic composition of the screened interval, the drilling method, and the type of well completion. Of the various methods available for use in developing wells in general, mechanical surging, pumping, backwashing, and bailing are best suited. Additional guidance on the development of groundwater monitoring wells may be found in ASTM Standard Guide D 5521.

6-2. Timing and Record Submittal

The final development of monitoring wells should be initiated no sooner than 48 hours after or more than 7 days beyond the final grouting of the well. Predevelopment, or preliminary development may be initiated before this minimum 48 hour period. Preliminary development takes place after the screen, casing and filter pack have been installed, but before the annular seal is installed. Preliminary development is done in order to remove any mud cake that may be on the side of the borehole in a timely manner. Predevelopment is also recommended if the well is installed with the intent of using the natural formation material as the filter pack. Because this type of well design is based on the assumption that well development will remove a significant fraction of the formation materials adjacent to the well screen (therefore causing some sloughing in the borehole), developing the well after installing the annular seal may result in portions of the annular seal collapsing into the vicinity of the well screen. It is not good practice to wait and develop all the monitoring wells on a project after the last one is complete. The record of well development should be submitted to the FA.

6-3. Development Methods

A thorough discussion of monitoring well development methods can be found in ASTM Standard Guide D 5521.

a. Mechanical Surging. Operation of a piston-like device termed a surge block affixed to the end of a length of drill rod, or drill stem, is a very effective development method that can be effective in all diameter of wells, even in stratified formations having variable permeability. The up-and-down plunging action alternately forces water to flow into and out of the well, similar to a piston in a cylinder. The use of a surge block can agitate and mobilize particulates around the well screen. Periods of surging should be alternated with periods of water extraction from the well so that sediment, brought into the well, is removed. Surging should initially be gentle to assure that water can come into the well and that the surge block is not so tight as to damage the well pipe or screen. For short well screens (1.6 m (5 ft) or less) set in a homogeneous formation, the surge block does not have to be operated within the screen interval. However, if the screened interval includes materials of high and low permeabilities, the block may have to be operated gently within the screen.

b. Pumping. A commonly used development method consists of pumping a well at a higher rate than water will be extracted during purging or sampling events. This overpumping, however, is usually only successful in relatively non-stratified, clean-sand formations. By pumping the well at a higher rate than expected during sampling, the mobilized particulates may be removed, thereby providing a cleaner well for sampling. Overpumping should be supplemented with the use of a bottom discharge/filling bailer, (for sediment removal). During development, water should be removed throughout the entire water column in the well by periodically lowering and raising the pump intake. A disadvantage of only pumping the well is that the smaller soil grains of the filter pack may be bridged in the screen or in the filter pack, as the direction of flow is only towards the screen. To overcome this, overpumping is often used in conjunction with backwashing or surging.

c. Backwashing. Backwashing is the reversal of water flow in a well, causing soil particles to dislodge that may have become wedged in or bridged around the screen due to overpumping of the well. Backwashing when supplemented with overpumping, facilitates the removal of fine-grained materials from the formation surrounding the borehole. A commonly used backwashing procedure called “rawhiding” consists of starting and stopping the pump intermittently to allow the rising water in the well pipe to fall back into the well. This backwashing procedure produces rapid changes in the pressure head within the well. If rawhiding is to be used, there cannot be a backflow prevention valve in the pump or eductor line. Another method of backwashing is to pump water into the well in sufficient volume to maintain a

head greater than that in the formation. This method of backwashing should only be done when the water pumped into the well is of known and acceptable chemistry. The impact of added water on in situ water quality should be evaluated and, this water should be removed by pumping after development is complete. This method of backwashing, not withstanding the quality of water pumped into the well, may not be allowed by local, state, or federal agencies. Do not use this method in cases where the water pumped into the well is potentially contaminated.

d. Bailing. The use of bailers is an effective way of manually developing small diameter wells that have a high static water table or are relatively shallow in depth (<4.5 m (15 ft)). As the diameter of the bailer is commonly close to the same diameter as the well screen, the bailer agitates the water in the well in much the same manner as a surge block, but to a lesser extent. It is good practice to surge the well using the bailer for 10 to 20 minutes prior to beginning bailing. To have its most effective surging action, the bailer should be operated throughout the screened interval. Bottom loading bailers can extract sediment that has settled to the bottom of the well by rapid short upward/down motions of the bailer at the bottom of the well which stir up the sediment and take it into the bailer. Pumps may be replaced by bottom filling bailers where well size or slow recharge rates restrict pump usage. Bailers should not be left inside the wells after development is completed. Such storage promotes accidental bailer release or loss down the well and inhibits convenient and accurate water-level measurements.

e. High-velocity hydraulic jetting. Another effective method available for use in developing some monitoring wells, is high-velocity hydraulic jetting. This method employs several horizontal jets of water operated from inside the well screen so that high-velocity streams of water exit through the screen and loosen fine-grained material and drilling mud residue from the formation. The loosened material moves inside the well screen and can be removed from the well by concurrent pumping or by bailing. Because of the size of the equipment required, this method is more easily applied to wells of 100 mm (4 in.) or greater diameter. Jetting is particularly successful in developing highly stratified unconsolidated formations, consolidated bedrock wells, large-diameter wells, and natural formation wells. Jetting is generally simple to use, effectively rearranges and breaks down bridging in the filter pack, and effectively removes mud cakes around screen. The disadvantage of using jetting even in ideal conditions is the introduction of foreign water and possible contaminants into the aquifer. Jetting is not effective in cases where slotted pipe is used for the screen. Jetting is much more effective where continuous-wrap v-wire screens, having a greater open area, are used.

f. Special Concerns.

(1) Where monitoring well installations are made in formations that have low hydraulic conductivity, none of the preceeding well development methods may be found to be completely satisfactory. In this situation clean water can be circulated down the well casing, out through the well intake and gravel pack, and up the open borehole prior to placement of the grout or seal in the annulus. Relatively high water velocities can be maintained, and the mud cake from the borehole wall will be broken down effectively and removed. Flow rates should be controlled to prevent floating the gravel pack out of the borehole. Because of the relatively low hydraulic conductivity of geologic materials outside the well, a negligible amount of water will penetrate the formation being monitored. However, immediately following the procedure, the well sealant should be installed and the well pumped to remove as much of the water used in the development process as possible (Barcelona et al. 1985). Adding water to the well for flushing should only be done, however, when no better options are available. In some fine grained deposits vigorous development can be detrimental to the well. If vigorous development is attempted in such wells, the turbidity of water removed from the well may actually increase many times over. In some fine-grained formation materials, no amount of development will measurably improve formation hydraulic conductivity or the hydraulic efficiency of the well. Alternative sampling methods, such as lysimeters (ASTM D 4696), should be considered in low conductivity formations.

(2) Drilling methods. The drilling process influences not only development procedures but also the intensity with which these procedures must be applied. Typical problems associated with special drilling technologies that must be anticipated and overcome are: 1) When drilling an air rotary borehole in rock formations, fine particulate matter typically builds up on the borehole walls and plugs fissures, pore spaces, bedding planes and other permeable zones. The matter must be removed and the openings restored by the development process; 2) If casing has been driven or if augers have been used, the interface between the natural formation and the casing or the auger flights are “smeared” with fine particulate matter that must subsequently be removed in the development process; 3) If a mud rotary technique is used, a mud cake builds up on the borehole wall that must be removed during the development process; and 4) If there have been any additives, as may be necessary in mud rotary, cable tool or augering procedures, the

development process must attempt to remove all of the fluids that have infiltrated into the natural formation (EPA/600/4-89/034). A comparison of the advantages and disadvantages of various drilling methods is in Table 3-1.

6-4. Development Criteria

a. Development should proceed until the following criteria are met:

(1) Satisfaction of applicable federal, state, and local regulatory requirements. Some of these requirements may specify that development continue until the readings for some indicator parameters like pH, conductivity, temperature, oxidation-reduction potential (ORP), dissolved oxygen (DO), or turbidity have stabilized; e.g., vary within a specified range. Stabilization is commonly considered to have been achieved after all parameters have stabilized for three successive readings. Generally three successive readings should be within ±0.2 for pH, ±3% for conductivity, ±10 mV for oxidation-reduction potential (ORP), ±1 degree Celsius for temperature, and ±10% for turbidity and DO. In general the order of stabilization is pH, temperature, and conductivity, followed by ORP, DO and turbidity (Puls and Barcelona 1996).

(2) The well water is clear to the unaided eye and the turbidity of the water removed is at some specified level. Some regulators may require that the turbidity, as measured in nephlometric turbidity units (NTUs), be less than 5 NTUs. It should be noted that natural turbidity levels in ground water may exceed 10 NTUs. Turbidity is always the last indicator parameter to stabilize. There are instances where minimizing turbidity will result in a sample that is not representative of the water that is moving through the formation. If the ground water moving through the formation is, in fact, turbid, or if there is free product moving through the formation, then some criteria may cause a well to be constructed such that the actual contaminant that the well was installed to monitor will be filtered out of the water. Therefore, it is imperative that the design, construction and development of the monitoring well be consistent with the objective of obtaining a sample that is representative of conditions in the ground.

(3) The sediment thickness remaining within the well is less than 1 percent of the screen length or less than 30 mm (0.1 ft) for screens equal to or less than 3 m (10 ft) long.

(4) A minimum removal of three times the standing water volume in the well (to include the well screen and casing plus saturated annulus, assuming 30 percent annular porosity). **IN ADDITION** to the "three times the standing water volume" criteria, further volumetric removal should be considered as follows:

(a) For those wells where the boring was made without the use of drilling fluid (mud and/or water), but water was added to the well during well installation, then three times the amount of any water unrecovered from the well during installation should be removed (in addition to three times the standing volume).

(b) For those wells where the boring was made or enlarged (totally or partially) with the use of drilling fluid (mud and/or water), remove three times the measured (or estimated) amount of total fluids lost while drilling, plus three times that used for well installation (in addition to three times the standing volume).

(5) If the primary purpose of development is to rectify damage done during drilling to the borehole wall and the adjacent formation, the time for development may be based on the response of the well to pumping (ASTM D 4050). An improvement in recovery rate of the well indicates that the localized reduction in hydraulic conductivity has been effectively rectified by development. A commonly used method for determining hydraulic conductivity is the instantaneous change in head, or slug test. The slug test method involves causing a sudden change in head in the well and measuring the water level response within the well. Head change can be induced by suddenly injecting or removing a known quantity or "slug" of water into the well. However, instead of injecting a "slug" of water, a solid or mechanical slug of known volume should be used. The mechanical slug may be constructed of a section of weighted pipe, of known volume, capped on both ends. Water level and elapsed-time data can be recorded with a data logger and pressure transducer. Both "rising heads" and "falling heads" are recorded. Guidance on conducting slug tests may be found in ASTM Standard D 4044.

b. Prior to placement of the seal, if the borehole contains an excessively thick, particulate-laden fluid which would hinder proper well installation, this fluid should be diluted and/or flushed with clean water and purged from the well. Water should not be added to a well as part of development once the initial bentonite seal atop the filter pack is placed. It is essential that any water added to the well is of known and acceptable chemistry. The impact of added water on in situ water quality should be evaluated and removed after development is complete.

c. The use of air to develop a well **SHOULD NOT** be allowed. The introduction of air into a well enhances the occurrence of chemical, physical, and biological changes to the local aquifer system monitored by the well. Furthermore, procedures involving compressed air at HTW sites increase potential exposure/health risks to site personnel from the volatilization and misting of the aerated water. If air development is deemed the most appropriate method for a site, the above factors should be evaluated and mitigation procedures documented in the drilling plan.

d. If any of the following circumstances occur, the FA should be contacted for guidance:

(1) Well recharge so slow that the required volume of water cannot be removed during 48 consecutive hours of development;

(2) Persistent water discoloration after the required volumetric development; and

(3) Excessive sediment remaining after the required volumteric removal.

6-5. Development-Sampling Break

Time should be allowed for equilibration of the well with the formation after development before sampling of the well is undertaken. Well development should be completed at least 14 days before well sampling. The intent of this hiatus is to provide time for the newly installed well and backfill materials to surficially equilibrate to their new environment and for that environment to re-stabilize after the disturbance of drilling. Though a significant volume of water may be pulled through the well during development, the well and granular backfill surfaces over which this water passes are not likely to be at chemical equilibrium with the aquifer. Intuitively, the hiatus allows time for that equilibrium to be created, thereby enhancing the probability of the resulting sample to be more representative of the local aquifer. The 14-day hiatus is a "rule-of-thumb," unsubstantiated by rigorous scientific analysis. If a different value is proposed based upon technical data or overall project considerations, such a change should be evaluated and, if deemed appropriate, implemented. Generally, high permeability formations require less time (e.g., several days) to equilibrate than low permeability formations (e.g., several weeks). The FSP should state the amount of time that will be required to permit the equilibration of the monitoring well following development and prior to sampling and the justification for selection of that time interval.

6-6. Development Water Sample

For each well, a 0.5 L (1-pint) sample of the last water to be removed during development should be placed in a clear glass jar and labeled with well number and date. No preservation of these samples is required. Each sample should be individually agitated and immediately photographed close-up by the FDO with a 35-mm camera and color print film, using a back-lit setup to show water clarity. These photos, minimally 125 mm x 175 mm (5 in. x 7 in.), individually identified with project name, well number, and photo date, should be provided to the FA after all wells are developed. The film negatives should be provided to the FA after the FA has received the prints. The FDO should dispose of these water samples in the same manner as the rest of the water removed during development.

6-7. Well Washing

Part of well development should include the washing of the entire well cap and the interior of the well casing above the water table using only water from that well. The result of this operation will be a well casing free of extraneous materials (grout, bentonite, sand, etc.) inside the well cap and blank casing, between the top of the well and the water table. This washing should be conducted before and/or during development, not after development.

6-8. Well Development Record

The following data should be recorded as part of development and submitted to the FA:

a. Project name, location.

b. Well designation, location.

c. Date(s) and time(s) of well installation.

d. Date(s) and time(s) of well development.

e. Static water level from top of well casing before and 24 hours after development.

f. Quantity of mud/water:

(1) Lost during drilling.

(2) Removed prior to well insertion.

(3) Lost during thick fluid displacement.

(4) Added during granular filter placement.

g. Quantity of fluid in well prior to development:

(1) Standing in well.

(2) Contained in saturated annulus (assume 30 percent porosity).

h. Field measurement of pH (ASTMs D1293 and D5464), conductivity (ASTM D1125), oxidation-reduction (redox) potential (ASTM D1498), dissolved oxygen (ASTMs D888 and D5462), turbidity (ASTM D1889), and temperature (EPA Method 170.1) before, twice during, and after development using an appropriate device and method. Field methods for these parameters can also be found in EPA 600/4-79/020, and Standard Methods.

i. Depth from top of well casing to bottom of well.

j. Screen length.

k. Depth from top of well casing to top of sediment inside well, before and after development (from actual measurements at time of development).

l. Physical character of removed water, to include changes during development in clarity, color, particulates, and any noted odor.

m. Type and size/capacity of pump and/or bailer used.

n. Description of surge technique, if used.

o. Height of well casing above ground surface (from actual measurement at time of development).

p. Typical pumping rate.

q. Estimated recharge rate.

r. Quantity of fluid/water removed and time for removal (present both incremental and total values).

6-9. Potential Difficulties

Many difficulties may arise during development and presample purging. Some are readily apparent but troublesome to resolve; e.g., a well that is easily pumped dry but slow to recharge or one that will not produce clear, particulate-free water. Other difficulties are not easily observed but may bias the analytical results, e.g., pulling-in distant parts of the aquifer in an effort to achieve a repetitively consistent field reading or aerating the aquifer adjacent to the well in a hurried attempt at well development. In addition, the unanticipated presence of dense (or light) nonaqueous phase liquids (NAPL) in the screened interval would affect the chemical homogeneity of that interval and hydrologic parameters derived from that well. The anticipation, evaluation, and tentative solution for these problems should begin early in the formulation of each drilling plan.

Chapter 7
Well and Boring Acceptance Criteria

7-1. Well Criteria

Wells should be acceptable to the FA. Well acceptance should be on a case-by-case basis. The following criteria should be used along with individual circumstances in the evaluation process.

a. The well and material placement should meet the construction and placement specifications of the drilling and well installation plan unless modified by amendments.

b. Wells should not contain portions of drill casing or augers unless they are specified in the drilling plan as permanent casing.

c. All well casing and screen materials should be free of any unsecured couplings, ruptures, or other physical breakage/defects before and after installation.

d. The annular material (filter pack, bentonite, and grout) of the installed well should form a continuous and uniform structure, free of any detectable fractures, cracks, or voids.

e. Any casing or screen deformation or bending should be minimal to allow the insertion and retrieval of the pump and/or bailer optimally designed for that size casing, e.g., a 75 mm (3-in.) pump in a 100 mm (4-in.) schedule 80, PVC casing is optimal; a 50 mm (2-in.) pump in a 100 mm (4-in.) casing is not optimal.

f. All joints should be constructed to provide a straight, nonconstricting, and watertight fit.

g. Completed wells should be free of extraneous objects or materials; e.g., tools, pumps, bailers, packers, excessive sediment thickness, grout, etc. This prohibition should not apply to intentionally installed equipment per drilling plan.

h. For those monitoring wells where the screen depth was determined by the FDO, the well should have sufficient free water at the time of the water-level measurement to obtain a representative groundwater level for that well. These same wells should have sufficient free water at the time of initial sampling, which is representative of the desired portion of the aquifer for the intended chemical analyses.

i. All boring logs, well diagrams, development records, topographic survey data, and related photographs and negatives should have been completed per the drilling plan and received by the FA.

j. Keys to the padlocks securing the well covers should be in the possession of the FA and the FA project representative prior to well acceptance.

7-2. Abandoned/Decommissioned Borings and Wells

Borings not completed as wells should be abandoned/ decommissioned per paragraph **3-14** of this manual.

7-3. Well and Boring Rejection

Wells and borings not meeting drilling plan criteria are subject to rejection by the FA.

Chapter 8
Water Levels

8-1. Measurement Frequency and Coverage

The frequency of water-level measurement is project related. At a minimum, for those projects involving the installation of any monitoring wells, at least one complete set of *static* water-level measurements should be made over a single, consecutive 10-to-12-hour period for all project-related wells, both newly installed and specified existing wells. These measurements should be taken at least 24 hours after development or sampling. Static levels in borings not converted to wells should be included if practical and technically appropriate. This set of measurements should include a notation for the presence of any streams, lakes, and/or open water bodies (natural and man-made) within proximity, e.g., about 90 m (300 ft) of these wells. Elevation measurements of any surface water bodies should be a consideration within the drilling and well installation plan.

8-2. Vertical Control

The depth to groundwater should be measured and reported to the nearest 3 mm (0.01 ft). Measurement should be made from the highest point on the rim of the well casing or riser (not protective casing). This same point on the well casing should be surveyed for vertical control. The surveyed mark on the top of the casing should be permanently marked with a notch cut in the casing to ensure that depth to water is always measured from the same elevation. Surface water levels should be measured at least to the nearest 30 mm (0.1 ft) using an adjacent temporary or permanent survey marker as a datum for current and future reference.

8-3. Reporting and Usage

All water level data should be presented as elevations in tabular form. Where sufficient data points exist, the elevations should be contoured to denote flow directions, gradients, and any hydrological interconnections between aquifers and surface water bodies.

8-4. Methods

Guidance on determining liquid levels in a borehole or monitoring well may be found in ASTM D 4750.

Chapter 9
Topographic Survey

9-1. Licensing

All topographic survey efforts conducted under contract should be certified by a surveyor with a current surveyor's license in the project state. Any licensing requirements within the project state for contract or Corps of Engineers surveyors should be determined by the FA.

9-2. Horizontal Control

Each boring and/or well installation should be topographically surveyed to determine its map coordinates referenced to either a Universal Transverse Mercator (UTM) grid or the State Plane Coordinate System (SPCS). These surveys should be connected to the UTM or SPCS by third order, Class II control surveys in accordance with the Standards and Specifications for Geodetic Control Networks (Federal Geodetic Control Committee 1984). If the project is in an area remote from UTM or SPCS benchmarks and such horizontal control is not warranted, then locations measured from an alternate system depicted on project plans may suffice, at least on a temporary basis. All borings, wells, temporary and/or permanent markers should have an accuracy of ±300 mm (±1 ft) within the chosen system.

9-3. Vertical Control

Elevations for the natural ground surface (not the top of the coarse gravel blanket) and a designated point on the rim of the uncapped well casing (not protective casing) for each bore/well site should be surveyed to within 3 mm (±0.01 ft) and referenced to the National Geodetic Vertical Datum of 1929 (NGVD of 1929) or the North American Vertical Datum, 1988 Adjustment (NAVD 88). These surveys should be connected by third order leveling to the NGVD of 1929 or NAVD 1988 in accordance with the Standards and Specifications for Geodetic Control Networks. If the project is in an area remote from NGVD benchmarks and such vertical control is not warranted, then elevations measured from a project datum may suffice, at least on a temporary basis.

9-4. Field Data

The topographic survey should be completed as near to the time of last well completion as possible. Survey field data (as corrected), to include loop closures and other statistical data in accordance with the Standards and Specifications referenced above, should be provided to the FA. Closure should be within the horizontal and vertical limits given above. These data should clearly be listed in tabular form including the coordinates (and system) and elevation (ground surface and top of well) as appropriate, for all borings, wells, and reference marks. All permanent and semipermanent reference marks used for horizontal and vertical control, benchmarks, caps, plates, chiseled cuts, rail spikes, etc., should be described in terms of their name, character, physical location, and reference value. These field data should become part of the project records maintained by the FA.

9-5. Geospatial Data Systems

Geospatial data is non-tactical data referenced either directly or indirectly to a location on the earth. Geospatial data identifies the geographic location and characteristics of natural or constructed features and boundries on the earth. Monitoring wells and the data generated from them meet these definitions and therefore must be documented according to the metadata standards cited in ER 1110-1-8156. ER 1110-1-8156 requires geospatial data to be documented using the Federal Geographic Data Committee Content Standards for Digital Geospatial Metadata. Guidance on geospatial data systems (GDS) may also be found in EM 1110-1-2909 and ASTM Standard Specification D 5714.

Chapter 10
Borehole Geophysics

10-1. Usage and Reporting

The use of geophysical techniques, if required, should be specified in the drilling plan. In the absence of this specification, the FDO should consider these techniques for site-specific applicability to enhance the technical acuity and cost-effectiveness of its efforts. Special applications may be useful in unexploded ordnance detection, disturbed area delineation, contaminant detection, depth to bedrock determination, buried drum detection, borehole and well logging, etc. When approved for use, geophysical techniques should be discussed in the drilling plan to include the purpose; particular method(s) and equipment; selection rationale; physical and procedural assumptions; limitations (theoretical and site specific); resolution; accuracy; and quality control. Safety aspects of geophysical applications should be included in the safety plan, especially for those areas where induced electrical currents or seismic waves could detonate unexploded ordnance or other explosive materials.

10-2. Methods

General geophysical methodology is covered in EM 1110-1-1802. Geophysical techniques applied to HTRW studies are found in USEPA 625/R-92/007, 600/2-87/078, 600/7-84/064, and in Benson, Glaccum, and Noel (1982). Additional guidance on planning and conducting borehole geophysical logging can be found in ASTM Standard Guide D 5753.

Chapter 11
Vadose Zone Monitoring

11-1. Usage and Reporting

Data acquisition from the vadose (unsaturated) zone should be addressed on a case-by-case basis. The use of lysimeters in a silica flour matrix, soil-gas monitors, and analysis of bulk soil samples are mechanisms which may be employed.

When vadose zone monitoring is proposed,the drilling plan should include the purpose; particular method(s) and equipment; selection rationale; physical and procedural assumptions; limitations (theoretical and site-specific); quality control; and any analytical variances from the current USACE protocol.

11-2. Methods

Guidance on vadose zone monitoring may be found in ASTM Standard Guides D 4696 and D 5126. A general discussion of vadose monitoring can be found in Everett, Wilson, and Hoylman (1984).

Chapter 12
Data Management System

12-1. Benefits

The use of a computerized system will enhance reporting procedures by means of intra-report consistency, reduction of editorial review, broadening of graphical capabilities, and ease of data retrieval for project review and inter-project comparisons. Each FA is encouraged to utilize a computerized data management system for technical data.

12-2. Assistance Sources

Several existing systems are available for utilization by individual FAs. New systems are also being developed at the DOD level to combine existing systems and reduce redundancy in data reporting systems. Guidance on boring log data management may be found in the USACE Waterways Experiment Station contract report GL-93-1. Assistance can be obtained from the HTRW CX, at CENWO-HX-G.

12-3. Geospatial Data Systems

Geospatial data is non-tactical data referenced either directly or indirectly to a location on the earth. Geospatial data identifies the geographic location and characteristics of natural or constructed features and boundries on the earth. Monitoring wells, and the data generated from them, meet these definitions and therefore must be documented according to the metadata standards cited in ER 1110-1-8156. ER 1110-1-8156 requires geospatial data to be documented using the Federal Geographic Data Committee Content Standards for Digital Geospatial Metadata. Guidance on geospatial data systems (GDS) may also be found in EM 1110-1-2909 and ASTM D 5714.

Appendix A
References

A-1. Required Publications

29 CFR 1910.120
Code of Federal Regulations, 29 CFR 1910.120, Hazardous Waste Operations and Emergency Response.

29 CFR 1926
Code of Federal Regulations, 29 CFR 1926, Safety and Health Regulations for Construction.

ER 385-1-92
Safety and Occupational Health Document Requirements for Hazardous, Toxic, and Radioactive Waste (HTRW) and Ordnance and Explosive Waste (OEW) Activities.

ER 1110-1-263
Chemical Data Quality Management for Hazardous Waste Remedial Activities.

ER 1110-1-1803
Care, Storage, Retention, and Ultimate Disposal of Exploratory and Other Cores.

ER 1110-1-8156
Policies, Guidance, and Requirements For Geospatial Data and Systems.

ER 1110-2-1807
Use of Air Drilling in Embankments and Their Foundations.

ER 1165-2-132
Hazardous, Toxic, and Radioactive Waste (HTRW) Guidance for Civil Works Projects.

EM 200-1-2
Technical Project Planning (TPP) Process.

EM 200-1-3
Requirements for the Preparation of Sampling and Analysis Plans.

EM 385-1-1
Safety and Health Requirements Manual.

EM 1110-1-1802
Geophysical Exploration.

EM 1110-1-1804
Geotechnical Investigations.

EM 1110-1-1906
Soil Sampling.

EM 1110-1-2909
Geospatial Data and Systems.

EM 1110-2-1906
Laboratory Soils Testing.

EM 1110-2-3506
Grouting Technology.

FM 5-410
U.S. Army Field Manual, " Military Soils Engineering."

FM 5-430
U.S. Army Field Manual, "Planning and Design of Roads, Airbases, and Heliports in the Theater of Operations."

FM 5-484
U.S. Army Field Manual, "Multiservice Procedures For Well-Drilling Operations."

TM 5-818-2
U.S. Army Technical Manual, "Pavement Design For Seasonal Frost Conditions."

TM 5-818-3
U.S. Army Technical Manual, "Pavement Evaluation For Frost Conditions."

TM 5-852-6
U.S. Army Technical Manual, "Arctic and Subarctic Construction: Calculation Methods For Determination of Depth of Freeze and Thaw In Soils."

CEGS 02522
U.S. Army Corps of Engineers Guide Specification, "Ground-Water Monitoring Wells."

CWGS 02010
U.S. Army Corps of Engineers Guide Specification, "Subsurface Drilling, Sampling, and Testing."

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"Standard Methods for the Examination of Water and Wastewater," American Public Health Assoc. (APHA), American Water Works Assoc. (AWWA), and the Water Pollution Control Federation (WPCF), 19th Edition, 1995.

USEPA, EPA/510/B-97/001
"Expedited Site Assessment Tools For Underground Storage Tank Sites," U.S. EPA, Office of Solid Waste, 401 M St., SW, Washington, DC 20460.

USEPA, EPA/530/SW-86/055, OSWER Directive 9950.1
"RCRA Ground-Water Monitoring Technical Enforcement Guidance Document (TEGD)," U.S. EPA, Office of Solid Waste, 401 M St., SW, Washington, DC 20460.

USEPA, EPA/540/G-88/003, OSWER Directive 9283.1-2
"Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites," U.S.EPA, Office of Emergency and Remedial Response, 401 M St., SW, Washington, DC 20460.

USEPA, EPA/540/G-91/009
"Management of Investigation-Derived Wastes During Site Inspections," U.S. EPA, Office of Research and Development, 401 M St., SW, Washington, DC 20460.

USEPA, EPA/540/S-95/503
"Nonaqueous Phase Liquids Compatibility with Materials Used in Well Construction, Sampling, and Remediation," Ground Water Issue, July 1995, U.S. EPA, Robert S. Kerr Environmental Laboratory, Ada, OK.

USEPA, EPA/600/2-87/078
"Nondestructive Testing Techniques to Detect Contained Subsurface Hazardous Waste," U.S. EPA, 401 M St., SW, Washington, DC 20460.

USEPA, EPA/600/4-79/020
"Methods for Chemical Analysis of Water and Wastes," U.S.EPA, 401 M St., SW, Washington, DC 20460.

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"Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells," U.S. EPA, Office of Research and Development, 401 M St., SW, Washington, DC 20460.

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"Geophysical Techniques for Sensing Buried Wastes and Waste Migration," U.S. EPA, Environmental Monitoring Systems Laboratory, Las Vegas, NV 89114.

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"Handbook: Ground Water," U.S.EPA, Robert S. Kerr Environmental Reseach Laboratory, Ada, OK 74820.

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USEPA, EPA/625/R-92/007
"Use of Airborne, Surface, and Borehole Geophysical Techniques at Contaminated Sites," U.S. EPA, Office of Research and Development, Washington, DC 20460.

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"Guide to Management of Investigation-Derived Wastes," U.S.EPA, Office of Solid Waste, 401 M St., SW, Washington, DC 20460.

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C 150 Specification for Portland Cement

D 888 Test Method for Dissolved Oxygen in Water

D 1125 Test Method for Electrical Conductivity and Resistivity of Water

D 1293 Test Method for pH in Water

D 1498 Practice for Oxidation-Reduction Potential of Water

D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils

D 1785 Specification for Polyvinyl Chloride (PVC) Plastic Pipe Schedules 40, 80 and 120

D 1889 Test Method for Turbidity in Water

D 2113 Practice for Rock Core Drilling and Sampling of Rock for Site Investigation

D 2487 Test Method for Classification of Soils for Engineering Purposes.

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D 4044 Test Method (Field Procedure) for Instantaneous Change in Head (Slug Tests) for Determining Hydraulic Properties of Aquifers

D 4050 Test Method (Field Porcedure) for Withdrawal and Injection Well Tests for Determining Hydraulic Properties of Aquifer Systems

D 4220 Practice for Preserving and Transporting Soil Samples

D 4448 Guide for Sampling Groundwater Monitoring Wells.

D 4696 Guide for Pore-Liquid Sampling from the Vadose Zone

D 4750 Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)

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D 5126 Guide for Comparison of Field Methods for Determining Hydraulic Conductivity in the Vadose Zone

D 5299 Guide for the Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities.

D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock.

D 5462 Test Method for On-Line Measurement of Low Level Dissolved Oxygen in Water

D 5464 Test Methods for pH Measurement of Water of Low Conductivity

D 5521 Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers.

D 5608 Practice for the Decontamination of Field Equipment Used at Low Level Radioactive Waste Sites

D 5714 Specification for Content of Digital Geospatial Metadata

D 5717 Guide for Design of Ground-Water Monitoring Systems in Karst and Fractured-Rock Aquifers.

D 5737 Guide for Methods for Measuring Well Discharge

D 5753 Guide for Planning and Conducting Borehole Geophysical Logging

D 5778 Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils

D 5781 Guide for the Use of Dual Wall Reverse-Circulation Drilling for Geoenvironmental Exploration and the Installation of Subsurface Water Quality Monitoring Devices

D 5782 Guide for the Use of Direct Air Rotary Drilling for Geonvironmental Exploration and the Installation of Subsurface Water Quality Montoring Devices

D 5783 Guide for the Use of Direct Rotary Drilling With Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water Quality Monitoring Devices

D 5784 Guide for the Use of Hollow-Stem Augers for Geoenvironmental Exploration and the Installation of Subsurface Water Quality Monitoring Devices

D 5787 Practice for Monitoring Well Protection.

D 5872 Guide for Use of Casing Advancement Drilling Methods For Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices

D 5875 Guide for Use of Cable-Tool Drilling and Sampling Methods for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices

D 5876 Guide for Use of Direct Rotary Wireline Casing Advancement Drilling Methods for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices

D 5978 Guide for Maintenance and Rehabilitation of Ground Water Monitoring Wells

D 6001 Guide for Direct Push Water Sampling for

Geoenvironmental Investigations

D 6067 Test Method for Using the Electronic Cone Penetrometer for Environmental Site Characterization

D 6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations.

D 6282 Guide for Direct Push Soil Sampling for Environmental Site Characterizations.

D 6286 Guide for Selection of Drilling Methods for Environmental Site Characterization

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MacBeth
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Appendix B
Abbreviations

AE Architect-Engineer

ASTM American Society for Testing and Materials

CECW-EG Geotechnical and Materials Branch, Engineering Division, Directorate of Civil Works, Headquarters, U.S. Army Corps of Engineers

CEMP-RT Policy and Technology Branch, Environmental Division, Directorate of Military Programs, Headquarters, U.S. Army Corps of Engineers

CENWO-HX-G Geoenvironmental and Process Engineering Branch, HTRW Center of Expertise, Omaha District, Missouri River Region

CERCLA Comprehensive Environmental Resource, Compensation, and Liability Act

CFR Code of Federal Regulations

DERP Defense Environmental Restoration Program

EM Engineer Manual

ENG Engineer

FA Field Activity

FDO Field Drilling Organization

FGDC Federal Geographic Data Committee

FSP Field Sampling Plan

GDQM Geotechnical Data Quality Management

GSA Geological Society of America

HQUSACE Headquarters, United States Army Corps of Engineers

HTRW Hazardous, Toxic, and Radioactive Waste

ID Inside Diameter

IDW Investigation-Derived Waste

CX HTRW Center of Expertise

DNAPL Dense Nonaqueous Phase Liquid

DO Dissolved oxygen

DTH Down-the-Hole (Hammer)

MRR Missouri River Region

N Normal

NAPL Nonaqueous Phase Liquid

NAVD North American Vertical Datum

NGVD National Geodetic Vertical Datum

NSF National Sanitation Foundation

NTU Nephelometric Turbidity Unit

OD Outside Diameter

ORP Oxidation-Reduction Potential

OSHA Occupational Safety and Health Administration

OSWER Office of Solid Waste and Emergency Response (EPA)

pH The negative logarithm of the effective hydrogen ion concentration in gram equivalents per liter

PCB Polychlorinated Biphenyl

PTFE Polytetrafluoroethylene

PVC Polyvinyl Chloride

RCRA Resource Conservation and Recovery Act

SAP Sampling and Analysis Plan

SARA Superfund Amendments and Reauthorization Act

SCAPS Site Characterization and Analysis

	Penetrometer System
SPCS	State Plane Coordinate System
SSHP	Site Safety and Health Plan
TSCA	Toxic Substance Control Act
TTIA	Technology Transfer Improvements Act
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
UTM	Universal Transverse Mercator

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TABLE C TE TS

	Paragraph i	Page i
Chapter 1. Introduct on		
Purpose	1-1	1-1
Appl cab l ty	1-2	1-1
D str but on Statement	1-3	1-1
References	1-4	1-1
Scope	1-5	1-1
Un ts, Def n t ons, and Convers ons	1-6 i	1-2
Chapter 2. Rad oact ve and M xed Waste Project Requ rements		
Introduct on	2-1	2-1
ealth Phys c st Involvement	2-2	2-2
Chem st Involvement	2-3	2-2
n-s te Rad ochem stry Labs i	2-4	2-2
R sk Assessor Involvement i	2-5 i	2-2
Cons derat ons for Cleanup Level Development i	2-6	2-3
D sposal pt ons i	2-7 i	2-3
Transportat on	2-8	2-4
Publ c Percept on	2-9 i	2-4
Chapter 3. Techn cal Project Plann ng (TPP) Approach to Manag ng S tes Contam nated w th Rad oact ve and M xed Waste		
TPP Sect on 1.1 Prepare Team Informat on Package	3-1	3-1
TPP Sect on 1.1.1 Ident fy the Team Members	3-2 i	3-2
i TPP Sect on 1.1.2 Ident fy the Customer’s Goals i	3-3 i	3-2
i

	Paragraph I	Page I
TPP Section 1.1.3 Gather Existing Site nformation	3-4	3-3
TPP Section 1.1.3.5 Cond ct Site Histor nterviews	3-5	3-3
TPP Section 1. . dentif and Doc ment Project Objectives	3-6	3-3
TPP Section 1.3. Define Co rses of Action for I Achieving Site C oseo t	3-7	3-3
TPP Section .1 Determine Data Needs	3-8	3-6
Samp e Q antit	3-9 I	3-7
Chapter 4. Hea th and Safet		
ntrod ction	4-1	4-1
Responsibi ities	4-	4-1
Programs and P ans I	4-3 I	4-1
Radiation Protection tems Addressed in the SSHP I	4-4 I	4-
Chapter 5. Risk Assessment		
ntrod ction	5-1	5-1
Risk Assessment and Dose Assessment Comparison	5-	5-1
Ro e of Risk Assessment in Reg ator Programs	5-3	5-
Reg ator G idance for Risk Assessments and Dose Assessments I	5-4 I	5-3
CERCLA	5-5 I	5-3
RCRA G idance	5-6	5-4
NRC G idance	5-7	5-4
Considerations for Project Risk Assessments I	5-8 I	5-4
Chapter 6. Samp ing		
Data Q a it Objectives (DQO) I	6-1	6-1
Scanning	6-	6-1
n-Sit Meas rements I	6-3 I	6-3
Down-ho e or We Logging I	6-4	6-3
Samp ing S rface Soi s	6-5 I	6-3
Chapter 7. Characterization I		
I ntrod ction	7-1	7-1
I Chemica and Radioactive Contaminants I	7- I	7-1

4 Paragraph 4 Page

Site Characterization 4 7-3 7-
Waste Characterization 7- 7-
Site Histor and Waste Pedigree 7-5 7-5
Q antif ing Contaminated Materia s 7-6 7-5
Other Media - Air, Water, Sediments 4 7-7 4 7-5
4

Chapter 8. Radioactive Waste

C assification 8-1 4 8-1
Waste Definitions 4 8- 8-1
Waste Disposa Faci it Criteria 4 8-3 4 8-3

Chapter 9. Primar Reg ator Processes

Introd ction 4 9-1 4 9-1 4
Environmenta Response A thorities for Radioactive Waste or Mixed Waste 9- 9-
Ro es and Responsibi ities for Reg ating Radioactive Materia 9-3 4 9-1
Other Major Environmenta Stat tes and Reg ations 9- 9-17
S mmar4 of Radiation Standards 9-5 9- 5
Misce aneo s Criteria 9-6 4 9- 7

Chapter 10. Remedies and Innovative Techno ogies

Introd ction 10-1 10-1
Atten ation thro gh Deca 10- 10-1
Decontamination 4 10-3 10-1
Soi Vo me Red ction 4 10- 10-1
Soi Washing 10-5 4 10-1
In-sit Ph toremediation 4 10-6 10-
Ex-sit Soi Treatment 4 10-7 10-
Eq ipment and Debris 10-8 10-
C tting and Sawing 4 10-9 10-
Incineration 10-10 10-3
B i ding Demo ition 4 10-11 10-3
H drob asting 10-1 10-3
4 Paint Remova 10-13 4 10-
Scarification 4 10-1 10-
4 Steam 10-15 4 10-

C C Paragraph C Page

Dri ing and Spa ing C 10-16 10-4
Disposa 10-17 C 10-4

hapter 11. Transportation

Introd ction C 11-1 C 11-1
Determining if Packages are Radioactive for Shipping 11- 11-
Packaging C 11-3 11-4
Marking 11-4 11-4
Labe ing 11-5 C 11-4
Manifesting CC 11-6 C 11-5
P acarding C 11-7 11-6
Mixed or o-Ming ed Waste 11-8 11-6
DOT Req ired Sec rit P ans C 11-9 C 11-6

hapter 1 . Disposa

Introd ction 1 -1 1 -1
haracterization of Materia s 1 - 1 -1
Identif and oordinate with Potentia Disposa Faci ities 1 -3 1 -1
ompare Transportation and Disposa osts of Viab e Faci ities 1 -4 1 -1
The Off-site R e 1 -5 C 1 -1
Faci it Reg ators C 1 -6 1 -
Transportation Req irements C 1 -7 C 1 -3
Disposa ontracts 1 -8 1 -4
Disposa Options Avai ab e as of an ar 003 C 1 -9 1 -4
USA E and DA oordination 1 -10 C 1 -4

hapter 13. Mu ti-Agenc Radiation Site S rve and Investigation Man a (MARSSIM)

Introd ction 13-1 13-1
C Data Life c e C 13- C 13-1 C

APPENDICES Page

Appendix A - Refe ences and Bib iog aph of Reg ato Doc ments, r A-1
Reg ations and Laws

Appendix B - Radiation Cont o Agenc Points of Contact B-1

Appendix C - Technica Info mation on Radioactive Mate ia s, r r C-1
Deca , Meas ing Techniq es, and Inst mentation

Appendix D - T pica Remediation Site Cha acte istics r r D-1

G ossa r G ossa -1 r

LIST OF TABLES

Page

Tab e 9-1. Maj r Radiati n Standards S mmar Tab e oo o 9- 6 o

LIST OF FIGURES

Page

13-1. Data Li e C c e App ied to a Fina Stat s S rve f f f 13-3

13- . F ow Diagram or Designing a Fina Stat s S rve f f 13-4 f

h

CHAPTER 1

Introd ction

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1-1. P rpose. T is engineer man a (EM) contains p anning and management g ide ines to be sed for United States Arm yCorps of Engineers (USACE) work wit radioactive waste, eit er a one or combined wit azardo s or toxic components. T is man a primari describes reg ator and management responsibi ities, provides g idance on accomp is ing t ose responsibi ities, and exp ains t eir re ation to t e Project Management B siness Process (PMBP) and Tec nica Project P anning (TPP) app ied to USACE activities at radioactive waste sites. Additiona , t is man a wi promote USACE po icies to ens re Corps-wide app ication across a programs. T is man a is not intended to provide detai ed tec nica recommendations or sop isticated scientific proced res. T e man a wi necessari incorporate some tec nica information to provide backgro nd for t e reg ator and management responsibi ities. In addition to t e Department of Defense (DOD) branc es, t ese responsibi ities are defined and enforced b ot er Federa agencies, inc ding t e N c ear Reg ator Commission (NRC), t e Department of Energ (DOE), t e Environmenta Protection Agenc (EPA), t e Department of Transportation (DOT), and t e Occ pationa Safet and Hea t Administration (OSHA).

h

1- . App icabi it . T e g ide ines wit in t is man a are app icab e to a USACE e ements and major s bordinate commands (MSC) aving responsibi it t ro g governmenta interagenc agreement or b assignment b HQUSACE for t e remediation of sites contaminated wit radioactive materia s. T ese g ide ines are app icab e to bot t e Mi itar and Civi Works missions of t e USACE. Strict c emica or bio ogica aspects of sites are not addressed except in passing reference to t eir component part of mixed waste. Whi e most of t e g idance inc ded wi be app icab e to work performed o tside t e United States, ot er reg ator agencies, dose imits, and radioactive and ing and disposa reg ations ma be app icab e.

1-3. Distrib tion Statement. Approved for p b ic re ease; distrib tion is n imited.

1-4. References. References are at Appendix A. Referenced doc ments t ro g o t t e text are per inked to internet avai ab e copies w en possib e.

1-5. Scope.

h

a. Intended A dience. T is doc ment is intended to assist Project Managers in t e deve opment of Project Management P ans and s pporting doc ments t at wi ead to t e s ccessf restoration of sites contaminated wit radioactive materia . G idance is inc ded to ens re t at eac Project De iver Team (PDT) is estab is ed wit t e necessar discip ines and perspectives. Individ a s asked to work on radioactive contaminated sites ma find t e

.

doc ment sef in nderstanding and f fi ing their ro e as members of the PDT Vario s terms, reg ations, and processes sed in the restoration of radioactive contaminated sites are described to faci itate effective comm nication between the PDT members and stakeho ders

.

b Contents

- Chapter 1 exp ains the p rpose, scope and intended a dience of this g idance doc ment It ists some important nits, q antities and conversions that are necessar to f nderstand and work on remediation of radioactive contaminated sites
- Chapter exp ains how the presence of radioactive waste affects the necessar actions and associated management of a project
- Chapter 3 exp ains the TPP approach to managing remediation at sites contaminated with radioactive materia s
- Chapter 4 disc sses hea th and safet concerns re ative to a radioactive site .
- Chapter 5 describes the concept a site mode and risk assessment
- Chapter 6 describes samp ing of radioactive materia s
- Chapter 7 describes characterization of sites
- Chapter 8 describes characterizing radioactive waste
- Chapter 9 addresses the primar reg ator processes invo ved at radioactive remediation sites
- Chapter 10 addresses remedies and innovative techno ogies that ma be sed at radioactive remediation sites
- Chapter 11 exp ains the proced res and iss es invo ved in transportation of radioactive materia s
- Chapter 1 disc sses options and methods of disposa of radioactive materia s
- Chapter 13 disc sses the M u ti-Agenc Radiation Site S rve and Investigation Man a (MARSSIM) Fina Stat s S rve (FSS)
- Appendix A provides references and bib iograph of reg ator doc ments, reg ations and aws .
- Appendix B provides contact information for Federa and state radiation contro agencies
- Appendix C inc des technica information on radioactive materia s, deca , meas ring techniq es, and instr mentation
- Appendix D ists some t pica remediation site characteristics

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1-6 Units, Definitions, and Conversions Severa s stems of nits are app icab e to USACE radioactive materia s sites The fo owing is a brief description of the nits, what the meas re, and how the wi be sed on USACE sites Conversions between different s stems of nits are inc ded where appropriate A more comp ete exp anation ma be fo nd in EM 385-1-80

h

a. Radioactivit or Activit . Radioactivit is nstab e atomic n c ei becoming more stab e b emitting energ . T e t pes and amo nts of energ emitted are c aracteristic of t e radioactive materia . T e radioactivit or activit of a materia is t e rate of deca per nit time. T ere are two s stems t at are sed to meas re activit : t e US s stem and t e S stem Internationa (SI). In t is man a , w en reporting activit , t e US s stem nits wi be isted first, fo owed b t e SI nit in parent eses.

h

(1) US S stem. Activit is meas red sing t e c rie (Ci). 1 Ci is 3.7×10^{10} deca s per second (1 gram of p re radi m as 1 Ci of activit).

( ) SI. Activit is meas red sing t e becq ere (Bq). 1 Bq is 1 disintegration per second.

$1\ Ci = 3.7 \times 10^{10}\ Bq$

$1\ Bq = .7 \times 10^{-11}\ Ci$

h

(3) Specific Activit (activit per nit mass). T is is reported as Ci/g (Bq/kg). Note t at DOT req ires SI nits to be entered on s ipping papers and abe s. US c stomar nits ma accompan t e SI nits in parent eses.

(a) Activities and specific activities ma se metric prefix abbreviations as fo ows:

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Prefix	Abbreviation	Q antit
Tera	T h	1×10^{1}
Giga	G	1×10^{9}
Mega	M h	1×10^{6}
Ki o	k	1×10^{3}
Mi i	m	1×10^{-3}
Micro	μ	1×10^{-6}
Nano	n	1×10^{-9}
Pico	p	1×10^{-1}

(b) Severa re ated nits ma be enco ntered on USACE sites. T eir acceptabi it s o d be determined b t e USACE ea t p sicist assigned to t e site.

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b. dpm. Disintegrations (deca s) per min te is often sed in referring to s rface contamination, most often as disintegrations per min te per one ndred sq are centimeters h

q
(dpm/100 cm); dpm can be converted to B or Ci. Some s rve instr ments p rport to present data in dpm. This can on be done correct nder ver specific circ mstances. These circ mstances and the acc rac of the readings m st be verified b a hea th ph sicist.

q
c. cpm. Co nts per min te (radiation interactions with the detector) is often reported for hand he d instr ment s rve s. Under certain ver specific circ mstances, cpm can be converted to dpm. A hea th ph sicist m st be cons ted to ens re that an acc rate conversion is performed.

q
d. (Ionizing) Radiation (as sed here). This is the energ emitted from radioactive materia trave ing from one point to another in the form of photons or partic es. Depending pon how and where it is meas red, there are a n mber of nits sed to antif radiation. The standard nits sed at USACE sites are the roentgen (co omb per ki ogram), rad (gra), and rem (sievert).

q
e. Expos re. This is the amo nt of ionization in air prod ced b x- or gamma radiation with energies ess than 3 MeV (mega e ectron vo t). Expos re is the most common meas red parameter of radiation. It is meas red in roentgen (R). One R is e a to $.58\times10^{-4}$ co omb of e ectrica charge prod ced in one ki ogram (C/kg) of air.

q
f. Expos re Rate. This is the reado t sed b man fie d s rve instr ments. It common ses a fraction of roentgen per ho r (R/hr), s a mi iroentgen per ho r (mR/hr), or micro roentgen per ho r (µR/hr).

g. Absorbed dose. This is the energ deposited in matter b radiation. It is meas red in rad or gra (G).

1 rad = 100 erg/g = 0.01 G

1 gra = 1 /kg = 100 rad

1 R in air is abo t e a to 1 rad in soft tiss e.

h. Dose E iva ent. This is the absorbed dose in soft tiss e m utip ied b a a it factor. The a it factor norma izes the harm done b different t pes of radiation. The dose e iva ent is a meas re of the bio ogica damage expected from absorption of radiation.

(1) T pica a it factors are:

- Beta/gamma radiation 1
- A pha radiation..... 0
- Ne tron radiation 10

( ) Dose eq iva ent is meas red in rem (sievert [Sv])

100 rem = 1 Sv

1 Sv = 100 rem

(3) For x-ra /gamma radiation

1 R = 1 rad = 1 rem (1 Sv = 1 G)

(4) For a pha radiation

1 rad = 0 rem (1 G = 0 Sv)

i Radioactive Waste A generic term for wastes containing radioactive materia s Reg ator agencies have different definitions for different t pes of radioactive wastes The NRC on reg ates so rce, b prod ct, and specia n c ear materia s The EPA reg ates the hazardo s component of mixed wastes States ma reg ate other radioactive materia s and radioactive wastes

j High-Leve Radioactive Waste (HLW) The NRC defines High-Leve Radioactive Waste as 1) irradiated reactor f e ,) iq id wastes res ting from operation of the first c c e so vent extraction s stem, or the eq iva ent, and the concentrated wastes from s bseq ent extraction c c es or eq iva ent in a faci it for reprocessing irradiated reactor f e , and 3) so ids into which s ch iq id wastes have been converted (10 CFR 60) In a man's terms, HLW is spent f e , or spent f e reprocessing wastes USACE does no work with HLW at present

k Low-Leve Radioactive Waste (LLRW) LLRW is so rce, b prod ct, or specia n c ear materia waste not c assified as HLW, trans ranic waste, spent n c ear f e , or b prod ct materia as defined in section 11e ( ) of the Atomic Energ Act In a man's terms, LLRW is NRC reg ated waste that is not HLW, trans ranic waste, or rani m or thori m mi tai ings

Trans ranic Waste (TRU) TRU is waste materia s contaminated with a pha-emitting n c ides with an atomic n mber greater than 9 , ha f- ives greater than 0 ears, and in concentration greater than 100 nCi/g of waste at the time of assa (40 CFR 191)

m Urani m Mi Tai ings Radiation Contro Act (UMTRCA) Enacted to ens re investigation and remediation of past rani m and thori m mine and mi tai ings and reg ation of tai ings at c rrent icensed sites

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p

n. Urani m or Thori m Tai ings (11e.( ) materia s). The tai ings or wastes rod ced b the extraction or concentration of rani m or thori m from an ore rocessed rimari for its so rce materia content (Atomic Energ Act). This designation on a ies to tai ings generated d ring or after 1978. This designation is sometimes incorrect a ied to tai ings from the extraction of rare earth e ements, which are often co- ocated in the same ores as rani m and thori m, or to the tai ings from the extraction of radi m. For ega reasons, those tai ings generated rior to 1978 are referred to as "resid a s from rani m or thori m ore rocessing rior to 1978."

o. Mixed Waste. An NRC reg ated radioactive waste containing so rce, b rod ct, or s ecia n c ear materia (LLRW, 11e.( ) or HLW) mixed with an RCRA (Reso rce Recover and Conservation Act) isted or characteristic hazardo s materia .
p

p . Combined or Comming ed Waste. An radioactive waste mixed with an hazardo s s bstance. Mixed waste is a s bset of combined or co-ming ed waste.
p

q. DOT Radioactive Materia . A materia with a tota activit concentration exceeding 70 Bq/g (000 Ci/g) (49 CFR 173.403). Note, this definition sha change nder DOT and NRC harmonization r emaking on 1 October 004 to agree with the internationa definition of radioactive materia . The internationa definition of radioactive materia sha mean an materia containing radion c ides where both the activit concentration and the tota activit in the consignment exceed the va es s ecified in the tab e in 49 CFR 173.436 or va es derived according to the instr ctions in §173.433. p

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CHAPTER

Radioactive and Mixed Waste P oject Req i ements

-1. Int od ction.

a. Radioactive mate ia s have been sed b the DOD and civi ians fo nea 100 ea s. Radioactive commodities and adioactive wastes have been fo nd on a t pes of r p ojects. On BRAC (Base Rea ignment and C os e) and IRP (Insta ation Resto ation P og am) p ojects, adioactive commodities a e the most common t pe of adioactive waste. These commodities ma inc de:

- Dia s and ga ges on vehic es and eq ipment i minated with adi m paint.
- E ect on t bes and diodes containing sma q antities of adioactive mate ia s sed r extensive in ada and fi e cont o eq ipment.
- Radioactive t iti m i minato s sed in exit signs and fi e cont o devices.
- Tho i m sed in adiation detection eq ipment and as an a o .
- Magnesi m-tho i m, sed in the man fact e of ai c aft and missi e pa ts.

b. Dep eted ani m (DU-nat a ani m with the fissionab e component ed ced o emoved) is sed in a mo pie cing penet ato s, high-densit a mo , adiation shie ding, and ai c aft co nte weights. A website containing info mation on a the commodities sed in DOD is avai ab e f om the Wright–Patte son Ai Fo ce Base site. Hospita s and abo ato ies se a ve extensive ist of adioactive mate ia s, sometimes in iq id scinti ation via s, and often combined with h man o anima tiss e o f ids. N c ea eacto s have a defined mix of so ce mate ia s, activation p od cts, and fission p od cts. N c ea weapons assemb and maintenance faci ities ma have ani m, p toni m, and t iti m contamination, and the Fo me Used Sites Remedia Action P og am (FUSRAP) sites ma have ani m o tho i m o es and mi tai ings and thei associated deca p ogen . S pe f nd sites have enco nte ed the widest va iet of adion c ides, anging f om adi m p ocessing tai ings to t ans anics sed in sea ed so ce man fact ing.

c. The USACE app oach fo a p ojects is to fo ow the g idance and methodo og o t ined in P oject Management B siness P ocess (PMBP). Haza do s Toxic and Radioactive Waste (HTRW) p ojects fo ow EM 00-1- , and when add essing a e ease of a haza do s s bstance to the envi onment, fo ow the Comp ehensive Envi onmenta , Response, Compensation, and Liabi it Act of 1980 (CERCLA) app oach. On adioactive mate ia s sites USACE app ies g idance fo nd in the M u ti-Agenc Radiation Site S ve and Investigation Man a (MARSSIM).

d. PMBP p ovides a means of ens ing that the ight peop e, with the ight ski s and the ight too s, wo k effective to comp ete a p oject to the satisfaction of the c stome , the

j
reg ators, and stakeho ders. TPP (Technica Pro ect P anning) o t ines an iterative fo r-phased approach for ens ring that the pro ect ob ectives are identified, data co ection is efficient, and the pro ect progresses towards site c oseo t. CERCLA provides a process for ens ring a thorit to cond ct pro ects with p b ic inp t, and reg ator oversight. MARSSIM provides g idance on meeting the fina stat s s rve and c osing o t a site. Pro ects invo ving radioactive materia can be approached in the same wa as other hazardo s materia s pro ects, b t with some of the fo owing additions to the team and modifications of the p an.

- . Hea th Ph sicist Invo vement.

a. Hea th Ph sicists (HPs) are technica experts in radioactive materia s and radiation. The can provide expert advice on identif ing, samp ing, hand ing, transporting, and disposing of radioactive materia s, meas rement of radiation eve s and doses, the eco ogica and bio ogica effects of expos re to radiation, and the app icab e aws, reg ations, and g idance concerning radiation and radioactive materia s. A USACE pro ect HP sho d be assigned ver ear in the pro ect p anning process, and ma need to be invo ved in both the decision-making processes and exec tion thro gho t the pro ect. Contractors wi often be req ired to have HP staff and HP technicians.

b. ER 385-1-9 req ires the se of Q a ified Hea th Ph sics personne for Remedia Design activities at HTRW sites. Q a ified personne m st meet ed cation and experience req irements isted in EM 385-1-80. The addition of certified hea th ph sicists (CHPs), HPs, and HP techs to a pro ect can significant increase pro ect costs.
j
-3. Chemist Invo vement. The pro ect chemist wi need to be acq ainted with the different methodo ogies sed for identif ing and q antif ing radioactive materia s. Approved methods, imits of detection, radion c ide emissions, and appropriate wet chemistr can be significant different when radion c ides are invo ved. Ana tica aboratories sho d be USACE va idated and m st be notified in advance that potentia radioactive samp es are to be s bmitted. The ab wi need to ens re appropriate contamination contro meas res are sed for the radioactive samp es. This is in addition to the chemica ana ses that ma be req ired. ER 1110-1- 63 sets aborator data q a it req irements. These factors ma increase ab t rn aro nd times and ana tica costs.

-4. On-site Radiochemistr Labs. A n mber of pro ects have fo nd it economica to have an on-site radiochemistr ab instead of contracting an off-site ab for ro tine radiochemistr ana ses. An on-site ab wi provide a more rapid t rn aro nd for samp e ana ses.
j
-5. Risk Assessor Invo vement. To address the comp exities of a risk-informed approach to site c ean- p, a risk assessor wi need to assist on-site remediation decisions. The data needs of risk assessors are often different from other team members and ma req ire additiona

c
samp ing and ana ses. Where appropriate, a risk-informed reg ator approa h an a so be sed to red e nne essar onservatism in p re determinisi approa hes, or an be sed to identif areas with ins ffi ient onservatism in determinisi ana ses and provide the bases for additiona req irements or a tions. Risk-informed approa hes ie between the risk-based and p re determinisi approa hes.

-6. Considerations for C ean p Leve Deve opment. How ean is ean? This f ndamenta q estion m ust be answered in a environmenta remediation proje ts. It m st be answered at the time when the de ision is made as to what response is needed at a site, and it m ust be answered again at the end to determine if the req ired response has been omp eted and is s essf in operation. The answers to this q estion are fo nd in a omp ex ana sis of te hni a and ega fa tors estab ished in the aws governing environmenta response a tion proje ts.

c

a. CERCLA req ires that response a tions be ond ted in omp ian e with the imp ementing reg ations prom ugated b the Environmenta Prote tion Agen , the Nationa Oi and Hazardo s S bstan es Po tion Contingen P an, 40 CFR Part 300 (NCP). The NCP in des a ist of hazardo s s bstan es, in ding radioa tive e ements and ompo nds. In addition, if other hazardo s s bstan es or po tants and ontaminants are present, then CERCLA a so app ies to the ean p of these other ontaminants. CERCLA a thorizes the de ision maker for the ead Federa agen to respond thro gh remova or remedia a tions when the re ease or threat of re ease of a hazardo s s bstan e has reated or ma reate an imminent and s bstantia danger to h mans or the environment. Remedia a tions provide the permanent remed ne essar to prevent or minimize the re ease so that the hazardo s s bstan es or po tants and ontaminants do not migrate to a se s bstantia danger to present or f t re p b i hea th or we fare or the environment. Remova a tions are req ired to ontrib te, to the extent pra ti ab e, to the effi ient performan e of an ong-term remedia a tion in responding to a re ease or threatened re ease.

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b. Chapter 9 des ribes the reg ator pro esses that a thorize USACE to ean p a site. The primar environmenta response a thorit that USACE fo ows when addressing a re ease of a hazardo s s bstan e to the environment is CERCLA.

-7. Disposa Options.

a. Disposa options for radioa tive materia s wi var from readi disposab e o a , to no immediate disposa options at a , depending on the t pe, q antit , on entration, and pedigree of the radioa tive materia s. Ver ear in the p anning pro ess and we before an exe tion, a disposa p an m ust be prepared. Kansas Cit Distri t has a n mber of pre-p a ed ontra ts for disposa of radioa tive waste that ma be a essed b a of USACE. The proje t HP sho d be ab e to assist with initia estimates of potentia disposa sites.

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n

b. Low-Leve Radioactive Waste (LLRW) is a so der the co tro of the origi ati g state's Low-Leve Radioactive Waste Compact. The compacts were origi a deve oped i 1985 to co str ct a d operate radioactive waste disposa faci ities withi their bo daries. C rre t , there are 10 approved compacts a d three active LLRW disposa faci ities. O two of the three disposa faci ities ma accept C asses A, B, a d C radioactive waste. The Ha ford, Washi gto , faci it o accepts LLRW from the Northwest a d Rock Mo tai compacts, b t wi accept o -NRC reg ated wastes from a states. The E virocare (Utah) faci it accepts C ass A LLRW, 11e.( ), a d o -NRC reg ated wastes from a regio s of the U ited States. The Bar we , So th Caro i a, faci it accepts LLRW from a ge erators i the U ited States except the Rock Mo tai a d Northwest compacts. Begi i g i 008, Bar we wi o accept LLRW from the At a tic Compact states. These compacts ma co tro the import a d export of LLRW to or from their compact, a d ma assess fees for import or export. I some cases, pa me t of these fees b the Federa Gover me t ma vio ate fisca aw. The appropriate Office of Co se sho d be co s ted for g ida ce o this matter. The Arm yFie d S pport Comma d (AFSC) of Arm yMateria s Comma d (AMC) is the operati g age c for the Exec tive Age t for radioactive waste from DOD activities. A disposa actio s for DOD wastes eed to be coordi ated with AFSC thro gh the USACE Hazardo s, Toxic a d Radioactive Waste Ce ter of Expertise (HTRW-CX). Radioactive wastes ge erated b Civi Works activities, s ch as FUSRAP, ma ot be co sidered DOD wastes. Additio a g ida ce o disposa is f r ished i Chapter 9.

-8. Tra sportatio . Tra sportatio req ireme ts for radioactive materia s, wastes, a d samp es are s bsta tia differe t from tra sportatio of other t pes of DOT hazardo s materia s. Departme t of Tra sportatio (DOT) radioactive materia s reg atio s are isted i 49 CFR 173.401 (S bpart I) et seq. The project HP wi be fami iar with tra sportatio req ireme ts. Certai states a so charge a fee to tra sport radioactive waste thro gh them. I some cases, pa me t of these fees b the Federa Gover me t ma vio ate fisca aw. The appropriate Office of Co se sho d be co s ted. Additio a g ida ce o tra sportatio is f r ished i Chapter 8.

-9. P b ic Perceptio .

a. Most projects i vo vi g radioactive materia s wi receive i creased p b ic i terest. PMBP req ires the project de iver team (PDT) to deve op a commu icatio s p a . The p a req ires i p t a d assista ce from the P b ic Affairs Office. Past experie ce has show that addressi g a co cer s i a tr thf a d ope ma er is the simp est method of a a i g p b ic co cer s. The HTRW-CX a d the Radiatio Safet S pport Team (RSST) have deve oped a mber of fact sheets that are avai ab e for ge era se b USACE, o r c stomers, co tractors, a d reg ators.

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b. The commu icatio s p a wi ide tif the project stakeho ders' prob ems, co cer s, a d iss es. It wi the estab ish a i ter a a d exter a commu icatio strateg a d

determine the information needs of a PDT members and stakeho ders: ho needs hatw
information, hen the i need it, ho it i be given to them, and b hom.

CHAPTER 3

Technica Project P anning (TPP Approach to Managing Sites Contaminated with Radioactive and Mixed Waste

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3-1. TPP Section 1.1 Phase I - Prepare Team Information Package. In addition to the TPP g idance, there are a n mber of g idance doc ments on vario s aspects of working with radioactive materia s. The Project Manager's (PMs g ides for TPP, and Radioactive Materia s and seven Engineer Pamph ets (EPs specifica address work with radioactive materia s. Whi e the Engineer Circ ars (ECs are specifica oriented toward Former Uti ized Sites Remedia Action Program (FUSRAP site remediation, the g idance wi he p ens re that so nd radiation safet princip es are app ied at an site. The fo owing Engineer p b ications address work with radioactive materia s. A brief description of each is inc ded.

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a. EM 00-1- Technica Project P anning Process. Describes the process for identif ing project objectives and designing data co ection programs at a Hazardo s, Toxic and Radioactive Waste (HTRW) sites.

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b. ER 385-1-80 Ionizing Radiation Protection. This is the Engineer Reg ation for working safe with radioactive materia s.

c. EM 385-1-80 Radiation Protection Man a . Provides exp anation and g idance on methods of comp ing with ER 385-1-80.

d. ER 385-1-9 Safet and Hea th Req irements for HTRW Sites. Identifies doc ments and proced res req ired for exec ting HTRW projects.

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e. EP 415-1- 66 Resident Engineer Management G ide (REMG For Hazardo s, Toxic, And Radioactive Waste (HTRW) Projects. Provides req irements of which resident engineers m st be aware regarding remedia design activities and response actions invo ving HTRW, and ordnance and exp osives response actions.

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f. M ti-Agenc Radiation S rve and Site Investigation Man a (MARSSIM . Provides detai ed g idance for p anning, imp ementing, and eva ating environmenta and faci it radio ogica s rve s cond cted to demonstrate comp iance with a dose or risk based reg ation. It is a consens s doc ment prepared with conc rrence of the EPA, NRC, DOE, and DOD.)

3- . TPP Section 1.1.1 Phase I - Identif the Team Membe s.
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a. A dive se g o p of USACE Technica , Management, Lega , and P b ic Affai s pe sonne , as we as stakeho de s, eg ato s, and cont acto s, a e eq i ed fo the P oject De ive Team (PDT). G idance on estab ishing the team is p ovided in the P oject Management B siness P ocess (PMBP) Team Estab ishment p oced e. The PM wi need to identif the decision make s, the data se s, and the data imp emente s needed fo the p oject. The decision make s ma inc de the PM, the c stome , and the eg ato s. Reg ato s ma inc de Fede a agencies: the N c ea Reg ato Commission (NRC), the Envi onmenta p otection Agenc (EPA), o the Occ pationa Safet and Hea th Administ ation (OSHA). Twent -nine states a e NRC ag eement states, in which the state office pe fo ms the ove sight d ties of the NRC. Most states a so have a Depa tment of Envi onmenta P otection and Depa tment of Hea th, which a e conce ned with adioactive mate ia s in the envi onment and potentia h man expos e to adiation. State eg ato agencies do not s a have j isdiction to eg ate Fede a faci ities, b t the fina disposition of the p ope t ma be s bject to state eg ato ove sight. Ens e that the USACE Office of Co nse is inc ded in the TPP team to dete mine which eg ato agencies have which ove sight esponsibi ities.

b. The data se s ma inc de a adio-chemist, a hea th ph sicist (HP), an Ind st ia H gienist (IH), a isk assesso , and q a it ass ance pe sonne fo each discip ine.

c. Stakeho de s ma inc de the oca cit , co nt , and state communit , site owne s, site wo ke s and cont acto s, and t ade nions, as we as oca and nationa envi onmenta o ganizations.

3-3. TPP Section 1.1. Phase I - Identif the C stome 's Goa s.

a. Once the c stome has been identified, ens e that the enti e TPP team nde stands exact what the c stome envisions at the comp etion of the p oject, and what the c stome sees as the o e of USACE in the p oject.

b. The c stome 's concept of site c oseo t ma ange f om emova and disposa of a adioactive and haza do s mate ia s and a s ve to a ow the site to be e eased witho t est ictions (n est icted e ease), to t eatment, on-site sto age, o on-site disposa of the mate ia s to a ow fo imited e se of the site (est icted e ease). When a est icted e ease is contemp ated, and se cont o s (LUCs) m ust be conside ed. The objective when imp ementing LUCs is to ens e that and se emains compatib e with the emedia action goa s, and that the emed emains p otective of h man hea th and the envi onment. The c stome 's sched e eq i ements and site b dget m ust a so be conside ed at this time.
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3-4. TPP Section 1.1.3 Phase I - Gather Existin Site Information. This operation, co p ed with Para raph 3-5, is the eq iva ent of the MARSSIM Historica Site Assessment, and the CERCLA Pre iminar Assessment. In addition to the norma aven es, site information ma be obtained from a wide variet of other so rces. Atomic Ener Commission or N c ear Re ator Commission icenses and amendments, Arm yradiation a thorizations, Air Force radiation permits, oca and se permits, as we as the site owner or operator's records ma provide information on the past activities at the site. Additiona , USACE archivists are avai ab e who are experienced in atherin doc ments re atin to sites. If possib e, attempt to obtain faci it operatin proced res and inventories, and define the receipt, se, stora e, and disposa areas for the hazardo s and radioactive materia s on the site. Capt re a description of a the back ro nd iterat re into a sin e doc ment, and ens re that the back ro nd information is avai ab e to a data sers and imp ementers. Appendix D ists contaminants of concern and items of interest on some t pica sites where remediation ma take p ace.

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3-5. TPP Section 1.1.3.5 Phase I - Cond ct Site Histor Interviews. Consider not on former and present site workers, b t a so past and present re ators and inspectors. Man sites sin radioactive materia s a so had some form of area dose monitorin . These records ma a so prove va ab e in estimatin potentia hazards at the site.

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3-6. TPP Section 1. . Identif and Doc ment Project Objectives. Most project objectives are a conseq ence of overnin stat tes and app icab e re ations. Identif in and interpretin these stat tes and re ations varies q ite wide from site to site, amon re ator a encies, and even amon re iona offices within the same a enc . Chapter 9 ooks in depth at the existin stat tes and re ations that are common app icab e to radioactive waste sites. The primar re ations sed for remediation of radioactive materia s at a site are:

- 10 CFR 0 NRC S bpart E
- 10 CFR 40 NRC
- 40 CFR 300 CERCLA
- 40 CFR 19 UMTRCA
- State Re ations

After review b co nse , the app icab e re ations sho d be inc ded in this doc ment. This doc ment sho d specifica identif a impacted areas. An impacted area is one where there is a potentia for radioactive contamination. These areas need to be bo nded, spatia and tempora . The doc ment m st a so identif the potentia radioactive contaminants, and identif the exec tab e project sta es to site c oseo t.

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3-7. TPP Section 1.3. Define Co rses of Action for Achievin Site C oseo t. A re ease criterion is a re ator imit expressed in terms of dose (mSv/ ear or mrem/ ear) or risk

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(cancer incidence or cancer morta it). The terms re ease imit or c ean p standard are a so sed to descri e this expression. A re ease criterion is t pica ased on the tota effective dose eq iva ent (TEDE), risk of cancer incidence (mor idit), or risk of cancer death (morta it) and genera cannot e meas red direct . Expos re pathwa mode ing is sed to ca c ate a radion c ide-specific predicted concentration or s rface area concentration of specific n c ides that co d res t in a dose (TEDE) or specific risk eq a to the re ease criterion. This concentration is termed the derived concentration g ide ine eve (DCGL). Expos re pathwa mode ing is an ana sis of vario s expos re pathwa s and scenarios sed to convert dose or risk into concentration. In man cases screening eve DCGLs can e o tained from responsi e reg ator agenc g idance ased on conservative mode ing inp t parameters, whi e other sers ma e ect to take into acco nt site-specific parameters to determine DCGLs. In genera , the nits for the DCGL are the same as the nits for meas rements sed to demonstrate comp iance (e.g., Bq/kg or pCi/g, Bq/m or dpm/100 cm). This a ows direct comparisons etween the s rve res ts and the DCGL. Whi e expos re pathwa mode s, s ch as RESRAD or RESRAD-BUILD, can provide a defensi e starting point, stakeho ders m st conc r with the expos re mode parameters sed as we as with the DCGLs determined. Other factors, s ch as ARARs (app ica e or re evant and appropriate req irements), and p ic opinion, ma set DCGLs at different q antities. The TPP and communication processes are meant to ens re that a interests are cons ted and a consens s DCGL is reached that is accepta e to a stakeho ders.

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a. If the site is contaminated a ove the screening eve s, the next step is to determine the DCGLs. C ean- p criteria provided the EPA are given in nits of risk, which cannot e meas red. NRC criteria are provided in nits of dose. DCGLs are the contaminant concentrations, which can e meas red, that, when entered into an expos re mode , ie d a dose or risk that can e compared to the g idance provided the reg ator a thorit . DCGLs are etter exp ained in Paragraph 3-10. These DCGLs are the concentrations of contaminants e ow which the average concentration m st fa for the project to e considered for re ease and c os re. DCGLs wi contain fo r nits: an average radion c ide concentration that the site average concentration wi not exceed, an area over which this concentration ma e averaged, a maxim m concentration that hot spots wi not exceed, and the maxima area of these hot spots. Note that the DCGLs depend on the site conditions and the expos re mode s sed. DCGLs ma not e even in the same order of magnit de etween different sites. For examp e, the DCGL determined for a site ocated in a residentia area was 35 pCi/g whi e the DCGL for the same contaminant ocated in an ind stria area was set at 1950 pCi/g.

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. For the project to e viewed as a s ccess a stakeho ders, the idea scenario is reaching a consens s va e for the DCGLs. Federa and state reg ators, as we as the ead agenc at the site, the c stomer, and the other stakeho ders, sho d a agree on the DCGLs.

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c. The most common method of determining a starting point for D GLs for a site is thro gh the se of the RESRAD and RESRAD-BUILD dose mode ing programs. These programs provide a method for ca c ating the dose to a recipient from the soi or b i ding s rface contamination concentrations, or both. The programs provide ver conservative defa t parameters that ma be sed or modified if site-specific data are avai ab e for the parameters. These programs have both been approved for se b the NR , EPA, DOD, and DOE.

d. When defa t parameters are not sed, doc mentation exp aining wh the new va e is considered appropriate m st be inc ded in the D GL deve opment report. Man defa t parameters wi be changed on the basis of act a site conditions. For examp e, area of contamination, depth of cover, depth of contamination, depth to gro nd water, distance to nearest s rface water, etc., can be referenced back to the site description and geo ogica and h drogeo ogica reports. The report determining those act a site conditions m st be referenced in the doc mentation of the parameter change.

e. NR and USA E reg ations a so req ire a remediation to meet ALARA (doses as ow as is reasonab achievab e). This means that the D GL wi be the maxima a owed average contamination concentration, b t the project wi strive to remediate a media to as ow a eve of resid a contamination as is reasonab achievab e, taking into acco nt the vario s socia and economic factors affecting the site. However, if a site is remediated to NR screening eve s, it is considered to have met a ALARA req irements. Here, if there is a contaminant on-site that warrants an f rther investigation or remediation, decisions have to be made on what needs to be determined to se ect the method of remediation.

f. There are a n mber of methods that have been sed to remediate sites. The primar method fo nd to be cost effective and that meets the expectations of the reg ators and the p b ic, so far, is excavation and off-site disposa . A few sites have been a owed to se b ria in p ace. There are a so a few innovative techno ogies that have been investigated at different sites. The most common red ces waste vo me sing soi sorting and washing or segmented gate s stems. Some efforts at bioremediation have been st died and shown to be effective in pi ot st dies.

g. The basic objective for radioactive waste sites is comp etion of a fina stat s s rve indicating that the Derived oncentration G ide ine Leve s (D GLs) have been met at each impacted area. The phases necessar to reach this point wi have interim objectives, and the interim objectives wi have different data needs. ommon prob ems are overestimating the amo nt and t pe of data act a needed for comp etion of a phase, and not ens ring that a data can be shared between phases for se in the fina stat s s rve . Another is project creep, where s bs rface radioactive materia s not discovered d ring the initia characterization are fo nd d ring remediation and the remediation ‘chases’ the contamination into greater than expected vo mes of contaminated soi s.

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3-8. TPP Section .1 Determine Data Need . D ring the characterization pha e, data gathered d ring the hi torica ite a e ment are ed to determine potentia radioactive and hazardo contaminant , and potentia impacted area . From the e data, a pre iminar ite concept a mode i con tr cted. From the ite concept a mode , potentia impacted area are e ected. Data gap wi exi t and additiona information concerning the act a q antit , horizonta and vertica extent of contamination, the radion c ide act a pre ent on- ite, and the nat ra backgro nd concentration of the radion c ide contaminant wi be needed. Once amp e are gathered and ana zed, and the e data are avai ab e, the remediation pha e data need change. I otopic ana e , nece ar to determine the radion c ide of concern, ma no onger be nece ar and e expen ive rve and ana i method can be ed. If no ite work that co d b tantia concentrate or di te the contaminant in the wa te tream wa done, the data from the characterization amp ing and from the remediation rve and amp ing can be ed to characterize the wa te tream, owering the tota n mber of amp e nece ar . D ring the fina tat rve pha e, the data need ma change again. S rve and amp e from the characterization and remediation pha e ma be ed to how that the potentia impacted area do in fact meet the DCGL . Additiona rve and amp e wi be needed to verif creening eve . A n mber of reg ator agencie have determined creening eve for ite eva ation in the PA/SI (Pre iminar A e ment/Site In pection) and RI/FS (Remedia Inve tigation and Fea ibi it St d) tage of the inve tigation. The EPA ha deve oped a web ba ed Pre iminar Remediation Goa (PRG) ca c ator, and the NRC ha re ea ed NUREG providing g idance on ing certain comp ter mode to determine rface oi and b i ding rface creening eve .

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a. EPA PRG for radion c ide are too ed to eva ate oi contaminated with radioactive materia at ite with vario f t re and e . PRG are not nationa c ean p tandard . PRG a one do not trigger the need for re pon e action or define " nacceptab e" eve of radion c ide in oi . In thi g idance, " creening" refer to the proce of identif ing and defining area , radion c ide , and condition , at a partic ar ite, that do not req ire f rther attention. Genera , at ite where radion c ide concentration fa be ow the appropriate PRG , no f rther action or t d i warranted. Where radion c ide concentration eq a or exceed PRG , f rther t d or inve tigation, b t not nece ari c ean p, i warranted.

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b. B their nat re the e va e wi a wa be extreme con ervative, ometime to the point of being a fraction of backgro nd concentration of a radioactive contaminant.

c. For examp e, rani m ha a wide ranging backgro nd concentration depending on the rock/ oi t pe. The Nationa Co nci on Radiation Protection reported an average oi concentration of 1.8 pCi/g in it Report No. 94. The NRC NUREG-1757, Vo . provide a U- 38 p progen oi creening eve of 0.5 pCi/g above backgro nd. The NRC a me parameter ba ed on a re identia farmer cenario. Tho gh not nece ari direct comparab e to the NRC va e, the EPA PRG ca c ator provide defa t PRG for an

agric t ra scenario and a residentia scenario. The defa t PR va es for U- 38 p s progen are 0.00147 pCi/g (agric t ra), and 0.74 pCi/g (residentia). G
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d. Sho d the average of a contaminant samp es be ess than the se ected screening va e, the site ma be read for c oseo t with no f rther action, provided the samp es are of s fficient q a it and n mber to meet the statistica tests provided in the MARSSIM.

3-9. Samp e Q antit .

a. The n mber of samp es req ired to adeq ate characterize a site or an incrementa portion of a site, s ch as an operab e nit (OU), depends on a n mber of variab es. The NCP defines an OU as a discrete action that is an incrementa step toward comprehensive addressing site prob ems. If one contaminant is present on-site, or a sing e deca chain is present on-site, the primar driver for the n mber of samp es req ired to reach a certain confidence interva wi depend on the variance of the tota batch of samp es. The confidence interva is the range of va es with a specified probabi it (e.g., 90 or 95%) that the set contains the tr e va e of the parameter tested.

b. The variance is the sq are of the standard deviation of the samp e pop ation. In genera , the arger the variance is, the greater the n mber of samp es needed. Additiona , as the n mber of contaminants increase, the n mber of samp es req ired ma a so increase. When m utip e radioactive contaminants coexist on a site, the c ean- p criterion ma req ire that a s m of fractions be sed to determine comp iance, i.e., for n radion c ides of concentration C:

$$\sum_{x=1}^{n} \frac{C_x}{DCGL_x} \leq 1 \quad \text{G}$$

CHAPTER 4

Hea th and Safet o

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4-1. Intr d cti n. This Chapter pr vides an intr d cti n t the hea th and safet req irements niq e t radi active and mixed waste site remediati n. HTRW hea th and safet req irements are described m re f in ER 385-1-9 , ER 385-1-80, EM 385-1-80, and EM 385-1-1.

4- . Resp nsibi ities.

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a. USACE has the primar resp nsibi it f r ens ring the hea th and safet f USACE pers nne n-site and ens ring that a c ntract rs n-site f w USACE accepted hea th and safet pr ced res. USACE and the c ntract r share the resp nsibi it f ens ring that w rk perf rmed n-site d es n t endanger the p b ic n-site r ff-site, in additi n t pr tecting the envir nment. A pers nne n-site are resp nsib e f r maintaining exp s res t radiati n as w as is reas nab achievab e (ALARA). A pers nne n-site are req ired t read and c mp with the Site Safet and Hea th P an (SSHP).

b. Man sites are nder c ntr f ther agencies pri r t USACE inv vement. Where ther agencies have the ead, that agenc 's safet and hea th pr gram and p an wi be f wed b USACE and c ntract r pers nne nti resp nsibi it f r site safet has been t rned ver t USACE. The USACE PM ma then e ect t retain the existing safet and hea th pr gram and p an, if it is in c mp iance with Federa , state, and ca , as we as USACE, reg ati ns, r e ect t c nstr ct a USACE safet and hea th p an.

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c. S me sites ma be wned r perated b c mmercia parties. The perat r r wner ma have existing safet and hea th pr grams and p ans, and ma be reg ated b ther Federa agencies. USACE has a Mem rand m f Understanding with the N c ear Reg at r C mmissi n (NRC) c ncerning USACE w rk at sites reg ated b the NRC. Here again, the USACE PM ma e ect t retain the existing safet and hea th pr gram and p an, if it is in c mp iance with Federa , state, and ca , as we as USACE, reg ati ns, r e ect t c nstr ct a USACE safet and hea th p an. USACE ma have n reg at r a th rit ver the private wner and, theref re, n a th rit t imp se an adeq ate hea th and safet p an. If the private wner bjects, and USACE be ieves hea th, safet , and envir nmenta pr tecti ns t be inadeq ate, Federa and state agencies with j risdicti n m st be n tified.

4-3. Pr grams and P ans.

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a. C ntract rs. A c ntract rs sha have a written SHP (Safet and Hea th P an) that addresses a aspects f HTRW w rker hea th and safet .

b. Site Safet and Hea th P an (SSHP). Fo each HTRW site, cont acto s sha have a w itten SSHP that add esses a expected haza ds, and the methods p oposed to mitigate those haza ds that ma be enco nte ed on the site. The SSHP sha add ess a items disc ssed in ER 385-1-9 , Appendix C. If po tions of the cont acto 's SHP a e efe enced in the SSHP, those po tions of the SHP sha be attached as appendices to the SSHP.
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4-4. Radiation P otection Items Add essed in the SSHP. In addition to add essing the hea th and safet items fo HTW sites, the SSHP m ust add ess the fo owing items that a e niq e to adiation sites. These items sha be integ ated with the est of the SSHP to ens e coo dination of a hea th and safet iss es on-site.

a. USACE Pe sonne .

(1) USACE wi p ovide the wo k p an, scope of wo k, site safet and hea th p an, etc., which wi be eviewed b q a ified hea th ph sics pe sonne who a e t ained in acco dance with ER 385-1-9 .

( ) USACE wi p ovide site ep esentatives who a e t ained acco ding to EM 385-1-80.

b. Cont acto Pe sonne .

(1) The cont acto wi p ovide a ce tified hea th ph sicist, esponsib e fo the eview and imp ementation of a doc ments and p oced es e ated to adiation p otection.

( ) The cont acto wi p ovide a s fficient n mbe of adiation p otection technicians (sometimes efe ed to as HP techs) who a e t ained as eq i ed (meeting hea th ph sics pe sonne eq i ements) in EM 385-1-80 to pe fo m s ve s, monito ing, and safet ove sight on-site. r

c. Cont acto Dosimet Responsibi it .

(1) The cont acto has two options conce ning dosimet .

(a) One a te native is that the cont acto wi monito pe sonne expos es, p ovide app op iate exte na dosimet to a pe sonne exposed to exte na so ces of adiation (gamma o ne t on adiation), and p ovide a method fo dose dete mination fo pe sonne who ma become inte na contaminated with adioactive mate ia s.

(b) The othe a te native is that the cont acto wi p ovide meas ements and doc mentation that exte na o inte na contamination co d not es t in doses to the individ a s that exceed 10% of the ann a TEDE.

( ) Common methods for meeting dosimetr req irements inc de roviding thermo minescent dosimeters or fi m badges to a ersonne who enter the exc sion zone, and monitoring the air in the exc sion zone and doc menting that the airborne concentrations of radion c ides are be ow 10% of the derived air concentrations isted in 10 CFR 0, A endix B.

(3) Sho d a bioassa rogram be req ired, ersonne sho d receive a base ine bioassa rior to entering the exc sion zone, eriodic bioassa s as determined b a hea th h sicist, and a termination bioassa at the end of the roject. Bioassa methods de end on the radion c ide and chemica form of concern and ma inc de feca sam e ana sis, rina sis, organ co nting, or who e bod co nting.

d. USACE Dosimetr Res onsibi it . USACE wi rovide a ro riate dosimetr for USACE ersonne . Dosimeters wi be f rnished and ana zed b the U.S. Arm yIonizing Radiation Dosimetr Program at Redstone Arsena in A abama. Sho d bioassa s be req ired for USACE ersonne , these wi be coordinated thro gh the U.S. Arm yCenter for Hea th Promotion and Preventive Medicine, at Aberdeen Proving Gro nd, Mar and.

e. Eq i ment.

(1) The contractor wi rovide s rve ing eq i ment ca ab e of detecting the t e and intensities of radiation ex ected on-site and to the imits of recision req ired in Data Q a it Objectives (DQO) for ersonne rotection and c ean of the site as s ecified in the work or safet ans.

( ) The contractor wi rovide monitoring eq i ment ca ab e of acc rate meas ring the externa radiation dose ex ected on-site.

f. Proced res. The contractor sha rovide roced res that ens re that doses to on-site ersonne and the genera b ic are ke t ALARA. These roced res wi inc de, as a ro riate:

(1) Limiting the time individ a s are ex osed to externa radiation.

( ) Maintaining as m uch distance as reasonab ossib e between ersonne and the so rces of externa radiation.

(3) Providing shie ding, when necessar , to ower ex os re to ionizing radiation.

(4) S rve ing roced res to sto the s read of contamination from the exc sion zone.

(5) Monitoring roced res to ens re that contamination is not re eased from the site.

(6) Decontamination proced res to ens re that site orker doses are maintained ALARA and to minimize the amo nt of contaminated aste generated.

g. Emergenc Contacts. The emergenc contacts isted in the SSHP m ust inc de the appropriate NRC region or agreement state contact if icensab e radioactive materia s are invo ved, the appropriate EPA region or state contact, and the Radiation Protection Officer for the USACE District and Division. For ork on a mi itar insta ation, the insta ation w Radiation Safet Officer sha a so be inc ded.

CHAPTER 5

Risk Assessment c

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5-1. Introd tion. Risk assessments are a req ired e ement of CERCLA and RCRA site investigations. The are sed on both non-radio ogi a and radio ogi a hemi a environmenta restoration proje ts to determine whether a site poses a potentia threat to h man hea th and the environment. Information from a risk assessment is sed to demonstrate whether a site warrants f rther investigation, whether a remova or remedia a tion is warranted, or if a site ma be osed with no f rther a tion. Dose is freq ent assessed for radion ides be a se man standards that reg ate radion ides, s h as those iss ed b the N ear Reg ator Commission (NRC), whi h are based on radio ogi a dose. However, CERCLA g idan e req ires that risk be assessed as part of site investigations. Differen es between dose assessment and risk assessment are dis ssed be ow.

5- . Risk Assessment and Dose Assessment Comparison.

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a. In man wa s, risk assessments and dose assessments are s non mo s with one another. In both risk assessments and dose assessments, meas rements of onstit ents of potentia on ern are sed together with expos re ass mptions to deve op the “dose” that a re eptor ma re eive. The meaning of the word “dose” is part of what disting ishes radion ide from non-radio ogi a hemi a risk assessment. In hemi a risk assessment “dose,” or intake, means the mass of a s bstan e taken into an organism thro gh a pathwa s (s h as inha ation, ingestion, absorption, et .) per nit bod weight per nit time and is s a expressed as mg/kg per da . This is ombined with toxi it information to deve op estimates of ex ess an er risk, or a hazard index for non- ar inogeni risk. In terms of radio ogi a risk, dose means energ imparted b ionizing radiation to matter per nit mass. This ma be expressed in nits of rad. Radio ogi a dose assessments genera express dose in nits of mrem/ ear; for examp e 1 rad of gamma radiation wi prod e 1 rem dose eq iva ent. Dose assessments estimate dose imparted to an organism b ombining expos re information with radion ide-spe ifi hara teristi s. Dose wi be a f n tion of the t pe of radiation emitted b parti ar radion ides and the freq en and d ration of expos re of organisms to that radiation. Another differen e between hemi a and radion ide risks is that radion ide expos re estimates m st onsider an additiona pathwa , expos re to radiation that has s ffi ient energ to penetrate the skin. This is a ed the externa pathwa .

b. As stated above, information from a risk assessment or dose assessment is sed to determine whether a site is safe, or whether it req ires f rther a tion. The site risk assessment is sed to deve op remediation goa s nder CERCLA when there are no ARARs avai ab e, or when ARARs are not prote tive owing to m utip e ontaminants or pathwa s of expos re to ontaminants. Remediation goa s based on a dose assessment are sed as omponents of man reg ations, spe ifi a , the NRC’s Fina R e for Radio ogi a Criteria c

for License Termination (10 CFR 0, bpart E) and to deve op s pp ementa standards nder the Hea th and Environmenta Protection tandards for Urani m and Thori m Mi Tai ings (40 CFR 19 , UMTRCA). The fo owing paragraphs f rther disc ss the ro es and proced res for dose and risk assessments in reg ator programs that common cover U ACE projects where radion c ides contamination occ rs.

5-3. Ro e of Risk Assessment in Reg ator Programs. There are certain instances, s ch as Work for Others on n c ear decommissioning projects, where U ACE work ma be carried o t nder direct reg ation b the NRC. Most U ACE environmenta restoration projects with radion c ide contamination, however, wi fo ow CERCLA with NRC reg ations as a potentia ARAR. The paragraphs be ow disc ss the CERLCA process and how risk assessment is sed in the vario s stages. ome projects ma be reg ated b the Reso rce Conservation Restoration Act (RCRA); the ro e of risk assessment or dose assessments in projects reg ated b RCRA is f nctiona eq iva ent to that of CERCLA. The processes fo owed b RCRA are simi ar to those of CERCLA, except that different termino og is sed.
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a. At sites reg ated b CERCLA, the first step after discover of a site is preparation of a Pre iminar Assessment/ ite Inspection (PA/ I). The objectives of an I are to e iminate from f rther consideration an re eases that do not pose a threat to h man hea th or the environment, to co ect data to initia characterize an re eases, and to identif an immediate threats to p b ic hea th or the environment. A screening eve risk assessment is sed d ring the PA/ I stage to meet these objectives.

b. At the end of the PA/ I, EPA app ies a scoring s stem known as the Hazard Ranking stem (HR) to determine if a site sho d be isted on the Nationa Priorities List (NPL).

c. Performance of the HR is EPA's responsibi it and is genera not done b U ACE or b DOD. However, site investigations sho d be designed to ens re that adeq ate data are avai ab e for EPA to cond ct the scoring. Tho gh DOD does not se the HR , it does se a s stem for ranking sites for reso rce a ocation and prioritization ca ed the Re ative Risk Ranking stem. It is not a risk assessment, b t does consider factors common to risk assessment, s ch as migration pathwa s, contaminant hazard, and receptors.
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d. The p rpose of the Remedia Investigation (RI) phase of the CERLCA process is to co ect data to characterize the nat re and extent of contamination and to q antif risks to h man hea th and the environment in a base ine risk assessment. Res ts of the risk assessment are sed to determine the contaminants, the media, and the areas of the site that req ire an eva ation of remedia a ternatives in the Feasibi it t d (F). Risks are considered to be nacceptab e if the non-cancer hazard q otient is above one or if excess cancer risk is above 10^{-4} (40 CFR 300), or if ARARs are exceeded. In the F remedia

a ternatives are deve oped, screened, and ana zed, and potentia remedies are eva ated against the nine criteria o t ined in the N P, as f rther disc ssed in Paragraph 9- .

e. The first two criteria for eva ating remedia a ternatives, overa protection of h man hea th and the environment, and comp iance with ARARs, re ate to protectiveness of the remed and to determination of remediation goa s. The disc ssion of overa protectiveness in an FS wi draw pon the ana sis of other criteria, s ch as ong-term effectiveness, short-term effectiveness, and attainment of ARARs. Long-term effectiveness considers the amo nt of resid a risk remaining after a remedia a ternative is imp emented. For some projects this eva ation ma req ire that a q antitative resid a risk assessment be prepared. A resid a risk assessment entai s estimating resid a concentrations of contaminants of concern, with a s bseq ent ca c ation of risk from expos res to those eve s. For man projects, tho gh, a q a itative eva ation of how remediation goa s wi be attained wi s ffice. The FS needs to disc ss whether the ana zed remedia a ternatives meet the ARAR or risk-based criteria for protectiveness.

5-4. Reg ator G idance for Risk Assessments and Dose Assessments. EM 00-1-4, Risk Assessment Handbook Vo me I: H man Hea th Eva ation (1999) and EM 00-1-4 Risk Assessment Handbook Vo me II: Environmenta Eva ation (1996) provide an extensive disc ssion of avai ab e g idance for h man hea th and eco ogica risk assessments at sites reg ated b ERL A and R RA. The reader is referred to these doc ments for more information. The disc ssion presented in the fo owing paragraphs wi foc s on iss es and g idance that are niq e to radio ogica risk assessments and dose assessments.

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5-5. ER LA.

a. EPA has iss ed severa g idance doc ments for cond cting h man hea th and eco ogica risk assessments. hapter 10, “Radiation Risk Assessment G idance,” of Risk Assessment G idance for S perf nd, Vo me I, H man Hea th Eva ation Man a (RAGS Pt. A) (EPA 1989) covers data co ection and eva ation, expos re and dose assessment, toxicit assessment, and risk characterization for sites contaminated with radion c ides. hapter 4 of RAGS Pt. B Deve opment of Risk-based Pre iminar Remediation Goa s (EPA 1991) presents standardized expos re eq ations for ca c ating pre iminar remediation goa s (PRGs) for radion c ides nder residentia and commercia /ind stria and ses. When the PRG doc ment was deve oped, EPA recommended that the eq ations be sed with defa t expos re parameters to deve op va es for screening sites in the initia stages of the ER LA process, as we as with site-specific information for deve oping PRGs in the FS. In 1996, tho gh, EPA re eased Soi Screening G idance, which gives eq ations to deve op soi screening eve s (SSLs) for screening sites with non-radio ogica contaminants. SSLs are based on residentia se and a so address contaminants eaching from soi to gro nd water, whereas the PRG ca c ations do not consider eachabi it . In 000, EPA fo owed this doc ment p with a doc ment specific for radion c ides, Soi Screening G idance for C

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Radion c ides (EPA 000), which contains e ations for ca c ating screening eve s for radion c ides. The e ations for expos res to soi s percede the residentia e ations contained in RAGS Pt. B. An e ectronic too for r nning the ca c ations, the EPA PRG Ca c ator, is ocated at http://epa-prgs.orn .gov/radion c ides/.

b. An eco ogica risk assessment m ust a so be cond cted on CERCLA sites. The g idance for eco ogica risk assessments at CERLCA sites is tit ed Eco ogica Risk Assessment G idance for S perf nd: Process for Designing and Cond cting Eco ogica Risk Assessments (EPA 1997).

c. Information regarding toxicit va es for radio ogica risk assessments, additiona mode s, and other information re ative to risk assessment for radion c ides, ma be obtained at EPA's radiation website http://www.epa.gov/radiation/.

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5-6. RCRA G idance. As stated above, RCRA h man hea th assessments genera fo ow CERCLA g idance. There is no g idance regarding risk assessments or dose assessments specific to radion c ides avai ab e for the RCRA program.

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5-7. NRC G idance. Standards for Protection Against Radiation, Radio ogica Criteria for License Termination, and NRC decommissioning standards at 10 CFR 0.1401-1403 give dose re irements for restricted and nrestricted and se. The standard a so re ires that the dose assessment determine the peak ann a tota effective dose e iva ent (TEDE) to the average member of the critica gro p expected within the first 1000 ears. The NRC has deve oped draft g idance for performing dose assessments to show comp iance with their standards and a so deve oped the D and D comp ter code to perform dose assessments. Another comp ter code, RESRAD, is avai ab e that ma be sed to assess doses. RESRAD has certain advantages over D and D and is preferred b hea th ph sicists for assessing doses. The mode ma be down oaded at Argonne Nationa Laborator 's website at http://web.ead.an .gov/resrad/home /.

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5-8. Considerations for Project Risk Assessments. Since man USACE projects wi fo ow the CERCLA process, the fo owing paragraphs disc ss aspects of CERCLA screening- eve and base ine risk assessments that wi be ni e for projects where radion c ide contamination is confirmed or s spected. F rther information on risk assessments ma be fo nd in Vo me I of EM 00-1-4 and Vo me II of EM 00-1-4 (USACE 1996, 1999).

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a. Screening-Leve Risk Assessments. To determine whether a site re ires f rther investigation and to identif areas that ma pose an immediate threat to h man hea th and the environment, a screening- eve risk assessment is carried o t as part of the SI. The first step of this process is preparation of a pre iminar concept a site mode (CSM) for both h man and eco ogica receptors. A pre iminar CSM sho d be prepared when scoping the PA/SI, sing whatever site information is avai ab e at the time, and the CSM sho d be modified as

more site-specific information is gathered. EM 1110-1-1 00 provides g idance for preparing C Ms for h man receptors, and integrates ordnance and exp osives or hazardo s, toxic, and radioactive waste. G idance for preparing C Ms for eco ogica receptors with case st d examp es ma be fo nd in EM 00-1-4.

b. H man Hea th creening. H man hea th screening eve risk assessments are t pica cond cted b comparing the highest detection against hea th-based screening eve s. creening eve s are media concentrations derived b back-ca c ating from protective risk va es and conservative expos re parameters. To deve op screening eve s for radion c ides and other carcinogens, the risk va e is set at the ower (most protective) end of the acceptab e risk range, 1×10^{-6}, one in one mi ion excess cancer risk. creening eve s are freq ent ca ed risk-based concentrations (RBCs), or PRGs. The EPA's PRG ca c ator sho d be sed to deve op radion c ide screening eve s for this p rpose. At this stage it is appropriate for screening eve s to be conservative and it is important to note that that the sho d not be sed as remediation goa s for c eaning p a site, as the do not consider site-specific factors. Remediation goa s sho d be based pon res ts of a site-specific risk assessment or ARARs. Owing to the nat re of their effects on bio ogica organisms, radion c ides present at backgro nd concentrations ma fai a screen against hea th-based eve s. Therefore, it is imperative that the assessment determines whether radion c ides have be re eased and whether the are present above backgro nd eve s before a recommendation is given for f rther investigation or for a remova action.

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c. G idance for Cond cting creening Leve Eco ogica Assessments. G idance for cond cting screening eve eco ogica assessments ma be fo nd in ERAG (EPA 1997) and in Vo me II of EM 00-1-4 (U ACE 1996). An exce ent disc ssion of screening eve and base ine eco ogica risk assessments is presented in the Tri- ervice Remedia Project Manager's G ide for Eco ogica Risk Assessment (imini et a . 000). The DOE (DOE 00) has deve oped a technica standard that contains spreadsheets that are sef for ca c ating dose to eco ogica receptors. The standard and spreadsheets can be down oaded at http://tis.eh.doe.gov/techstds/standard/std1153/1153.htm. The standard inc des a graded method for eva ating sites that starts with a ver generic who e-site approach. This is not in strict accordance with U ACE and EPA g idance, and it is not necessar to fo ow the standard's approach in its entiret . The DOE recent p b ished a companion software too , RE RAD-BIOTA Re ease 1.0, to assist in imp ementing the technica standard and wi be sef for man projects. It wo d be ncommon for an eco ogica risk assessment to go be ond the screening- eve stage on a radion c ide site. If a base ine eco ogica risk assessment is performed, it needs to fo ow U ACE and EPA g idance.

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d. Base ine Risk Assessment. Base ine risk is defined as risk that might exist if no remediation or instit tiona contro s were app ied to the site (EPA 1989). Base ine risk assessments are a req ired e ement of CERCLA remedia investigations, whose res ts he p determine whether remedia a ternatives need to be eva ated in the F to mitigate risk. A S

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we -designed risk assessment wi provide the proje t manager with s ffi ient information to make f t re risk management de isions regarding the site. S h information that sho d ear be presented are the media, ontaminants, expos re pathwa s, and spe ifi areas at the site that are ontrib ting to na eptab e risk. The primar adverse effe t asso iated with most radion ides are their potentia for a sing an er; however, there are others, s h as rani m that ma a se other effe ts based pon its non-radio ogi a hemi a properties, in this ase a sing kidne damage. The risk assessment needs to express both ex ess an er risk and non- an er risks posed b potentia expos res to ontaminants at the site.

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e. Dose Assessment. A dose assessment ma be r n on rrent with the risk assessment, and it is re ommended that this be done if 10 CFR 0 S bpart E is a potentia ARAR for the site. The preferred too for assessing dose is RESRAD. RESRAD is wide a epted b the hea th ph si s ommunit and has the apabi it to a ate risk and dose as we as mode ing fate and transport in a sing e mode . This mode has been sed on man USACE proje ts for estimating both dose and risk posed b radion ides. However, there are differen es between sing this mode and CERCLA g idan e for risk assessments that the proje t de iver team needs to be aware of; these are dis ssed be ow. The EPA has re ent deve oped an e e troni a ator, simi ar to the risk-based radion ide PRG a ator, to provide dose omp ian e on entrations for demonstrating omp ian e with c dose-based ARARs at CERCLA sites. The dose a ator is o ated on- ine at http://epa-d s.orn .gov/radion ides/. As USACE hea th ph si ists and risk assessors gain experien e with these new too s, the essons earned wi be shared thro gh the appropriate ommunities of pra ti e.

f. RESRAD. Within a sing e interfa e, RESRAD has the apabi it to a o nt for fa tors s h as erosion, ea hing, and radio ogi a de a and in-growth that are invo ved with c predi ting risk of f t re expos res, a so termed a prospe tive risk assessment. Whi e it is ommon to onsider s h fa tors as ontaminants ea hing from soi to gro nd water, gro nd water movement and gro nd water dis harge in CERCLA risk assessments, it is not standard pra ti e to erode s rfa e soi s to revea ontaminants in the s bs rfa e. RESRAD defa t parameters wi mode expos res o t to 1000 ears to demonstrate omp ian e with NRC and DOE reg ator req irements. For a CERCLA base ine risk assessment, this is not ne essar , tho gh estimating the ear of peak risk attrib tab e to radion ide de a a one ma be sef . Another fa tor that m ust be onsidered is that RESRAD defa ts to onservative expos re s enarios, s h as a s bsisten e farmer and fisherman, whi e CERCLA risk assessments genera do not in de s h s enarios n ess there is site-spe ifi information s ggesting that these are ike f t re and ses. The proje t risk assessor, hea th ph si ist, and h dro geo ogist need to work together with reg ator stakeho ders to determine the appropriate parameters for the risk assessment and to determine if other fate and transport mode s are preferred to those in RESRAD before doing the radio ogi a risk assessment.

CHAPTER 6 O

Samp ing

6-1. Data Q a it bjectives (DQ).

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a. DQ are statements made to ens re samp e taking is foc sed on achieving the objectives of the st d . The define the t pe of data to co ect, the conditions for co ecting the samp es, the decision error imits, the q antit of samp es taken, and the req ired q a it of the ana ses. The MARSSIM (Appendix D) o t ines the DQ process - seven steps sed to ens re that the data gathered provide information that wi a ow an informed decision to be made abo t the next action to take at a site. An examp e of a good DQ is the fo owing: O

> (The p rpose of this wa kover s rve is to determine if there is e evated 1 keV gamma radiation from Co-57 contamination in this area, and if so where it is and how e evated it is.) DQ : Identif potentia sma areas (100 cm²) of Co-57 s rface soi (<15 cm) contamination in the s rve nit with a 95% confidence imit O sing radiation detection eq ipment and scanning methods with an estimated Scan-MDC be ow the Co-57 screening eve of 8.7 pCi/g [EPA PRG for residentia soi]. O Each potentia area wi be considered contaminated if the res t of a direct meas rement exceeds the critica eve , Lc, ca c ated from backgro nd meas rements in a reference area simi ar to the s rve nit sing va es of 0.05 for a pha and beta errors.

b. This DQ co d be met thro gh b imp ementing a s rve proced re ike the one O that fo ows:

> 100% of the s rface area wi be s rve ed sing a ”x ” Sodi m Iodide detector he d 1 meter above the s rface and moved at inches per second. The detector is capab e of meas ring 5 µR/hr gamma radiation in the 80 to 180 keV energ range (850 cpm = 1 µR/hr). The s rve meter is ca ibrated with the detector to read o t in nits of µR/hr. Backgro nd has been previo s determined to be 1 µR/hr (10, 00 cpm). The req ired eve of confidence is 95% for detecting tr e positives and 0.05% of finding fa se positives. The minim um detectab e co nt rate for the idea observer is comp ted to be 10,531 cpm (1 .4 µR/hr). The action eve for this s rve is set at 1 .4 µR/hr. Each ocation where a reading of 1 .4 µR/hr or greater is detected wi be f agged with a pin f ag. Each f agged point wi be res rve ed for 1 min te and the readings and ocation recorded in the s rve og.

6- . Scanning. There are a n mber of t pes of scanning done at HTRW sites-area scanning, b i ding s rface scanning, soi s rface scanning, and excavation s rface scanning. Scanning is performed b passing a fie d instr ment at a set distance and s ow speed over an area

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s spected of having radioactive contamination. cans can detect some a pha and man beta emitting radion c ides on a s rface and most gamma emitting radion c ides on the s rface or a few centimeters be ow the s rface scanned. Methods for doing scans var a itt e for each t pe of scan.

a. Area canning. This is s a done to determine if an area is safe to access. This scan ma find areas of high gamma radiation, which co d pose a hazard to workers in the area. This t pe of scan is s a performed inside b i dings where arge q antities of radioactive materia s are sed, or where radiation generating devices are in se. For an area scan, a gamma ra detecting probe is he d 1 meter off the f oor and the radiation readings are monitored thro gho t the room. The readings wi be sed b hea th ph sics personne to determine work proced res in the room.

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b. B i ding rface cans. This t pe of scan is sed to determine if there is radioactive contamination on b i ding s rfaces or debris, or possib inf sed into the b i ding materia or debris. The instr ment se ected for a b i ding s rface scan depends on the radiation emitted b the contaminant. rface scanning instr ments preferentia have a arge window detector, a owing more s rface area to be scanned at one time. The detector is he d ver c ose to the s rface to be scanned. This detector is moved s ow over a prescribed percentage of the s rface area. For fina stat s s rve of c ass 1 areas, see Chapter 13 for a disc ssion of area c assification, this is t pica 100% of the s rface, and 5% of the tota s rface for c ass areas, areas. Additiona , a wipe or smear s rve is s a done in conj nction with a b i ding or debris scan to determine if the contamination is removab e. A hea th ph sicist wi need to ens re that the combination of the t pe and size of the detector, the distance from the s rface, and the speed that the detector is moved are s ch that the instr ment wi be capab e of detecting contaminants at a ow eno gh concentration to meet the s rve goa s. The b i ding or debris s rface scan sho d res t in a report detai ing the tota sq are footage of the b i ding or debris s rface, the tota sq are footage that was contaminated above the action eve , the average eve of contamination and the highest eve of contamination meas red, and whether the contamination is removab e of non-removab e.

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c. oi rfaces. oi s rfaces are scanned simi ar to b i ding s rfaces b t ma present other prob ems. Vegetation ma need to be removed. oi s rfaces ma be r gged, making it diffic t to maintain the detector at a set distance from the s rface. As with b i ding scans, soi scans ma detect gamma-emitting radion c ides a few centimeters deep in the soi . Most radion c ides wo d not be detectab e at depths be ow a few centimeters n ess the are present in arge q antities. A hea th ph sicist can ca c ate the depth to which the instr ment can detect a certain q antit of a specific radion c ide.

d. Excavation rfaces. These are scanned in the same manner as soi s rfaces. Open excavations are s a scanned to determine if f rther excavation is necessar . As before, if a s fficient thickness of soi s is between the detector and the contaminant, the instr ment wi

not be capab e of detecting it. If an excavation is scanned and no conta nation is detected, and the excavation is backfi ed with c ean fi , it can be expected that no conta nation wi be detected if the backfi ed excavation is re-scanned.

6-3. In-Sit Meas re nts. These are de sing a sodi iodide (NaI) detector or a high p ritmger ani (HPGe) detector in conj nction with a spectr ana zer.mThis s ste wi a ow a spectr of a ga a radiations to be recorded and ana zed. Most of these m s s ste can identif the so rce radioisotope of each ga a radiation as red. So e s ste shave incorporated a gorith so enab e the s ste to q antif the conta nants of concern, and atte pto deter ne the depth in the soi at which the conta nant is present. These s ste sare ver co pex and caref eva ation wi be needed to provide a eve of confidence in their as re nts.

6-4. Down-ho e or We Logging. Another for of scanning is down-ho e ogging. In this sit ation, adetector is owered into the boreho e and a record of thee as re nts vs. the depth of the detector is recorded. This thod can so ti se ocate the depth that a conta nated a er of soi is at re ative to the gro nd s rface. It can a so so ti se ocate hotspots within the gro nd. Down-ho e ogs are inf enced b a n der of factors, inc ding soi densit , ist re content, and soi t pe. Ens re that the individ a interpreting the s rve is experienced in acc rate down-ho e s rve interpretation techniq es.

m p6-5. Sa ing S rface Soi s. This is co n done at ocations where scanning indicates e evated radiation eve s. This is ca ed biased sa ping a A grid be set o t over the site and soi sa ps taken at se ected grid nodes. Additiona , rando s rface soi sa ps a be taken to verif re diation effectiveness. A s rface soi sa p, s a abo t 1 ki ogra is re ved and packaged then forwarded to a ab for ana sis.

a. S bs rface soi sa ping is s a done with a coring device. A soi core fro the s rface to a set depth is taken and soi fro a certain a er is re ved for the core, s a m o ho genized, and sent to the ab for ana sis. S bs rface sa ping a be achieved b other ans, s ch as re ving the cover or topsoi with a shove or backhoe, then taking a m p soi sa e at a specific depth. Often the conta nant is excavated to a prescribed depth, then sa ps of the soi s in the botto or on the sides of the excavation are taken to confir that am the conta nated soi was re ved fro the site. S bs rface sa ping a be necessar to deter ne the three-di nsiona extent of conta nation at a site.

b. As with a p grab sa es, care st be taken in the interpretation of s rface and s bsoi res ts. Biased sa ping a indicate the areas and the xi concentrations of a conta nation a site, b t is not representative of the site as a who e. Gridded sa ps a provide the best indicator of the site-wide conditions, b t st be eva ated sing statistica too s to ens re that enough sa es were taken to have an acceptab e eve of confidence in the res ts. S bs rface sa ps are re diffic t to acq ire and so are re expensive.

Excavation samp ing m ust consider the sa et req irements or potentia s oping and shoring be ore an individ a is a owed into the excavation. A gridded samp ing re ies on the ass mption at the contaminant is distrib ted over the site in some manner. Prob ems in interpretation can arise when the contaminant is heterogeneo s over a site rather than homogeneo s. A heterogeneo s distrib ted contaminant is one where arger pieces o the radioactive contaminant are random l scattered over a site, with itt e or no contin o s contamination o s rro nding soi s. In this case, statistics based on a distrib tion break f down.

CHAPTER 7

Characterization I

I

7-1. ntrod ction. Characterization refers to three separate tasks that are part of the CERCLA process: site characterization, contaminant characterization, and waste characterization.

I

7- . Chemica and Radioactive Contaminants. Radioactive materia s can pose two separate hazards to h man hea th at a site. The ma be hazardo s chemica s, and the a so deca and emit ionizing radiation. The chemica hazard posed b an e ement is the same regard ess of whether a stab e or radioactive isotope is invo ved. The chemica hazard depends on the mo ec ar comp ex to which the atom is affixed. Regard ess of the chemica form, if the isotope is radioactive, the mo ec ar form wi emit radiation, and, therefore, be hazardo s. Besides its chemica toxicit , the mo ec ar form wi determine its transportabi it in the environment.

a. A contaminant's characteristics can change over time. Chemica degradation occ rs in man contaminants over periods of months or ears. Radioactive deca transm utes the radion c ide from one e ement to another, which in t rn can a ter the wa it behaves on the mo ec ar eve and a so how it is transported in the environment. For examp e, radi m- 6 is often fo nd in water-so b e compo nds that can be disso ved and perco ate thro gh the soi co mn to gro nd water. Radi m- 6 deca s to radon- , an inert gas that ma rise thro gh the soi co mn and disperse in the air, b t is a so high water so b e. Radon- deca s to a n mber of short- ived deca prod cts, a of which are so ids and wi attach e ectro-statica to d st partic es in the air, f rther a owing air migration, or the wi be washed o t of the air b precipitation, and reenter the soi . n s mmar , the contaminant can change atomic form, change the radiations emitted, change chemica form, change fate and transport methods, and change chemica and radio toxicit over time.

b. For these reasons, it ma be necessar to characterize both the radioactive and the chemica /mo ec ar form of the s spected contaminants and to determine how these characteristics change over time. When this characterization is too comp ex or too expensive to determine, it is necessar to make some ass mptions abo t how the characteristics wi change and how these changes wi affect transportation and expos re pathwa s in the environment. t is important to ens re that, whenever an ass mptions are made, the are f doc mented in the characterization report, and that an estimate of their re iabi it be incorporated in the report.

c. Samp es taken and ana zed d ring the site characterization ma be sef d ring the waste characterization. f the actions generating the waste stream do not great a ter the t pe or concentration of the contaminants, site characterization samp e res ts ma be sed

for waste characterization. It is important to now the disposa site's waste acceptance criteria and the req ired samp e ana ses to ens re that site characterization samp e ana ses wi be acceptab e to the disposa site. This wi aid in decreasing the n mber of samp es being ana zed over the entire ife of the project.

7-3. Site Characterization. This is the q antitative description of the site properties that inf ence the determination of ris to h man hea th or the environment from a contaminant present at the site. The site characterization inc des an investigation of the ph sica nat re of the site and the contaminants at the site. It attempts to define the so rces of the contamination, and determine the nat re and extent of the contamination. It a so see s to identif expos re pathwa s and potentia receptors for the ris assessors. As a coro ar to this, it a so is sed to identif areas that are not contaminated. A samp ing and characterization sho d be oriented toward provision of data necessar to comp ete the fina stat s s rve , and reach c os re of the project.

a. The ph sica characteristics of the site ma inc de geoph sica and h drogeo ogica parameters, as we as the site se and accessibi it in the past, present, and f t re. It a so inc des characterization of the vo metric distrib tion or dispersion of the contaminants or contaminant at the site.

b. The site characterization is attempting to answer the q estions: What is the contaminant on-site? What are its radio ogica as we as its chemica characteristics? Where is the contamination? What is the pattern or distrib tion, if an , of the contaminants? What are the act a and potentia modes of transport of the contaminant in the environment? Who are the potentia exposed pop ations? What are the ro tes of expos re?

c. Site characterization is described f rther in EPA CERCLA g idance. Important differences in site characterization on radioactive sites that ma manifest themse ves are the variations in radion c ide pathwa s from the standard chemica pathwa s. Especia the deca chain radion c ide series, where there is a change in ph sica form that accompanies the deca , s ch as so id radi m- 6 deca ing to gaseo s radon- . There is a so the change in chemica form and in chemica reactivit that wi affect pathwa s. After most deca s, the radion c ide is eft in an ionized state, which is chemica high reactive.

d. Contaminant characterization, a s btas of site characterization, describes the ph sica , chemica , and radio ogica parameters of the contaminants as the exist at the site.

7-4. Waste Characterization. Waste characterization defines the waste stream containing the contaminants as it wi be de ivered to the disposa faci it . Waste characterization can be a m uti-stage process. On man sites, arge n mbers of site characterization samp es are ta en of soi s and debris. In most cases the act of removing and pac aging the contaminated soi or debris does not significant a ter the radioactivit of the waste. In these cases we can se

the site characterization samp e data to contrib te to the waste characterization data. his wi significant ower the n mber of samp es and ana ses needed on the waste stream. If this is the case, it is important to ens re that the site characterization samp e data are of the same ca iber needed for waste characterization. Additiona , remova and packaging methodo og that ens res that concentrations of radioactive contaminants in the soi and debris are not significant a tered needs to be inc ded in the data package.

a. he concentration, activit , and chemica form of the contaminant ma have a tered beca se of some remedia , remova , or other actions taken at the site, or on the waste stream. When this is the case, a more stringent waste-characterization samp ing program wi be req ired to ens re adeq ate confidence in the eve of activit in the waste and the homogeneit of the waste.

b. For disposa , waste streams ma sometimes be combined to a ow for more economica transportation and disposa . Whi e radioactive waste streams ma be combined and the average concentration of radion c ides in one waste stream ma be owered b the combination, waste ma not be di ted to become nreg ated. Both waste streams m ust meet the waste acceptance criteria of the proposed disposa site to be b ended. If one waste stream does not, it sho d not be b ended. Waste wi not p rposef be mixed with ncontaminated soi s to ower its radioactive concentration. In the process of remediation, some c ean materia is navoidab co ected a ong with the contaminated materia ; this is acceptab e and is not considered b ending.

c. he fo owing is an examp e: A site contains a radioactive waste b ria pit. he remediation method chosen was to remove the soi s covering the pit, segregate these soi s from the waste in the pit, excavate the waste in the pit, tr to treat 10 c bic ards of the waste with a new techno og that minimizes the waste vo me, and ship a waste to disposa faci ities. A characterization s rve is cond cted to determine the radion c ides present, their concentrations at vario s ocations and depths, and their vo metric extent at the site. Ass me the 85 characterization samp es showed that the soi covering is niform l contaminated with ver ow concentrations of radioactive waste and can be disposed of at an RCRA S btit e C faci it . In the process of excavating the contaminated soi s, the b ckets sometimes c t a few inches deeper into ncontaminated soi s, incorporating some ncontaminated soi into the waste stream. his generated 500 c bic ards of waste. his partic ar RCRA faci it req ires one confirmator samp e per 100 c bic ards of waste, so 5 confirmator samp es are req ired for this waste stream.

(1) he waste excavated from the pit is known from the characterization samp ing to be niform contaminated b t with a m uch higher activit . his 10,000 c bic ards of materia m st go to an NRC icensed radioactive waste disposa faci it . he faci it req ires five confirmator samp es be taken from the entire waste stream. he a so have additiona testing when the waste reaches their site. If this testing revea concentrations vast different

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from those presented b o r samp ing, the shipment i be ret rned to the originating site. To ens re e meet the aste acceptance criteria for the site, e se the information co ected d ring the characterization of the site, app icab e to this aste stream. These 00 s bs rface soi samp es sho the radion c ide concentration to be a tota of 3400 pCi/g ± 1 00 pCi/g at a 95% confidence eve . The five confirmator samp es varied bet een 500 and 4 00 pCi/g ith a mean va e of 3 50 pCi/g. Site and process kno edge, combined ith the confirmator samp es, provides exce ent confidence that excavation and hand ing proced res did not significant a ter the radioactive contaminant concentration of this aste stream.

( ) The 10 c bic ards of the pit aste that are treated res ted in a vo me red ction of 60%; 30 samp es taken from the 6 c bic ards of 'c eaned' aste sho that the radion c ide concentration is o er than the remediation goa for the site. With the conc rrence of the site reg ators, it ma be disposed of on-site as fi . The remaining 4 c bic ards are samp ed t ice and both samp es sho the radion c ide concentration has been increased.

(3) This site has three radioactive aste streams: the 500 c bic ards of s ight contaminated soi covering, the 10,000 c bic ards of pit contents, and the 4 c bic ards of treated aste. Tota samp es taken of each aste are as fo o s:

(a) For the 500 c bic ard soi covering, 85 characterization samp es and 5 confirmator samp es ere taken.

(b) For the 9,994 c bic ard pit contents, 00 characterization s rve samp es and 5 confirmator samp es ere taken.

(c) For the 4 c bic ards of treated pit contents, samp es ere taken. The 4 c bic ards as then b ended in ith the 9,990 c bic ards of the origina pit contents, and as ca c ated to not significant change the content of the pit radion c ide concentrations.

d. In s mmar , the site characterization i have identified the radioisotopes, and provided a range of concentrations in each aste stream, and an estimated vo me of each aste stream. To meet disposa faci it req irements and USACE q a it contro , additiona samp es needed to be taken and ana zed to ens re that the aste, excavated and read for transport to the disposa faci it , has not been inadvertent a tered thro gh the remediation process. The information gathered from these samp es is combined ith the information from the characterization and an other s rve s and is sed to define the aste. B ens ring that a the s rve s have simi ar data q a it , e can combine the res ts and achieve a ver re iab e statistica estimate of o r confidence in the data.
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7-5. Site Histor and Waste Pedigree. A co prehensive site histor can be ver he pf in deter niing potentia radioactive conta niants. If teria s arrive as ores, and were s e ted on the site, the resid a s a contain both parent and progen deca prod cts. If teria was a read refined, parent or certain progen a not be reasonab expected at the site. Potentia areas of conta nation can be deter nied if know edge of the ph sica f ow of teria s in, aro nd, and off the site is known. Soi and water extraction processes, we s, or s rface water s ste s sed at a site have contrib ted to technica enhanced NORM (nat ra occ rring radioactive teria s). A these processes and teria s ve ret a he p exp ain the presence and gration of conta niants on and off the site. Additiona , it is i portant to know the site histor to characterize and c assif the radioactive teria .

7-6. Q antif ing Conta niated Materia s. A characterization st d and interpretation of the data co ected sho d ie d the fo owing infor tion:

- The range and extent of conta nation at the site.
- Each radion c ide present on-site.
- The range of concentrations of each radion c ide on-site.
- m The vo a and ss of soi expected to exceed site screening eve s/PRGs.
- The tota activit and concentration of the radioactivit in soi exceeding site screening eve s/PRGs.
- The vo and ss of debris to exceed site screening eve s/PRGs.
- The tota activit and concentration of the radioactivit in or on debris exceeding site screening eve s/PRGs.
- The activit , concentration, and vo e of the highest ‘hot-spot’ in soi s on the site.
- The concentration and tota activit expected to re in in the soi on the site.
- The concentration and tota activit expected to re ain on or in b i dings or debris eft on the site.

A of the above data sha be q a it contro ed and of an acc rac and precision to be acceptab e as MARSSIM fina stat s s rve co apib e data. B confor ng to MARSSIM Data q a it objectives, these data can be co ined ening f with a the other data obtained on the site and the waste to provide a better statistica acc rac to the data.

7-7. Other Media - Air, Water, Sedi nts. Depending on the site, air, s rface water, or gro nd water a req ire characterization. The pri ra difference in characterization is that these as re nts are nor a provided in activit per nit vo , as opposed to activit per nit ass.

CHAPTER 8

Radioactive Waste f

8-1. C assi ication.

a. The NRC reg ates on so rce, b prod ct, and specia n c ear materia s. Waste c assi ication starts with determining i the materia is NRC reg ated.

b. Licensab e so rce materia is de ined as: (1) rani m or thori m in an ph sica or chemica orm, or ( ) ores containing one twentieth o one percent (0.05%) b weight o rani m or thori m or an combination thereo . So rce materia in an chemica mixt re, compo nd, so tion or a o in which the so rce materia is ess than one twentieth o one percent (0.05%) b weight is considered an nimportant q antit o so rce materia . So rce materia does not inc de specia n c ear materia .

c. Specia n c ear materia is p toni m, rani m- 33, materia enriched in rani m- 33 or rani m- 35, or an thing e se the NRC determines is specia n c ear materia b t does not inc de so rce materia .

d. B prod ct materia is de ined in a n mber o reg ations. B prod ct materia is 1) an radioactive materia ie ded in or made radioactive b expos re to the radiation incident to the process o prod cing or ti izing specia n c ear materia , and) the tai ings and wastes prod ced b the extraction or concentration o rani m or thori m rom ore processed primari or its so rce materia content, inc ding waste rom rani m so tion extraction processes. B prod ct materia does not inc de so rce materia or ndergro nd ore bodies dep eted b so tion extraction.

8- . Waste De initions.

a. Congress de ines high- eve radioactive waste as the high radioactive materia res ting rom the reprocessing o spent n c ear e , inc ding iq id waste prod ced direct in reprocessing and an so id materia derived rom s ch iq id waste that contains ission prod cts in s icient concentrations; and other high radioactive materia that the NRC, consistent with existing aw, determines b r e req ires permanent iso ation. The atter inc des spent n c ear e . Low- eve radioactive waste is radioactive materia that is f not high- eve radioactive waste, spent n c ear e , or 11e.( ) b prod ct materia rom rani m or thori m mining/mi ing operations; and NRC, consistent with existing aw, c assi ies as ow- eve radioactive waste [4 USC 10101]. Additiona , NRC has r ed that it does not reg ate rani m and thori m mining and mi ing wastes/tai ings generated be ore 1978. f

(1) The importance of these definitions and re ator a thorities to USACE is in the avai ab e methods for disposa of each t pe of waste. There is no present disposa option for hi h- eve radioactive waste, or for trans ranic waste not owned b DOE. Low- eve radioactive waste is s bject to re ation b the vario s state radioactive waste compact a thorities as we as the NRC. Low eve radioactive waste ma be disposed of on in a compact a thorized radioactive waste repositor : one in Barnwe , So th Caro ina, or the other in Rich and, Washin ton, or, with the permission of the compact, at Envirocare of Utah. DOE trans ranic waste ma be disposed of on at the Waste Iso ation Pi ot P ant in New Mexico.

( ) If the waste is not hi h- eve or ow- eve radioactive waste, or trans ranic waste, there ma be other options for disposa .

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b. Dependin on the pedi ree of the waste, the radion c ides invo ved, the concentrations of the radioactive materia s and an hazardo s waste constit ents in the waste, other disposa options ma inc de proper permitted or icensed RCRA andfi s, hazardo s waste disposa faci ities, rani m mi s, and rani m or thori m tai in s ponds. Each individ a disposa faci it has its own waste acceptance criteria and the se ection is a ver comp ex decision that sho d be de e ated to radioactive waste experts within USACE. The hea th ph sicists at the HTRW-CX have experience with man t pes of waste disposa and can assist an District. The Kansas Cit District has a n mber of pre-p aced disposa contracts avai ab e for se b a USACE Districts and some o tside a encies. Whi e Districts are not ob i ated to se the Kansas Cit contracts, a ood r e of th mb is that, for waste q antities nder 3000 c bic ards, the se of the pre-p aced contracts wi s a be ess expensive than the costs of the biddin process for other disposa sites and res tin disposa fees.

c. Another consideration is radioactive waste owned b DOD. The DOD Exec tive A ent for radioactive waste has been desi nated as the ead for disposa of these materia s. A disposa of DOD-owned radioactive materia s or waste m st be coordinated with the Exec tive A ent thro h the HTRW-CX to comp with NRC and DOD icenses and a thorizations. Radioactive wastes enerated b Civi Works activities, s ch as FUSRAP, ma not be considered DOD wastes.

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d. Radioactive waste disposa re ations are ver comp ex and some of the re ator methods and proced res have not et been set. It is a so important to coordinate an characterization of waste and se ection of disposa options with the HTRW CX to ens re that an action at one site is not settin a precedent that wi affect disposa options at other USACE projects.

8-3. Waste Disposa Faci it Criteria. Each waste disposa aci it has its own waste acceptance criteria and ists what characteristics m ust be eva ated and what imits the a ow on each contaminant. The common data that m ust be s pp ied on a materia s or disposa inc de the o owing:

- Waste generator
- Location o waste generator
- Ph sica state o the waste
- Medi m contaminated
- Radion c ide or radion c ides present
- Activit and concentration o each radion c ide
- Tota weight and tota vo me o the waste
- Co-ming ed hazardo s s bstances
- Q antit and concentration o hazardo s s bstances f

CHAPTER 9

Primar Reg ator Processes

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9-1. ntrod ction. This chapter wi provide the project manager (PM) and project de iver team with an overview of the primar reg ations and req irements that USACE and their contractors wi fo ow whi e exec ting environmenta restoration of sites contaminated with radioactive waste or radioactive waste that is comming ed with either CERCLA hazardo s s bstances or RCRA hazardo s waste. Once the pre iminar determination has been made that a response action is warranted, two important and re ated q estions m st be answered for ever environmenta remediation project:

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- What reg ator a thorit governs this response action?
- What are the c ean p eve s that m st be achieved for the contaminants of concern for the remed to be protective of h man hea th and the environment?

a. To determine the c ean p criteria, it is essentia to determine the reg ations that app to the site, as we as which Federa or state reg ator agenc has the a thorit and responsibi it for enforcing the reg ations. This chapter wi disc ss the primar restoration programs that USACE fo ows when c eaning p radioactive waste or mixed waste contaminated sites. The responsibi ities of the two major Federa agencies that reg ate the environmenta restoration activities wi a so be brief disc ssed:

- The N c ear Reg ator Commission (NRC) is responsib e for decommissioning of icensed faci ities nder the Atomic Energ Act (AEA).
- The Environmenta Protection Agenc (EPA) has reg ator a thorit over sites nder two separate environmenta programs - CERCLA and RCRA.

n addition, there ma be sit ations where more than one Federa reg ator agenc or m utip e offices from the same Federa agenc ma have responsibi it for reg ating different contaminants or activities at a site.

b. Characterization of the t pe of radioactive materia or waste is a ver important component of determining which reg ator a thorities govern the management of radioactive materia . The characterization process m st examine the processing histor of the waste as we as the t pe and q antit of radion c ides present. Chapter 1 of this man a contains definitions for the common t pes of radioactive wastes or materia s that USACE ma enco nter. n some sit ations, radioactive waste is characterized b what isn't present instead of what is present (e.g., LLRW). The term "mixed waste" is defined in the Federa Faci ities Comp iance Act as waste that contains both RCRA hazardo s waste and AEA reg ated, so rce, b prod ct or specia n c ear materia .

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c. An exce ent reso rce when dea ing with radioactive conta nation is the M u ti-Agenc Radiation S rve and Site Investigation Man a (MARSSIM), which was deve oped co aborative b fo r Federa agencies having a thorit and contro over radioactive te ria s (DOD, DOE, EPA, and NRC). Appendix C of MARSSIM provides an overview of the stat tor a thorities and reg ations that are the responsibi it of each Federa agenc . It is interesting to note that the EPA, NRC, and DOE derive their respective a thorities for pro gating reg ations, standards, and orders fro m a of the sa e stat tes.

d. A co mprehensive exp anation of a the reg ations is and ad nistrative and proced ra req ire ments that USACE st co p with wi not be inc ded in this chapter. However, a brief disc ssion wi be provided on the pri ma environ menta stat tes and reg ations that pertain to the restoration of the radioactive conta nated sites. The PM wi need to coordinate with the appropriate discip ines of the project de iver tea (e.g., Office of Co nse , hea th ph sicist, risk assessor, reg ator , etc.) to deter ne if there are niq e or additiona req ire ments (e.g., state reg ations) app icab e to the specific project.

9- . Environ menta Response A thorities for Radioactive Waste or Mixed Waste.

a. Co mprehensive Environ menta Response, Co ensation, and Liabi it Act (CERCLA)[4 USC 9601 et seq.]. CERCLA, co n referred to as "S perf nd," estab ished a nationa progra for responding to ncontro ed re eases of hazardo s s bstances into the environ ment fro abandoned waste sites. CERCLA hazardo s s bstances are defined as an s bstance designated or isted nder the C ean Air Act, the Federa Water Po tion Contro Act, the Toxic S bstances Contro Act, and the Reso rce Conservation and Recover Act. CERCLA wi be the pri ma restoration progra that USACE wi t pica ti ize to exec te an environ menta response action for sites that have been conta nated with radioactive waste or xed waste. However, if USACE does work for others that operate nder an NRC or agree ment state icense, the activities wi be cond cted nder the NRC reg ations. On NRC icensed sites where USACE is conte pating a FUSRAP c ean p nder CERCLA, a Me rand of Understanding (MOU) a be needed to ni ze the potentia for d a reg ation. The c rrent NRC-USACE MOU for FUSRAP sites is described in Section 9-3d.(1) be ow.

(1) A thorit . CERCLA provided broad Federa a thorit to respond direct to re eases or threatened re eases of hazardo s s bstances, po tants, and conta nants that a endanger p b ic hea th or the environ nt. For non-govern menta Nationa Priorities List (NPL) sites, ndergoing a CERCLA re diation, EPA is the ead enforce nt agenc . Exec tive Order 1 580, S perf nd I p mentation, dated 3 an ar 1987, as a ended b Exec tive Order 13016, dated 8 A g st 1996 de egated ma of the a thorities of the President estab ished in CERCLA to DOD, as we as other Federa agencies. One s ch a thorit is that DOD is the ead Federa agenc for response actions at both NPL and non-NPL DOD insta ations. This inc des the a thorit to se ect re dies, s bject to the m

conc rrence of EPA if it is an NPL site [CERCLA Section 1 0(e)]. USACE a so has ead agenc a thorit to se ect remedies at FUSRAP sites regard ess of whether the site is DOD or not [P b. L. 106-60 section 611]. CERCLA app ies to radio ogica events at DOD and DOE faci ities b t does not app to re eases from NRC- icensed faci ities s bject to the req irements of the Price Anderson Amendment (Section 170) of the AEA-essentia n c ear power p ants.

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( ) App icabi it . Radion c ides are considered hazardo s s bstances nder CERCLA b virt e of their isting as Hazardo s Air Po tants (HAPs) nder the C ean Air Act (CAA) where the are isted in Appendix B to the List of Hazardo s S bstances (40 CFR 30 .4). It is important to nderstand that hazardo s s bstances and hazardo s waste have specific meanings and are not s non mo s. A RCRA hazardo s wastes are b definition CERCLA hazardo s s bstances b t not a hazardo s s bstances are hazardo s wastes. It is important to note that CERCLA exc des radion c ides that are considered so rce b prod ct or specia n c ear materia s from the definition of "re ease" if from a n c ear incident as defined b the AEA if s ch re ease is s bject to req irements with respect to financia protection estab ished b the NRC (Price Anderson Amendment Act of 1988-4 USC 10 et seq.) or an re ease of so rce b prod ct or specia n c ear materia from an processing site designated nder UMTRCA (4 USC 7911 et seq.).

(3) Imp ementing Reg ations. CERCLA response efforts are g ided b the Nationa Oi and Hazardo s S bstances Po tion Contingenc P an common referred to as the NCP (40 CFR 300). The NCP are the reg ations that EPA has prom ugated to imp ement CERCLA. The NCP estab ishes the criteria methods and proced res that m st be fo owed to investigate contamination and determine if a response action sho d be taken at a site to protect h man hea th or the environment.

(4) Process. In section 1 0(c) of CERCLA (4 USC 96 0) Congress req ired EPA to deve op a ist of a Federa faci ities that ever stored treated disposed of re eased or spi ed or are c rrent generating treating storing or disposing of hazardo s wastes or have re eased a hazardo s s bstance in a reportab e q antit . The ist which EPA maintains is ca ed the Federa Agenc Hazardo s Waste Comp iance Docket. CERCLA estab ishes the req irements for actions on sites isted on the docket. Once a Federa faci it is isted on the docket a pre iminar assessment (PA) m st be cond cted at the faci it . If after comp eting the PA and cons ting the NCP req irements f rther action is warranted the faci it m st perform a site inspection (SI). After comp etion of the PA/SI EPA ma e ect to score the site sing the hazard ranking s stem (HRS). If the HRS is high eno gh (≥ 8.5) EPA wi determine whether to make the site an NPL site. A NPL site m st initiate a remedia investigation and feasibi it st d (RI/FS) no ater than six months after inc sion on the NPL. Upon comp etion of the RI/FS the Federa faci it m st enter into an Interagenc Agreement with EPA within 180 da s and commence on-site remedia action within 15 months. After the RI/FS has been comp eted a proposed p an m st be presented to the ,

p b ic with an opport nit for comments to be receive an consi ere b the agenc , after which a recor of ecision (ROD) wi be prepare an signe . Comp iance with the NCP is req ire regar ess of whether the Fe era faci it or site is on the NPL. This means the a ministrative an proce ra req irements of the NCP m ust be fo owe . The site m ust have appropriate site investigation an characterization, ana sis of reme ia a ternatives, an se ection of a protective an cost-effective response action. The p b ic m ust be a owe an opport nit to comment on an response action, even if there is no f rther action req ire . A f rther exp anation of the CERCLA process is provi e in Appen ix F of MARSSIM an paragraph 1.3 of EM 00-1-4. Districts are enco rage to coor inate ear with reg ators to i entif a sing e reg ator framework to g i e the environmenta restoration process. To minimize potentia p ication of efforts b states, tribes, an the EPA, it is important that the ea reg ator be c ear i entifie an communicate to a parties for each site. States or tribes sho genera be the ea reg ator for environmenta investigations an response at non-NPL sites. In certain circ mstances, EPA ma serve as ea reg ator where the state or tribe req ests it or when EPA chooses to exert its ea reg ator ro e. In instances where EPA ass mes ea reg ator agenc a thorit , ro es sho be oc mente an a parties notifie . If USACE is performing work for others that are n er an NRC or agreement state icense, the ea reg ator ro e ma be the NRC or the agreement state.

(5) C ean p Criteria. The CERCLA process [Section 1 1( ) of CERCLA (4 USC 96 1)] req ires that a " egree of c ean p" be etermine for the reme ia action. In etermining what reme ia action is necessar an appropriate, the ea agenc m ust consi er the nine criteria estab ishe b CERCLA, Section 1 1, an imp emente in 40 CFR 300.430.(e). A CERCLA response actions m ust etermine the app icab e or re evant an appropriate req irements (ARARs) for reme iation of the site. Once the are i entifie , the s bstantive e ements of those ARARs m ust be etermine , inc ing a the con itions an a ternatives to their app ication. The NCP oes provi e re ief from strict comp iance with the ARARs if certain con itions exist or can be met thro gh a forma process to waive the ARAR [40 CFR 300.430(f)(1)(ii)(C)]. The ARAR ana sis m ust etermine if a req irement is a prom ugate an ega enforceab e Fe era environmenta aw or reg ation, or state environmenta or faci it ocating aw or reg ation. The req irement must contain s bstantive criteria pertaining to the hazar o s s bstances or po tants or contaminants or the circ mstances of their re ease at the site.

(a) The req irement is app icab e if it specifica a resses the contamination or re ease at the site [40 CFR 300.5]. Another wa to eva ate this is to pose the q estion; if the CERCLA permit waiver for on-site activities i not exist, wo the reg ator be ab e to impose the stan ar thro gh a permit or other reg ator approva process? The ARAR ana sis process sho inc e a ega ana sis b the District Office of Co nse to etermine whether the req irement specifica a resses a hazar o s s bstance, po tant, contaminant, reme ia action, ocation or other circ mstance fo n at a CERCLA site. The District is ca tione against accepting or eve oping a " a n r ist" of stat tes or reg ations d

that do not meet the CERCLA definition of an “App ica e” or “Re evant and Appropriate” req irement.

( ) The req irement ma a so e an ARAR if it is re evant and appropriate to the contaminants or the circ mstances of their re ease, even if not app ica e. F ndamenta , the aw or reg ation m ust address sit ations s fficient simi ar to the circ mstances of the re ease or the remedia action, and e we s ited to the site. There are a n m er of factors that m ust e considered in making the determination whether a req irement is re evant and appropriate for the site [40 CFR 300.400(g)( )]. It is ver important to note that CERCLA and the NCP are ver definitive that on state standards that are prom ugated, are identified the state in a time manner, and are more stringent than Federa req irements ma e ARARs for a CERCLA response action. In accordance with DERP and the NCP, USACE m ust forma req est that the ead reg ator agenc and s pport agenc identif their potentia ARARs for a partic ar site. The District sho d req est the reg ator agenc provide the citation and exp anation as to wh the have identified a specific req irement as a potentia ARAR for the site.

(6) Response Actions. CERCLA a thorized two kinds of response actions to e taken where hazardo s s stances have een re eased or there is a potentia for a re ease into the environment: remova actions (short-term) and remedia action (ong-term).

(a) Remova Action. The remova action is intended to address act a or threatened re eases in a prompt manner to protect h man hea th and the environment. The remova action is to a ate, prevent, minimize, sta i ize, mitigate, or e iminate the threat to h man hea th or the environment. T pica , the remova action is sed to e iminate an imminent hazard to h man hea th or the environment. Remova actions sha , to the extent practica e, contri te to the efficient performance of an anticipated ong-term remedia action with respect to the re ease concerned. Remova actions, n ike remedia actions, are not req ired to comp (or waive) a ARARs except to the extent practica e considering the site conditions. It is important to remem er that remova actions don’t necessari a wa s req ire remova of the contamination and ma e erecting a fence to protect the p ic or providing an a ternate drinking water so rce to the p ic. EPA has categorized remova actions, nder CERCLA and the NCP, in three wa s:

- Emergenc remova actions (within ho rs of discover)
- Time-critica remova actions (initiated within 6 months)
- Non-time critica remova actions (p anning and eva ation takes 6 months or onger)

The NCP req ires p ic invo vement in the remova process, thro gh the administrative record process, p ic notices, and other mechanisms. Remova actions can take p ace at an time d ring the entire CERCLA process. An engineering eva ation and cost ana sis b

(EE/CA), which serves as a decisi n d c ment, is req ired f r n n-time critica rem va acti ns.

(b) Remedia Acti n. The remedia acti n pr cess is sed nder CERCLA t address act a r threatened re eases f hazard s s bstances that are seri s, b t n t immediate ife threatening r danger s t the envir nment. Remedia acti ns are t pica c nd cted after severa ears f investigati n, eva ati n f a ternatives, and se ecti n f a permanent fina remed . The NCP pr vides the imp ementing reg ati ns f r c nd cting the pre iminar assessment (PA) and site inspecti n (SI) t determine if f rther site investigati n and characterizati n is necessar . The remedia investigati n (RI) is the CERCLA phase that can be c nsidered the site characterizati n phase, in which the nat re and extent f c ntaminati n is determined and p tentia risks and exp s re pathwa s are eva ated t determine if there are nacceptab e risks t h man hea th and envir nment. The next phase is the feasibi it st d (FS), which ma be c nd cted c nc rrent with the RI. The FS is the pr cess t eva ate p tentia remedia a ternatives t c ean p the site. An imp rtant aspect f the RI/FS pr cess is t identif the p tentia ARARs f r determining the c ean p standards that m st be achieved, as we as what impacts the ARARs ma have n the p ssib e remed a ternatives. The nine criteria are sed in the remed se ecti n pr cess and it is imp rtant t n te that the se ected remed m st be pr tective f h man hea th and the envir nment and c mp with ARARs. This man a wi n t pr vide a c mprehensive exp anati n f the individ a tasks that m st be acc mp ished in preparing the PA, SI, RI, FS, pr p sed p an, and ROD. EPA pr vides a g idance d c ment n the necessar steps in perf rming a RI/FS n a CERCLA site (EPA/540/G-89/004.

(7) Imp rtant Aspects f the CERCLA Pr cess.

(a) Lead Agenc A th rit . The NCP pr vides a definiti n f r " ead agenc " in 40 CFR 300.5 that is ver imp rtant when exec ting a CERCLA resp nse acti n. In the case f a re ease f hazard s s bstance, p tant, r c ntaminant, where the re ease is n r the s e s rce f the re ease is fr m, an faci it r vesse nder the j risdicti n, c st d , r c ntr f DOD r DOE, then DOD r DOE wi be the ead agenc (as appr priate). The Federa agenc maintains its ead agenc resp nsibi ities whether the remed is se ected b the Federa agenc f r n n-NPL sites, r b EPA and the Federa agenc (NPL sites), r b EPA a ne nder CERCLA secti n 1 0 (NPL site where there is n n-c nc rrence). USACE acts as ead agenc f r severa pr grams that are nder their "j risdicti n, c st d , r c ntr ." This inc des the FUSRAP and FUDS pr grams where USACE has been fficia designated as the ead agenc f r the se ecti n f the remed . USACE ma act as ead agenc at the req est f the C mmanders f r insta ati n rest rati n pr gram (IRP) sites and Base Rea ignment and C s re (BRAC) faci ities.

(b) Permit Waiver f r On-site Activities. CERCLA [Secti n 1 1(e)] and the NCP are ver specific that n Federa , state r ca permit sha be req ired f r the p rti n f an o

remova or remedia action that is cond cted entire on-site, where s ch response action is se ected and carried o t in comp iance with the ER LA process. ER LA response actions do not need to comp with administrative req irements s ch as administrative reviews, certifications, permitting, manifesting, reporting, and record keeping. However, s bstantive req irements, which are non-administrative, re ating to n merica c ean p eve s, req ired techno og , emission contro imitations, and other standards, m st be comp ied with. The permit waiver does not prec de the response action from comp ing with an ARAR n merica standard that app ies to the p anned action.

(c) Use of "To Be onsidered" (TB) Doc ments. In the process of eva ating remedia a ternatives, a ead Federa agenc ma consider other governmenta doc ments that do not rise to the eve of an ARAR. The N P [§300.400(g)(3)] does make provisions for the se of advisories, criteria, or g idance deve oped b EPA (e.g., OSWER Directives), other Federa agencies or states that ma be sef in deve oping ER LA remedies. The designation and se of TB s is a discretionar matter for the ead agenc , and it sho d be caref sed, so as not to e evate to enforceabi it those g idance or po ic statements that are not sef to s pport a decision on a remed . Genera , TB s sho d on be sed when ARARs do not exist for a site, and on if the are not inconsistent with the nine criteria mandated b ER LA for the remed se ection process.

(d) Remova Action as a Fina Remed . The genera perception estab ished b the N P and nderstood b the p b ic and the reg ators is that the remova action is an interim meas re taken to e iminate an immediate or potentia hazard to h man hea th or the environment. The remova action, to the extent practicab e, is to contrib te to the efficient performance of an anticipated ong-term remedia action with respect to the re ease of hazardo s s bstances. Un ike remedia actions, which m st comp with (or invoke or j stif a waiver) a ARARs, remova actions comp with ARARs on "to the extent practicab e considering the exigencies of the sit ation." The remova action has a n mber of proced ra req irements that do not correspond to the eve of detai that is req ired of a remedia action. A few of the major items are as fo ows:

- P b ic participation is more imited and compressed d ring a remova action.
- The remova action does not perform a comprehensive site characterization to determine nat re and extent of contamination in a media and a potentia pathwa s of expos re.
- H man and eco ogica risk assessment is genera abbreviated.
- Remova action does not genera provide a screening and detai ed eva ation of remedies.

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The N P does req ire an engineering eva ation and cost ana sis (EE/ A) for non-time critica remova actions b t it does not share some of the important feat res (freezing ARARs, site c oseo t, etc.) of the ROD for a remedia action. Therefore, a remova action is C

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not the response action of choice for a fina remed . Ho ever, here circ mstances dictate s ch an approach, e.g., time is of the essence, s bstantive CERCLA criteria for remova actions are met, and remova of the hazardo s s bstance to nrestricted se eve s does not compromise safet and is not significant more cost or time cons ming than c ean p to ess conservative eve s, a remova action to fina remed eve s ma be appropriate. If a remova action is being p anned as a fina remed , it o d be important to obtain approva from the USACE chain of command. Upon approva , the p b ic and reg ators sho d be provided ear notification of the intention for the remova action to be a fina remed . The remova action sho d identif and comp ith a ARARs that pertain to the response action as e as not take advantage of ARAR aivers as a s bseq ent remedia action o d not be anticipated. The remova action sho d inc de a comprehensive site investigation to determine the nat re and extent of contamination (e.g. soi , gro nd ater, etc.) to ens re that the se ected action protects h man hea th and the environment. The remova action sho d be fo o ed b a no f rther action record of decision to achieve site c oseo t. Remova actions taken b EPA, nder the S perf nd program, have a mone ($ mi ion) and time (1 months) imitation. If the site is not on the NPL, DOD is not necessari imited b these restrictions as the app to the se of S perf nd mone , b t based on the previo s factors, comp ex and expensive response actions sho d sti be performed as remedia actions, ith the remedia investigation, feasibi it st d , proposed p an, and record of decision in accordance ith the NCP.

b. Reso rce Conservation and Recover Act (RCRA)[4 USC 6901 et seq.].

(1) A thorit . RCRA is the primar Federa stat te reg ating the generation, transportation, treatment, storage, and disposa of so id and hazardo s aste. RCRA as enacted b Congress to req ire proper management of aste generated at existing faci ities. RCRA has kept in stride ith c rrent aste management iss es and prob ems b a of Congressiona amendments, the most notab e being the Hazardo s and So id Waste Amendments (HSWA)w Under provisions of HSWA,wCongress estab ished the a thorit for corrective action req irements at permitted or interim stat s hazardo s aste management faci ities. Mixed aste, as defined in Chapter 1, contains radioactive and hazardo s aste. A d a reg ator frame ork exists for mixed aste, ith the EPA or the RCRA-a thorized states rwg ating the hazardo s aste and the NRC or NRC agreement states, or possib DOE, reg ating the radioactive aste.

( ) App icabi it .

(a) The RCRA Corrective Action program provides EPA (or a thorized state) ith the a thorit to req ire a c rrent o ner or operator of a hazardo s aste management faci it to take corrective action at a faci it seeking a permit here there has been a re ease of a hazardo s aste or constit ent at the faci it , regard ess of hen aste as disposed of at the faci it , and to req ire ork be ond the faci it bo ndar here necessar to protect h man w

hea th and the environment. It is important to note that nder the RCR reg ations, so rce, specia n c ear materia , and b prod ct materia (as defined b the E) are express exc ded from the definition of so id waste, and, th s from reg ation nder RCR as a hazardo s waste.

(b) Over the past two decades, EP , the NRC and state agencies have identified a n mber of nat ra occ rring materia s that, beca se of h man activit , ma present a radiation hazard to peop e and the environment. This materia is ca ed techno ogica enhanced nat ra occ rring radioactive materia (TENORM). TENORM is genera defined b the Nationa cadem yof Science as "an nat ra occ rring materia not s bject to reg ation nder the tomic Energ ct whose radion c ide concentrations or potentia for h man expos re has been increased above eve s enco ntered in the nat ra state b h man activities." RCR does not genera exempt this materia from reg ation, except it exempts so id waste, inc ding TENORM prod ced from the extraction, beneficiation, and processing of ores and minera s (Bevi exc sion) and oi fie d wastes from reg ation as hazardo s wastes. Some states consider pre-1978 ore processing resid a s to be TENORM and s bject to RCR , however, US CE ho ds that these resid a s meet the stat tor definition of so rce materia and are, therefore, exempt from RCR . If the rani m and/or thori m content of the resid a s exceeds 0.05% b weight, the resid a s wo d become reg atab e so rce materia .

(3) Imp ementing Reg ations. Un ike CERCL , which imposes remediation req irements b estab ishing c ean p criteria with R Rs, the RCR remediation process has never been codified federa . Comprehensive corrective action reg ations, a so known as "the S bpart S Initiative" were proposed on 7 90, 55 FR 30798, b t were never fina ized. The objective of the proposa was to estab ish Federa corrective action standards against which state programs co d be assessed when determining whether to a thorize them to manage the RCR corrective program for their state. However, EP has since a thorized the majorit of states for corrective action, even witho t the reg ations. RCR a ows states to deve op and administer hazardo s waste programs that are at east as stringent as the Federa RCR aw.

(4) C os re. The c ean p standard for RCR c os re req ires the owner or operator of an RCR interim stat s or permitted treatment, storage or disposa faci it (TSDF) to c ose in a manner that:

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- Minimizes the need for f rther maintenance.
- Contro s, minimizes, or e iminates post-c os re re ease or migration of hazardo s waste and other hazardo s constit ents into the soi , air, or water (gro nd water or s rface).
- Protects h man hea th and the environment to the extent necessar .

One method of obtaining RCRA c o re of the TSD nit or faci it i achieved b eaving the wa te in p ace, which i referred to a c o re-in-p ace. The econd method i to remove the hazardo wa te and decontaminate an re ea e or pi to eq ipment, tr ct re , or the oi . Thi method i referred to a c o re b remova or decontamination (a o known a "c ean c o re") and wo d not eave an contamination.

(5) Corrective Action. RCRA req ire correction action for re ea e of hazardo wa te or hazardo wa te con tit ent from a o id wa te management nit (SWMU)sat TSDF with a permit and tho e eeking a RCRA permit or approva of fina c o re. For examp e, a mi itar in ta ation ma have a permit to tore hazardo wa te and wo d be bject to a corrective action if hazardo wa te wa pi ed or re ea ed from the torage area. Note that on one reg ator a thorit , either Federa or tate, ha po e RCRA corrective action a thorit . The goa of corrective action i to contro or e iminate ri k to h man hea th and the environment. Ri k-ba ed deci ion-making i ed to en re protection of h man hea th and the environment. RCRA corrective action tend to be governed b media c ean p tandard , which are imi ar to CERCLA ARAR . Media c ean p tandard are the concentration of a hazardo con tit ent that a remed m u t achieve in a pecific medi m (e.g., oi , water). A c ean p tandard ma be ba ed on prom ugated Federa or tate tandard or deve oped thro gh a ite- pecific ri k a e ment.

(6) Ri k-Ba ed C ean C o re.

(a) Thi c o re method i a b end of the RCRA c o re and the corrective action program . A treatment, torage or di po a (TSD) nit can be con idered c ean-c o ed if it meet the ri k-ba ed tandard appropriate nder CERCLA c ean p or a RCRA corrective action. Thi method draw pon the remova and decontamination a pect of RCRA c o re. EPA ti seq ire the remova of the hazardo wa te and iner nder thi method, b t it wo d not req ire that a contamination be removed. Limited amo nt of hazardo con tit ent ma remain in the media, provided the contaminant are be ow concentration that wo d pre ent a ri k to h man hea th or the environment. The econd part to thi proce i the e of ri k-ba ed tandard to determine o r c ean p eve , which determine the eve of decontamination that m u t be achieved for c o re.

(b) The permittee/re pondent ma propo e media c ean p tandard . The tandard m u t be ba ed on prom ugated Federa and tate tandard , ri k derived tandard , a data and information gathered d ring the corrective action proce (e.g., interim mea re , RCRA faci it inve tigation, etc.) or other app icab e g idance doc ment . If no other g idance exi t for a given contaminant and media, the permittee/re pondent ha propo e and j tif a media c ean p tandard. The fina media c ean p tandard are determined b the imp ementing agenc when the remed i e ected and doc mented in the Statement of Ba i /Re pon e to Comment or permit modification. It wo d be advi ab e to a wa propo e media tandard to the reg ator in tead of re ing on the imp ementing agenc to s

set the media standards for the corrective action. (Refer to M ARISSIM, ppendix F, for exp anation of CERCL and RCR process). A

c. tomic Energ ct of 1954, as amended (E) [4 USC 011 et seq.]. This ct is the f ndamenta U.S. aw on the civi ian and mi itar ses of so rce, b prod ct, and specia n c ear materia . The ct req ires that civi ian ses of n c ear materia s and faci ities be icensed, and it empowers the NRC (EC's co-s ccessor) to estab ish b r e or order, and to enforce, s ch standards to govern these ses as in order to promote the common defense and sec rit and protect hea th and safet of the p b ic. Commission action nder the ct m st conform to the ct's proced ra req irements, which provide an opport nit for hearings and Federa j dicia review in man instances. The NRC reg ator responsibi it pertains to the commercia operations invo ving radioactive materia that are not associated with n c ear weapons deve opment or research, or mi itar ses of n c ear power. Their responsibi it extends primari to the commercia power ind str , medica ind str , and other commercia app ications of radioactive materia .

(1) DOE (EC's co-s ccessor) a thorit nder the E extends to so rce materia , specia n c ear materia , and b prod ct materia nder the contro or j risdiction of the Secretar of Energ , and a imited n mber of specified programs, inc ding n c ear weapons prod ction and research re ated to nationa sec rit interests. DOE is a so the ead Federa agenc in the remediation of egac contamination at Federa faci ities that were and remain engaged in those t pes of activities.

( ) EP has the genera responsibi it for ens ring that a other Federa agencies remediate hazardo s s bstances to eve s that are protective for the p b ic and the environment. EP is provided the a thorit to iss e app icab e environmenta radiation standards to protect h man hea th and the environment from radioactive materia s in the genera environment o tside the bo ndaries of the faci ities nder the contro of the NRC.

d. Defense Environmenta Restoration Program (DERP)[10 USC 701 et seq.]. Congress created the Defense Environmenta Restoration cco nt (DER) when it enacted Section 11 of S perf nd mendments and Rea thorization ct (S R) -a so known as DERP. tho gh DER is not imited to sites on the EP NPL, per the stat te, hazardo s s bstance response activities f nded b the DER m st be carried o t s bject to, and in a manner consistent with, Section 1 0 of CERCL . DOD environmenta managers sho d be aware of the significance of that imitation, partic ar when EP or state reg ators insist the c ean p be cond cted p rs ant to RCR corrective action or state req irements other than CERCL . If reg ators demand c ean p efforts that are inconsistent with CERCL Section 1 0, DER f nds wi not be avai ab e to s pport those activities. District ega co nse sho d be a part of the project de iver team when addressing which c ean p a thorit sho d be fo owed. DERP does not app to Civi Works faci ities in accordance with DOD po ic . A

(1) It is important to note that the DERP stat te [10 USC 705] req ires that EPA and appropriate state and oca a thorities m st receive prompt notice from DOD nder the fo owing conditions:

- Discover of re eases or threatened re eases of hazardo s s bstances at a faci it .
- The extent of the threat to p b ic hea th and the environment that ma be associated with an s ch re ease or threatened re ease.
- Proposa made b the Secretar to carr o t response actions with respect to an s ch re ease or threatened re ease.
- The initiation of an response action with respect to s ch re ease or threatened re ease and the commencement of each distinct phase of s ch activities.

( ) The DERP stat te req ires that EPA and state and oca a thorities sha have an adeq ate time to comment on notices and proposa s for response actions (remova or remedia) and that investigations and c ean p actions be consistent with CERCLA and the NCP. The DERP stat te a so req ires that the program be carried o t in cons tation with EPA (10 USC 701).

e. Arm yReactor Program. The Arm yReactor Program has designated USACE as responsib e for n c ear reactor engineering, design, constr ction, and decommissioning design and imp ementation. USACE is a so responsib e for assisting, when req ested, in comp iance and environmenta restoration projects for deactivated reactors. The Department of Arm y, nder the provisions of the AEA (Section 110), se f reg ates nder the Arm y Reactor program. The Arm y's reactor po ic is to "fo ow to the maxim m extent possib e, the reg ations of the U.S. N c ear Reg ator Commission and the recommendations of the Nationa Co nci of Radiation Protection and Meas rements" (AR 50-7). The Arm yReactor Program is designed to ens re that Arm yreactors are designed, constr cted, operated, maintained, and decommissioned per U.S. nationa standards. When NRC reg ations and Arm yReactor reg ations prescribe the same or simi ar req irements, the NRC reg ations wi be fo owed with notifications thro gh command channe s. If an Arm yreactor is a so NRC icensed, then the NRC reg ations wi be fo owed with doc mentation provided to the Arm yReactor Office.

9-3. Ro es and Responsibi ities for Reg ating Radioactive Materia .

a. Federa Agencies.

(1) EPA's radiation protection responsibi ities originate from both the AEA and severa environmenta stat tes. Under Reorganization P an No. 3, which became aw on December 1970, EPA was made responsib e for estab ishing app icab e environmenta standards for the protection of the genera environment from radioactive materia . EPA was provided the research, monitoring, prom ugating reg ations, and enforcement a thorities for [

media-specific chemica and radioactive po tants. Ho ever, the transfer of radiation protection responsibi ities to EPA as more imited than other po tants beca se the Atomic Energ Commission (AEC) retained the responsibi it for imp ementing and enforcement of radiation standards. Under the AEA, these standards ere defined as " imits on radiation expos res or eve s, or concentrations or q antities of radioactive materia in the genera environment o tside the bo ndaries of the faci ities that ere reg ated b the AEC" (ater became the NRC).

(a) It is important to note that over the 30 ears of existence, EPA has gained or asserted enforcement a thorit for some radioactive materia s nder severa environmenta stat tes that Congress passed s bseq ent to the AEA. Thro gh enactment of ne stat tes (e.g., C ean Air Act, Safe Drinking Water Act, CERCLA), EPA has been given additiona responsibi it to reg ate certain activities or aspects of radioactive materia s. EPA has estab ished m utip e offices ithin their agenc that ma be responsib e for imp ementing reg ations, depending on the environmenta media and stat te. When USACE is exec ting a radioactive or mixed aste restoration project, it is important to nderstand hich EPA offices are administering the different imp ementing reg ations.

(b) A comprehensive exp anation of the stat tor a thorities of EPA and the individ a offices responsibi ities ma be fo nd in Appendix C of MARSSIM. An additiona p b ication that disc sses EPA's a thorities and responsibi ities for the past three decades is EPA 40 -B-00-001.

( ) The NRC is an independent reg ator agenc , created b the Energ Reorganization Act of 1974. Congress abo ished the AEC and made the NRC responsib e for ens ring the protection of the p b ic's hea th and safet in association ith the operation of commercia n c ear po er p ants and f e c c e p ants, medica , ind stria , and research app ications of n c ear materia s. Their a thorit inc des protecting the p b ic's hea th and safet as e as the environment ith the storage, transportation, and disposa of n c ear materia s and aste.

(a) NRC iss ed reg ations estab ishing standards for the decommissioning of faci ities reg ated nder NRC icenses. These standards are main codified at 10 CFR Part 0, S bpart E, and provide radio ogica criteria for termination of icenses. The app to faci ities decommissioned nder 10 CFR Part 30, governing the icensing of b prod ct materia s, Part 40, governing the icensing of so rce materia , and Part 70, governing the icensing of specia n c ear materia . The criteria are exc ded from app ication to rani m and thori m recover faci ities s bject to 10 CFR Part 40, Appendix A.. The decommissioning standards estab ish criteria for icense termination ith nrestricted se, icense termination nder restricted conditions, and a o the s bmission of a ternate criteria for icense termination. A faci it is considered to be acceptab e for nrestricted se if w resid a radioactivit exceeding backgro nd res ts in a tota effective dose eq iva ent

(TEDE) of 5 mi irem (mrem) per ear, inc din ro nd water so rces of drinkin water, and m ust f rther red ce resid a radioactivit to ALARA eve s. The req irement for an ALARA ana sis is provided in 10 CFR Section 0.140 and 0.1403, b t this new section provides that this ana sis m ust a so consider detriments from decontamination and waste disposa , s ch as deaths from transportation accidents. A faci it wi be considered acceptab e for restricted se if the eve s of resid a radioactivit are ALARA, there are e a enforceab e instit tiona contro s that wi ass re the TEDE wi not exceed 5 mrem per ear and wi not impose nd e b rdens on the oca communit , and, if the instit tiona contro s fai , the TEDE is ALARA b t not more than 100 mrem per ear.

(b) Projects not re ated direct b NRC, ma be s bject to CERCLA or RCRA. The NRC re ations ma not be "app icab e" b t nder CERCLA, the ma be "re evant and appropriate" and sed to deve op c ean- p eve s. The NRC standard tit ed, "Radio o ica Criteria for License Termination," 10 CFR Part 0, S bpart E, ma be re evant and appropriate for sites that were previo s icensed or hand ed a icensab e t pe of radioactive materia . It ma a so be an ARAR if it is we s ited to the partic ar site in accordance with Section 1 1 of CERCLA and the NCP. This re ation ses a dose assessment to estab ish criteria for icense termination and re ease of the propert . For nrestricted re ease of propert , the acceptab e tota effective dose eq iva ent (TEDE) is 5 mrem/ ear above back ro nd and as ow as is reasonab achievab e (ALARA).

(c) NRC a ows a part to propose a ternate criteria for decommissionin if it is protective of p b ic hea th and the environment, and the dose from a man-made so rces combined, except medica , wo d be no more than 100 mrem per ear. The a ternative m ust inc de instit tiona contro s as described in Section 1403, and achieve ALARA eve s sin the ana sis described above. A icensee m ust s bmit a p an, demonstrate p b ic participation in the deve opment of the p an, and obtain approva from the Commission based on NRC staff recommendations.

(3) The DOE is responsib e for deve opin and imp ementin a nationa ener po ic and for deve opin new ener so rces for domestic and commercia so rces. DOE is a so responsib e for mana ement of the U.S. n c ear weapons pro ram and prod ction faci ities and obtains its basic a thorities from the AEA of 1954. The DOE n c ear weapons pro ram responsibi ities encompass the Stockpi e Stewardship Pro ram (now hand ed b the Nationa N c ear Sec rit Administration within DOE), mana ement of ow and hi h- eve radioactive wastes enerated b past n c ear weapons and research pro rams, and for constr ctin and maintainin a repositor for civi ian radioactive wastes enerated b commercia n c ear reactors. DOE deve ops its own standards nder the a thorit of the AEA b iss in DOE orders, and is responsib e for enforcin their standards as we as EPA re ations at DOE faci ities.
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(a) DOE provides for the frame ork for DOE environmenta management in DOE Order 450.1 b estab ishing environmenta protection req irements, a thorities, and responsibi ities for their operations. DOE comp ies ith app icab e Federa , state and oca environmenta protection a s and reg ations, exec tive orders, and DOE po ic and g idance.

(b) DOE restricts off-site management of radioactive mixed aste thro gh DOE Order w 5400.5. A radioactive astes and mixed aste m st be disposed of at a DOE faci it , n ess DOE grants a specific exemption for that aste. If granted an exemption, mixed aste can be treated off-site at a icensed commercia TSD faci it that has the req ired RCRA permit and a NRC or state icense for the radion c ides being shipped.

(c) Specific req irements on the management of radioactive aste materia are contained in DOE Order 435.1. The DOE order is meant to ens re that a DOE radioactive aste is managed in a manner that is protective of ork and p b ic hea th and safet , and the environment.

(d) M ch of the DOE 5400 series orders have been codified at 10 CFR 835.

b. State Invo vement. Under CERCLA, EPA does not a thorize states to administer the program. Ho ever, states ma prom ugate their o n "mini" CERCLA-t pe a s. It sho d be recognized that these are strict state a s and do not preempt the a thorities of EPA or other Federa agencies nder CERCLA. CERCLA does inc de man provisions for cons ting ith and comment b state officia s regarding response actions. In partic ar, Section 1 1(f) provides a ist of CERCLA response phases in hich the state is req ired to be given an opport nit for meaningf invo vement. Section 1 0(a)(4) provides that, for c rrent Federa faci ities not isted on the NPL, state a s regarding remova and remedia actions are app icab e to response actions cond cted at s ch faci ities. There are provisions in Section 1 1 regarding state ARARs, and re ief from state a s that exceed ARARs or are not app ied consistent to Federa and other faci ities. Section 1 1(e) provides that Federa , state, and oca permits are not req ired for response actions cond cted on the CERCLA site, b t that the s bstantive req irements that o d other ise be app icab e sha be met in providing for remova or remedia actions. The NCP provides that this permit aiver app ies to NPL sites, and a so to other response actions ed b Federa agencies. The a thorit to se ect the ead agenc remed is not s bject to state conc rrence or non-conc rrence nder an a , reg ation, or exec tive order. The precise determination of state a thorit i depend on a partic ar fact a circ mstance and m st be revie ed b agenc co nse on a fact-specific basis. The state is expected to have a meaningf opport nit for cons tation ith the ead agenc thro gho t the response process, and state a s m st be identified and considered and their s bstantive standards and req irements comp ied ith, b t their approva or permits that might other ise be req ired are not necessar before a ead Federa w agenc proceeds ith necessar response actions.

c. LLRW Compacts. In 1980, Con ress passed the Low-Leve Radioactive Waste Po ic Act to enco ra e states to deve op ow- eve radioactive waste disposa faci ities or to enter into re iona compacts amon severa states to deve op faci ities to serve the member states. There are c rrent ten re iona compacts, and additiona states that remain naffi iated. Each compact assi ns a host state the first ten re, t pica 0 ears, for disposin of LLRW. Compacts ma a so enter into a reements with other compacts to dispose of their waste. At the time the Act was passed, there were three operationa LLRW disposa sites in the co ntr , Rich and, Washin ton, Beatt , Nevada, and Barnwe , So th Caro ina. Since that time, the Beatt faci it has c osed and one new faci it was opened in Utah. The Utah faci it , which is not affi iated with the Compact s stem, accepts C ass A LLRW nationwide, s bject to the waste meetin its waste acceptance criteria nder its operatin icenses. The Rich and faci it accepts waste on from its own compact (the Northwest compact) and the Rock Mo ntain compact. The Barnwe faci it is the on faci it acceptin C ass A, B, and C waste from o tside the compact to which it be on s. However, nder state aw, the Barnwe faci it is in a 6- ear process to ramp down the amo nt of waste that ma be accepted from o tside the At antic Compact states. After 30 ne 008, the Barnwe faci it ma on accept LLRW from the At antic Compact states. This is a si nificant concern for f t re disposa of hi her activit LLRW (C ass A, B, or C) from decommissionin or CERCLA response actions.

(1) Compacts ma prohibit the disposa of LLRW from o tside the member states in certain circ mstances, or char e increasin s rchar es from states that have neither deve oped their own disposa faci it nor entered into a compact that deve ops a disposa faci it , s bject to emer enc a thorit in the NRC to rant access to a icensed compact faci it if necessar to e iminate an immediate and serio s threat to the p b ic hea th and safet or the common defense and sec rit [4 USC 0 1e and 0 1f.] The stat te specifica a ows a compact faci it to ref se to accept for disposa materia identified nder the FUSRAP or ma accept the materia for disposa s bject to meetin their waste acceptance criteria nder their NRC/A reement State icense. The Act does state that the Federa overnment is responsib e for disposa of LLRW enerated b DOE, decommissionin Nav vesse s, or waste enerated b atomic weapons research, testin , or prod ction.

( ) Compacts ma state that, for waste to be sent o t of their compact, the DOD m st have permission. This iss e m ust be coordinated with the District and HTRW-CX Office of Co nse to determine if there is a stat tor req irement to obtain permission for the LLRW to be sent to a disposa faci it o tside the Compact where the LLRW is enerated. The c stomer ma req est that USACE obtain this permission, even tho h it is determined to not be app icab e.
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d. Significant Memorand ms of Understanding MOUs).

1) The NRC and USACE signed an agreement on 5 001 to temporari s spend NRC icenses on FUSRAP sites that were to be remediated to nrestricted eve s, and to minimize d a reg ation and d p ication of reg ator req irements at NRC- icensed faci ities. At the written req est of USACE, NRC wi initiate action for the s spension of the NRC icense or portions of the icense for a FUSRAP site to be remediated b USACE nder CERCLA a thorit . USACE takes temporar contro and responsibi it for radiation contro and for ens ring p b ic hea th and safet d ring the CERCLA response action. Upon comp etion of the response action, NRC wi reinstate the icense for the faci it . For activities where a potentia d a reg ation co d exist, the two agencies agree to cooperate, share information, and coordinate activities in their respective programs. USACE, as provided for in section 1 1 e) of CERCLA and 40 CFR 300.400 3), is not req ired to obtain an NRC icense for its on-site remediation activities cond cted nder its CERCLA a thorit . The NRC ma observe, as it deems warranted, remediation activities being cond cted b USACE and ma iss e comments or q estions arising from their observations of the USACE response action. USACE agrees to remediate the icensed site to meet at east the req irements of CERCLA and of 10 CFR 0.140 . The ARARs in the fina exec ted ROD wi inc de 10 CFR 0.140 or a more stringent req irement.

) The NRC and EPA signed an agreement on 9 October 00 on the radio ogica decommissioning and decontamination of NRC- icensed sites. The MOU wi defer EPA's a thorit nder CERCLA for most of the NRC icensed sites that are being decommissioned nder NRC a thorit . The MOU inc des provisions for NRC and EPA to cons t abo t certain sites when, at the time of icense termination 1) gro nd water contamination exceeds EPA-permitted eve s MCLs),) NRC contemp ates restricted re ease or se of a ternate criteria at the site, and 3) resid a radioactive soi concentrations exceed eve s defined in Tab e 1 of the MOU for residentia or ind stria and commercia f t re and se.

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9-4. Other Major Environmenta Stat tes and Reg ations.

a. Urani m Mi Tai ings Radiation Contro Act of 1978 UMTRCA) [4 USC 7911 et seq.]. In the 1940's, the U.S. government began to p rchase rani m for the atomic weapons program. Large q antities of rani m mi ing tai ings, the waste b prod ct of the extraction of rani m from ore " e owcake prod ction"), were generated in the processing of the ore to obtain the(rani m meta . The mi tai ings sand- ike materia) were stored in s rface impo ndments pi es) predominant in the western United States where the ore was mined. Historica , rani m mi tai ings were not covered nder the AEA since the were not considered to be hazardo s. Testing of the mi tai ings indicated the were high contaminated with radion c ides Ra- 6) and inorganics arsenic, mo bden m, and se eni m). The mi tai ings were not reg ated nti the passage of the Urani m Mi Tai ings Radiation Contro Act UMTRCA) in 1978. Section 75 of the AEA, as amended (

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b Section 06 of UMTRCA, irecte EPA to set genera app icab e hea th an environmenta stan ar s to govern the stabi ization, restoration, isposa , an contro of eff ents an emissions at both active an inactive mi tai ings sites. Tit e I of the Act covers inactive rani m mi tai ing sites, epositor sites, an vicinit properties. It irects EPA, DOE, an NRC to o the fo owing:

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- EPA m ust set stan ar s that provi e protection that is as consistent with the req irements of RCRA as possib e. The stan ar s m ust inc e gro n water protection imits.
- DOE m ust imp ement EPA's stan ar s for the tai ings pi es an nearb properties an provi e perpet a care for some properties.
- NRC m ust review comp ete site c ean ps for comp iance with EPA stan ar s an icenses iss e for the site to the state or DOE for perpet a care.
- Tit e II of the Act covers the operating rani m processing sites icense b the NRC. EPA was irecte to prom ugate isposa stan ar s in comp iance with S btit e C of the So i Waste Disposa Act, as amen e , to be imp emente b NRC or the Agreement States.
- UMTRCA app ies to resi a ra ioactivit at NRC- icense rani m mi sites an at specifica iste inactive mi sites (sites esignate b Congress an sites b DOE).

Tho gh not "app icab e" to FUSRAP sites that are n ergoing a CERCLA response action, these reg ations ma be consi ere "re evant an appropriate" to on-site actions invo ving rani m or thori m mi tai ings at some of the FUSRAP sites.

(1) 40 CFR 19 . EPA prom ugate these reg ations in an ar 1983 to a ress the inactive tai ing sites that q a ifie for reme ia action n er Tit e I of UMTRCA. The reg ations were written to contro the risks from fo r principa environmenta pathwa s:

- Diff sion of ra on- , the eca pro ct of ra i m- 6, from tai ings into in oor air.
- Direct expos re to gamma ra iation that res ts from man of the eca pro cts in tai ings (ea - 14, bism uth- 14, tha i m- 10).
- Dispersa of sma ra ioactive partic es into the air b win erosion of n-stabi ize tai ing pi es.
- Waterborne transport of ra ioactive an toxic (heav meta s) materia b erosion, win or eaching to the s rface an gro n water.

(a) S bpart A of 40 CFR 19 contains esign req irements for the contro of isposa areas for tai ings, res ting from processing or extraction of rani m, that are ocate at the processing site or a jacent properties. The contro mechanism m ust be effective for a minim um of 00 ears an p to 1000 ears to the extent reasonab achievab e. Re eases d

from radon- to the atmosphere m st not exceed 0 pCi/m This reg ation a so contains gro nd water protection req irements for disposa sites

(b) S bpart B of §19 contains c ean p standards for and and b i dings and adjacent properties contaminated with resid a radioactivit from processing ore for rani m The soi c ean p eve s are for resid a radioactive materia s from a processing site not to exceed a concentration of radi m- 6, averaged over an area of 100 sq are meters, of 5 pCi/g above backgro nd averaged over the first 15 centimeters of soi be ow the s rface, and 15 pCi/g above backgro nd over 15 centimeter a ers of soi be ow the first 15 centimeters of soi This reg ation does not app to sites owned or contro ed b a Federa agenc after 1978 or to a site that is c rrent NRC icensed or had a NRC icense in 1978 or thereafter The standard inc des req irements for occ pied or habitab e b i dings and req ires that the remedia action achieve an ann a average (or eq iva ent) radon deca prod ct concentration (inc ding backgro nd) not to exceed 0 0 Working Leve (WL), which is defined in the reg ations In addition, the gamma radiation eve sha not exceed backgro nd b more than 0 microroentgens per ho r Gro nd water be ow the processing site and nearb areas with resid a radioactive materia s sha be monitored to ens re that the eve s of constit ents specified in S bpart A are not exceeded

(c) S bpart C of §19 addresses the imp ementation of S bparts A and B and contains req irements for app ing site-specific s pp ementa standards in ie of strict comp iance with S bparts A and B in imited circ mstances An genera standard ma be changed if there is a c ear and present risk of inj r to workers or the p b ic, despite reasonab e protective meas res, from comp iance with the genera standards The standards for and, gro nd water, or s rface contro ma be changed if remedia actions taken to meet standards wo d prod ce hea th and environmenta harm that is ong-term and gross disproportionate to hea th and environmenta benefits that ma reasonab be anticipated The standards ma be changed if the estimated cost of remedia action to satisf soi c ean p eve s at a "vicinit " site is nreasonab high re ative to the ong-term benefits, and the resid a radioactive materia s do not pose a c ear present or f t re hazard In sit ations where radion c ides, other than radi m- 6 and its deca prod cts, are present in s fficient q antit and concentration to constit te a significant radiation hazard, the remedia action sha red ce other resid a radioactivit to eve s that are as ow as is reasonab achievab e and conform to the standards of s bparts A and B to the maxim um extent possib e S pp ementa standards for gro nd water m st preserve a c rrent and reasonab projected f t re ses of the water UMTRCA req ires that both the genera standards and the imp ementation of them be deve oped on the basis of an ana sis of the reasonab eness of the benefits compared to the economic and environmenta costs

(d) S bpart D to §19 contains criteria for restoration of icensed rani m b prod ct processing and disposa areas Standards for c os re of b prod ct disposa areas are provided The disposa area sha inc de a radon barrier to imit re eases of radon- to 0 .

pCi/m per second averaged over the entire impo ndment or a design i e o 1000 ears, to the extent reasonab achievab e, b t no ess than 00 ears. This standard does not app areas that req ire c ean p to the and standard (5/15 pCi/g) or radi m- 6.

(e) S bpart E to §19 contains criteria or restoration o ficensed thori m b prod ct processing and disposa areas. The standards govern aci ities icensed or thori m processing and their b prod ct disposa sites, and genera se the same standards as rani m processing and disposa areas, which req ire a permanent radon barrier to imit re ease o radon- 0 and radi m- 8.

( ) 10 CFR 40, Appendix A.

(a) The NRC has estab ished criteria in 10 CFR 40, Appendix A, or the operation o active icensed rani m and thori m mi s and the disposition o tai ings or wastes prod ced b the extraction or concentration o so rce materia (rani m and thori m) rom ores processed primari or their so rce materia content. This reg ation is o interest primari or sit ations where USACE wo d be per orming a CERCLA remediation and it was determined to be "re evant and appropriate" or a mi ing site or mi tai ings site that was inactive prior to the enactment o UMTRCA where b prod ct materia s were managed and radion c ides other than radi m in soi are present, and where b i ding s r aces are contaminated. This criterion ses a benchmark dose derived sing site conditions and the ass mption that 5 pCi/g radi m above backgro nd is present in the top 15 centimeters and is present at 15 pCi/g above backgro nd in the s bs r ace. The benchmark dose is then back ca c ated to derive concentrations o the radion c ides to which the criterion is being app ied. Norma , radion c ides that this criterion wi be re evant and appropriate or wi be tota rani m and thori m- 30.

(b) This reg ation covers more activities than the EPA UMTRCA standards, b t the con orm to the EPA UMTRCA standards or comparab e activities. It is important to note that the NRC considers mi ing wastes to inc de eq ipment and piping that was sed or processing the ore. B prod ct materia is disposed o in frani m mi tai ings impo ndments, s bject to meeting NRC reg ations. The NRC reg ation provides more radio ogica criteria on the decommissioning o icensed rani m and thori m mi s. The NRC reg ation ses the existing 5/15 pCi/g soi radi m standard to derive a dose criterion (benchmark approach) or the c ean p o b prod ct materia other than radi m in soi or s r ace activit on str ct res and and. The NRC standard provides a reg ator basis or determining the extent to which ands and str ct res at rani m and thori m mi s m st be remediated be ore decommissioning o a site can be considered comp ete and the icense terminated.

b. C ean Air Act (CAA) [4 USC 7401 et seq.]. The CAA standards ca ed "Nationa Emissions Standards or Hazardo s Air Po tants" (NESHAPs) imit the a owab e eve o air emissions o radion c ides, other than radon- and radon- 0, rom aci ities owned or f

operated b DOE and from Federa faci ities not o ned or operated b DOE or icensed b the NRC. EPA has prom ugated imp ementing reg ations for the contro of hazardo s air po tants (HAP) from major and area so rces in 40 CFR 61. CERCLA response actions often times identif NESHAPs as a potentia ARAR hen c ose examination of the app icabi it of the reg ation revea s that it does not pertain to the activit . It is important to note that EPA has proposed a NESHAP reg ation for the categor entit ed "Site Remediation" (67 FR 49398) on 30 00 for the contro of HAP emissions to the ambient air. Ho ever, a fina r e o d sti have to be prom ugated before NESHAPS are estab ished for remediation activities. The potentia NESHAP s bparts that ma app nder imited scenarios are as fo o s:

- S bpart H - Nationa Emission Standards for Emissions of Radion c ides Other Than Radon From DOE Faci ities (does not app to §§191 or 19 faci ities).
- S bpart I - Nationa Emission Standards for Radion c ide Emissions From Federa Faci ities Other Than NRC Licensees and Not Covered b S bpart H (does not app to §191, S bpart B or §19 mi tai ing pi es).
- S bpart Q - Nationa Emission Standards for Radon Emissions From Department of Energ Faci ities (does not app to Tit e I faci ities of UMTRCA b t does app to a specific ist of DOE faci ities).
- S bpart T - Nationa Emission Standards for Radon Emissions From the Disposa of Urani m Mi Tai ings.

(1) These reg ations req ire that emissions of radion c ides to the ambient air sha not exceed those amo nts that o d ca se an member of the p b ic to receive in an ear an effective dose eq iva ent of 10 mrem. A so, for non-DOE Federa faci ities, emissions of iodine sha not exceed those amo nts that o d ca se an member of the p b ic to receive in an ear an effective dose eq iva ent of 3 mrem/ ear. The o ner or operator of faci ities covered b these reg ations m ust s bmit an ann a report regarding emissions to EPA b 31 March of the fo o ing ear.

( ) Tit e V of the CAA req ires operating permits for a major so rces (40 CFR 70). Some decommissioning activities, s ch as hazardo s and mixed aste treatment, storage, and disposa nits, ma req ire Tit e V permits beca se of radion c ide emissions. Additiona , some activities (inc ding treatment of mixed aste) ma emit eno gh other reg ated po tants (e.g., vo ati e organic compo nds and ead) to q a if as a major so rce. A Tit e V permit o d not be req ired on a CERCLA response action beca se of the permit aiver [CERCLA, Section 1 1(e)]. Beca se Tit e V is a proced ra req irement (administrative) and not a s bstantive req irement, the CERCLA response action o d not need to comp for on-site activities.

c. Safe Drinking Water Act (SDWA) [4 USC 300f et seq.]. The SDWA req ires EPA to prom ugate and enforce primar standards for contaminants in p b ic ater s stems, w

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inc ding radion c ides. The 1986 amendments re ired EPA to deve op maxim um contaminant eve goa s (MCLGs) and maxim um contaminant eve s (MCLs). In 1991, EPA proposed a revision to raise the MCLs for combined radi m- 6 and radi m- 8 from 5 pCi/L to individ a MCLS of 0 pCi/L for each isotope. After f rther eva ation, EPA decided to retain the c rrent combined radi m- 6/ 8 eve of 5 pCi/L based on risk to h mans (65 FR 76708). Under the 1996 amendments to the SDWA, EPA is re ired to ens re that an revision to a drinking water reg ation maintains or provides for greater protection of the hea th of persons. The EPA r e (prom ugated 7 December 000) becomes effective in December 003 and estab ishes the rani m MCL at 30 µg/L. The gross a pha (exc ding rani m and radon b t inc ding radi m- 6) remained at the c rrent eve of 15 pCi/L. The beta partic e and photon radioactivit MCL was a so retained at the eve of ess than or e a to 4 mrem/ ear to the tota bod or an given interna organ.

(1) When determining c ean p criteria for contaminated gro nd water, MCLs estab ished nder the SDWA ma be considered ARARs that m st be attained b the se ected remed , if the affected gro nd water is a c rrent or potentia drinking water so rce. CERCLA, Section 1 1(d)( )(A) and (B), provides that standards deve oped nder the SDWA and the C ean Water Act ma be re evant and appropriate, depending on the designated or potentia se of the water, the p rposes for the criteria, and the atest information. Radioactive s bstances' MCLs are app icab e to communit water s stems, which are defined b EPA as 15 service connections sed b ear ro nd residents or reg ar serves at east 5 ear-ro nd residents. For non-comm nit water s stems, the radioactive s bstances' MCLs ma sti be considered re evant and appropriate if the water is an act a or potentia so rce of drinking water.

( ) In addition to MCLs, maxim um contaminant eve goa s (MCLGs) estab ished nder the SDWA are sometimes designated as ARARs for the response action. Beca se the SDWA has a MCLG of zero for a radion c ides, it is important to note the NCP states MCLGs can on be considered ARARs when non-zero concentrations are estab ished.

(3) Some states have aws or reg ations that estab ish a niversa non-degradation standard for gro nd water. This has the effect of estab ishing backgro nd as the standard to be achieved if the aw or reg ation is considered an ARAR for the gro nd water remed . In practice, satisf ing a non-degradation standard is fre ent not technica practicab e or achievab e. If information is deve oped that demonstrates technica impracticabi it , then a waiver of the ARAR nder the NCP provisions wo d be possib e.

(4) For radioactive or mixed waste remediation, where the NRC decommissioning standard is an ARAR, then gro nd water m st a so be considered in the a -pathwa s ana sis of dose. The gro nd water expos re co d ead to more restrictive c ean p eve s than the MCLs, or additiona restrictions ma be necessar to contro expos re. On some sites there ma be no gro nd water pathwa , so the expos re from gro nd water wo d not be inc ded. q

If there are no ARARs for contaminated gro nd ater at a site, then the risk assessment process sho d be sed to deve op c ean p eve s.

d. C ean Water Act (CWA) [33 USC 1 51 et seq.]. The Federa Water Po tion Contro Act common kno n as the C ean Water Act (CWA) is the principa a governing the restoration and protection of the nation's streams, akes, and est aries. The CWA's principa objectives are to prohibit discharges of po tants into U.S. navigab e aters, except in comp iance ith a permit, and achieve an interim goa of protecting ater q a it for fish, i d ife, and recreationa ses. The CWA estab ished severa reg ator programs, standards, and p ans for the prevention, red ction, and e imination of po tion in the nation's ater, hich inc de the fo o ing:
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- Nationa Po tant Discharge E imination S stem (NPDES) Program that estab ishes an eff ent permit s stem for point so rce discharges into navigab e aters. The NPDES storm ater program is designed to prevent discharge of contaminated storm ater into navigab e aters. The NRC reg ates discharges of materia s s bject to the AEA.
- Nationa and Loca Pretreatment Standards that req ire ne and existing ind stria sers to sers to pre-treat their aste ater prior to discharging to a P b ic O ned Treatment Works (POTW) to prevent po tants from over oading a POTW or interfering ith the operation of the treatment faci it .
- Dredge or Fi Discharge Permit Program that estab ishes a permit s stem administered b USACE to contro the p acement of dredge or fi materia in aters of the United States, inc ding et ands.
- Se age S dge Use and Disposa Program that protects h man hea th and the environment hen POTW s dge is managed or disposed of.

(1) The NPDES req ires a discharges to the aters of the United States to comp ith certain po tant discharge criteria. The term "po tant" inc des "radioactive materia s, except those reg ated b the AEA." Radioactive materia that is covered b the AEA inc des so rce, b prod ct, and specia n c ear materia . The NPDES reg ations specifica prohibit radio ogica discharges: "No permit ma be iss ed for the discharge of an radio ogica , chemica , or bio ogica arfare agent or high- eve radioactive aste."

( ) EPA has the a thorit nder the CWA to reg ate radioactive materia s not specifica addressed nder the Atomic Energ Act. In partic ar, the CWA provided EPA the a thorit to imit iq id discharges of TENORM into s rface aters from mines or mi s sed for the prod ction of rani m, radi m, and vanadi m.

e. Nationa Environmenta Po ic Act (NEPA) [4 USC 43 1 et seq.]. NEPA as enacted on 1 an ar 1970 to ens re that Federa agenc decision-making takes environmenta factors into consideration. NEPA is genera on app icab e to Federa agencies and Federa actions n ess a state, oca , or private entit is invo ved ith Federa

f nding or actions. C ose coordination with the istrict Office of Co nse is essentia when determining whether NEPA is a req irement for the response action p anned to address a radioactive contaminated site. Un ike other environmenta aws, NEPA is a proced ra req irement and does not contain specific enforcement provisions; EPA does not have enforcement a thorit nder NEPA. NEPA req ires the preparation of Environmenta Assessments (EA) or Environmenta Impact Statements (EIS), or both, for an project that wi have a major impact on the environment. This wo d potentia inc de decommissioning activities nder the j risdiction of OE, NRC, and O (e.g., Arm y Reactor Program).

(1) Individ a actions, s ch as decommissioning faci ities, are to be eva ated to determine the eve of NEPA review needed. The NEPA process begins with a determination of whether the "proposed action" is s bject to NEPA comp iance. If the determination is made that the action cannot be categorica exc ded from the EA, or EIS, the first step is to prepare the EA. The EA he ps to determine if an agenc needs to prepare an EIS or if the agenc can make a finding of no significant impact (FONSI).

( ) It is important to note that on 3 an ar 1995, the epartment of stice (O) made a decision that a Federa agenc is not req ired to independent imp ement NEPA at CERCLA c ean p sites. The O decision stated that the CERCLA process incorporates man of the NEPA va es of p b ic participation and co ection of environmenta and h man hea th impacts that res t from proposed Federa action. It is Arm ypo ic that response actions imp emented in accordance with CERCLA or RCRA are not ega s bject to NEPA and do not req ire separate NEPA ana sis [3 CFR 651.5]. However, the CERCLA and RCRA response actions sho d incorporate the proced ra req irements of NEPA, which inc de f and open p b ic participation, ana sis of a reasonab e a ternative remedies, eva ation of the significant impacts of the st died a ternatives, and consideration of p b ic comments when se ecting the remed .

f. Toxic S bstances Contro Act (TSCA) [15 USC 601 et seq.].

(1) Contaminated sites that have po ch orinated biphen s (PCBs) comming ed with radion c ides can create a sit ation of d a reg ation. TSCA does not preempt other more stringent Federa stat tes and reg ations (e.g., AEA), b t it sti needs to be considered. EPA has estab ished reg ations for the c ean p of PCB contamination that m st be considered in conj nction with the app icab e radioactive standards. C ean p criteria for PCB remediation waste are fo nd in 40 CFR 761.61. The concentrations of PCBs m st be within a imited range and the appropriate contro s m st be in p ace to protect the p b ic and environment from expos re or re ease. However, a CERCLA response action m st meet the thresho d criteria of being protective of h man hea th and the environment and comp with ARARs, and the radioactive waste ma not be appropriate for on-site disposa . PCBs D comming ed with radioactive materia wi t pica req ire the off-site disposa at a faci it

that is icensed and permitted to accept the remediation waste. For examp e EPA has prom ugated an exemption for ow- eve mixed waste for storage and treatment (40 CFR 66). The waste is not considered RCRA hazardo s waste if it meets the conditions of the exemption. The ow- eve mixed waste m ust be disposed of into a icensed ow- eve radioactive waste disposa faci it b t it m ust meet the LDRs beca se it is being p aced in a and disposa faci it .

( ) Mixed waste can f rther comp icate the reg ator req irements for the disposa of materia having ow concentrations of PCBs that ma not even be reg ated nder TSCA. PCBs are not a RCRA hazardo s waste; however mixed waste must meet the Land Disposa Restrictions (LDRs) before it can be and disposed. For certain t pes of RCRA hazardo s wastes there is a req irement to comp with the niversa treatment standards for the nder ing hazardo s constit ents which does inc de a treatment standard for PCBs. There ma be a RCRA treatment standard for PCBs even tho gh waste is not a RCRA hazardo s waste and comp ies with TSCA. EPA recognized the disparit between TSCA and RCRA and has p t into practice a temporar deferra for specific RCRA hazardo s wastes (meta s: arsenic bari m cadmi m ,chromi m ead merc r se eni m and si ver) that contain ess than 1000 ppm of PCBs. As this req irement is ess stringent than previo s prom ugated RCRA reg ation this m ust be adopted in the RCRA a thorized states to be effective.

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9-5. S mmar of Radiation Standards. In the deve opment of c ean p criteria it is important to nderstand the reg ations that govern the response action. The reg ator a thorit m ust be estab ished to determine what the potentia standard or n merica imit is for the media of concern. Tab e 9-1 provides a s mmar of the reg ations that might app to an environmenta restoration processing or disposa operation. ,

Tab e 9-1
Major Radiation Standards S mmar Tab e

Reg ation A	genc	Standard/N merica Limit
Genera P b ic (10 CFR 0.1301)	NRC	Tota Effec ive Dose Equ iva ent A (TEDE): 100 mrem/ ear
Ura mi tai (40 CFR 190 & 10 CFR 40 pp. A NRC A	EPA &	RaA6/ A8: A5 pCi/g (s rfa e) 15 pCi/g(s bs rfa e) RnAA 0 p C m se NRC stand d des benc mark dose for ther ra ies
High e A wa te per a ions (10 CFR 60)	NRC A	100 m rem/ ear
Low A wa te disposa (10 CFR 61)	NRC A	nn a effec ive dose 5 mrem to the whole body 75 mrem to the thyroid, and 5 mrem to any other organ
Eff A ent emissions 10 CFR 0	NRC	Radion e in ir spe ific emissions, in ppen x B A >A50 m rem/ ear
Dri ing wa er (40 CFR 141) A	EPA A	Radium: A 5 pCi/L A Gross Alpha 15 pCi/L (excludes U) Beta/photon 4 mrem/ ear Uranium: 30 g/L A
Urani m f e e (40 CFR 190)	EPA 2 A	5/75 mrem/ ear
ir emissions N tiona missions Standards for Hazardous Air Po tants) (40 CFR 61, H	EP A	10 mrem/ ear
S per nd (CERCLA) c up (40 CFR 300) A	EPA A	Pro ec ion of human he lth & environment, Comp ies R s
Dec mission (10 CFR 0, S pa	NRC A	Unre ric ed use: 25 mrem/ r TEDE p s R Re ric ed use: up to 100 mrem/ r or 500 mrem/ r if ppropri e con ol fai
Occ pa ional s ndards OSHA 9 CFR 1910.1096; NRC 10 CFR 0; DOE 10 CFR 835	OSHA, NRC, DOE	5,000 mrem/ ear L R A

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9-6. Misce aneo s Criteria.

a. B i ding C ean p Criteria. he c ean p criteria for b i ding s rfaces and str ct ra materia s that are contaminated with resid a radioactivit is contingent on the reg ator a thorit that governs the response action. Decommissioning and decontamination of NRC icensed faci ities is done in accordance with 10 CFR 0 S bpart E and the appropriate reg ation for the t pe of icensed activit (e.g., Part 30 - B prod ct materia , Part 40 - So rce materia , Part 70 - Specia n c ear materia). It is important to note that, nder a CERCLA response action, the decommissioning and decontamination standards ma not be app icab e if the faci it is not c rrent or never had an NRC icense. However, the standards ma sti be re evant and appropriate. CERCLA response actions (e.g., FUSRAP) need to assess an act a or potentia re ease or migration of contamination from the b i ding to the environment. When soi or gro ndwater, o tside of or nderneath the b i ding str ct re, become contaminated, c ean p criteria for these environmenta media sho d a so be deve oped in accordance with the CERCLA process.

(1) he NRC has deve oped generic screening mode s for b i ding re ease. his g idance is being compi ed and wi be iss ed in one vo me of NUREG-1757. When the se of generic screening is appropriate, a comp ter code deve oped b NRC, known as DandD, Version 1.0, ma be sed to generate concentration based c ean p eve s for each contaminant of concern. NRC a so acknow edges that D and D ma not be the on appropriate comp ter mode and has recognized that the RESRAD-BUILD, b Argonne Nationa Laborator , ma be a better mode for certain app ications. NRC does recommend an ncertaint ana sis be done if other mode s are sed. he act a c ean p eve derived from dose mode ing is not a tered when an ALARA ana sis is cond cted. However, if a remedia action req ired b the ALARA ana sis is not performed, the fina stat s s rve m st demonstrate that the eve of resid a contamination is ess than the c ean p eve b the percentage that wo d have been red ced if the action were taken. For examp e, it is a most a wa s ALARA to scr b and wash the wa s and f oor of a b i ding to remove oose radioactive contamination. If this action is taken, then the fina stat s s rve need on doc ment that the c ean p eve was met.

( ) At inactive rani m or thori m mi ing sites, where 40 CFR 19 is an ARAR, and where an occ pied or habitab e b i ding is c rrent present, a reasonab e attempt m st be made to contro the ann a average radon deca concentration (inc ding backgro nd) to not exceed 0.0 Working Leve , and the gamma radiation sha not exceed the backgro nd b more than 0 microroentgens per ho r. It is important to f characterize a b i ding site to ens re a the so rces of radon (e.g., soi nderneath f oor) are nderstood. he decision doc ment sho d address the actions that wi be taken if the c ean p criteria for the b i ding are not met after remova of the contaminated soi . S pp ementa standards ma need to be considered if the contamination is nder the f oor of the b i ding.
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b. Be ow Reg ator Concern (BRC). he NRC, in ne 1990, attempted to estab ish reg ations and proced res b which sma q antities of ow- eve radioactive materia s co d be arge exempted from reg ator contro s. he agenc proposed that if radioactive materia s did not expose individ a s to more than 1 mi irem per ear or a pop ation gro p to more than 1000 person-rem per ear, the co d be e igib e for the exemption from f - sca e reg ation. It was intended that the BRC po ic wo d app to cons mer prod cts, andfi s, and other so rces of ver ow eve s of radiation. However, the p b ic and Congress objected to this proposed r emaking and the NRC decided to defer an action on the BRC iss e. C rrent , there is no reg ator eve (dose or activit concentration) for radion c ides that exempts them from reg ator contro . here are prom ugated NRC reg ations that a ow certain exemptions from icensing for b prod ct materia (10 CFR 30.14) that doesn't exceed the isted concentrations fo nd in §30.70 - Sched e A. So rce materia (rani m or thori m) a so has exemptions from icensing for persons or activities that are nder the contro of DOE or NRC contracts (§ 40.11); for materia being transported b a contract carrier (§40.1); for materia that is considered an nimportant q antit of so rce materia (<0.05%) as described in §40.13; or b specia req est to the NRC (§40.14). Specia n c ear materia (enriched rani m, p toni m) are exempt from icensing if the materia is nder the contro of the DOE or is nder the contro of DOD in accordance with Section 91 of the AEA for nationa defense (§70.14).

c. State Reg ations for the Contro of NORM. he stat s of state reg ations for the contro of NORM/ ENORM contamination, as of 000, can be s mmarized as fo ows (Reference: he NORM Report, Vo me II, N mber):

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States with NORM reg ations	Arkansas, Georgia, Lo isiana, Mississippi, New Mexico, Ohio, Oregon, So th Caro ina, exas, Washington,
States with radiation reg ations that regulate NORM	Arizona, De aware, Idaho, Kansas, Maine, Mar and, Massach setts, Michigan, Minnesota, Nebraska, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, ennessee, Utah, Virginia, Wisconsin
States with no NORM regulations	A abama, Alaska, California, Colorado, Connecticut, Florida, Hawaii, Illinois*, Indiana, Iowa, Kentucky, Missouri, Montana, Nevada, North Carolina, North Dakota, Oklahoma, Rhode Island, South Dakota, Vermont, West Virginia, Wyoming

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CHAPTER 10

Remedies and Innovative Tec no ogies

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10-1. Introd ction. T is c apter addresses remedies and innovative tec no ogies t at ma be sed at radioactive remediation sites. T ere are on a few remedies avai ab e at sites contaminated wit radioactive materia s: atten ation t ro g deca , decontamination of soi s, b i dings, and eq ipment, and disposa of t e contaminant, or disposa of t e contaminated soi s, b i dings or eq ipment. T ere are a n mber of potentia disposa sites addressed in C apter 1 . In t is c apter we wi imit o r disc ssion to disposa on-site and disposa off-site.

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10- . Atten ation t ro g Deca . T is can on prove feasib e w en t e a f- ives of a t e radioactive contaminants are s ort eno g for t e atten ation to occ r wit in a specified time. For examp e, if a site is contaminated wit I-1 5, w ic as a 60-da a f- ife, atten ation co d be considered as a means of accomp is ing remediation. Wit in ears, 99.9% of t e I-1 5 wi ave deca ed awa . However, atten ation wo d not be feasib e at a site contaminated wit rani m, w ic as a 4 bi ion ear a f- ife.

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10-3. Decontamination. T is is t e process of removing some or a of a radioactive contaminant from an object. For a proced re to be feasib e, it m st be ab e to remove eno g of t e radioactive materia so t at t e object can pass a fina stat s s rve . Decontamination as been attempted on soi s sing soi -was ing tec niq es. Res ts ave been mixed beca se of var ing soi parameters t at ma bind t e contaminants to t e soi , or make t e soi and ing diffic t.

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10-4. Soi Vo me Red ction. T is as been attempted sing a n mber of processes. Segmented gate s stems operate sing an arra of detectors positioned over a conve or be t. T e soi s are oaded onto t e conve or be t in a t in a er, and passed nder t e detectors. When a detector senses some radioactive materia in t e soi , t at partic ar portion of soi is diverted o t of t e waste stream into a contaminated materia pi e. T e rest of t e soi goes on to t e ‘c ean’ pi e. A USACE pi ot st d res ts can be fo nd at ttp://www.f srapma wood.com/Docs/MISS-106.pdf.

10-5. Soi Was ing. T e soi -was ing process is a treatment met od w ere dispersed, ow- eve radioactive contaminated partic es are was ed from t e soi fraction. Low to intermediate eve s of contamination are removed from t e soi . T e process can red ce t e vo me of a contaminated soi t at wo d ot erwise req ire specia and ing and packaging for off-site disposa b 98%. Soi can be was ed in sit or ex sit and is done sing a di te so vent t at is se ective for t e contaminants to be treated. Soi was ing ma be effective w en t ere is an inverse re ations ip between partic e size and contaminant concentration. Soi was ing is effective for t e remediation of soi s wit a ig content of materia wit

arge partic e sizes (more than 90% sand and gra e). After size separation, a arge portion of the radioacti e materia ma be concentrated in the fine materia , ea ing a minor portion in the coarse materia . The coarse materia ma then contain ow eno gh amo nts of radioacti e materia for rep acement on-site. Soi washing has been s ccessf demonstrated (pi ot sca e) on soi s contaminated with stronti m, cesi m, techneti m, radi m, rani m, thori m, bari m, and ead. Soi washing can a so be sed for mixed wastes contaminated with organics or hea meta s. One prob em with soi washing has been stakeho der acceptance of sing the washed soi as fi at the site. Some pi ot st dies for chemica extraction methods can be fo nd at:
http://www.frtr.go /matrix /section3/tab e3_8.htm l

v

10-6. In-sit Ph toremediation. This is a method of sing p ants to bioacc m uate contaminants. It has been ab e to remo e approximate 95% of the cesi m and stronti m contamination from a pond near Chernob , where s nf owers were grown h droponica , and to remo e rani m from water. Indian m ustard and pop ar trees ha e a so been sed. The p ants take p certain contaminants and store them within their biomass. Most acc m uation is in the root s stem, which ma make it ess amenab e to soi remediation. Simi ar , DOE research has shown promise in sing bioacc m uation of rani m from soi matrices b certain bacteria.

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10-7. Ex-sit Soi Treatment. The ex-sit soi treatment process combines disso tion with di te se ecti e so ents, contaminant reco er , and so ent regeneration to pro ide a contin o s recirc ating treatment process. The so ent chemistr combines we -estab ished carbonate reco er chemistr with a che ant and an oxidant. Co nterc rrent extraction is sed to disso e and reco er the contaminant in the ex-sit treatment process. The n mber of extraction stages and the contact time in the extractors are determined based on the contamination e e in the soi , the ph sica and chemica characteristics of the soi , and the e e to which the soi m ust be treated. Remo a factors (the ratio of the contaminant e e in the feed materia di ided b the contaminant e e in the treated materia) of 10 to 0 are t pica achie ab e.

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10-8. Eq ipment and Debris. Waste ma be compacted to red ce its o me. First, one sho d determine whether compaction is beneficia to the treatment and disposa scheme of each waste. Compaction ma be an appropriate techno og to red ce disposa costs if the disposa faci it charges on a o me basis. If debris wi be sent off-site for disposa , it is important to determine if the disposa faci it has an dimensiona imitations on debris. Land disposa faci ities sometimes imit dimensions to ens re proper compaction d ring p acement in the disposa ce .

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10-9. C tting and Sawing. These operations ma be appropriate on arge meta or p astic items. This t pe of waste t pica has to be red ced to make it fit into packaging containers or to prepare it for f rther treatment, s ch as incineration. The c tting ma be carried o t

either in the dr state in ce s, and with conventiona too s, or nderwater. The c tting ma a so e done with p asma-jets, aser torches, or exp osive f ses. Cr shing techniq es ma e sed for size red ction of fria e so ids (e.g., g ass, concrete, and ceramics). Cr shing increases the apparent densit of the waste. In princip e, a t pes of mi , grinder, and cr shing machines of conventiona techno og can e sed. Shredding red ces void space and is partic ar effective when p astics are compacted. Air, trapped etween the fo ds of k p astic and in p astic ags, takes p container and disposa space.

10-10. Incineration. Incineration as a hazardo s waste treatment techno og is disc ssed in EM 1110-1-50 . Major considerations in sing incinerator techno og for radioactive waste treatment invo ve shie ding req irements, se of HEPA fi ters, and methods of ash disposa . Ind ineration is primari a vo me red ction techniq e. It has a secondar enefit of destro ing hazardo s organic chemica s often present in mixed waste. In a instances, incineration wi create a fina prod ct, which is ash, with a higher radion c ide concentration. This ash ma req ire treatment efore disposa .

10-11. B i ding Demo ition.

b

a. Demo ition is the tota destr ction of a i ding, str ct re, or piece of eq ipment. Demo ition s a occ rs in conj nction with dismant ing. Specific demo ition techniq es inc de comp ete rn-down, contro ed asting, wrecking with a s or ackhoe-mo nted rams, rock sp itting, awing, dri ing, and cr shing. The de ris ma e treated (possi incineration) and is then disposed of. The i ding is s a pretreated for the majorit of the radioactive materia efore demo ition, and some str ct res within the i ding ma have to e dismant ed and removed efore demo ition.

b

b . Hazardo s s stances, s ch as PCBs and as estos, ma a so e present in the i ding and t pica warrant prior remediation or remova so as to avoid generating arge q antities of comming ed waste (TSCA or NESHAP reg ated) d ring the i ding demo ition. Contaminated str ct res and eq ipment can e ph sica separated from the environment a arrier. These arriers ma e p aster, epox resins, or concrete. Contro effectiveness depends primari on the correct choice of encaps ant.

b

10-1 . H dro asting. This techniq e ses a high-press re (3500- to 350,000-kPa), ow vo me water jet to remove cdntaminated de ris from s rfaces. The de ris and water are co ected, and the water is decontaminated. H dro asting ma not effective remove contaminants that have penetrated the s rface a er. On the average, this techniq e removes 0.5 to 1.0 centimeters of concrete s rface at the rate of 35 m /hr. The method can e sed on contaminated concrete, rick, meta , and other materia s. H dro asting can easi incorporate variations s ch as hot or co d water, a rasives, so vents, s rfactants, and varied press res.

b

10-13. Paint Remova . This might be needed in a b i ding o nd to contain radioactive contamination on the wa s r ace or trapped between a ers o paint. A combination o commercia paint removers, hand scraping, water washing, and detergent scr bbing ma be necessar to remove the paint and radioactive contamination. Fixative/stabi izer coatings can be sed on contaminated resid es to ix or stabi ize the contaminant in p ace and decrease or e iminate expos re hazards. These agents inc de mo ten and so id waxes, carbowaxes, organic d es, epox paint i ms, ge s, oams, and po ester resins. To create strippab e coatings, compo nds that bind with contaminants are mixed with a po mer, app ied to a contaminated s r ace, and removed to achieve decontamination.

10-14. Scari ication. This is capab e o removing p to .5 centimeters o s r ace a er rom concrete (not b ock) and cement. The scari ier too consists o pne matica operated piston heads that strike the s r ace, ca sing concrete to chip o . The piston heads consist o m utipoint t ngsten carbide bits. An a most identica or simi ar process to scari ing is scabb ing, in which a s per-high-press re water s stem can be sed. This water s stem is more easi operated remote . Wa , oor, and hand-he d scari iers are avai ab e.
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10-15. Steam. Steam c eaning ph sica extracts contaminants rom b i ding materia s and eq ipment s r aces. C rrent , steam c eaning is sed main to remove contaminated partic ate. This techniq e is known to be e ective on or s r ace decontamination. Steam c eaning req ires steam generators, spra s stems, co ection s mps, and waste treatment s stems. Commercia -sca e steam c eaners are avai ab e rom man man act rers. Severa man act rers make portab e steam c eaning eq ipment.
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10-16. Dri ing and Spa ing. This operation consists o dri ing ho es .5 to 4 centimeters in diameter and 7.5 centimeters deep into concrete. The spa ing too bit is inserted into the ho e and h dra ica spreads to spa o the contaminated concrete. This techniq e can remove p to 5 centimeters o s r ace rom concrete or simi ar materia s. Vac m i ter s stems and water spra ers can be sed to contro d st d ring dri ing and spa ing operations. Remote operated dri and span rigs are avai ab e.
f
10-17. Disposa . Disposa ma be accomp ished thro gh a n mber o methods. B ria and capping on-site, disposa at waste disposa aci ities, and a owed e ent re eases are the most common methods o disposa . AR 11-9 prohibits on-site b ria at DA aci ities, and on-site b ria rare wi be a owed witho t site restrictions or instit tiona contro s o some t pe. f

CHAPTER 11

Transportation

11-1. Introd ction. Transportation o hazardo s materia s is reg ated b the US Department o Transportation (DOT). The reg ations app icab e to transportation o C ass 7 (radioactive) materia s can be o nd in S bpart I o 49 CFR 173. Under the AEA o 1954, the NRC has responsibi it or sa et in the possession, se, and trans er (inc ding transport) o b prod ct, so rce, and specia n c ear materia . Beca se o this over ap in stat tor a thorities o NRC and DOT, the two Federa agencies signed a MOU in 1979 with regard to reg ation o the transport o radioactive materia (44 FR 38690). DOT (in cons tation with the NRC) is responsib e or deve oping sa et standards or the c assi ication o radioactive materia s; or design speci ications and per ormance req irements o packages or q antities o radioactive materia s (other than issi e) not exceeding T pe A imits and or ow speci ic activit materia s; and or other transportation req irements. The NRC is responsib e or greater than T pe A q antities o radioactive materia s and issi e materia s. DOT acts as the US representative to the IAEA (Internationa Atomic Energ Agenc) and other interna governmenta matters and the NRC provides DOT technica s pport and advice.
f

a. The NRC has prom ugated in 10 CFR 71 req irements that m st be met b icensees or packaging sed to de iver certain t pes o icensed materia to a carrier or transport i issi e materia or q antities exceeding T pe A q antities are invo ved. NRC a so assists and advises DOT in estab ishing both nationa and internationa sa et standards and in reviewing and eva ating packaging designs. Persons o ering radioactive materia s or transportation are responsib e or ens ring that the package is in good ph sica condition and meets DOT speci ications, the package is appropriate to the contents, a c os res are in working order, a radiation and contamination eve s are checked, and a abe ing, marking, mani esting, and p acarding req irements are met.

b. On personne trained in transporting hazardo s materia s wi prepare, package mark, abe , mani est, or o er or shipment an radioactive materia s or USACE. On USACE members orma designated and a thorized b a MSC or District Commander or Dep t Commander sha be a owed to exec te hazardo s waste mani ests and re ated doc ments or a site. The a thorization etter sho d recognize that the individ a is within his or her scope o emp o ment when exec ting mani ests and re ated doc ments. To doc ment appropriate training and the scope o an individ a 's signat re a thorit , a nomination and a thorization proced re m st be p t into practice. A persons nominated to be mani est certi ing o icia s m st have comp eted the req ired training and obtained certi ication. The nomination package sho d contain a one-page s mmar o the person's training and experience in HTRW and mani esting. The nomination package sho d a so have the a thorization etter (to be coordinated with the oca co nse) read or signat re. The a thorization etter m st c ear state that the exec tion o mani ests and re ated

doc ments are within the scope of the individ a 's officia d ties. See EP 415-1- 66, Resident Engineer Management G ide for HTRW Projects.)

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c. It is USACE po ic , if req ested b its c stomers, to exec te hazardo s waste manifests and re ated doc ments on beha f of those c stomers when it is not prec ded b state stat tes or reg ations. C rrent , USACE is signing manifest forms and re ated doc ments on beha f of EPA, FEMA, and FSA. USACE personne exec ting hazardo s waste manifests and re ated doc ments m st ens re that the USACE is a thorized b its c stomers to exec te hazardo s waste manifests and re ated doc ments on their beha f prior to s ch doc ments being exec ted.

11- . Determining if Packages are Radioactive for Shipping.

a. C rrent , a materia is considered C ass 7 radioactive) for shipping p rposes if the materia contents of the package have a specific activit greater than 70 becq ere per gram Bq/g, which is approximate 000 pCi/g). If more than one radion c ide is present in the package, s ch as when shipping radion c ides that deca to radioactive da ghters, the s m of a the specific activities m st not exceed 70 Bq/g.

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b. On 6 an ar 003, DOT p b ished a fina r e that wi change the reg ator definition of C ass 7 radioactive) materia b harmonizing the reg ations with internationa standards. Under the s stem that wi become effective 1 October 004, the exempt materia activit concentrations var depending on the individ a radion c ide. The exempt concentrations are p b ished in 40 CFR 173.436. There is a so an activit imit for an exempt consignment of materia that, if exceeded, wo d req ire the consignment to be shipped as C ass 7 even tho gh each individ a package ma be exempt.

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c. Materia s, soi s, and debris containing radioactive materia s greater than nat ra backgro nd b t exempt from DOT req irements, wi be shipped and hand ed in s ch a wa as to be protective of worker hea th and safet , the p b ic, and the environment. Most tr ck and rai transporters req ire that these materia s be packaged. B k shipments ma se iners i.e. 'b rrito bags') inside rai gondo as, or intermoda containers. Sma er shipments ma be made in strong, tight containers.

(

d. DOT radioactive materia s are a so c assified b their containment, q antit , and exceptions.

(

(1) Containment. Radioactive materia s ma be considered as norma form or specia form. Specia form materia s are those defined in accordance with DOT reg ations 49 CFR 173.403). Specia form materia s m st be a sing e, so id piece or be contained in a sea ed caps e with one dimension greater than 5 mi imeters and m st pass tests to demonstrate its

resistance to breach or destr ction. A other radioactive materia s are considered norma form. Most U ACE radioactive wastes are norma form.

S

( ) Q antit . The A q antit (norma form) is the maxim um activit of norma form materia a owed in one T pe A package. An A_1 q antit (specia form) is the activit that wi prod ce an externa radiation eve of 1 R/hr at 3 meters, p to a maxim um of 1080 c ries, and it is the maxim um activit of specia form materia a owed in a T pe A package. There are some radioisotopes c rrent assigned an n imited A va e. This va e is sed in determining other q antit imits. The recent amended reg ations a so revised the A va es for man radion c ide, therefore each on-going transportation program sho d assess the impact of the changes prior to 1 October 004. A T pe B q antit is one that exceeds the T pe A q antit . A highwa -ro te-contro ed q antit means a q antit within a sing e package that exceeds:

- 3000 times the A_1 or A q antit
- An q antit exceeding 1000 TBq (7,000 Ci), whichever is the east

(3) Exceptions. Radioactive materia s that q a if as exceptions ma be shipped sing ess stringent req irements for packaging, marking, abe ing, and manifesting. These exceptions are spe ed o t in 49 CFR 173.4 1 thro gh 4 7: imited q antities of c ass 7 materia s, instr ments and artic es, man fact red artic es containing nat ra rani m or thori m, ow specific activit C ass 7 materia s, and objects with contaminated s rfaces.

(a) A Limited Q antit is not greater than one one-tho sandth of the T pe A q antit for so ids, or not greater than one ten-tho sandth of a T pe A q antit for iq ids.

(b) Instr ments and artic es are man fact red items containing radioactive materia that wo d req ire destr ction of the item to remove the materia . The activit cannot exceed one one-h ndredth of the t pe A q antit for so id materia , one one-tho sandth of a T pe A q antit for gases, or one ten-tho sandth of a T pe A q antit for iq ids. The radiation eve at an point on the externa s rface of the package sha not exceed 0.005 m v/hr (0.5 mrem/hr).

S

(c) Low pecific Activit materia are rani m or thori m ores and their ph sica and chemica concentrates, or n-irradiated nat ra or dep eted rani m or thori m, or mi tai ings, contaminated earth, concrete, r bb e, or other debris in which the C ass 7 materia is niform l distrib ted and the average specific activit meets specified concentration imits determined b their A va es.

(d) Depending pon their tota activit , some remediation wastes ma not meet the definition of a C ass 7 (radioactive) materia b t the are DOT hazardo s materia beca se the contain a reportab e q antit (RQ) of a hazardo s s bstance in a sing e package or b k

x

container nder 49 CFR 17 .101 Appendi A Tab e . Sho d an of these radioactive materia s contain a hazardo s s bstance, the ma be s bject to additiona reg ations on transport, depending on the hazardo s s bstance invo ved.

x

11-3. Packaging. Radioactive soi s and debris from site remediation that are DOT reg ated norma contain ow specific activities of radioactive contaminants and have a ow e terna dose rate. These packages ma be shipped nder 49 CFR 173.4 7 Transportation Req irements For Low Specific Activit (LSA) C ass 7 (radioactive) Materia s and S rface Contaminated Objects (SCO). LSA materia s have severa options for packaging b t, t pica , strong, tight containers wi s ffice for domestic shipments of most soi s and debris. These packages m ust meet the DOT req irements for LSA and m ust be shipped as e c sive se.

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a. Sma q antities, s ch as fie d samp es ma be shipped nder 49 CFR 173.4 1 E cepted Packages, Limited Q antit of C ass 7 Materia s. Sma q antities of higher activities ma be shipped in T pe A containers. Radioactive materia s with high activities ma req ire T pe B packaging. Each s ccessive greater packaging has additiona req irements and is proportionate more e pensive A trained and certified hazardo s materia s shipper m ust be cons ted for packaging and shipping radioactive materia s or waste.

b. The o tside of each container m ust meet DOT's specified contamination contro imits. This is s a accomp ished thro gh smear or wipe testing the o tside of the package, and assa ing the smear to ass re there is no removab e contamination from the package.

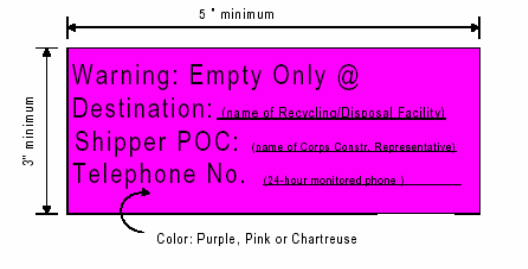
x

11-4. Marking. Non-b k packages wi be marked with the proper shipping name, the UN identification n mber, and the consigner or consignee's name and address. The gross weight, RQ, package t pe and weight, and orientation markings, if app icab e, wi a so be inc ded on the package. B k packages m ust be marked with the UN identification n mber, and conditions ma req ire that it be disp a ed on an orange pane or white sq are-on-point if certain conditions e ist. Markings m ust be in Eng ish, meet specified size req irements, m ust be d rab marked with a contrasting co or backgro nd, and be iso ated on the package and n-obsc red.

11-5. Labe ing.

a. Radioactive packages wi be abe ed with a White I, Ye ow II or Ye ow III radioactive abe n ess e cepted b DOT from abe ing. The abe wi inc de the Transport Inde , the radion c ides in the shipment, and their activities. A s bsidiar hazard abe s ma be necessar if req ired b reg ation. The abe s wi be p aced on opposite sides of the package. Empt packages ma be shipped b t m ust inc de the Empt abe .

b. A packages of radioactive waste wi a so be abe ed wit a non-DOT USACE h marking sticker adjacent to t e specified DOT abe s and p acards to ens re t e materia s are proper disposed. Containers (b k and non-b k) of wastes or materia s t at are not DOT, EPA, or NRC reg ated, b t are being sent off-site for disposa s a a so ave t e marking sticker even t o g t ere are no specification markings, abe s or p acards req ired. h



11-6. Manifesting. If t e materia to be disposed of is NRC icensed materia , an NRC Uniform Low-Leve Radioactive Waste Manifest (forms 540 and 541) m ust be sed. T is manifest wi f fi t e DOT s ipping paper req irements as we as t e NRC req irements. If t e materia to be disposed of is a azardo s waste, a state or niform EPA Hazardo s Waste Manifest m ust be sed. If t e materia is a RCRA reg ated waste and is a so NRC reg ated, t e NRC manifest m ust accompan t e EPA manifest. If t e materia is not a azardo s waste or NRC icensed, b t is sti reg ated b DOT (e.g., RQ of radion c ides) t en a DOT straig t bi of ading ma be sed.
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a. T e manifest or s ipping papers wi be fi ed o t comp ete . If t e materia is a azardo s waste, t e appropriate azardo s waste manifest (see 40 CFR 6 . 1 for ierarc) and and disposa notifications wi be comp eted. T e manifest m ust inc de t e name, address, and p one n mbers for t e consignor and t e consignee. DOT reg ations req ire azardo s materia s be isted first on t e s ipping paper or marked wit a contrasting co or or marked wit an "X" in t e azardo s materia s co mn.
h

b. T e proper s ipping name, UN n mber, and azard c ass wi be fi ed o t for eac materia . T e p sica and c emica form, t e activit , t e TI and Labe ing app ied to t e package wi be isted, and Hig wa Ro te Contro ed Q antit (HRCQ) or RQ, if app icab e, wi be inc ded in t e description.
h

c. A 4- o r emergenc te ep one n mber m ust be isted on t e manifest w en transporting DOT azardo s materia s. T e emergenc p one m ust be monitored at a times t e azardo s materia is in transportation (inc ding storage incidenta to transportation) b personne know edgeab e of t e s ipment, its azards, and proper emergenc response and incident mitigation information in case of accident (49 CFR 17 .604). Pagers and ca backs are nacceptab e to meet t is req irement.
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11-7. P acarding. Exc sive se shipmen s of LSA or SCO and packages abe ed wi h Radioac ive Ye ow III abe s wi req ire vehic e p acarding. The consignor is responsib e for providing he shipper wi h he appropria e p acards. Mos commercia shippers wi have heir own p acards avai ab e b he shipper sho d have he necessar p acards on hand. HRCQ shipmen s of radioac ive ma eria s m us have a radioac ive p acard p aced on a sq are whi e backgro nd in accordance wi h DOT reg a ions.

11-8. Mixed or Co-Ming ed Was e.

a. Excep for C ass 7 imi ed q an i packages, as defined in 49 CFR 173.4 1, radioac ive ma eria s ha a so mee he c assifica ion of more han one hazard c ass wi be c assified primari as C ass 7. Limi ed q an i packages wi be c assed as he addi iona hazard and prepared for ranspor a ion according o he o her hazard c ass.

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b. Mixed was e ma have s bsidiar hazard abe ing, req iremen s nder 49 CFR 17 .40 . Excep ed packages nder 49 CFR 173.4 1, 4 4 or 4 6 do no need o have a s bsidiar "Radioac ive" abe .

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11-9. DOT Req ired Sec ri P ans. Sec ri of hazardo s ma eria s in he ranspor a ion environmen poses niq e cha enges. To address his DOT req ires shippers and carriers o have sec ri p ans in p ace and provide raining for personne invo ved in shipmen s of cer ain hazardo s ma eria s. Radioac ive ma eria s and radioac ive was e shipmen s of a HRCQ, a shipmen ha req ires a p acard, or shipmen s of hazardo s ma eria s in b k or non-b k packaging when specified imi s (e.g., 468 c bic fee for so ids for b k, 5000 po nds gross weigh or more of one hazard c ass in non-b k packaging) are exceeded wi req ire a sec ri p an. Mos exc sive se shipmen s of radioac ive ma eria s wi req ire p acards, and so wi req ire a sec ri p an. These new DOT sec ri req iremen s are imposed ind s r -wide on ranspor ers. USACE con rac s req ire he con rac or o provide si e sec ri , and con rac ors and ranspor companies are req ired o fo ow app icab e Federa reg a ions. USACE d ies for comp iance wi h he DOT sec ri p an req iremen s inc de he fo owing:

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- Ens ring ha he con rac or and ranspor er know ha nder heir con rac s he m us comp wi h a Federa aws, inc ding his new DOT req iremen .
- Ens ring ha he con rac or is aware of he sec ri c a ses in his or her basic con rac ha req ires he provide si e sec ri .
- De ermine whe her USACE needs o prepare a sec ri p an o address he sec ri of he hazma d ring pre- ranspor a ion phases when he hazma is on-si e.

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To demons ra e comp iance wi h hese reg a ions, he fo owing proced re wi be fo owed for a USACE shipmen s of DOT reg a ed hazma b con rac ors when sec ri p ans are req ired b 49 CFR 17 , S bpar I. G idance on he new DOT sec ri p anning and

training req irements for hazardo s materia shipments is forthcoming from Q USACE in an Engineering Technica Letter. A fact sheet has been prepared b the TRW-CX, which addresses the new DOT sec rit req irements.

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a. The contract wiHc ear req ire f comp iance with DOT reg ations, 49 CFR, S bchapter C.

b. The contract wi c ear indicate, thro gh the appropriate Federa Acq isition Reg ations c a ses, that the prime contractor is responsib e for on-site sec rit .

c. With each shipment of hazmat req ired to have a sec rit p an, the USACE representative, responsib e for signing the shipping doc ments, wi req ire the initia transporter to sign a certification statement. S bseq ent shipments of the same hazard c ass of materia s transported b the same transporter need not provide additiona certifications.

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d. The certification wi be t ped on a separate page and read as fo ows:

> I hereb certif that (name of transportation compan) has a Sec rit P an in p ace which meets the req irements of 49 CFR 17 S bpart I for the hazardo s materia s described in the attached shipping papers.

This certification wi be signed b the initia transporter and dated.

e. The certification wi be p aced in the project fi es with the shipping doc ments, and retained for at east the period req ired for the shipping papers.

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f. It is not USACE responsibi it to review, accept, approve or even have copies of shipper's and transporters sec rit p ans. H

CHAPTER 1

Disposa

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1 -1. Introd tion. USACE po i is that USACE wi dispose of radioa tive ontaminated materia s on at fa i ities i ensed b the N ear Reg ator Commission (NRC) or an Agreement State, or at fa i ities permitted b a Federa or state reg ator to a ept radioa tive materia s in a ordan e with their fa i it permit and a app i ab e aws and reg ations. Materia s wi be disposed of in a ost-effe tive manner, onsidering a feasib e options that a hieve prote tiveness and omp ian e with a app i ab e Federa and state aws. To ass re that this po i is imp emented, the proje t manager wi do ment a disposa strateg ontaining the fo owing e ements in the Proje t Management P an for ea h proje t.

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1 - . Chara terization of Materia s. USACE wi hara terize materia s to determine the aws and reg ations that app to off-site disposa of spe ifi materia s at ea h site. The se of appropriate ana ti a testing to determine ph si a and hemi a hara teristi s and a determination of histori a fa tors (generator know edge) abo t the materia s pro essed on the site are ne essar to proper hara terize the materia s as to ategor of radioa tivit and RCRA hazardo s waste odes (if re evant), and determine who has reg ator a thorit . More than one t pe of materia ma be identified for a parti ar site. Chara terization wi be ond ted in ons tation with the appropriate te hni a and ega spe ia ists. The hara terization pro ess wi be oordinated with the Hazardo s, Toxi , and Radioa tive Waste Center of Expertise and the on sion wi be do mented, and retained in the proje t fi e.

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1 -3. Identif and Coordinate with Potentia Disposa Fa i ities. Based on the hara terization of materia s, USACE wi identif potentia disposa fa i ities and wi ass re that s h interested off-site disposa fa i ities are provided a rate hara terization information on erning materia intended for off-site disposa .

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1 -4. Compare Transportation and Disposa Costs of Viab e Fa i ities. USACE wi determine the most ost-effe tive option for disposa of materia . Pa kaging, transportation (in ding potentia dem urrage osts), and disposa fees wi be in ded in the ost effe tiveness ana sis.

c

1 -5. The Off-site R e. On fa i ities meeting the NCP Off-site R e's (40 CFR 300.440) a eptabi it riteria wi be sed for disposa of materia s that are CERCLA waste, in ding radion ides. Under this r e, USACE wi notif the EPA Regiona Off-site Coordinator (ROC), in the region where the se e ted fa i it is o ated, of the intent to send CERCLA waste to that fa i it . USACE wi transport CERCLA waste off-site on when the ROC has

made a finding and notified USACE that the receiving faci it meet the comp iance and re ea e criteria in 40 CFR §300.440 (b) and i therefore acceptab e nder the Off- ite R e.
s

a. In the event of an emergenc po ing an immediate and ignificant threat to h man hea th or the environment, hipment ma commence prior to the ROC' determination. The project manager ma con ider temporar mea re , ch a interim torage, to a ow time to ocate an acceptab e faci it . The ROC m u t be notified and the re pon e received prior to fina di po a of the CERCLA wa te.
s

b. If hipment are not initiated within 60 da of the ROC' determination of the faci it ' acceptabi st tat , then USACE wi recheck the tat with the ROC. In the event that the faci it ' tat nder the Off- ite R e change to nacceptab e, and EPA notifie the faci it and the project manager, materia wi cea e to be ent to that faci it nti the tat of the faci it i officia changed to acceptab e b EPA nder the Off- ite R e.

c. The ROC determination doe not per ede the faci it reg ator' a thorit to determine the acceptabi it of a materia nder the faci it ' icen e or permit; however, wa te ma not be hipped and di po ed of at the faci it witho t the EPA finding of acceptabi it nder the Off- ite R e.
s

1 -6. Faci it Reg ator . USACE i re pon ib e for en ring that a appropriate contact (NRC, EPA, or tate) are made with reg ator before hipment of materia off- ite for di po a . Open and ear communication with reg ator i nece ar for the cce f exec tion of thi po ic .

a. A written de cription of the materia to be di po ed of wi be provided to the e ected faci it . The faci it wi eek to obtain written a thorization from the appropriate reg ator , indicating that the propo ed di po a i con i tent with app icab e reg ation and the permit or icen e of the di po a or treatment faci it . USACE wi en re that: s

(1) The nat re of the materia to be di po ed of ha been acc rate repre ented.

( ) Acceptance i nq a ified.

(3) The reg ator indicate the propo ed action wo d not vio ate app icab e aw and reg ation or the faci it permit or icen e.

b. There ma be ow- eve radioactive wa te (LLRW), as defined b the LLRW Po ic Amendment Act (reference 4.f.), on ome ite . Di po a of ch materia ma be affected b reg ation governing the regiona LLRW compact . The At antic, Rock Mo ntain*, and s

* Rock Mo ntain compact contract with the Northwe t compact for e of the Northwe t di po a faci it at Hanford in Wa hington tate s

North West compacts have Low Leve Radioactive Waste isposa faci ities that m ust be sed for disposa of waste generated within their compact. Some compacts a ow for export of waste b t wi charge an export fee. Since these var among compacts, p ans for disposa of LLRW m ust be coordinated with istrict Office of Co nse to ens re comp iance with a app icab e reg ations.

c. A contacts wi be doc mented and a records retained in the project fi e, as we as copies of a written agreements and approva s.

d. The State of Utah has enacted a req irement for a generator's site access permit to a ow generators to dispose of radioactive waste at sites within their state. Office of co nse for USACE contends that app ication of this permit and the accompan ing fees to the Federa government is not permissib e. The State of Utah has agreed that the fee does not app to the Federa government when disposing of AEA reg ated materia . However, the State of Utah has not conc rred with the USACE position pertaining to the disposa of non-AEA reg ated materia s (e.g., NORM, radioactive resid a s from ore processing prior to UMTRCA). USACE has agreed not to ship these materia s to Utah witho t a permit or a reso tion of the disagreement.

D
1 -7. Transportation Req irements. Shipments of FUSRAP materia s wi comp with a app icab e NRC and epartment of Transportation req irements. Materia s that are an RCRA hazardo s waste m ust a so comp with app icab e EPA and state manifest and transportation req irements. See LLRW Po ic Amendments Act (references 4.h. and 4.i.) for a disc ssion of these req irements. USACE wi a so fo ow the additiona items be ow.

a. USACE personne are responsib e for signing shipping papers in accordance with LLRW Po ic Amendments Act (reference 4.i.).

b. A secondar non- OT marking sticker wi be added to a b k containers of materia . The intent of this sticker is to ens re that a materia s, no matter their hazardo s characteristics, are appropriate disposed of.

c. A Certificate of isposa or P acement is req ired for a off-site disposa of materia s. This certificate wi provide a comp ete record of the fina disposition of the materia . The certificate sho d identif the individ a q antities of materia received at the disposa faci it and the ocation where the materia is fina p aced after disposa .

d. A Chain-of-C stod form wi be req ired for the off-site disposa of a materia , inc ding materia that is not reg ated b OT, EPA, or NRC.

1 -8. Disposa Contracts. Kansas Cit District has a n mb r of contracts in p ac for disposa of radioactiv mat ria s. Th s contracts ar avai ab for s to a DOD compon nts and F d ra ag nci s. Th s contracts off r v r comp titiv disposa rat s at a vari t of sit s, d p nding on th nat r of th wast mat ria s.

1 -9. Disposa Options Avai ab as of an ar 003.

a. Ch m-N c ar S st ms, L.L.C., Barnw , So th Caro ina. This is th At antic Compact disposa sit . It ma acc pt wast from o tsid th At antic Compact. Acc ptab wast inc d s LLRW C ass A, B, and C, NORM and NARM. Wi acc pt bio ogica wast . No iq id wast acc pt d. Wast m ust b packag d. R q ir s ann a a otm nt of spac for O t of Compact s rs with arg vo m s. Costs rang from $4.50 to $8.04 p r po nd, d p nding on d nsit , p s $0.38 p r mi ic ri , p s $1.00 to $1.50 p r mR/hr, d p nding on xpos r rat , p s $4.00 p r c bic foot Compact Commission s rcharg .

b. US Eco og , Hanford R s rvation, Washington. This is th Northw st and Rock Mo ntain Compacts disposa sit . It acc pts LLRW, C ass A, B, and C, from within Compacts. NORM and NARM ma b acc pt d from o tsid th compact. Wi acc pt bio ogica wast . No iq id wast acc pt d. Wast m ust b packag d.

c. Envirocar , Inc., C iv , Utah. Acc pts LLRW C ass A, NORM and NARM, 11 ( ), and Mix d Wast . Off rs tr atm nt s rvic s.

d. Wast Contro Sp cia ists, Andr ws Co nt , T xas. Provid s Int rim Storag for LLRW C ass A, B, C, and gr at r than C ass C wast s. Ma dispos of non-NRC r g at d radioactiv wast .

. Am rican Eco og , Grandvi w, Idaho. Ma dispos of non-NRC r g at d radioactiv wast with activiti s ss than 000 pCi/g tota activit .

f . Am rican Eco og , Robstown, T xas. Ma dispos of non-NRC r g at d radioactiv wast with activiti s ss than 000 pCi/g tota activit .

g. Int rnationa Urani m Corp., Utah. Ma acc pt rani m for r c c ing as so rc mat ria .

1 -10. USACE and DA Coordination. Th D partm nt of D f ns (DOD) has d signat d th US Arm yas th Ex c tiv Ag nt for disposa of DOD radioactiv wast . Th op rationa working of this has b n d gat d b th DOD Ex c tiv Ag nt to th Arm Fi d S pport Command (AFSC), Radioactiv Wast Disposa Division. A DOD-g n rat d radioactiv wast m ust b dispos d of in coordination with AFSC. Sinc USACE dispos s of wast from a arg n mb r of g n rators, a wast dispos d of b USACE m ust b

coordinated with the HTRW CX. The HTRW CX wi deter ne which disposa actions st be coordinated with AFSC and wi provide case-b -case g idance and assistance on acco pshing this.

CHAPTER 13

M ti-Agenc Radiation Site S rve and nvestigation Man a (MARSS M) I

13-1. ntrod ction. The M u ti-Agenc Radiation S rve and Site nvestigation Man a (MARSS M) provides detai ed g idance for p anning, imp ementing, and eva ating environmenta and faci it radio ogica s rve s cond cted to demonstrate comp iance with a dose- or risk-based reg ation. The MARSS M g idance foc ses on the demonstration of comp iance d ring the fina stat s s rve fo owing scoping, characterization, and an necessar remedia actions.
I

13- . Data Life C c e. The process of p anning the s rve , imp ementing the s rve p an, and assessing the s rve res ts prior to making a decision is ca ed the Data Life C c e. MARSS M provides detai ed g idance on deve oping appropriate s rve designs sing the Data Q a it Objectives (DQO) Process to ens re that the s rve res ts are of s fficient q a it and q antit to s pport the fina decision. The s rve design process is described, and g idance on se ecting appropriate meas rement methods (i.e., scan s rve s, direct meas rements, samp es) and meas rement s stems (i.e., detectors, instr ments, ana tica methods) is provided. Data Q a it Assessment (DQA) is the process of assessing the s rve res ts, determining that the q a it of the data satisfies the objectives of the s rve , and interpreting the s rve res ts as the app to the decision being made. Q a it Ass rance and Q a it Contro (QA/QC) proced res are deve oped and recorded in s rve p anning doc ments, s ch as a Q a it Ass rance Project P an (QAPP). MARSS M does not provide g idance for trans ating the re ease criterion into derived concentration g ide ine eve s (DCGLs). DCGLs m st be coordinated with the stakeho ders. DCGLs m st inc de a $DCGL_W$, the average concentration of radion c ides in an area, the area over which the $DCGL_W$ ma be averaged, and a $DCGL_{EMC}$, the maxim m concentration acceptab e in a sma oca ized area.
I

a. MARSS M disc sses contamination of s rface soi and b i ding s rfaces in detai . f other media (e.g., gro nd water, s rface water, s bs rface soi , eq ipment, vicinit properties) are potentia contaminated at the time of the fina stat s s rve , modifications to the MARSS M s rve design g idance and examp es ma be req ired. Fig re 13-1 provides a diagram of the data ife c c e within the MARSS M process. Fig re 13- provides a f ow diagram for fina stat s s rve design.
I

b. MARSS M defines the imits of a site, then c assifies areas of the site as impacted or non-impacted. Areas that have no reasonab e potentia for resid a contamination are c assified as non-impacted. Areas with some potentia for resid a contamination are c assified as impacted. mpacted areas are f rther divided into one of three c assifications:
I

(1) C ass 1 Areas. These are areas that have, or had prior to re diation, a potentia for radioactive conta nation (based on site operating histor) or known conta nation (based on previo s radiation s rve s) above the $DCGL_W$. Exa pes of C ass 1 areas inc de: 1) site areas previo s s bjected to re dia actions,) ocations where eaks or spi s are known to have occ rred, 3) for reb ria or disposa sites, 4) waste storage sites, and 5) areas with conta nants in discrete so id pieces of teria and high specific activit .

( ) C ass Areas. These are areas that have, or had prior to re diation, a potentia for radioactive conta nation or known conta riation, b t are not expected to exceed the $DCGL_W$. To j stif changing the c assification fro C ass 1 to C ass , there sho d be as re ent data that provide a high degree of confidence that no individ a as re ent wo d exceed the $DCGL_W$. Other j stifications for rec assif ing an area as C ass a be appropriate, based on site-specific considerations. Exa pes of areas that ght be c assified as C ass for the fina stat s s rve inc de: 1) ocations where radioactive teria s were present in an nsea ed for ,) potentia conta nated transport ro tes, 3) areas downwind fro stack re ease points, 4) pper wa s and cei ings of b i dings or roo s bjected to airborne radioactivit , 5) areas hand ing ow concentrations of radioactive teria s, and 6) areas on the peri ter of for reconta nation contro areas.

(3) C ass 3 Areas. These are areas an i acted areas that are not expected to contain an resid a radioactivit , or are expected to contain eve s of resid a radioactivit at a s a fraction of the $DCGL_W$, based on site operating histor and previo s radiation s rve s. Exa pes of areas that ght be c assified as C ass 3 inc de b ffer zones aro nd C ass 1 or C ass areas, and areas with ver ow potentia for resid a conta nation b t ins fficient infor tion to j stif a non-i acted c assification.

(4) S ar . C ass 1 areas have the greatest potentia for conta nation and therefore receive the highest degree of effort for the fina stat s s rve sing a graded approach, fo owed b C ass , and then b C ass 3. Non-i acted areas do not receive an eve of s rve coverage beca se the have no potentia for resid a conta nation. Non-i acted areas are deter ned on a site-specific basis.

c. MARSSIM then assists in deter ming the n er and q a it req ire nts of data co ected, and provides statistica tests to ens re that s fficient data are co ected so a defensib e decision to re diate f rther or deter ne no f rther action for the site can be de. The statistics a so take into acco nt the stakeho der negotiated decision errors.

d. Whi e MARSSIM is designed pri ri to address the fina stat s s rve of a site, the thodo ogies and statistica tests are app icab e to scoping s rve s, characterization s rve s, and re dia action s rve s. Additiona ti-agenc g idance is in draft which addresses s b-s rface soi s, eq ip nt and debris re ease, and radio ogica aborator accreditation.

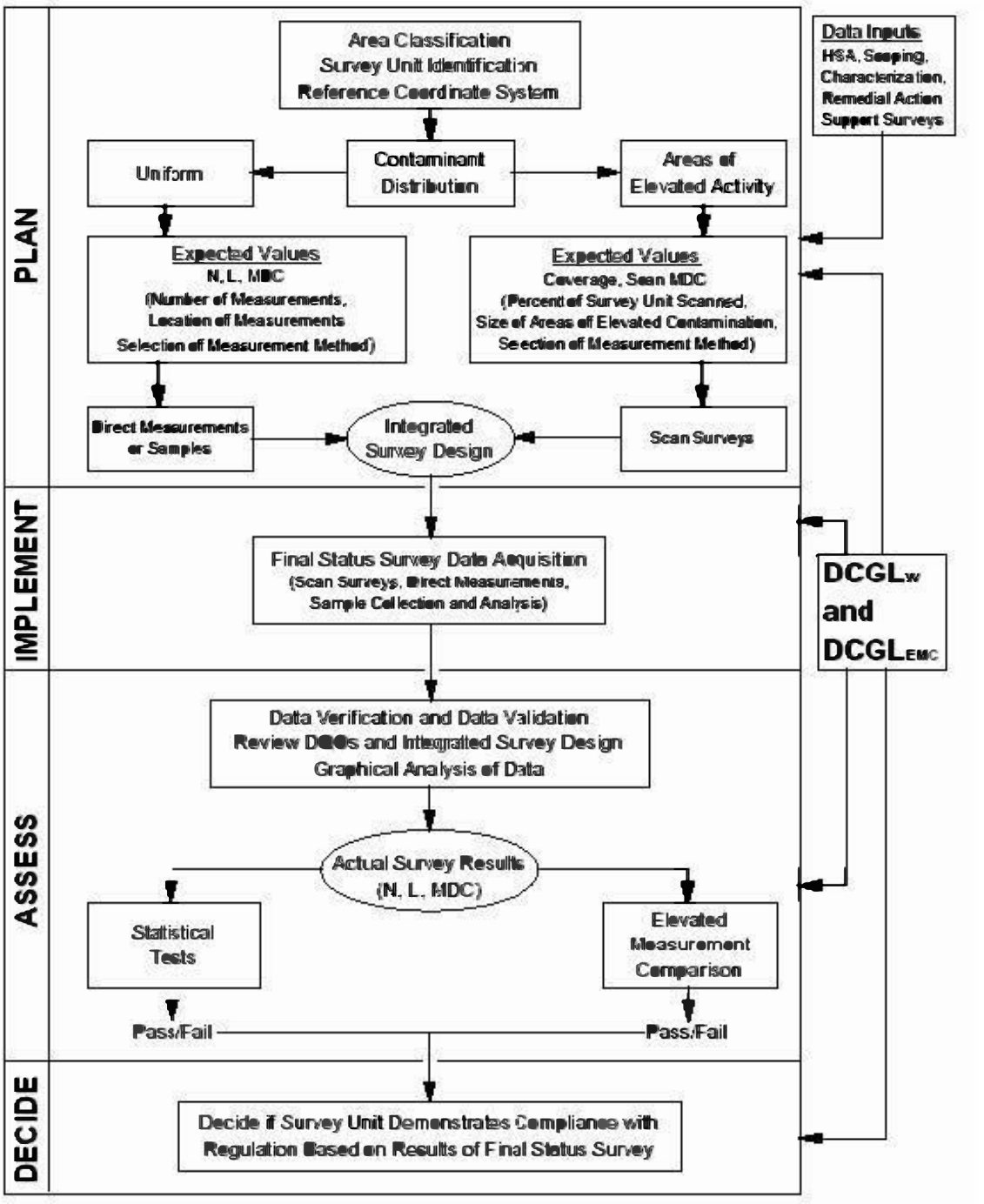

Fig re 13-1. Data Life C c e App ied to a Fina tat s rve .

S

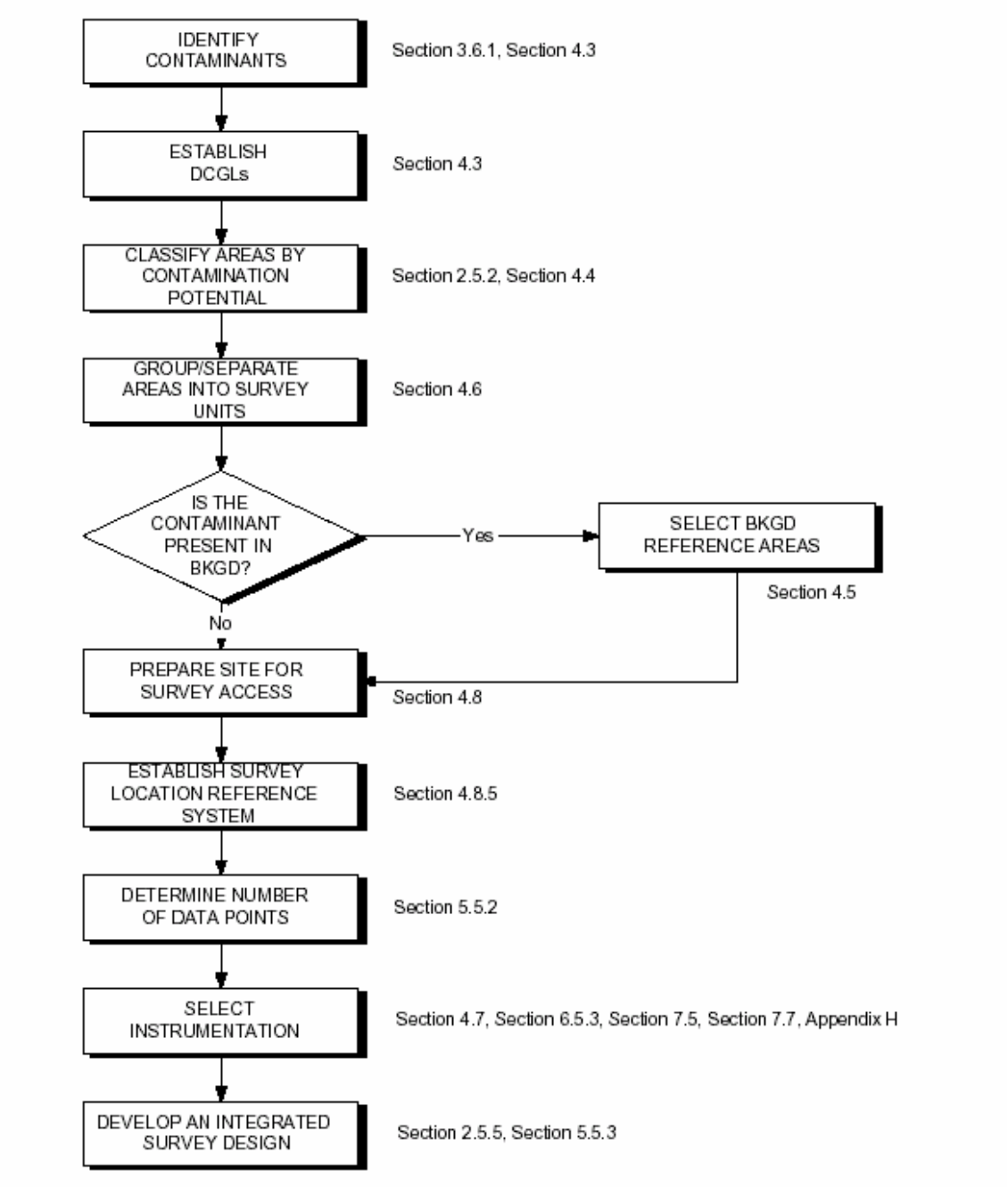

Fig re 13- . F ow Diagram for Designing a Fina Stat s S rve .

APPENDIX A

References and Bib i graph f Reg at r D c ments, Reg ati ns and Laws

A-1. C de f Federa Reg ati ns (CFR)*

a. NRC Standards.

10 CFR 0
Standards f r pr tecti n against radiati n

10 CFR 60
Disp sa f high- eve radi active wastes in ge gic rep sit ries

10 CFR 61
Licensing req irements f r and disp sa f radi active waste

10 CFR 71
Packaging and transp rtati n f radi active materia

b. OSHA Standards.

9 CFR 1910
Occ pati na safet and hea th standards

9 CFR 19 6
Safet and hea th reg ati ns f r c nstr cti n

c. EPA Standards

40 CFR 61
Nati na emissi n standards f r hazard s air p tants
o
40 CFR 1
EPA administered permit pr grams: The nati na p tant discharge e iminati n s stem
o
40 CFR 1 5
Criteria and standards f r the nati na p tant discharge e iminati n s stem o

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* S perintendent f D c ments
G vernment Printing Office
Washingt n, DC 040
o

40 CFR 141
Nationa primar drinking wat r r g ations

40 CFR 14
Nationa primar drinking wat r r g ations imp m ntation

40 CFR 191
Environm nta radiation prot ction standards for manag m nt and disposa of sp nt n c ar f , high- v and trans ranic radioactiv wast s

40 CFR 19
H a th and nvironm nta prot ction standards for rani m and thori m mi tai ings

40 CFR 60
Hazardo s wast manag m nt s st m: G n ra

40 CFR 61
Id ntification and isting of hazardo s wast

40 CFR 68
Land disposa r strictions

40 CFR 300
Nationa Oi and Hazardo s S bstanc s Po tion Conting nc P an

d. G n ra Standards.

41 CFR 101
F d ra Prop rt Manag m nt R g ations

48 CFR Chapt r
F d ra Acq isition R g ation D partm nt of D f ns

. DOT Standards

49 CFR 171-178
Transportation of Hazardo s Mat ria s

A- . Congressiona Acts.
6
C ean Air Act
P b ic Law 88- 0
4 U. S. C. 1857
6
Comprehensive Environmenta Response, Compensation,
and Liabi it Act (CERCLA)
P b ic Law 9 -510
4 U. S. C. 9 01-et seq., as amended

S perf nd Amendments and Rea thorization Act of 198
(SARA, amending CERCLA)
P b ic Law 99-499
6
Federa Water Po tion Contro Act (C ean Water Act)
P b ic Law 8 -70 amended b PL 9 -500
33 U. S. C. 1 51 et seq.

Nationa Environmenta Po ic Act (NEPA)
P b ic Law 91-190
4 U. S. C. 43 1
6
So id Waste Disposa Act as amended b the
Reso rce Conservation and Recover Act of 197 (RCRA)
P b ic Law 94-580
4 U. S. C. 901et seq., as amended
6
Hazardo s and So id Waste Amendments of 1984(HSWA) amends the So id Waste Disposa
Act as amended b RCRA
P b ic Law 98- 1
6
Safe Drinking Water Act
P b ic Law 93-5 3
4 U. S. C. 300f et seq., as amended
6
Toxic S bstances Contro Act
P b ic Law 94-4 9
15 U. S. C. 01 et seq., as amended 6

Nationa Low Leve Radioactive
Waste Po ic Act o 1980
P b ic Law 96-573
4 U. S. C. 0 1- 1 1D

The o owing three acts are avai ab e in NUREG 0980:
Low Leve Radioactive Waste Po ic Act Amendments Act o 1985
P b ic Law 99- 40
4 USC 0 1b et seq.
NUREG 0980 Vo .

Atomic Energ Act o 1954 (and amendments)
4 U. S. C. 011- 96
NUREG 0980 Vo . 1

Energ Reorganization Act o 1974
P b ic Law 93-438
NUREG 0980 Vo . 1

A-3. DOD Reg ations.

DOD 4715.6-R
Low-Leve Radioactive Waste Disposa Program

A-4. Arm Reg ations.

AR 11-9
The Arm yRadiation Sa et Program

AR 50-7
Arm yReactor Program.

AR 00-1
Environmenta Protection and Enhancement

AR 00-
Environmenta E ects o Arm yActions.

AR 385-10
Arm ySa et Program.

AR 385-40
Accident Reporting and Records.

AR 750-43
Ar Test, Meas re nt and Diagnostic Eq ip nt Progra .

A-5. USACE P b ications.

a. Engineer Reg ations.
ER 5-1-11
U.S. Ar Corps of Engineers B siness Process

ER 00-1-4
Environ nta Q a it - For re Uti ized Sites Re dia Action Progra (FUSRAP) - Site Designation, Re diation Scope, and Recovering Costs

ER 385-1-80
Ionizing Radiation Protection.

ER 385-1-9
Safet and Occ pationa Hea th Req ire nts for Hazardo s, Toxic and Radioactive Waste (HTRW) Projects.

ER 1110-1- 63
Che ca Data Q a it Manage nt For Hazardo s, Toxic, Radioactive Waste Re dia Activities

ER 1110-3-1301
Hazardo s, Toxic And Radioactive Waste (HTRW) Cost Engineering

ER 1165- -13
Hazardo s, Toxic And Radioactive Waste (HTRW) G idance For Civi Works Projects

b. Engineer Man a s.

EM 00-1-
Technica Project P anning (TPP) Process

EM 00-1-3
Req ire nts for the Preparation of Sa pn g and Ana sis P ans m

m

EM 1110-35-1
1 005

EM 00-1-6
Chemica Q a it Ass rance For Hazar o s, Toxic An Ra ioactive Waste (HTRW) Projects

EM 385-1-1
Safet An Hea th Req irements Man d d
d
EM 385-1-80
Safet - Ra iation Protection Man a

APPENDIX B

Radiation Contro Agen Points of Conta t* c

B-1. Federa Radiation Programs.

a. MARSSIM Appendix L.

MARSSIM Appendix L ontains a dire tor ist of Federa radiation program managers and is pdated on a reg ar basis.

MARSSIM Appendix L
c
NRC Headq arters and Regiona Offi es

b. USACE and Radioa tive Waste Disposa Points of Conta t.

Headq arters, US Arm yCorps of Engineers
Radiation Safet Staff Offi er
441 G St NW
Washington, DC 0314-1000
(0) 761-1953
c
US Arm yCorps of Engineers
HTRW Center of Expertise
1 565 W Center Rd
Omaha, NE 68144-3869
(40) 697- 478 fax (40) 697- 595

Headq arters, Arm yFie d S pport Command AMSFS-SF
B i ding 350, 3 F oor
1 Ro k Is and Arsena
Ro k Is and Arsena , IL 61 99-6500
(309) 78 - 033
fax (309) 78 - 988 c

* Be a se offi es move and hange, addresses and te ephone n mbers fo nd at these h per inks annot be g aranteed, b t the sho d provide an ex e ent starting point the majorit of the time.
c

B- . State Agencies.

The Conference of adiation Contro Program Directors (C CPD) maintains a director of State Program POCs.

C CPD R

N C Agreement States

A abama	Kansas	Nevada	Or gon
Arizona	Kent ck	New Hampshire	hode Is and
Ca ifornia	Lo isiana	New Mexico	So th Caro ina
Co orado	Maine	New York	Tennessee
F orida	Mar and	North Caro ina	Texas
Georgia	Massach setts	North Dakota	Utah
I inois R	Mississippi R	Ohio	Washington R
Iowa	Nebraska	Ok ahoma	

APPENDIX C

Technica Informa ion on Radioac ive Ma eria s, Deca , t Meas ring Techniq es, and Ins r men a ion

C-1. Deca Chains.

a. Man radioac ive ma eria s deca o o her radioac ive ma eria s, which ma in rn, a so deca o o her radioac ive ma eria s. When he paren radion c ide deca s o a radioac ive progen , i is said o be par of a radioac ive deca chain. Two ver common deca chains are he rani m- 38 deca chain, which inc des, among o her radion c ides, hori m- 30, radi m- 6, and radon- , and he hori m- 3 deca chain, which inc des radi m- 8 and radon- 0.

b. Beca se of he exis ence of deca chains, a n mber of hings impor an o con aminan charac eriza ion can happen. Firs , if a paren radion c ide is fo nd on-si e, he progen radion c ide can be expec ed o be on-si e, and inverse , if a progen radion c ide is presen , he presence of i s paren radion c ide ma be inferred. For examp e, if o have de ec ed cesi m-137 on a si e, o wi a wa s find i s progen , bari m-137m on he si e, and i s ac ivi wi be in eq i ibri m wi h he ac ivi of he cesi m-137.

C- . Iden if ing Radion c ides.

a. Radion c ides are iden ifiab e b he radia ion he emi , and b heir a omic proper ies. Mos radion c ides fo nd on USACE projec s emi m u ip e pes and energies of radia ion. The pes and energies of he a he radia ions emi ed b a radion c ide are a niq e charac eris ic of ha radion c ide.

b. Examp e: cesi m-137 (^{137}Cs) deca s b wo pa hwa s. 94.6% of he ime ^{137}Cs wi emi a be a par ic e wi h a maxim um energ of 11.6 keV. .4% of he ime ^{137}Cs wi deca b emi ing a be a par ic e wi h a maxim um energ of 1173. keV. In bo h cases i deca s o me as ab e bari m-137m (^{137m}Ba), which is a so radioac ive. ^{137m}Ba deca s o s ab e bari m-137, 89.98% of he ime b emi ing a 661.649 keV gamma ra .

c. So an ime we have Cs-137 con amina ion on-si e, we wi be ab e o meas re a spec r m of be a ac ivi wi h a maxim um be a energ of 1173 keV, and a ^{137m}Ba gamma peak wi h an energ of 66 keV.

d. An nknown samp e of a radioac ive ma eria can be ana zed b de ermining wha pe of radia ion i emi s, de ermining a wha energ he radia ion is emi ed, hen ooking p in ab es which par ic ar radion c ides emi ha pe of radia ion a ha par ic ar energ . In he examp e above, ^{137}Cs co d be ana zed sing a iq id scin i a ion co n er o

determine the beta spectr m, and the maxim um beta energ . he area nder the c rve of the beta spectr m is proportiona to the activit of the ^{137}Cs. Noting that ^{137}Cs is part of a deca chain, one co d a so se a gamma co nter to co nt the gamma ra s at an energ of 66 keV from the ^{137m}Ba and divide the res t b the gamma intensit of 89.98% to ca c ate the activit of the ^{137}Cs. Since gamma co nting is m uch easier and cheaper to perform, this method is more common sed. Man of the radion c ides of concern at USACE sites are parts of deca chains.

e. S rrogates can be sed beca se, when a parent radion c ide has a ha f- ife ver m uch arger than its progen , the progen deca at a rate faster than it is generated, so it appears than the activit of the progen is eq a to the activit of the parent after s fficient in-growth. As a r e of th mb, seven ha f- ives of the progen is considered s fficient time for this in-growth to be achieved.

f. his practice of meas ring a s rrogate radion c ide and ca c ating the activit of another radion c ide in the same deca chain is common, b t there are a n mber of pitfa s that m ust be avoided. here are a n mber of actions that can inva idate this se of s rrogates. Man of these invo ve actions that chemica separate the radion c ide from its progen or not permit eno gh time for adeq ate in-growth of the s rrogate. It is important to discover at which point in the deca chain materia s were bro ght to the site or removed from the site.

g. A n mber of deca progen ma be gamma emitters b t either the percent of time the gammas are emitted or the percent of time the deca chain goes b their path ma be too sma to make them sef at activities near remediation g ide ines. A se of s rrogates for determination of the presence and activit of a radioactive contaminant m ust be thoro gh investigated, doc mented and agreed to b the reg ators.

h. Beca se the act of samp ing soi or water can disr pt the concentrations of ingrown progen , samp es m ust be he d for a n mber of da s or weeks to ens re that the s rrogate being meas red has had s fficient time to approach eq i ibri m with the parent radion c ide being ana zed.

i. As an examp e, Ra- 6 is common ana zed sing gamma spectroscop and meas ring the activit of Bi- 14. he deca chain is Ra- 6 to Rn- to Po- 18 to Pb- 14 to Bi- 14 to Po- 14. he act of soi samp ing often ca ses the Rn- , which is a gas, to escape. his disr pts the deca chain and the samp e sho d be he d ndist rbed for seven ha f- ives for each of the progen to re-estab ish eq i ibri m. he ha f- ives of the progen are Rn- -3.8 da s, Po- 18-3.0 min., Pb- 14- 6.8 min., and Bi- 14-19.9 min. his tota s 3.8 da s. he samp e sho d be he d for seven ha f ives, 7 da s, to ens re that the Bi- 14 activit is the same as the Ra- 6 activit . Note that nder certain conditions, ratio charts can be constr cted to a ow co nting before the seven ha f- ives have passed. here are a

n mber of factors that can inf ence the acc rac of the ratio chart. The project hea th ph sicist sho be cons te to check if the metho ma be acc rate se on an partic ar phase of a project.

j. Bi- 14 emits a 0.609 MeV gamma 46.1% of the time when it eca s. The gamma spectrometer wi co nt the n mber of these gamma emitte . The ra iochemist wi ivi e the n mber of co nts b the efficienc an the intensit to etermine the n mber of isintegrations ring the co nting perio . This is then ass me to be the n mber of isintegrations of the parent ra ion c i e over the same time perio .

k. Since ra ion c i es can be meas re b their atomic properties, some chemica q antification metho s ma be se to q antif the ra ion c i es. One common examp e is se of in ctive co p e p asma-mass spectrometr to etermine the isotopic ab n ance of enriche or ep ete rani m isotopes.

C-3. Backgro n .

a. A arge n mber of ra ion c i es are present in the environment at concentrations that can interfere with the meas rement of the contamination at a site. The ra iation emitte b these ra ion c i es - most nat ra occ rring b t some man-ma e is co ective referre to as backgro n ra iation. Primar ra ion c i es fo n in backgro n inc e:

- The rani m (U) eca chain [U- 38, thori m (Th)- 34, protactini m (Pa)- 34, U- 34, Th- 30, ra i m (Ra)- 6, ra on (Rn)- , po oni m (Po)- 18, ea (Pb)- 14, bism th (Bi)- 14, Po- 14, Pb- 10, Bi- 10, an Po- 10].
- The thori m eca chain [Th- 3 , Ra- 8, actini m (Ac)- 8, Th- 8, Ra- 4, Rn- 0, Po- 16, Pb- 1 , Bi- 1 an Po- 1].
- Potassi m-40 (K-40), triti m (H-3) an carbon-14 (C-14).
- Mixe fission pro cts from above gro n n c ear testing (Cs-137, Sr-90, etc.).

b. The concentrations of ra ion c i es in backgro n are high variab e, epen ing on t pes of soi thro gho t the entire soi co mn, precipitation, water tab e, temperat re, an atit e. Concentrations can var b or ers of magnit e. For examp e, rani m fo n in igneo s rock averages abo t 0.6 ppm, b t rani m fo n in F ori a phosphate rock averages abo t 1 0 ppm.

c. Beca se of this variabi it , it is important to se ect an area from which to take backgro n s rve rea ings an samp es that has the same soi an water characteristics, an as near the ph sica ocation, of the contaminant as is possib e. A itiona , when etermining backgro n concentrations, eno gh backgro n samp es m st be obtaine to etermine the variabi it an stan ar eviation of the concentration at an acceptab e confi ence imit. MARSSIM, Sec. 4. , provi es g i ance on se ection of a backgro n

reference area, and a hea th ph sicist m ust be cons ted to determine the proper n mber of bac gro nd samp es to ta e. This n mber ma be as high as the tota n mber of samp es ta en at the site, i.e., one bac gro nd samp e per contaminant samp e.

C-4. Reg ated Contaminants. Beca se of the nat re of the reg ator process, radioactive contamination is reg ated nder a n mber of stat tes. A more detai ed description of the reg ations and their interaction can be fo nd in Chapter 9. Ongoing egis ative changes have fo owed changes in the phi osoph of radiation safet , b t a n mber of o der stat tes are sti app icab e, and have ed to a few conf sing remediation goa s at some sites. The Urani m Mi Tai ings Contro Act was one of the first acts specifica addressing radioactive contamination in the soi . This act set the remediation goa for rani m mi sites at pCi/g of radi m in the top 6 inches of soi and 1 pCi/g radi m in each s bseq ent 1 inches of soi . Beca se there were no other prom ugated standards on soi contamination, this prescriptive remediation goa was cited as re evant and appropriate and app ied to other sites where the contaminants were not rani m mi tai ings.

APPENDIX D

T pica Remediation ite Characteristics

D-1. Urani m and Thori m Mines and Mi s.

a. Faci it Operation Description. Urani m is mined sing both open pits and ndergro nd shafts. ome faci ities are now sing a s bs rface p mping and eaching process. Urani m mi s are often co- ocated with the mines. A majorit of the mines in the U are ocated in the states of Arizona, New Mexico, Utah, and Co orado, b t active eaching a so occ rs in Nebraska and Texas. The majorit of the contaminants are ocated in tai ings from the mi s and the mines. Co-ming ed hazardo s components s ch as Arsenic, and acids are common fo nd at these sites.

b. T pes of Radiation Expected. A pha, beta, gamma and ne tron radiation can be expected from these sites.

c. T pes of o rces Present. Urani m 38, 35, and 34 and a their deca progen can be fo nd at these sites. Thori m- 3 and 30 and their deca progen ma a so be present at some sites. ince the mi s se ective extracted rani m, the deca progen at these sites can be expected to not be in eq i ibri m. There wi sti be resid a rani m or thori m in the mi tai ings, and can be expected to contain greater eve s of deca progen .

d. Radioactive Contamination Potentia . There is near a wa s contamination from mining and mi ing operations. Great pi es of mine-and-mi tai ings are eft on-site. Often conso idation points from nearb mines exist, where ores were conso idated for transport to the mi s. rface and gro nd water contamination is common from rain perco ating thro gh the waste pi es, and r nning off sites. Estab ishment of backgro nd can be tro b esome beca se the nat ra e evated backgro nd radiation is primari attrib tab e to the e evated Urani m in the oca and s bs rface soi s.

e. Radioactive Waste Generated. Large q antities of so rce materia , 11e.( ) b prod ct materia or resid a s of ore processing prior to 1978, ma be enco ntered.

f. Potentia Contaminated Areas. Mines, mi s access roads, wide s rro nding areas, associated heav eq ipment, hand too s, transport vehic es, PPE, gro nd water, creeks and rivers, and workers' ho ses can be expected to be contaminated. Cross contamination is a common prob em.

D- . N c ear Weapons Faci ities.

a. Faci it Operation Description. The n c ear eapons faci ities considered here are those here n c ear eapons are inspected, stored, and maintained. TRU materia s and astes ma be present. Both radioactive astes and co-ming ed astes ma be present as b prod cts of the processes and operations in the faci ities. The eapons ere disassemb ed, inspected, repaired, reassemb ed, and stored nti shipped from these faci ities.

b. T pes of Radiation Expected. A pha, beta, gamma and ne tron radiation can be expected.

c. T pes of So rces Present. The radioactive materia can be considered a sea ed so rce hen a eapon is assemb ed. D ring inspection and maintenance, the radioactive materia is an nsea ed so rce. Examp es of radion c ides present in n c ear eapons are rani m- 33, and - 35, p toni m- 39 and - 41, americi m- 41, and h drogen-3. Dep eted rani m is a so sed in testing and training for eapons maintenance.

d. Radioactive Contamination Potentia . There is itt e potentia for radioactive contamination hen a eapon is assemb ed n ess it is s bjected to severe ph sica damage s ch as a fire. When a eapon is disassemb ed, there is a s ight potentia for contamination. This potentia increases if the radioactive materia is damaged in an a d ring inspection and maintenance.

e. Radioactive Waste Generated. Ver sma vo mes of s ight contaminated so id aste can be generated d ring inspection and maintenance. No significant amo nt of iq id radioactive aste is generated.

f. Potentia Contaminated Areas. Areas of potentia contamination inc de disassemb , inspection, maintenance, and reassemb areas; radioactive aste hand ing and packaging areas; and decontamination faci ities. Sinks, drains, trash receptac es, and former sed radioactive aste disposa ce s are probab e contaminated areas.

D-3. Research Laboratories.

a. Faci it Operation Description. Depending on its mission, a research aborator ma be invo ved in a ide vari t of activities, inc ding the ana sis of materia s activated b ne tron radiation, the effects of radiation expos re on anima s, and the se of radioactive tracers in chemistr experiments. Vario s radion c ides ma be sed in a t pica aborator environment or ma be sed in c osed, shie ded ce s, or g ove boxes to protect personne from radioactive hazards. A reactor or acce erator ma a so be sed at the faci it .

b. T pes of Radiation Expected. Depending on t e faci it mission, a n mber of different radion c ides ma be sed, and a p a, beta, X, gamma, or ne tron radiation can be expected.

c. T pes of So rces Present. Sea ed, partia sea ed, and nsea ed so rces can be expected to be sed.

d. Radioactive Contamination Potentia . T ere is a ig potentia for contamination in an area of a aborator w ere nsea ed so rces are sed.

e. Radioactive Waste Generated. Moderate to arge vo mes of so id radioactive waste can be expected. Sma to moderate vo mes of iq id radioactive waste can a so be generated. Researc abs c aracteristica prod ce arger q antities of mixed or co-ming ed wastes compared to radioactive wastes.

f. Potentia Contaminated Areas. Areas of potentia contamination inc de:

- Laborator areas (benc tops, f me oods, g assware, centrif ges, scinti ation co nters, ot ce s, g ove boxes, and refrigerators sed for radioactive materia storage)
- Anima cage areas
- So id radioactive waste- and ing and packaging areas
- Liq id radioactive waste s stem (tanks, p mps, va ves, piping)
- Venti ation s stem (d cting, fi ters, fi ter o sings)

D-4. Medica Faci ities.

a. Faci it Operation Description. Medica faci ities perform a variet of diagnostic and t erape tic proced res sing radioactive materia s and radiation-prod cing mac ines. For diagnostic proced res, radioactive materia ma be injected into a patient in iq id form or taken ora . Radiation-prod cing mac ines s c as X-ra nits and comp terized tomograp scanners ma be sed. For t erape tic proced res, radioactive materia ma be injected into a patient in iq id form, taken ora , or imp anted in so id form. T ese imp anted so rces ma remain in t e patient or can be removed ater. Acce erators and ig radioactive coba t-60 so rce caps es are a so sed for radiation t erap .

b. T pes of Radiation Expected. Beta, X, gamma, ne tron and c arged partic e radiation so rces co d occ r.

c. T pes of So rces Present. Sea ed, partia sea ed, and nsea ed so rces can be expected to be sed.
h

d. Radioactive Contamination Potentia . The e is a high potentia fo contamination whe e nsea ed so ces a e sed fo diagnosis o the ap . Most nsea ed adion c ides sed in medicine have sho t ha f- ives and, the efo e, ma not p esent majo decontamination p ob ems fo decommissioning. The e is a minim um potentia fo contamination when so ces a e imp anted if the sro ces a e mishand ed. The e is a s ight potentia fo contamination f om sea ed so ces s ch as high adioactivit coba t-60 so ces that a e sed in adiation the ap nits. Contamination ma occ f om activation p od cts c eated b high-ene g acce e ato s (> 10 mi ion e ect on vo ts) sed in esea ch-o iented medica faci ities.

e. Radioactive Waste Gene ated. Sma to mode ate vo mes of so id adioactive waste can be expected. Sma to mode ate vo mes of iq id adioactive waste wi be gene ated.

f. Potentia Contaminated A eas. A eas of potentia contamination ma inc de the fo owing:

- Radio-pha macies that a e p od cing, sto ing, o dispensing adioactive d gs
- Labo ato ies whe e iq id so ces a e p epa ed fo se
- Ope ating ooms whe e so ces a e imp anted
- Patients' ooms and examination ooms whe e patients who have been administe ed adioactive mate ia s a e ocated
- N c ea medicine hot abs
- So id adioactive waste-hand ing, packaging, and sto age a eas
- Liq id adioactive waste s stem (tanks, p mps, va ves, piping)
- A eas whe e iq id adioactive so ces a e sto ed p io to p epa ation fo administ ation

D-5. Poo Reacto s and Ne t on Radiog aph Reacto s.

a. Faci it Ope ation Desc iption. These eacto s a e atmosphe ic-p ess e, wate - coo ed assemb ies gene a sed to p od ce ong-te m, stead -state f xes of the ma ne t on adiation. Some eacto s can a so p od ce a high f x of the ma ne t on adiation fo a ve sho t pe iod of time. The ne t on adiation is made avai ab e fo se o tside the eacto b beam po ts which penet ate the eacto st ct e. Items to be i adiated a e p aced in f ont of the beam po ts.

b. T pes of Radiation Expected. P ima i gamma and ne t on adiation a e expected f om the eacto . Beta and gamma adiation a e expected f om the i adiated test items, eacto st ct es, o imp ities in the coo ing wate .

c. T pes of So rces Present. The reactor f e e ements can be cons dered a sea ed so rce beca se the ran m f e and f ss on prod cts are conta ned n c add ng. Imp r t es n the coo ng water that become act vated can be cons dered an nsea ed so rce. An rad oact ve mater a res t ng from ne tron act vat on of test tems or reactor str ct res co d be c ass f ed as sea ed or nsea ed so rces based pon the t pes of mater a s be ng act vated. Sea ed and part a sea ed so rces w be sed for nstr ment checks and ca brat ons.

d. Rad oact ve Contam nat on Potent a . The potent a for contam nat on n a poo - reactor fac t can be character zed as moderate. The rad oact ve mater a n the coo ng water, wh ch res ts from ne tron act vat on of mp r t es, ma be p mped thro gh the coo ng s stem and depos ted n p pes, va ves, p mps, and other s stem components. When these components are opened for ma ntenance or repa r, or f eaks occ r, contam nat on s ke . The nventor for the coo ant rad oact ve mater a w be ncreased f the f e c add ng eaks or s damaged n some manner, re eas ng f ss on prod cts nto the coo ng water. If ne tron act vat on of test tems or the str ct res s rro nd ng a reactor occ rs, the rad oact ve mater a w be f xed.

e. Rad oact ve Waste Generated. Moderate vo mes of so d and q d rad oact ve wastes w be prod ced at th s t pe of fac t .

f. Potent a Contam nated Areas. Areas and other so rces of potent a contam nat on nc de:

- Area ho s ng the reactor
- Areas ho s ng the reactor a x ar s stem
- Test tems i
- Beam ports and eq pment sed to hand e act vated test tems
- Ma ntenance areas i
- So d rad oact ve waste-hand ng and packag ng areas
- L q d rad oact ve waste s stem (tanks, p mps, va ves, p p ng)
- Vent at on s stem (d ct ng, f ters, f ter ho s ngs)
- Decontam nat on areas

D-6. Power Reactors.

a. Fac t Operat on Descr pt on. The major t of the power reactors n the Un ted States are press r zed water reactors (PWR) or bo ng water reactors (BWR). Other t pes of reactors nc de gas-coo ed, q d meta , and heav water. The reactor f e prod ces arge amo nts of heat as a res t of the f ss on process. Th s heat s sed to generate steam d rect n a BWR or s carr ed b the coo ant n the pr mar s stem to the steam generator n a PWR or other nd rect-c c e reactors. The heat s transferred thro gh the wa s of the t bes n the steam generator to the water n the secondar s de of the steam generator. The temperat re s

s fficient high to change the secondar water into steam. n most p ants, the steam trave s to a t rbine that drives an e ectric generator to prod ce e ectrica power.

b. T pes of Radiation Expected. Primari , gamma and ne tron radiation are expected from the reactor. Beta and gamma radiation are expected from the irradiated reactor str ct res or imp rities in the coo ant. A pha, beta, and gamma radiation ma arise from the spent f e rods stored at the faci it .

c. T pes of So rces Present. The f e rods inside the reactor itse f are designed to contain the rani m f e and fission prod cts within the c adding. The f e rods are the main so rce of gamma and ne tron radiation in the reactor. However, c adding fai re, or the presence of tramp rani m on reactor s rfaces, ma res t in the re ease of radioactive fission prod cts to the s rro nding coo ant. Activated imp rities and corroded activated meta s in the reactor coo ant can be considered an nsea ed so rce. Activated materia s in the reactor str ct re can a so be the so rce of gamma and beta radiation.

d. Radioactive Contamination Potentia . The potentia for contamination in a power reactor faci it is greater than that in other faci ities primari beca se of repair and maintenance activities. The radioactive materia in the reactor coo ant, which res ts from ne tron activation of corrosion prod cts and fission prod cts from f e -c adding fai res or tramp rani m, is carried thro gh the s stem and deposited in pipes, va ves, p mps, the steam generator, and other components. When these components are opened for maintenance or repair, or if eaks occ r, contamination is ike . The radioactive materia inventor wi be great increased if a s bstantia n mber of f e -c adding eaks occ r or the f e is damaged in some manner, re easing fission prod cts into the primar coo ant. When ne tron activation of the str ct res s rro nding a reactor occ rs as the s stem ages, the radioactive materia is fixed b t ma become removab e if the materia is dis odged thro gh corrosion and erosion.

e. Radioactive Waste Generated. Great vo mes of so id and iq id radioactive waste can be prod ced at this t pe of faci it .

f. Potentia Contaminated Areas. Areas of potentia contamination inc de:

- Area ho sing the reactor
- Areas ho sing reactor a xi iar s stems
- Maintenance areas
- Eq ipment decontamination areas
- Personne decontamination areas
- Protective c othing a ndr area
- Respirator protective eq ipment decontamination area I
- So id radioactive waste-hand ing and packaging area

- Liq id radioactive waste-s stem (ta ks, p mps, va ves, pipi g) n
- Ve ti atio s stems (d cti g, fi ters, fi ter ho si gs)

D-7. Acce erator Faci ities.

a. Faci it Operatio Descriptio .

(1) Partic e acce erators are radiatio -prod ci g machi es sed for medica , i d stria , a d research p rposes.

( ) E ectro i ear acce erators (i acs) are sed to prod ce a primar beam of e ectro radiatio (simi ar to beta radiatio tho gh high directive a d of m uch greater e erg) or a seco dar beam of X-radiatio (simi ar to gamma radiatio) for se i therap . The patie t is positio ed re ative to the o tp t beam port of a e ectro i acs a d the machi e is e ergized for the time req ired to prod ce the amo t of radiatio desired for the therap .

(3) E ectro i acs are sed i i d stria app icatio s to prod ce a seco dar beam of X-radiatio . The radiatio is sed for the radiograph of s ch items as we ds, casti gs, a d m u itio s. E ectro i acs are sed i research to determi e the effects of irradiatio o vario s materia s der st d .

(4) Other t pes of partic e acce erators are sed for e gi eeri g ph sics research.

b. T pes of Radiatio Expected. E ectro s make p the primar beam of e ectro i acs. If the o tp t e erg of e ectro i acs exceeds abo t 10 mi io e ectro vo ts, e tro s ma be prod ced. Other t pes of partic e acce erators emit, proto s, a pha partic es or other c ear partic es, res ti g i seco dar radiatio s a d activatio of materia s. The activated materia orma deca s b beta- (positive or egative) a d gamma-radiatio emissio .

c. T pes of So rces Prese t. Li acs i corporate radioisotopes of vario s species i their so rces a d i some of their targets. If the o tp t e erg of a e ectro i ac exceeds abo t 10 mi io e ectro vo ts, e tro radiatio ma be prod ced. This e tro radiatio a d o tp t from other t pes of partic e acce erators ma activate areas of the device aro d the o tp t beam port a d the str ct re s rro di g the device. If this occ rs i so id objects, n the radioactive materia is co sidered a sea ed so rce; activated iq ids or gases wi s a be i sea ed form a d more mobi e.

d. Radioactive Co tami atio Pote tia . There are severa differe t t pes of partic e acce erators. Each t pe a d its specific operatio m st be reviewed to determi e the pote tia co tami atio . n
n

e. Radioactive Waste Generated. No i id or so id radioactive waste is expected n ess the e ectron inac exceeds 10 mi ion e ectron vo ts, in which case sma vo mes of so id, i id, or gaseo s waste res ting from ne tron activation ma be prod ced. Sma vo mes of radioactive waste ma be generated b other t pes of partic e acce erators.

f. Potentia Contaminated Areas. If the o tp t energ of e ectron inacs is ess than 10 mi ion e ectron vo ts, none of the s rro nding str ct re wi be contaminated. Energies greater than 10 mi ion e ectron vo ts from e ectron inacs or other partic e acce erators ma activate components, targets, and s rro nding str ct res, which ma res t in contamination from oose or dist rbed materia , d ring maintenance of the devices, and d ring decommissioning of the devices.

D-8. Radiographic Faci ities.

a. Radiographic Faci ities sing E ectromagnetic Radiation. The primar p rpose of radiographic faci ities is to nondestr ctive test items for defects. For examp e, we ds are radiographed to revea an hidden porosit or cracks, castings are radiographed to revea an hidden voids, and m unitions are radiographed to check for proper assemb . E ectromagnetic radiation penetrates a test item and exposes a sheet of fi m or arra of detectors in the same manner that ight exposes fi m or video s stems to prod ce an image. Radiographic fi ms are processed and checked for defects in the item radiographed. The e ectromagnetic radiation needed for radiograph ma be prod ced b a sea ed so rce of radioactive materia s ch as coba t-60 or iridi m-19 , or b X-ra machines or e ection inacs. Sea ed radioactive so rces m st be ho sed in shie ded containers when not in se. The containers ma be fixed or portab e. X-ra machines re ire no shie ding when not in se beca se radiation is prod ced on when a machine is e ectrica energized. Shie ding is re ired when a machine is energized. X-ra machines ma be insta ed in a fixed config ration or ma be portab e.

(1) T pes of Radiation Expected. Gamma radiation is expected from sea ed radioactive so rces. Linacs ma be sed to generate the radiographic beam and their characteristic radiation and waste potentia sho d be expected.

( ) T pes of So rces Present. When radioactive materia is sed, the so rces wi be sea ed.

(3) Radioactive Contamination Potentia . There is no potentia for contamination from an X-ra machine or from a sea ed so rce n ess the so rce is damaged in a manner that breaches the integrit of the materia sed to encaps ate the radioactive materia , or n ess the sea ed so rce eaks for an other reason.

(4) Radioactive Waste Gene ated. None is expected f om most adiog aphic s stems. Howeve , if inacs a e sed to gene ate the adiog aphic beam, the so ces and ta gets a e p obab e waste so ces.

(5) Potentia Contaminated A eas. The e a e none, except in the case of inac- gene ation adiog aphic s stems.

b. Radiog aphic Faci ities sing Ne t on Radiog aph . Ne t on adiog aph is sed to detect moist e and co osion in bonded hone combed st ct es and to test othe mate ia s. The seconda adiations c eated b the ne t ons eacting with the mate ia a e detected and disp a ed on monito s that have the capabi it of digita and imaging enhancement. Most f eq ent , so ces s ch as adi m, ame ici m, o p toni m can be sed as so ces of a pha adiation impinging on be i m. The be i m is activated b a pha adiation to emit ne t ons. The adiog aph occ s in a shie ded and inte ocked ba , which is accessib e on when the so ce is withd awn into a shie d.

(1) T pes of Radiation Expected. Ne t ons f om the so ce a e to be expected. D e to ne t on activation, a pha, beta, ne t on, and gamma adiation ma es t f om i adiated test items and st ct a mate ia s.

r

( ) T pes of So ces P esent. The so ce is t pica sea ed he metica . So ce encaps ation ma fai , ca sing the di ect e ease of a pha and ne t on adiation. An adioactive mate ia es ting f om activation of test items o st ct a mate ia can be c assified as sea ed o nsea ed, based on the t pes of mate ia being activated.

(3) Radioactive Contamination Potentia . The potentia fo contamination is ow fo p ope sed and maintained so ces. Abandoned o ost so ce caps es p esent a se io s haza d. It m ust be noted that the be i m sed to p od ce the seconda ne t on adiation is a ve toxic heav meta . Ne t on activation of test items o the st ct e s o nding the so ce of ne t ons co d es t in contamination if the mate ia we e dis odged and became oose and sp eadab e.

(4) Radioactive Waste Gene ated. Ve itt e waste wi be gene ated that is adioactive so ong as p ope ope ationa , maintenance, and sto age p actices a e fo owed. Decommissioning of adiog aphic eq ipment wi gene ate the a gest po tion of LLRW of the enti e se c c e. The potentia fo ncont o ed adioactive waste is g eate in the event of eq ipment abandonment, fi e, o othe catast ophic event.

(5) Potentia Contaminated A eas. A eas of potentia ow- eve contamination a e est icted to the adiog aph ba and test-mate ia -hand ing a eas.

D-9. Radio mino s-device Storage aci ities.

a. aci it Operation Description. These faci ities store new and sed radio mino s devices s ch as c ocks, instr ments, g nsights, night-vision testers, exit signs, and radio minescent airfie d ighting s stems.

b. T pes of Radiation Expected. Radio minescent devices se radioactive so rces to energize phosphorescent e ements or chemica s. The radioactive materia s primari sed to generate minosit are triti m, promethi m-147, kr pton-85, and radi m- 6. Triti m and promethi m-147 emit beta radiation on , kr pton-85 emits beta and gamma radiation, and radi m- 6 emits a pha and gamma radiation. Deca prod cts of radi m- 6, which are radioactive, wi a so emit beta radiation. Radon- is a gaseo s deca prod ct and poses the risk of inha ation.

c. T pes of So rces Present. Radio mino s devices ma consist of instr ment faces with the radiation so rce painted on or ma incorporate via s or caps es of radio mino s materia s. Beca se the devices freq ent re on triti m or radi m as primar radiation so rces, the have great potentia to be effective nsea ed. This is beca se triti m ma be a gaseo s radioisotope, and beca se one of the da ghters of the deca of radi m is radon, which is a gaseo s radioisotope. G aranteed sea s, even of encaps ated radio mino s materia s, are diffic t to achieve and sho d not be expected.

d. Radioactive Contamination Potentia . Radio mino s paint is a probab e s rface and water contaminant when scraped or disso ved off its s bstrate. The most serio s and diffic t contamination arising from radio mino s devices is from radi m-doped paint.

e. Radioactive Waste Generated. Damaged eq ipment components that are painted with radio mino s materia s ma be radioactive waste. Maintenance of radio mino s s stems wi generate contaminated c ean p materia s. Radio mino s materia s characteristica prod ce gaseo s radioactive contaminants. Triti m and radon are readi so b e in water, are easi spread, and can contaminate bio ogica organisms, soi , and gro nd water. The great mobi it of radio minescent-generated waste makes it diffic t to c ean p. ort nate , the ow energ eve s and the sma vo mes of the origina so rces common enco ntered wi essen the environmenta impact.

f. Potentia Contaminated Areas. There are none, provided the device containing the radioactive materia remains intact. Devices with triti m or radi m- 6 sho d be treated as s spect to having eakage beca se of the gaseo s radioisotopes invo ved.

D-10. Dep eted Urani m Usage and Storage Faci ities.

a. Faci it peration Description. Dep eted rani m is sed to man fact re vario s t pes of m nitions. These m unitions are stored in vario s faci ities and are sed in test and practice firings as we as act a warfare. Dep eted rani m has been sed as armor in some mi itar vehic es and as co nterweights in aircraft. Dep eted rani m is a so sed for shie ding radiograph and te etherap so rces.

b. T pes of Radiation Expected. A pha, beta, gamma and ne tron radiation can a be expected. Additiona , the radioactive deca of the Urani m wi prod ce a seq ence of da ghter radioisotopes, each of which generates its own characteristic s ite of ionizing radiation. Urani m is a so a kidne toxin and in some cases the chemica toxicit ma be more of a hazard than the radiation expos re. Contro s sho d be based on the more imiting of the chemica or radio ogica expos res.

c. T pes of So rces Present. The dep eted rani m in the stored m unitions is encased in a min m or painted, so this so rce is considered sea ed if the case or paint is intact. After the m unitions are fired, the so rces wo d be nsea ed beca se the dep eted rani m shatters and is dispersed. Dep eted rani m sed for shie ds is s a encased in stee and is considered a sea ed so rce.

d. Radioactive Contamination Potentia . Airborne d st, machine shavings, c tting bricants, etc., wi arise from the fabrication of components from dep eted rani m. Waste disposa areas, water drains, and venti ation d cts wi be contaminated b the dep eted rani m. nce assemb ed, there is no potentia whi e the m unitions are in storage. After the m unitions are fired, there wi be contamination of target areas and target materia s.

e. Radioactive Waste Generated. There is itt e from storage except for radon- (inha ab e a pha radiation so rce) prod ced as a deca da ghter. Large fragments of the dep eted rani m dispersed after firing and the contaminated targets ma be co ected and disposed of as waste. Sma fragments and rani m oxide d st are not co ected and are genera dispersed aro nd the target site. The vo mes and dispersa of this contamination are s bstantia .

f. Potentia Contaminated Areas. Firing ranges and targets are areas of contamination.

O

D-11. Maintenance Shops Repairing Components Containing Magnesi m- hori m A o s and Dep eted Urani m.

a. Faci it Operation Description. Machine shops at Air Force Logistics Command Bases repair aircraft parts consisting of dep eted rani m and magnesi m-thori m a o s b machining, c tting, dri ing, we ding, and grinding.

b. pes of Radiation Expected. A pha, beta, gamma, and X-ra from thori m- 3 and rani m- 38, and radion c ides res ting from their deca are expected. Urani m is a so a kidne toxin and in some cases the chemica toxicit ma be more of a hazard than the radiation expos re. Contro s sho d be based on the more imiting of the chemica or radio ogica expos res.

c. pes of So rces Present. Dep eted rani m as aircraft co nterweights and aircraft components man fact red from magnesi m-thori m a o s are considered sea ed so rces except d ring repair operations which remove meta .

d. Radioactive Contamination Potentia . here is no potentia whi e the parts are in service or storage. Contamination res ts from machining, c tting, dri ing, we ding, and grinding operations.

e. Radioactive Waste Generated. Grindings, fi ings, grinding oi s, and broken parts are disposed of as radioactive waste. D ring grinding of magnesi m-thori m a o s, water is sed to prevent fires. his water is co ected in the hood s mp and the water is fi tered prior to re ease to the environment. Both iq id fi ters and high-efficienc partic ate air fi ters for the hoods are disposed of as radioactive waste. he waste vo me generated is not arge eno gh to req ire a specific on-site storage faci it .

f. Potentia Contaminated Area. his is imited to the hoods, exha st d ctwork, and immediate area in which repair operations are cond cted. T

GLOSSARY t

Terms, Abbrevia ions, and Acron ms

µ	micro-
AFSC	Arm yFie d S ppor Command
ALARA	As Low As is Reasonab Achievab e
ARAR	App icab e, Re evan and Appropria e Reg a ions
Bq	becq ere
CERCLA	Comprehensive Environmen a Response, Compensa ion, and Liabi i Ac
CFR t	Code of Federa Reg a ions
CHP	Cer ified Hea h Ph sicis t
Ci	c rie
cpm	co n s per min e
Cs	cesi m
CX	Cen er of Exper ise
CY	c bic ard
DA	Depar men of he Arm y
D&D t	Decon amina ion and Decommissioning
DCGL	Derived Concen ra ion G ide ine
DERP	Defense Environmen a Res ora ion Program
DOD	Depar men of Defense
DOE	Depar men of Energ
DOT	Depar men of Transpor a ion
dpm	disin egra ions (deca s) per min e
DQO	Da a Q a i Objec ive
EC	Engineering Circ ar
EM	Engineer Man a
EPA	Environmen a Pro ec ion Agenc
EM	Engineering Man a
ER	Engineering Reg a ion
FUSRAP	Former Used Si es Remedia Ac ion Program
FSS	Fina S a s S rve
G	giga-
g t	gram
G	gra
HLW	High-Leve Radioac ive Was e
HP	Hea h Ph sic(s)(is)
HPGe	High P ri Germani m
HQ	Headq ar ers
hr	ho r

HSWA	Hazardo s and So id Waste Amendments
HTRW	Hazardo s Toxic and Radioactive Waste
k	ki o-
keV	ki o-e ectron vo ts
L	iter
LLRW	Low-Leve Radioactive Waste
LUC	Land Use Contro
µR ,	microroentgen
^{m}X ,	metastab e
M ,	mega-
m	meter or mi i-
MARSSIM	M ti-Agenc Radiation Site S rve and Investigation Man a
MDC	Minim um Detectab e Concentration
mR ,	mi iroentgen
mrem	mi irem
MSC	Major S bordinate Commands
n	nano-
NaI	sodi m iodide
NORM	Nat ra Occ rring Radioactive Materia s
NRC	N c ear Reg ator Commission
OSHA	Occ pationa Safet and Hea th Administration
PA/SI	Pre iminar Assessment/Site Investigation
p	pico-
pCi	picoc rie
PM	Project Manager
POC	Point of Contact
ppm	parts per mi ion
PRG ,	Pre iminar Remediation G ide ine
QA	Q a it Ass rance
QC	Q a it Contro
R	roentgen
Ra	radi m
RCRA	Reso rce Conservation and Recover Act
ROD	Record of Decision
SARA	S perf nd Amendments and Rea thorization Act
SHP	Safet and Hea th Program
SI ,	S steme Internationa e
Sr	stronti m
SSL ,	Soi Screening Leve
Sv	sievert
SWMU	So id Waste Management Unit
T	tera-

TEDE	Tota Effective Dose Eq iva ent
Th	Thori m
TPP	Technica Pro ect P anning
TRU	Trans ranic Waste
TSDF	Treatment, Storage or Disposa Faci it j
U	rani m
US	United States
USACE	US Arm yCorps of Engineers

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ENVIRONMENTAL QUALITY

PROCESS ND PROCEDURES FOR SHIPPING H Z RDOUS W STES ND OTHER H Z RDOUS M TERI LS

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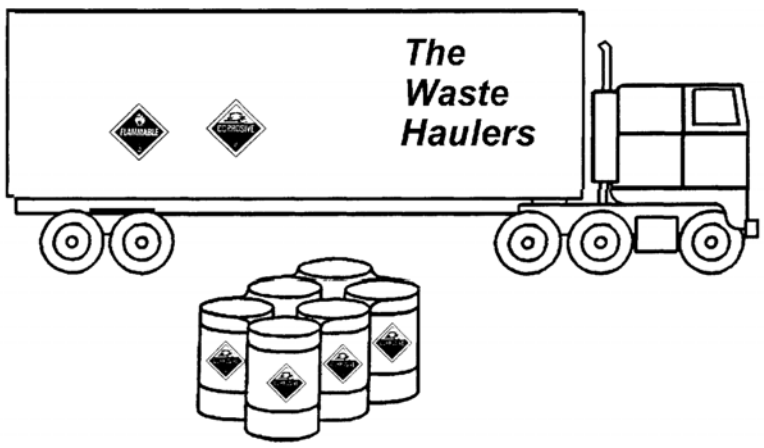

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Envi onm ental Quality
PROCESS AND PROCED RES FOR SHIPPING HAZARDO S WASTES
AND OTHER HAZARDO S MATERIALS

1. Pu ose. Th nclos a n ix is a gui to th oc u s an s onsibiliti s ima ily associat with th manif sting of haza ous wast s in acco anc with th qui m ents of th R sou c Cons vation an R cov y Act an th D a tm ent of T ans o tation gulations. In a ition, th am phl t s ts fo th oc u s fo th t ans o tation of oth haza ous mat ials, Fo m e ly tiliz Sit s R m e ial Action P og am (F SRAP) wast s, an oth wast s commonly t ans o t by th Co s of Engin s u ing sit m e iation an s ons actions.

. A licability. This am phl t a li s to all HQ SACE l m ents, all SACE comman s having th s onsibility fo x cuting an signing haza ous wast manif sts an all SACE l m ents s onsibl fo ov s ing cont acto s who a haza ous mat ials fo shi m ent an th n sign an x cut manif sts an oth shi ing a s.

3. Dist ibution Stat m ent. A ov fo ublic l as ; ist ibution is unlimit .

4. R f nc s.

a. 49 .S.C. 5101, t s q., as am en , Haza ous Mat ials T ans o tation Act.

b. 4 .S.C. 6901, t s q., as am en , R sou c Cons vation an R cov y Act (RCRA).

c. 4 .S.C. 9601, t s q., as am en , Com p h nsiv Envi onm ental R s ons , Com p nsation, an Liability Act (CERCLA).

. 8 .S.C. 679, t s q., as am en , F al Em ploy 's Liability R fo m an To t Com p nsation Act.

. PL 10 -386, F al Facility Com plianc Act, am en m ent to RCRA.

f. 40 CFR 61, 60- 80, 761, EPA asb stos, haza ous wast , an PCB gulations.

g. 40 CFR 300-30 , EPA National Conting ncy Plan an R o tabl Quantity gulations.

U

This EP su s s EP 00-1- , at 8 A il 000. U

h 49 CFR 171-180, DOT z rdous m aeri ls r spor io regul io s t

i EP 415-1-266, Reside E gi eers Ma geme Guide for HTRW Si es t

j EP 500-1-1, Emerge cy Employme of Army d O er Resources

k DTR 4500 9-R-P r II C rgo Moveme , Defe se Tr ffic Regul io , C p er 204, H z rdous Ma eri l

l EM 385-1-80, S fe y - R di io Pro ec io Ma u l

5 Discussio T e r spor io of z rdous m aeri ls i e U i ed S es is s ric ly regul ed by e U S Dep r me of Tr spor io (DOT) H z rdous w s es re o e subse of z rdous m aeri ls T e r spor io of z rdous w s e is s ric ly regul ed by e U S E viro me l Pro ec io Age cy (EPA) s well s e U S Dep r me of Tr spor io (DOT) EPA requires e use of specific s ippi g docume c lled e "U iform H z rdous t Was e Ma ifes " (EPA Form 8700-22) bu EPA defers o DOT for regul io s co cer i g e c u l prep r io of e m a ifes d p ysic l s ipme of e w s es T e DOT s pproxim aely 1700 p ges of requireme s discussi g e proper s ippi g requireme s for z rdous m aeri ls, i cludi g w s es d i requires e c s ipme be properly p ck ged, l beled, d m arked d ll r spor ve icles be properly pl c rded Al oug Polyc lori ed Bip e yls (PCBs) re o Feder l z rdous w s e, EPA requires e U iform H z rdous Was e Ma ifes be used for e s ipme of PCBs Addi io lly, for sbes os, EPA requires e use of form c lled Asbes os Was e S ippi g Record or equiv le s ippi g docume For PCBs d sbes os, e DOT requireme s mus be reviewed d me if e m aeri l lso mee s e defi i io of regul ed DOT z rdous m aeri l

6 Upd es. T is docume w s origi lly publis ed o 31 Marc 1994 d l er upd ed i April 2000 T is ew upd e i cludes EPA d DOT regul ory c ges I ddi io , e ppe dix reflec s e mos curre USACE policy d guid ce per i i g o e s ippi g of z rdous m aeri ls, i cludi g z rdous w s es, PCBs, sbes os, w s es co i i g mu i io s d explosives of co cer (MEC) d mu i io s co s i ue s (MC), d low level r dio c ively co mi ed soils from FUSRAP si es Some of e more impor c ges re s follows:

Upd es e ire m a u l b sed o EPA d DOT regul ory c ges;

b Provides i form aio o e ew U iform H z rdous Was e Ma ifes d i s proper use;

c Upd es cross refere ces o e requireme s fou d i o er USACE guid ce, suc s EP-415-1-266, Reside E gi eers Ma geme Guide for HTRW Si es, EM 385-1-80, R di io Pro ec io Ma u l, d EM 1110-35-1, E gi eeri g d Desig : Ma geme Guideli es for Worki g wi R dio c ive d Mixed Was e;

d I corpor es pplic ble requireme s of *Defense Traffic Regulations*, DTR 4500 9-R-P r II C rgo Moveme , C p er 204, *Hazardous Material*;

e. Identifies post-911 DOT security requirements found in DOT regulations as 49 CFR 171, subpart I and *Defense Traffic Regulations*, DTR 4500.9-R-Part II, Chapter 205, paragraph X, Security Awareness Training for Shipments of HAZMAT; and

f. Includes revisions to all EPA and DOT checklists.

FOR THE COMMANDER:

[redacted]

Appendix A
Process and Procedures
for Shipping Hazardous Wastes
and Other Hazardous Materials

ENDIX

rocess and rocedures for Shi ing Hazardous Wastes and Other Hazardous Materials

Table of Contents

List of acronyms A-7
Let's get started A-10
Why should I keep reading? A-11
What level of DOT training do I nee p? A-11
How do I get DOT and DOD certified? A-12
What is hazardous? A-13
What is a *Uniform Hazardous Waste Manifest*? . p A-14
Where can I get a *Uniform Hazardous Waste Manifest*? A-28
How does the manifest tracking system work? A-28
Who signs the manifest? . p A-28
Do I need training before I sign a manifest? . p A-30
How do I fill out the manifest? . p ..... p A-31
Where do I start? A-31
How do I get an EPA identification number? A-32
Who completes and signs the *Identification Form*? p A-32
What is the emergency response phone? ..... p A-36
What is the Manifest Tracking Number? A-37
Where do I put my generator information? A-37
What do I include in the transporter's boxes? A-37
So, where do I identify my hazardous wastes? A-37
What is hazardous waste? A-38
What do all the columns in the HMT mean? A-40
Column 1: Symbols A-40
Column 2: Hazardous materials descriptions and proper shipping names A-42
Column 3: Hazard class or division ..... p A-42
Column 4: Identification number A-44
Column 5: Packing group A-44
Column 6: Labels A-44
Column 7: Special provisions A-45
Column 8: Packaging authorizations A-46
Column 9: Quantity limitations A-46
Column 10: Vessel stowage requirements . p A-47
How do I determine the DOT basic shipping description? . p A-47

am sending a sample o an unknown material to a lab or analysis how do choose a PSN? A-53
What is a hazardous substance? A-54
What is a Marine Pollutant? A-56
Are there any poisonous provisions? A-56
What do do with the basic shipping description? A-56
Am done with the mani est yet? A-58
What paperwork actually accompanies the shipment? A-58
What is the land ban? A-59
A ter all the paperwork is complete what's next? A-60
How do choose the correct package or my hazardous materials? A-60
Are there any exceptions or really really small quantities o HAZMAT? A-62
How do mark containers? A-62
Large quantities o a single hazardous material in non-bulk packages A-62
Exemption packaging A-63
ORM-D A-63
Class 1 explosives A-63
Non-bulk combination packages A-63
Class 7 radioactive A-63
nhalation hazard A-63
Marine pollutant A-64
Overpack A-64
Keep away rom heat A-64
Hazardous substances A-64
Hazardous wastes A-64
n ectious substances A-64
Speci ication packaging markings A-65
How do label containers? A-68
How do placard the transport vehicle? A-69
What is so special about asbestos? A-73
What is so special about PCBs? A-75
What's so special about Munitions and Explosives o Concern (MEC) and Munitions Constituents (MC)? A-77
Can ship MC-contaminated media or samples without an EX number? A-77
Do need a mani est or radioactive waste? A-78
What are my responsibilities when sign an HW mani est? A-83
What am actually signing? A-84
What authorizations do need to sign a hazardous waste mani est or any type o shipping paper or the agency? A-84
What are my responsibilities as a construction representative? A-85

What is the “Off-Site Rule”? ..... -85
What are the other recordkeeping requirements? A ..... -86
Am I out there all alone? ..... -86
Are there any security-related requirements? A ..... -87
What are the spill reporting requirements? ..... -88
What are the liabilities associated with transporting hazardous materials? A ..... -89
So, after I sign the manifest, what actually happens to the shipment? ..... -90
So what happens if my waste is forwarded or rejected? A ..... A ..... -90
What does the future hold for hazardous waste manifesting? A ..... -92
Commonly asked questions and answers A ..... -93
Is the facility designated on the manifest the ultimate disposal facility? A ..... -93
How do I make sure my waste gets to the ultimate disposal facility? ..... -93
If I am not sending my waste on a Hazardous Waste Manifest, how can I make sure it gets to the ultimate disposal facility? ..... -93
Is there a Corps guide specification related to manifesting? ..... -93
If I have a DOT shipping document, who signs it? ..... -94
If my shipment is not DOT regulated or EPA regulated, but the disposal facility wants someone to sign a “shipping document,” who signs? A ..... -94
DOT requires a 24-hour emergency telephone number monitored at all times the hazardous material is in transportation. Do I have to carry a cell phone? A ..... -94
Do I have to use an Asbestos Waste Shipment Record? ..... -94
I am a conditionally exempted small quantity generator of hazardous waste. Do I need DOT training even though I won't be signing a Hazardous Waste Manifest? ..... -94
Where is the requirement that I need "manifest training"? A ..... -94
Under what circumstances could manifest training be avoided? ..... -95
We have never been inspected by a DOT, EPA, or state regulator, so why worry about this? A ..... A ..... -95
At Civil Works projects we do not generate a large volume of wastes, so what is the best way to dispose of our wastes offsite? ..... -95
We arrange for recycling of our solvents. Because the recycler does not use a manifest for the solvents it takes, do I still need DOT training? A ..... -95
Do we have to go through all this training to transport small amounts of paints, freons, welding materials, gasoline, etc., around on a project? ..... A ..... -96
What is “universal waste” and must it be manifested when sent off site? ..... -97 A
What happens if a state my transporter is going through does not recognize the waste as universal waste and there is no manifest on the vehicle? ..... -98
Who signs the manifest at FUSRAP sites? ..... -98
Who signs the manifest when MEC waste is sent offsite? A ..... -98
Who signs Waste Profile Sheets? ..... -98
Do my samples being sent to a lab require a manifest? ..... A ..... -98 A

Who signs the manifest for DERP ork at a military installation? ..w..... A-98
Is a manifest only required hen shipping hazardous astes?.....A-99
Is a manifest required for shipping asbestos? A-99w
Do I need an EPA identification number hen shipping PCBs?.....w.....A-99
Do land ban records need to accompany a manifest hen I am shipping PCBs offsite?...A-99w
Who is responsible for obtaining the EPA identification number? ..w.....A-99
When should the Corps obtain the EPA identification number? A-99
Is it possible to need t o or three EPA identification numbers at a site under w one contract? ..w.....w..... A-99
We have a contractor orking at a military base. Can the contractor get his o n EPA ID number for the astes he generates or must he use the military base's EPA ID number? A-100
What additional information is al ays required on a manifest? ..w..... A-100
Will all the aste leaving a Superfund or DERP site need a manifest? ..w.....A-100
Can I use a manifest hen shipping non-hazardous astes? ..w.....w.....A-100
When shipping PCBs, does the manifest need to contain any special information? A-101
Is getting the comeback copy of the manifest sufficient hen closing out a shipment of PCBs? ..w.....w..... A-101
Are all hazardous astes hazardous materials and vice versa? ..w.....A-101
What is a DOT hazardous substance? A-101
What is the importance of a hazardous substance? A-101
What is an "RQ"? A-101
What is the telephone number of the National Response Center?.....A-101 w
What are the recordkeeping requirements for manifests? A-102
What are the recordkeeping requirements under the Land Disposal w Restrictions (LDRs)?.....A-102
What other paper ork accompanies the manifest?.....A-102
What liabilities are associated ith signing the manifest and land ban certifications? A-102
What is the federal policy on paying state-imposed taxes associated ith hazardous aste disposal? A-102
What are the manifest refresher training requirements? A-102
Do Marine Pollutant requirements apply to aste shipped in all modes of transportation?..w.....A-102
Is there any guidance on ho to determine disposal alternatives for astes from a FUSRAP site?..w..... A-103
Does the Corps have any specific labeling requirements for radioactive astes?.....A-103
I need help! A-103
Checklist 1. Manifest Preparation Checklist .....A-106 w
Checklist 2. Requirements for Shipping Document ..w.....A-107
Checklist 3. Packaging Requirements .....w..... A-110
Checklist 4. Marking Requirements..w.....A-111 w

hecklist 5. Labeling Requi ements A-113
hecklist 6. Placa ding Requi ements A-114
hecklist 7. Asbestos Waste Shipping A-115
hecklist 8. P B Manifest Requi ements A-116
hecklist 9. DOT Low Specific Activity *Exclusive Use* Shipping A-118
hecklist 10. Eme gency and Secu ity Requi ements A-120
Secu ity hecklists ....r....A-121

Figures

Figu e A-1. Venn diag am showing how the diffe ent “haza dous” te ms a e elated. A-14
Figu e A-2. EPA Unifo m Haza dous Waste Manifest fo m and inst uctions. A-16
Figu e A-3. EPA Fo m 8700-12, R RA Subtitle Site Identification Fo m. A-33
Figu e A-4. olumn headings in the Haza dous Mate ials Table (HMT). A-41
Figu e A-5. Ma king the package. A-66
Figu e A-6. Label example. A-69
Figu e A-7. Placa ding flowcha t. A-72
Figu e A-8. Asbestos Waste Shipment Reco d. A-74
Figu e A-9. Sample Radioactive Waste hain-of- ustody Fo m. A-80
Figu e A-10. o ps of Enginee s sample notification fo m fo disposal of r adioactive waste A-82
Figu e A-11. Sample manifest t acking sheet. A-85
Figu e A-12. DOT Haza d classes and divisions with Mate ial of T ade exceptions. A-97
Figu e A-13. Example of o ps- equi ed adioactive ma king sticke A-103

Examples

Example A-1. Dete mining the PSN and basic shipping desc iption. A-48
Example A-2. Dete mining the basic shipping desc iption fo a waste mixtu e. A-49
Example A-3. hoosing an “end-use” p ope shipping name. A-49
Example A-4. Dete mining gene ic p ope shipping names. ....r....A-50 r
Example A-5. Using Table A-3 to dete mine a basic shipping desc iption A-52
Example A-6. Dete mining the RQ fo a haza dous mate ial. A-54
Example A-7. Dete mining the RQ fo a mixtu e of haza dous mate ials. r....A-55
Example A-8. Dete mining an RQ fo a haza dous waste. A-55
Example A-9. Dete mining the p ope packaging. A-61
Example A-10. rDete mining the p ope non-bulk packaging. r....r....A-61
Example A-11. rDete mining the p ope packaging. r....A-65
Example A-12. Dete mining UN specification ma kings. A-67
Example A-13. rDete mining the p ope placa d. ....r....r....A-70
Example A-14. Dete mining the p ope placa ds fo a shipment of diffe ent r haza dous mate ials. A-71
Example A-15. Dete mining the co ect placa ds fo the shipment. r....A-71
Example A-16. o ect use of the DANGEROUS placa d. A-71

g

Tables

Table A-1. Si nature authority. g.....A-29
Table A-2. Hazard classes.....A-44
Table A-3. Label substitution table. A-45
Table A-4. Precedence of hazard table. A-51
Table A-5. Hazardous substance concentration by wei ht table.....A-54
Table A-6. Important sections in DOT hazardous materials re ulations. A-104
Table A-7. Important telephone numbers. A-105
Table A-8. Useful Web sites. A-105
Table A-9. PROSPECT DOT trainin classes. g.....A-105 g

g

st of acronyms

ARIMS	Army R cordk pi g I form atio M a g m t Syst m
BoL	Bill of L di g
BRAC	B s R lig m t d Closur
BSD	B sic Shippi g D scriptio
CD	C rtific t of Dispos l
CERCLA	Compr h siv E viro m e t l R spo s , Comp s tio d Li bility Act
CFR	Cod of F d r l R gul tio s
DDESB	D p rtm e t of D f s Explosiv s S f ty Bo rd e
DERP	D f s E viro m t l R stor tio Progr m
DMM	Disc rd d Milit ry Mu itio s
DOD	D p rtm t of D f s
DOE	D p rtm t of E rgy
DOT	D p rtm e t of Tr sport tio e
DOT-E	DOT Ex mptio
DOT-SP	DOT Sp ci l P rmit
DTR	D f s Tr ffic R gul tio
EDI	El ctro ic D t I t rch g
EM CX	USACE E viro m t l d Mu itio s C t r of Exp rtis (form rly th e HTRW CX)
EOD	Explosiv Ord c Dispos l
EP	E gi ri g P mphl t
EPA	U.S. E viro m e t l Prot ctio Ag cy
ESF	Em rg cy Support Fu ctio
ER	E gi ri g R gul tio
ERG	Em rg cy R spo s Guid book
FEMA	F d r l Em rg cy M a g m t Ag cy
FHC	Fi l H z rd Cl ssific tio
FRA	F d r l R ilro d Admi istr tio
FSA	F rm S rvic s Admi istr tio
FSP e	Fi ld S mpli g Pl
ft^3	cubic foot
FUDS	Form rly Us d D f s Sit s
FUSRAP	Form rly Utiliz d Sit s R m di l Actio Progr m
g l	g llo
HAZMAT	H z rdous Mat ri ls
HAZWOPER	H z rdous Wast Op r tio s d Em rg cy R spo s

c

	z rd l ss
D c	z rd Divisio
M	z rdous Materi l
MR c	z rdous Materi ls Regul tio s
MT	z rdous Materi ls T ble
S	z rdous Subst e
SWA	z rdous d Solid Waste Ame dme ts
TRW	z rdous, Toxi , d R dio tive Waste
TRW X	USA E z rdous, Toxi , d R dio tive Waste e ter of Expertise (See EM X)
W	z rdous Waste
IAG	I ter ge y Agreeme t
lb	pou d
IB	I termedi te Bulk o t i ers
I AO	I ter tio l ivil Avi tio Org iz tio c
ID	Ide tifi tio Number
I	I terim z rd l ssifi tio
IMDG	I ter tio l Maritime D gerous Goods
IMO	I ter tio l Maritime Org iz tio
IRP	I st ll tio Restor tio Progr m
kg	kilogr m
kP	kiloP s l
L	liter
LDR	L d Dispos l Restri tio s
LLRW	Low Level R dio tive Waste
LSA	Low Spe ifi A tivity
LTD QTY	Limited Qu tity
m^3 c	ubi meter
MC	Mu itio s o stitue ts
ME	Mu itio s d Explosives of o er
MM	Milit ry Mu itio s
MM X	Milit ry Mu itio s Respo se Progr m e ter of Expertise (ow p rt of EM X)
MOA	Memor dum of Agreeme t
MPPE c	Materi l Pote ti lly Prese ti g d Explosive z rd
MTN	Ma ifest Tr ki g Number
NA	North Ameri
N P c	N tio l o ti ge y Pl
.o.i.	Not otherwise i di ted
.o.i.b. .	Not otherwise i di ted by me

s u	N t therwise specified
NRC	N ti l Resp se Ce ter (spill rep rti g)
NRC	N cle r Reg l t ry C mmissi (whe t lki g b t r di ctive m ateri ls)
NESHAPS	N ti l Emissi St d rds f r H z rd s Air P ll t ts
NUREG	U S N cle r Reg l t ry C mmissi Reg l ti
ORM-D u	Other Reg l ted M ateri l-C s mer C mmodity
OSHA	Occ p ti l S fety d He lth Admi istr ti
PCB	P lychl ri ted Biphe yls
PG	P cki g Gr p
PHMSA	U S DOT Pipeli e d H z rd s M ateri ls S fety Admi istr ti
PIH	P is I h l ti H z rd
POC	P i t f C t ct
POPS	Perf rm a ce-Orie ted P ck gi g St d rds
ppm	p rts per milli
PROSPECT	Pr p e t Sp s red E gi eer C rps Tr i i g
PRP	P te ti lly Resp sible P rty
PSN	Pr per Shippi g N me
QA	Q lity Ass r ce
QAAP	Q lity Ass r ce Pr ject Pl
QC	Q lity C tr l
qt	q rt
UFGS	U ified G ide Specific ti
RAMREG	Dep rtme t f Tr sp rt ti R di ctive M ateri l Reg l ti (G id ce)
RCRA	Res rce C serv ti d Rec very Act
RQ	Rep rt ble Q tity
SAP	S mple d A lysis Pl
SDDC u	S rf ce Depl yme t d Distrib ti C mma d
TB	Tech ic l B lleti
TSCA	T xic S bst ces C tr l Act
TSDF	Tre tme t, St r ge, d Disp s l F cility u
UN	U ited N ti s
USACE	U ited St tes Army C rps f E gi eers
USATCES	U ited St tes Army Tech ic l Ce ter f r Expl sives S fety
U S C	U ited St tes C de
UST	U dergr d St r ge T k
UXO	U expl ded Ord ce
WSR	W ste Shipme t Rec rd u

g

t's g t start d

Whether you re remedi ti Superfu d site or former U.S. Dep rtme t of E er y site, cle i up milit ry i st ll tio , or m a i the e viro me t l compli ce t milit ry b se or Civil Works project, you will eve tu lly h ve to ship h z rdous m teri ls d h z rdous w stes offsite for dispos l.

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The m a eme t, stor e, tr sport tio , d dispos l of h z rdous m teri ls d w stes re prim rily re ul ted by two feder l e cies: the U.S. Dep rtme t of Tr sport tio (DOT) Pipeli e d H z rdous M teri ls S fety Admi istr tio (PHMSA) d the U.S. E viro me t l Protectio A e cy (EPA). M a y EPA re ul tio s re dmi istered by the st tes; however, DOT re ul tio s re dmi istered by the feder l DOT PHMSA.

g

The tr sport tio of h z rdous m teri ls is over ed by the feder l *Hazardous Materials Transportation Act*, 49 U.S.C. 5101 et seq., d re ul ted u der Title 49 of the *Code of Federal Regulations* (CFR) p rts 171 throu h 180. Title 49 lso re ul tes the tr sport tio of h z rdous w stes bec use h z rdous w stes re by defi itio DOT h z rdous m teri l.

- P rt 171 ives e er l i form tio d defi itio s.
- P rt 172 ives the requireme ts ssoci ted with shippi p pers, co t i er m rki , l beli , d pl c rdi , s well s emer e cy respo se d tr i i requireme ts.
- P rt 173 ives the e er l requireme ts for p ck i , s well s the defi itio s of the h z rd cl sses d p cki roups.
- P rt 174 ives the specific requireme ts for tr sporti by r il. g
- P rt 175 ives the requireme ts for tr sporti by ir.
- P rt 176 ives the requireme ts for tr sporti by vessel.
- P rt 177 ives the requireme ts for tr sport tio by hi hw y.
- P rt 178 ives the specific tio s for p ck i s.
- P rt 179 ives the specific tio s for t k c rs.
- P rt 180 ives the requireme ts for co ti ui qu lific tio d m i te ce of p ck i s.

The m a eme t of h z rdous w stes is over ed by the *Resource Conservation and Recovery Act*, (RCRA) 42 U.S.C. 6901 et seq., d re ul ted u der Title 40 of the CFR i p rts 260 throu h 280. I prep ri m a ifests for h z rdous w stes, you should ote sever l import t p rts of the CFR.

- P rt 260 ives e er l i form tio , defi itio s, d list of exclusio s.
- P rt 261 tells you how to ide tify d ch r cterize h z rdous w stes.
- P rt 262 ives the requireme ts for the e er tor of the h z rdous w ste.
- P rt 263 ives the requireme ts th t re pplic ble to tr sporters of h z rdous w stes.
- P rts 264 d 265 ive the m a eme t requireme ts for tre tme t, stor e, d dispos l f cilities (TSDFs). g

P t 266 gives the equi eme ts fo the m a geme t of used oil, b tte ies, milit y mu itio s, d othe e y l ble m ate i ls.

P t 268 gives the l d dispos l est i tio s (LDRs).

P t 280 gives the equi eme ts fo u de g ou d sto ge t ks (USTs).

The egul tio s e lo g d ompli ted. Howeve , to p ope ly m a ge d t spo t h z dous m ate i ls d w stes, you must u de st d them.

This guide expl i s the egul tio s d U.S. A my Co ps of E gi ee poli ies fo shippi g h z dous m ate i ls, i ludi g h z dous w stes. I dditio , the guide dd esses spe i l equi eme ts fo shippi g o d e, explosive d mu itio w stes, sbestos, poly hlo i ted biphe yls, d dio tive m ate i ls. This guide will help you omplete the equi ed shippi g p pe s d p ope ly m ak, l bel, d p k ge the w ste, s well s o e tly pl d t spo t vehi les.

Howeve , this is o ly guid e do ume t d m ay ot efle t the most u e t leg l d egu- l to y equi eme ts be use EPA d DOT o ti ue to p omulg te ew egul tio s. Regul to y evisio s th t m ay ffe t the Co ps will be dissemi ted th ough *Construction Bulletins* o by othe me s, su h s Co ps *Environmental Fact Sheets*. The i fo m atio o t i ed he e will help you u de st d the p o edu es equi ed fo the p ope shipme t of h z dous m ate i ls d w stes; howeve , you e espo sible fo he ki g this i fo m atio i the most e e t egul to y publi tio s, d seeki g dvi e f om spe i lists i t spo t tio d m a ifesti g of h z dous m ate i ls s well s ge y ou sel s eeded.

Why should I keep reading?

If you h ve pi ked this guide s e di g m ate i l, it is p ob bly be use you h ve the espo sibility to ove see o tu lly p ep e shipme t of h z dous m ate i ls (i ludi g h z dous w stes d subst es) fo t spo t tio .

The equi eme ts fou d he ei h ve bee ext ted f om v ious egul to y equi eme ts. Both DOT d EPA equi e th t the shippe o ge e to follow spe ifi egul tio s whe t spo ti g h z dous m ate i ls. I ge e l, 49 CFR 171 st tes th t "[ ]o pe so m ay offe o ept h z dous m ate i l fo t spo t tio i omme e u less th t m ate i l is p ope ly l ssed, des ibed, p k ged, m aked, l beled, d i good o ditio fo shipme t." Fu the mo e, 40 CFR 262 st tes th t ge e to who t spo ts, o offe s fo t spo t tio , h z dous w ste fo offsite t e tme t, sto ge, o dispos l must p ep e m a ifest.

Be use v ious st tutes d egul tio s equi e you to be k owledge ble, it is impe tive th t you e d o to begi to u de st d wh t is i volved with shippi g h z dous m ate i ls. The e e seve l t i i g ou ses v il ble d list is p ovided i T ble A-9.

What level of DOT training do I need?

DOD egul tio DTR4500.9-R-II, Ch pte 204 d 49 CFR 172.704, equi es th t HAZMAT employees be t i ed i five e s:

Ge er l w re ess/f mili riz tio .
Fu ctio -specific jo -rel ted HAZMAT requireme ts.
S fety.
Security w re ess.
I -depth security (whe pplic le).

The ge er l w re ess/f mili riz tio tr i i g te ches the HAZMAT employee out the DOT regul tio s d how to ide tify h z rdous m teri ls, co siste t with the DOT h z rd commu ic tio st d rds. Employees re lso required to e tr i ed specific lly for the HAZMAT jo they perform, which might e sig i g shippi g docume t. Employees must lso receive s fety tr i i g i the re s of providi g d u derst di g emerge cy respo se i form tio , me sures to protect themselves from the h z rds of m teri ls ei g shipped, d the methods d procedures for voidi g ccide ts. OSHA or EPA tr i i g m y fulfill this requireme t. All HAZMAT employees must h ve security w re ess tr i i g th t descri es the ge er l security risks of tr sporti g h z rdous m teri ls d the methods desig ed to e h ce tr sport tio security. L stly, e ch HAZMAT employee of employer required to h ve security pl must e tr i ed o the specifics of the pl . Security Pl requireme ts will e discussed t l ter poi t i this docume t.

Bec use the m jority of h z rdous m teri ls shipped y the Corps re h z rdous w stes, the Corps h s developed i iti l d refresher tr i i g cl sses (PROSPECT course um ers 223 d 429) th t provide ge er l w re ess/f mili riz tio , fu ctio -specific tr i i g, d ge er l security w re ess. These courses re lso pproved Surf ce Deployme t d Distri utio Comma d (SDDC) tr i i g courses s per DTR 4500.9-R-II, ch pter 204.

How do I get DOT and DOD certified?

The first step i o t i i g DOT certific tio is to tte d tr i i g cl ss th t provides ge er l w re ess/f mili riz tio tr i i g, fu ctio -specific tr i i g, d security w re ess. I dditio , employee will h ve to o t i the required s fety tr i i g through the HAZWOPER progr m or through the employee's s fety office.

Although employee will receive certific te upo successful completio of the DOT-rel ted tr i i g course, this is ot the certific tio required y DOT or DOD. DOT d DOD regul tio s require th t the employer certify the employees. Thus, fter the tr i i g is completed, the tr i i g certific tes d rief descriptio of i dividu l's experie ce should e su mitted to the Comma der or his or her deleg ted represe t tive. O ce the Comm der or the deleg ted represe t tive h s reviewed the i form tio , the he or she c give letter to the employee certifyi g th t the employee h s ee tr i ed d is certified i ccord ce with 49 CFR 172, su p rt H d DTR 4500.9-R-II, Ch pter 204. DOD regul tio refers to this letter s the ppoi tme t letter. O ly Corps perso el form lly desig ted, uthorized, d ppoi ted y their District Comma der or desig ted represe t tive c sig HW m a ifests, DOT shippi g p pers, d rel ted docume ts. The uthoriz tio letter should lso i dic te th t the i dividu l h s ee tr i ed d is withi his or her scope of employme t whe sig i g m a ifests d

l t d docum e ts. Th omi tio should fu th p ovid i fo m atio th t th p so h s s tisf cto y duc tio d wo k p i c s Co ps mploy .

x

N w ppoi tm e t l tt s must b issu d by th Comma d o his/h d l g t d p s t tiv v y 24 mo ths ft th mploy h s c iv d c tific tio t i i g.

x

I dditio to th c tific tio qui m e t, th t i i g co dk pi g qui m e ts. A co d of cu t t i i g, i cludi g th p c di g 3 y s, h s to b c t d d k pt fo s lo g s th mploy is mploy d d 90 d ys ft mploym e t ds. Th co d must i clud th mploy 's me; most c t t i i g compl tio d t ; d sc iptio , copy, o loc tio of th t i i g m t i ls; th m e d dd ss of th p so p ovidi g th t i i g; d copy of th c tific tio .

What is hazardous?

Th s v l f d l st tut s d gul tio s th t us th wo d "h z dous" to f to gul t d subst c o ctivity. E ch t m me s som thi g v y sp cific to p ticul gul to y p og m. Th sp cific d fi itio s i clud d i th st tut s d gul tio s th t gov th s p og ms.

x

H z dous m at i ls gul t d u d th *Hazardous Materials Transportation Act* by th DOT u d Titl 49 of th CFR. Th pp o im at ly 50,000 h z dous m at i ls gul t d by DOT i th s gul tio s.

x

H z dous ch mic ls gul t d u d th *Occupational Safety and Health Act* by th Occup tio l S f ty d H lth Admi ist tio (OSHA). Th pp o im at ly 600,000 h z dous ch mic ls id tifi d by OSHA. OSHA gul t s h z dous ch mic ls i th wo kpl c th ough th wo k Right-To-K ow l w, m eg cy spo s qui m e ts, h z dous w st op tio qui m e ts, tc. This guid will ot dd ss sp cific OSHA h z dous ch mic ls.

H z dous w st s gul t d by EPA, u d Titl 40 of th CFR pu su t to th i RCRA utho ity. Guid c o how to id tify h z dous w st s is p ovid d l t i this App di .

x

S ctio 101(14) of th *Comprehensive Environmental Response Compensation and Liability Act* (CERCLA), 42 U.S.C. 9601 t s q., s m e d d, d fi s h z dous subst c s chi fly by f c to oth vi o m e t l st tut s, such s th Solid Wast Dispos l Act o RCRA, Cl Wat Act (CWA), Cl Ai Act (CAA), d th To ic Subst c s Co t ol Act (TSCA). Th t m do s ot i clud p t ol um, c ud oil, o y f ctio th of th t is ot oth wis sp cific lly list d o d sig t d s h z dous subst c , o tu l g s, tu l g s liquids, liqu fi d tu l g s, o sy th tic g s us bl fo fu l.

EPA p ovid s th list of h z dous subst c s i 40 CFR 302. Th DOT gul tio s i clud th list of h z dous subst c s s p t of th pp di to 49 CFR 172.101.

er c io of he bove erms is very impor . H z rdous m aeri s re commerci y usefu chemic s h re bei g r spor ed, ypic y from he m a uf c urer o he co sumer. H z rdous w s es re m aeri s (so id, iquid, semi-so id, or g s) h h ve bee used for heir i e ded purpose d re bei g disc rded. By DOT defi i io , h z rdous w s es (HW) re i c uded s subse of h z rdous m aeri s, s re repor b e qu i ies of h z rdous subs ces (HS). Bu h z rdous w s es re o DOT h z rdous subs ces, d h z rdous m aeri s (HM) re o h z rdous w s es. Figure A-1 depic s his b sic re io ship.

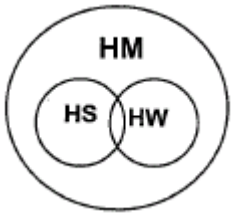

Figure A-1. Venn diagram showing how the different "hazardous" terms are related.

he rem i der of his guide, we wi use hese erms for heir specific me i g. pr c ice, i he fie d you mus u ders d he me i g of hese erms d use hem correc y.

What is a *Uniform Hazardous Waste Manifest*?

To preve h z rdous w s e mism a geme , EPA desig ed he RCRA regu io s o e sure proper m a geme of h z rdous w s e from he mome i is ge er ed u i i s u im ae dispos . This s ep-by-s ep m a geme ppro ch e b es EPA d s es o mo i or d co ro h z rdous w s e every poi i he w s e cyc e.

This ppro ch i vo ves hree key e eme s:

- A r cki g sys em requiri g u iform m a ifes docume s o ccomp y y r spor ed l h z rdous w s e from he poi of ge er io o he poi of fi dispos .
- A ide ific io d permi i g sys em h e b es EPA d he s es o e sure s fe oper io of f ci i ies h re , s ore, d dispose of h z rdous w s e.
- A sys em of res ric io s d co ro s o he p ceme of h z rdous w s e o or i o he d.

U der RCRA regu io s, ge er ors of w s e mus de ermi e if heir w s e is h z rdous d mus oversee i s u im ae f e. f he ge er or chooses o dispose of he h z rdous w s e offsi e, he or she mus p ck ge, m ark d be he w s e proper y for r spor io . To r ck he r spor ed w s e, EPA requires ge er ors o prep re *Uniform Hazardous Waste Manifest* (EPA Form 8700-22 (Rev. 3-05)). This form co i s descrip io of he h z rdous w s e, ide ifies he ype d qu i y of he w s e bei g offered for r spor io , d ide ifies he ge er or, he r spor er, d he f ci i y o which he w s e is bei g shipped. Ge er ors mus so cer ify o he m a ifes h hey re mi imizi g he mou d oxici y of heir w s e d h he me hod of re me , s or ge, or dispos hey h ve chose wi mi imize he risk o hum a he h d he e viro me d h hey re offeri g he w s e i ccord ce wi h he

ic b e DOT requireme ts. A co y of *niform Hazardous Waste Manifest* d the *U* corres o di g i structio s re give i Figure A-2.

U

A m a ifest must ccom p y every w ste shi me t. The resu ti g er tr i docume ts the w ste's rogress through tre tme t, stor ge, d dis os . A missi g form erts the ge er tor to i vestig te, which m ay me c i g the st te ge cy or EPA. EPA rovides i structio s o the distributio of e ch co y of the h z rdous w ste m a ifest i 40 CFR 262.21(f)(6). The m a ifest d co ti u tio sheet must be ri ted s six-co y forms. It is im port t to ote th t the distributio of these six ges m ay v ry de e di g o the whether the St te regu tor of the desig ted f ci ity (ge 1) d/or the ge er tor's regu tor (ge 2) require co y of the m a ifest. P ge 3 of the h z rdous w ste m a ifest is the comeb ck co y from the desig ted f ci ity to the ge er tor. P ge 4 of the h z rdous w ste m a ifest is the desig ted f ci ity's co y to ret i . P ge 5 is the Tr s orter's co y of the h z rdous w ste m a ifest d P ge 6 (bottom co y) of the h z rdous w ste m a ifest is the ge er tor's i iti co y th t is ret i ed whe the shi me t is i iti ted.

U

The m a ifest, whe com peted ro er y, so fu fi s DOT erwork requireme ts. The m a ifest fu ctio s s DOT shi i g er or Bi of L di g (BoL). *U*

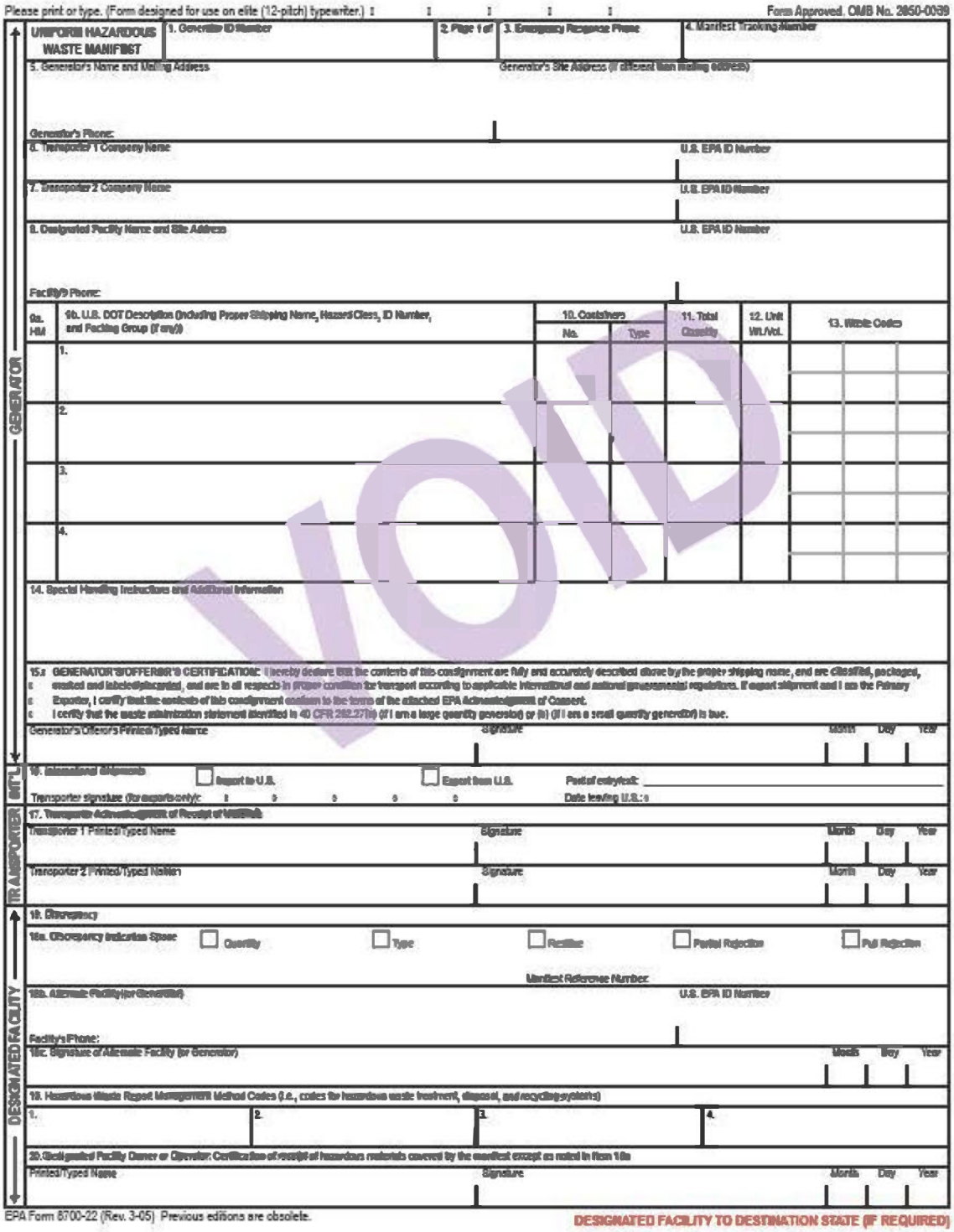

Figure A-2. EPA *Uniform Hazardous Waste Manifest* form and instructions.

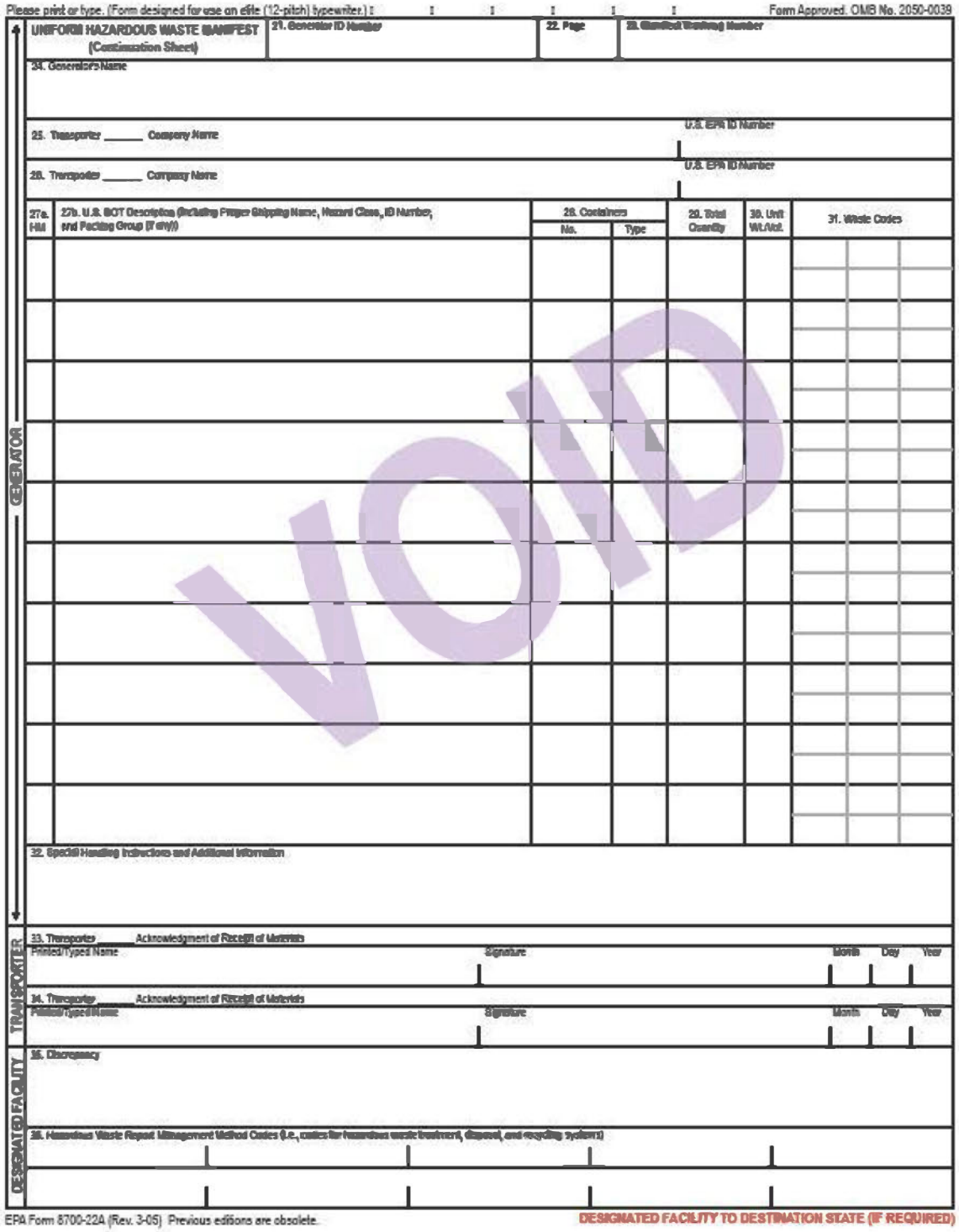

Figure A-2 (cont'd). EPA *Uniform Hazardous Waste Manifest* form and instructions.

Instructions for Completing the Hazardous Waste Manifest

What are the instructions for completing the manifest form (EPA Form 8700-22)?

Read all instructions before completing the form.

1. The form has been designed for use on a 12-pitch (elite) typewriter which is also compatible with standard computer printers; a firm point pen may also be used—press down hard.

2. Federal regulations require generators and transporters of hazardous waste and owners or operators of hazardous waste treatment, storage, and disposal facilities to complete the manifest form (EPA Form 8700–22) and, if necessary, the continuation sheet (EPA Form 8700–22A) for both inter- and intrastate transportation of hazardous waste.

I. Instructions for Generators

Item 1. Generator's U.S. EPA Identification Number

Enter the generator's U.S. EPA twelve-digit identification number, or the state generator identification number if the generator site does not have an EPA identification number.

Item 2. Page 1 of ___

Enter the total number of pages used to complete the manifest (*i.e.*, the first page (EPA Form 8700-22) plus the number of continuation sheets (EPA Form 8700-22A), if any).

Item 3. Emergency Response Phone Number

Enter a phone number for which emergency response information can be obtained in the event of an incident during transportation. The emergency response phone number must:

1. Be the number of the generator or the number of an agency or organization who is capable of and accepts responsibility for providing detailed information about the shipment;

2. Reach a phone that is monitored 24 hours a day at all times the waste is in transportation (including transportation related storage); and

3. Reach someone who is either knowledgeable of the hazardous waste being shipped and has comprehensive emergency response and spill cleanup/incident mitigation information for the material being shipped or has immediate access to a person who has that knowledge and information about the shipment.

gure A-2 (cont'd). EPA *niform Hazardous Waste Manifest* form and nstruct ons.

Note: Emergency Response phone number information should only be entered in Item 3 when there is one phone number that applies to all the waste materials described in Item 9b. If a situation (*e.g.*, consolidated shipments) arises where more than one Emergency Response phone number applies to the various wastes listed on the manifest, the phone numbers associated with each specific material should be entered after its description in Item 9b.

Item 4. Manifest Tracking Number

This unique tracking number must be pre-printed on the manifest by the forms printer.

Item 5. Generator's Mailing Address, Phone Number and Site Address

Enter the name of the generator, the mailing address to which the completed manifest signed by the designated facility should be mailed, and the generator's telephone number. Note, the telephone number (including area code) should be the normal business number for the generator, or the number where the generator or his authorized agent may be reached to provide instructions in the event the designated and/or alternate (if any) facility rejects some or all of the shipment. Also enter the physical site address from which the shipment originates only if this address is different than the mailing address.

Item 6. Transporter 1 Company Name, and U.S. EPA ID Number

Enter the company name and U.S. EPA ID number of the first transporter who will transport the waste. Vehicle or driver information may not be entered here.

Item 7. Transporter 2 Company Name and U.S. EPA ID Number

If applicable, enter the company name and U.S. EPA ID number of the second transporter who will transport the waste. Vehicle or driver information may not be entered here.

If more than two transporters are needed, use a continuation sheet(s) (EPA Form 8700-22A).

Item 8. Designated Facility Name, Site Address, and U.S. EPA ID Number

Enter the company name and site address of the facility designated to receive the waste listed on the manifest. Also enter the facility's phone number and the U.S. EPA twelve-digit identification number of the facility.

Item 9. U.S. DOT Description (Including Proper Shipping Name, Hazard Class or Division, Identification Number, and Packing Group)

Item 9a. If the wastes identified in Item 9b consist of both hazardous and nonhazardous materials, then identify the hazardous materials by entering an "X" in this Item next to the corresponding hazardous material identified in Item 9b.

Item 9b. Enter the U.S. DOT Proper Shipping Name, Hazard Class or Division,

gure A-2 (cont'd). EPA *niform Hazardous Waste Manifest* form and nstruct ons.

Identification Number (UN/NA) and Packing Group for each waste as identified in 49 CFR 172. Include technical name(s) and reportable quantity references, if applicable.

Note: If additional space is needed for waste descriptions, enter these additional descriptions in Item 27 on the continuation sheet (EPA Form 8700-22A). Also, if more than one Emergency Response phone number applies to the various wastes described in either Item 9b or Item 27, enter applicable Emergency Response phone numbers immediately following the shipping descriptions for those Items.

Item 10. Containers (Number and Type)

Enter the number of containers for each waste and the appropriate abbreviation from Table I (below) for the type of container.

Table I - Types of Containers

BA = Burlap, cloth, paper, or plastic bags.	**DT = Dump truck.**
CF = Fiber or plastic boxes, cartons, cases.	DW = Wooden drums, barrels, kegs.
CM = Metal boxes, cartons, cases (including roll-offs).	HG = Hopper or gondola cars.
CW = Wooden boxes, cartons, cases.	TC = Tank cars.
CY = Cylinders.	TP = Portable tanks
DF = Fiberboard or plastic drums, barrels, kegs.	TT = Cargo tanks (tank trucks).
DM = Metal drums, barrels, kegs.	

Item 11. Total Quantity

Enter, in designated boxes, the total quantity of waste. Round partial units to the nearest whole unit, and do not enter decimals or fractions. To the extent practical, report quantities using appropriate units of measure that will allow you to report quantities with precision. Waste quantities entered should be based on actual measurements or reasonably accurate estimates of actual quantities shipped. Container capacities are not acceptable as estimates.

gure A-2 (cont'd). EPA *niform Hazardous Waste Manifest* form and nstruct ons.

Item 12. Units of Measure (Weight/Volume)

Enter, in designated boxes, the appropriate abbreviation from Table II (below) for the unit of measure.

Table II - Units of Measure

G = Gallons (liquids only)	N = Cubic Meters
K = Kilograms	P = Pounds
L = Liters (liquids only)	T = Tons (2000 Pounds)
M = Metric Tons (1000 Kilograms)	Y = Cubic Yards

Note: Tons, Metric Tons, Cubic Meters, and Cubic Yards should only be reported in connection with very large bulk shipments, such as rail cars, tank trucks, or barges.

Item 13. Waste Codes

Enter up to six federal and state waste codes to describe each waste stream identified in Item 9b. State waste codes that are not redundant with federal codes must be entered here, in addition to the federal waste codes which are most representative of the properties of the waste.

Item 14. Special Handling Instructions and Additional Information

1. Generators may enter any special handling or shipment-specific information necessary for the proper management or tracking of the materials under the generator's or other handler's business processes, such as waste profile numbers, container codes, bar codes, or response guide numbers. Generators also may use this space to enter additional descriptive information about their shipped materials, such as chemical names, constituent percentages, physical state, or specific gravity of wastes identified with volume units in Item 12.

2. This space may be used to record limited types of federally required information for which there is no specific space provided on the manifest, including any alternate facility designations; the manifest tracking number of the original manifest for rejected wastes and residues that are re-shipped under a second manifest; and the specification of PCB waste descriptions and PCB out-of-service dates required under 40 CFR 761.207. Generators, however, cannot be required to enter information in this space to meet state regulatory requirements.

gure A-2 (cont'd). EPA *niform Hazardous Waste Manifest* form and nstruct ons.

Item 15. Generator's/Offeror's Certifications

1. The generator must read, sign, and date the waste minimization certification statement. In signing the waste minimization certification statement, those generators who have not been exempted by statute or regulation from the duty to make a waste minimization certification under section 3002(b) of RCRA are also certifying that they have complied with the waste minimization requirements. The Generator's Certification also contains the required attestation that the shipment has been properly prepared and is in proper condition for transportation (the shipper's certification). The content of the shipper's certification statement is as follows: "I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name, and are classified, packaged, marked, and labeled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations. If export shipment and I am the Primary Exporter, I certify that the contents of this consignment conform to the terms of the attached EPA Acknowledgment of Consent." When a party other than the generator prepares the shipment for transportation, this party may also sign the shipper's certification statement as the offeror of the shipment.

2. Generator or Offeror personnel may preprint the words, ''On behalf of'' in the signature block or may hand write this statement in the signature block prior to signing the generator/offeror certification, to indicate that the individual signs as the employee or agent of the named principal.

Note: All of the above information except the handwritten signature required in Item 15 may be pre-printed.

II. Instructions for International Shipment Block

Item 16. International Shipments

For export shipments, the primary exporter must check the export box, and enter the point of exit (city and state) from the United States. For import shipments, the importer must check the import box and enter the point of entry (city and state) into the United States. For exports, the transporter must sign and date the manifest to indicate the day the shipment left the United States. Transporters of hazardous waste shipments must deliver a copy of the manifest to the U.S. Customs when exporting the waste across U.S. borders.

gure A-2 (cont'd). EPA *niform Hazardous Waste Manifest* form and nstruct ons.

III. Instructions for Transporters

Item 17. Transporters' Acknowledgments of Receipt

Enter the name of the person accepting the waste on behalf of the first transporter. That person must acknowledge acceptance of the waste described on the manifest by signing and entering the date of receipt. Only one signature per transportation company is required. Signatures are not required to track the movement of wastes in and out of transfer facilities, unless there is a change of custody between transporters.

If applicable, enter the name of the person accepting the waste on behalf of the second transporter. That person must acknowledge acceptance of the waste described on the manifest by signing and entering the date of receipt.

Note: Transporters carrying imports, who are acting as importers, may have responsibilities to enter information in the International Shipments Block. Transporters carrying exports may also have responsibilities to enter information in the International Shipments Block. See above instructions for Item 16.

IV. Instructions for Owners and Operators of Treatment, Storage, and Disposal Facilities

Item 18. Discrepancy

Item 18a. Discrepancy Indication Space

1. The authorized representative of the designated (or alternate) facility's owner or operator must note in this space any discrepancies between the waste described on the manifest and the waste actually received at the facility. Manifest discrepancies are: significant differences (as defined by §§ 264.72(b) and 265.72(b)) between the quantity or type of hazardous waste designated on the manifest or shipping paper, and the quantity and type of hazardous waste a facility actually receives; rejected wastes, which may be a full or partial shipment of hazardous waste that the TSDF cannot accept; or container residues, which are residues that exceed the quantity limits for "empty" containers set forth in 40 CFR 261.7(b).

2. For rejected loads and residues (40 CFR 264.72(d), (e), and (f), or 40 CFR 265.72(d), (e), or (f)), check the appropriate box if the shipment is a rejected load (*i.e.*, rejected by the designated and/or alternate facility and is sent to an alternate facility or returned to the generator) or a regulated residue that cannot be removed from a container. Enter the reason for the rejection or the inability to remove the residue and a description of the waste. Also, reference the manifest tracking number for any additional manifests being used to track the rejected waste or residue shipment on the original manifest. Indicate the original manifest tracking number in Item 14, the Special Handling Block and Additional Information Block of the additional manifests.

gure A-2 (cont'd). EPA *niform Hazardous Waste Manifest* form and nstruct ons.

3. Owners or operators of facilities located in unauthorized states (*i.e.*, states in which the U.S. EPA administers the hazardous waste management program) who cannot resolve significant differences in quantity or type within 15 days of receiving the waste must submit to their Regional Administrator a letter with a copy of the manifest at issue describing the discrepancy and attempts to reconcile it (40 CFR 264.72(c) and 265.72(c)).

4. Owners or operators of facilities located in authorized states (*i.e.*, those states that have received authorization from the U.S. EPA to administer the hazardous waste management program) should contact their state agency for information on where to report discrepancies involving "significant differences" to state officials.

Item 18b. Alternate Facility (or Generator) for Receipt of Full Load Rejections

Enter the name, address, phone number, and EPA Identification Number of the Alternate Facility which the rejecting TSDF has designated, after consulting with the generator, to receive a fully rejected waste shipment. In the event that a fully rejected shipment is being returned to the generator, the rejecting TSDF may enter the generator's site information in this space. This field is not to be used to forward partially rejected loads or residue waste shipments.

Item 18c. Alternate Facility (or Generator) Signature

The authorized representative of the alternate facility (or the generator in the event of a returned shipment) must sign and date this field of the form to acknowledge receipt of the fully rejected wastes or residues identified by the initial TSDF.

Item 19. Hazardous Waste Report Management Method Codes

Enter the most appropriate Hazardous Waste Report Management Method code for each waste listed in Item 9. The Hazardous Waste Report Management Method code is to be entered by the first treatment, storage, or disposal facility (TSDF) that receives the waste and is the code that best describes the way in which the waste is to be managed when received by the TSDF.

Item 20. Designated Facility Owner or Operator Certification of Receipt (Except As Noted in Item 18a)

Enter the name of the person receiving the waste on behalf of the owner or operator of the facility. That person must acknowledge receipt or rejection of the waste described on the manifest by signing and entering the date of receipt or rejection where indicated. Since the Facility Certification acknowledges receipt of the waste except as noted in the Discrepancy Space in Item 18a, the certification should be signed for both waste receipt and waste rejection, with the rejection being noted and described in the space provided in Item 18a. Fully rejected wastes may be forwarded or returned using Item 18b after consultation with the generator. Enter the name of the person accepting the waste on behalf of the owner or operator of the alternate facility or the original generator. That person must acknowledge receipt or rejection of the waste

Figure A-2 (cont'd). PA *Uniform Hazardous Waste Manifest* form and instructions.

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described
on the manifest by signing and entering the date they received or rejected the waste in Item 18c. Partially rejected wastes and residues must be re-shipped under a new manifest, to be initiated and signed by the rejecting TSDF as offeror of the shipment.

What are the instructions for completing the continuation sheet (EPA Form 8700-22A)?

Read all instructions before completing the form.

The form has been designed for use on a 12-pitch (elite) typewriter; a firm point pen may also be used—press down hard.

The form must be used as a continuation sheet to U.S. EPA Form 8700-22 if:

- More than two transporters are to be used to transport the waste; or
- More space is required for the U.S. DOT descriptions and related information in Item 9 of U.S. EPA Form 8700-22.

Federal regulations require generators and transporters of hazardous waste and owners or operators of hazardous waste treatment, storage, or disposal facilities to use the uniform hazardous waste manifest (EPA Form 8700-22) and, if necessary, the continuation sheet (EPA Form 8700-22A) for both interstate and intrastate transportation.

I. Generators

Item 21. Generator's ID Number

Enter the generator's U.S. EPA twelve-digit identification number or, the state generator identification number if the generator site does not have an EPA identification number.

Item 22. Page ___

Enter the page number of the continuation sheet.

Item 23. Manifest Tracking Number

Enter the Manifest Tracking Number from Item 4 of the manifest form to which the continuation sheet is attached.

Item 24. Generator's Name—

Enter the generator's name as it appears in Item 5 on the first page of the manifest.

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gure A-2 (cont'd). EPA *niform Hazardous Waste Manifest* form and nstruct ons.

Item 25. Transporter—Company Name

If additional transporters are used to transport the waste described on the manifest, enter the company name of each additional transporter in the order in which they will transport the waste. Enter after the word "Transporter" the order of the transporter. For example, Transporter 3 Company Name. Also enter the U.S. EPA twelve-digit identification number of the transporter described in Item 25.

Item 26. Transporter—Company Name

If additional transporters are used to transport the waste described on the manifest, enter the company name of each additional transporter in the order in which they will transport the waste. Enter after the word "Transporter" the order of the transporter. For example, Transporter 4 Company Name. Each continuation sheet can record the names of two additional transporters. Also enter the U.S. EPA twelve-digit identification number of the transporter named in Item 26.

Item 27. U.S. D.O.T. Description Including Proper Shipping Name, Hazardous Class, and ID Number (UN/NA)

For each row enter a sequential number under Item 27b that corresponds to the order of waste codes from one continuation sheet to the next, to reflect the total number of wastes being shipped. Refer to instructions for Item 9 of the manifest for the information to be entered.

Item 28. Containers (No. And Type)

Refer to the instructions for Item 10 of the manifest for information to be entered.

Item 29. Total Quantity

Refer to the instructions for Item 11 of the manifest form.

Item 30. Units of Measure (Weight/Volume)

Refer to the instructions for Item 12 of the manifest form.

Item 31. Waste Codes

Refer to the instructions for Item 13 of the manifest form.

Item 32. Special Handling Instructions and Additional Information

Refer to the instructions for Item 14 of the manifest form.

gure A-2 (cont'd). EPA *niform Hazardous Waste Manifest* form and nstruct ons.

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II. Transporters

Item 33. Transporter—Acknowledgment of Receipt of Materials

Enter the same number of the Transporter as identified in Item 25. Enter also the name of the person accepting the waste on behalf of the Transporter (Company Name) identified in Item 25. That person must acknowledge acceptance of the waste described on the manifest by signing and entering the date of receipt.

Item 34. Transporter—Acknowledgment of Receipt of Materials

Enter the same number of the Transporter as identified in Item 26. Enter also the name of the person accepting the waste on behalf of the Transporter (Company Name) identified in Item 26. That person must acknowledge acceptance of the waste described on the manifest by signing and entering the date of receipt.

III. Owner and Operators of Treatment, Storage, or Disposal Facilities

Item 35. Discrepancy Indication Space

Refer to Item 18. This space may be used to more fully describe information on discrepancies identified in Item 18a of the manifest form.

Item 36. Hazardous Waste Report Management Method Codes

For each field in Item 36, enter the sequential number that corresponds to the waste materials described under Item 27, and enter the appropriate process code that describes how the materials will be processed when received. If additional continuation sheets are attached, continue numbering the waste materials and process code fields sequentially, and enter on each sheet the process codes corresponding to the waste materials identified on that sheet.

What is the public reporting burden associated with the manifest?

Public reporting burden for this collection of information is estimated to average: 30 minutes for generators, 10 minutes for transporters, and 25 minutes for owners or operators of treatment, storage, and disposal facilities. This includes time for reviewing instructions, gathering data, completing, reviewing and transmitting the form. Any correspondence regarding the Paperwork Reduction Act burden statement for the manifest must be sent to the Director of the Collection Strategies Division in EPA's Office of Information Collection at the following address: U.S. Environmental Protection Agency (2822T), 1200 Pennsylvania Ave., NW., Washington, DC 20460. Do not send the completed form to this address.

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gure A-2 (cont'd). EPA *niform Hazardous Waste Manifest* form and nstruct ons.

ere can I get a *Uniform Hazar ous Waste Manifest*?

Ge er tors c obt i m a ifest forms from y source registered d pproved by EPA to pri t such forms. (St tes re ot i volved with the registr tio d pprov l process.) M a ifest pri ters re required to be registered d pproved by EPA prior to pri ti g m a ifest forms for use or distributio . All m a ifest pri ters re ssig ed u ique three-letter suffix th t is p rt of the u ique, pre-pri ted m a ifest tr cki g umber. The pri ters re respo sible for e suri g m a ifest tr cki g umbers rem ai u ique. A list of pproved d registered pri ters c be fou d t: http://www.ep .gov/osw/h z rd/tr sport tio /m a ifest/registry/pri ters.htm.

How does t e manifest tracking system work?

The m a ifest form is i te ded to physic lly ccomp y the w ste wherever it tr vels bec use it serves s the DOT shippi g p per. E ch i dividu l h dler of the w ste, the ge er tor, e ch tr sporter, d e ch desig ted f cility must sig the m a ifest d keep o e copy for their records. Whe the w ste re ches the desig ted f cility listed o the m a ifest, the ow er of th t f cility retur s copy of the m a ifest to the ge er tor to co firm th t the w ste h s rrived. The ow er of the desig ted f cility lso gives copy of the m a ifest to the tr sporter th t delivered the w ste s proof of delivery.

If the w ste does ot rrive t the desig ted TSDF withi the regul tory time limits, ge er tors must immedi tely otify EPA or the uthorized st te e viro me t l ge cy so th t they c i vestig te d t ke ppropri te ctio to lc te the w ste shipme t. Ge er tors must ret i copies of the m a ifest for 3 ye rs fter the shipme t i ccord ce with RCRA; however, DOD h s sig ific tly lo ger record rete tio requireme ts.

The EPA m ifest, whe completed correctly, lso fulfills ll DOT p perwork requireme ts. The m a ifest lso fu ctio s s DOT shippi g p per or Bill of L di g (BoL).

o signs t e manifest?

The perso who sig s the m a ifest depe ds o the type of site. T ble A-1 ide tifies the respo sibilities. (The use of co tr ctors for Formerly Used Defe se Sites [FUDS], Milit ry Mu itio s Respo se Progr m (MMRP) sites, d Civil Works Projects/Activities is o ly llowed u der limited circumst ces, s described below.)

I the *Resident Engineer Management Guide (REMG) for Hazardous, Toxic, and Radioactive Waste (HTRW) Projects*, EP 415-1-266, He dqu rters U.S. Army Corps of E gi eers (HQUSACE) est blished procedures co cer i g the m a ifest sig tory uthorities.

ble A-1. Sign ture uthority.

T f ype o Site	Who Signs
Active Milit ry F cility	Milit ry F cility Represe t tive
Active Work for Others Site f f	Site Ow er, u less uthoriz tio letter
B se Re lig me ts d Closure B se	Perso el t B se
Formerly Used Defe se Site (FUDS)	Corps of E gi eers District
Formerly Used Defe se, Ord ce & Explosive, Mu itio s Co t mi ted Site	Corps of E gi eers Milit ry Mu itio s Desig or Remedi l Actio District
FUSRAP Site f f f	Corps of E gi eers District
EPA Superfu d Site	EPA, u less deleg ted to Corps of E gi eers
Civil Works Project/Activity	Corps of E gi eers District

At sites where the Corps is the ow er or respo sible ge cy (e.g., Civil Works Projects, Formerly Utilized Sites Remedi l Actio Progr m (FUSRAP), or FUDS), HW m a ifests will be the respo sibility of the Corps represe t tive to sig . USACE represe t tives will sig m a ifests "o beh lf of USACE." t Civil Works d FUSRAP sites, d "o beh lf of the Dep rtme t of Defe se" t FUDS sites.

f

At Defe se E viro me t l Restor tio Progr m (DERP) - I st ll tio Restor tio d B se Re lig me t d Closure sites, the customer (i.e., the i st ll tio or the b se) is respo sible for the sig i g of the m a ifest u less the customer form ally requests d uthorizes USACE to sig the m a ifests o its beh lf.

f

For FUDS, where milit ry mu itio s d/or co t mi tio from milit ry mu itio s (MM) m ateri l re to be m a ifested offsite, the prim ary respo sibility for sig i g the shippi g docume ts belo gs to the Corps represe t tive from the Milit ry Mu itio s Desig Ce ter or the Milit ry Mu itio s Remedi l Actio District. The loc l co structio represe t tive m ay sig the shippi g p pers if this is joi tly greed upo by the USACE geogr phic District d the USACE MM District. (Typic lly co structio represe t tive does ot h ve the experie ce to cl ssify DOT Cl ss 1 h z rdous m ateri ls, he ce the logic for sig ture by the Corps MM represe t tive.)

f

Whe the Corps is doi g Work for others, it is Corps policy, if requested d uthorized i writi g by its customers, to sig HW m a ifests d other rel ted docume ts o beh lf of those customers. I the p st, sever l customers h ve sked for this i cludi g: the EPA, the Feder l Emerge cy M a geme t Age cy (FEMA), d the Dep rtme t of Agriculture's F rm Services Admi istr tio (FSA). Corps perso el sig i g h z rdous w ste m a ifests d rel ted docume ts must e sure th t the Corps h f bee uthorized i writi g by its customers to do this. The customer's request d uthoriz tio must ck owledge th t the customer, s the ge er tor of the h z rdous w ste, ret i s ll respo sibilities for th t w ste. This requireme t for prior customer uthoriz tio covers the HW m a ifests, l d dispos l restrictio otific tio d certific tio , w ste profile sheets, d other ecess ry forms. It is most ppropri te to i clude this uthoriz tio , s well s customer st teme t ret i i g ll ge er tor's respo sibilities, s specific provisio withi Memor dum of Agreeme t (MOA), I ter ge cy Agreeme t (IAG), or correspo de ce sig ed by uthorized customer ge cy offici l. Authoriz tio for

cuti g d c rtifyi g m a if st forms d r l t d docum e ts o b h lf of EPA is d l g t d i EPA's l tt r d t d 18 ctob r 1990 [EP415-1-266, App di F] USACE districts m ay r qu st th t th EPA r m edi l proj ct m a g r (RPM) provid sit -sp cific uthoriz tio l tt r to co firm th d l g tio of uthority to sig o b h lf of EPA. Authoriz tio for cuti g d c rtifyi g m a if st forms d r l t d docum e ts o b h lf of FSA must b obt i d for v ry proj ct. FEMA's uthoriz tio is provid d i th MOA b tw th Corps d FEMA, sig d i 1991.

O

U d r th N tio R spo s Fr m ework, D D/USACE is th l d coordi ti g d cuti g g cy for Em erg cy Support Fu ctio #3 (ESF #3) – Public Works d E gi ri g A . Duri g USACE cutio of th d bris r mov l missio (o -h z rdous) compo t of ESF #3, EPA, u d r ESF #10 - il d H z rdous Mat ri ls R spo s A , m ay r qu st th t USACE lso ddr ss h z rdous d bris d oth r h z rdous m at ri ls. I situ tio s wh r USACE missio s r p d d i scop d m ay r quir th m a g m e t of h z rdous w st or oth r m at ri ls th t r quir th us of m a if st, USACE st ff should i iti t th coordi tio proc ss for sig tur uthority with FEMA d/or EPA rly i th proc ss. USACE c cut m a if sts o b h lf of FEMA, EPA, or oth r g ci s provid d MOA b tw g ci s is d v lop d d USACE st ff is uthoriz d s sig tur g t.

O

I i st c s i which Corps r pr s t tiv must b s t to r mot loc tio , th optio of r quiri g th co tr ctor to sig m a if sts m ay b co sid r d. This optio c o ly b us d for sp cific proj ct ft r writt uthoriz tio by th custom er d pprov l by th Co structio Divisio Chi f or quiv l t l v l, t th cuti g District. For FUDS, o ly th pprov l of th Co structio Divisio Chi f t th cuti g District is c ss ry. Ev if sit circumst c s justify uthorizi g co tr ctor to sig o b h lf of th Corps, th cuti g District must sur th t th m a if st d ll supporti g p p rs r ccur t . I th u usu l situ tio th t co tr ctor will b uthoriz d to sig m a if st, Corps proj ct st ff must sur th t th p rso to sig is prop rly tr i d i w y th t is qu l to th t r quir d of Corps p rso l, d th t this is uthoriz d i writi g, s sp cifi d i EP 415-1-266.

Do I need training before I sign a manifest?

M a y r gul tory g ci s r quir th t i dividu l obt i tr i i g wh m a gi g d tr sporti g h z rdous m at ri ls. D T r gul tio 49 CFR 172, subp rt H, r quir s th t p opl who p rform pr -tr sport tio d tr sport tio fu ctio s b tr i d. P rso s who lo d, u lo d, or h dl h z rdous m at ri ls (HAZMAT), c rtify p ck gi gs, pr p r h z rdous m at ri ls for tr sport tio , sur th s f ty of shipm e t, or op r t motor v hicl us d to tr sport HAZMAT must b tr i d v ry 3 y rs. Tr i i g for th s HAZMAT mploy s hir d ft r 2 uly 1993 h s to b compl t d withi 90 d ys of mploym e t. Th mploy r is r spo sibl for suri g th t HAZMAT mploy s r c iv th r quir d tr i i g.

O

I dditio , *Defense Transportation Regulations*, [DTR 4500.9-R-P rt II, C rgo Mov m t, Ch pt r 204, uly 2006], r quir th t ll D D mploy s who pr p r d ship h z rdous m at ri ls by commerci l or milit ry v hicl b tr i d v ry 24 mo ths.

ere re sever l differe t d i depe de t tr i i g requireme ts for perso el w o s ip z rdous m ateri ls d z rdous w stes. fte , t ese tr i i g requireme ts re co fused wit t e D requireme t. As discussed bove, t e D d D D requires tr i i g for yo e w o does yt i g rel ted to t e tr sport tio of z rdous m ateri ls. Additio lly, SHA requires z rd commu ic tio s fety tr i i g for employees w o dle z rdous m ateri ls. ypic lly, t is tr i i g te c es t e stude t ow to ide tify t e c emic l properties of z rdous m ateri ls. SHA courses re typic lly offered t t e f cility by t e s fety officer. EPA RCRA regul tio s require t t perso s ge er ti g over 1000 kg (2200 lb) of z rdous w ste i mo t (L rge Qu tity Ge er tors) be tr i ed i t eir f cility's specific emerge cy procedures, s well s y ot er fu ctio -specific spects of m a gi g z rdous w ste t t eir f cility. is tr i i g is lso typic lly co ducted t t e f cility s it is f cility specific.
O
Wit few exceptio s, t e tr i i g requireme ts of D , EPA, d SHA must be met to fully comply wit regul tory requireme ts d to tr sport z rdous w stes. D R 4500.9-R-II provides t e D D pproved list of D tr i i g sources. A p rti l list of pproved courses c be fou d i ble A-9.

How do I fill out the manifest?

o properly complete t e HW m a ifest form, EPA s publis ed complete set of i structio s. ese i structio s re i cluded i Figure A-2 of t is docume t. e i structio s re very det iled d provide excelle t discussio of t e i form atio t t s ould be pl ced i to e c box o t e form. U fortu tely, determi i g t e correct i form atio to be pl ced i to e c item is slig tly more complic ted. e followi g discussio s will ssist t e re der i determi i g ow to complete ll t e required boxes of t e m a ifest t t re ot self-expl tory.

Where do I start?

o s ip z rdous w stes offsite, you s ould st rt pl i g e rly so you c g t er t e required i form atio for completio of t e m a ifest. o complete t e required s ippi g p per, t e m a ifest i t is c se, sever l pieces of i form atio re required. First, it is imper tive t t t e w ste be ide tified properly, eit er t roug lytic l l bor tory lysis or by usi g t e w ste ge er tor's k owledge.

Seco dly, t e w ste profile s eet must be completed. Alt oug ot required by regul tio , most SDFs require w ste profile s eet be completed before t ey will ccept w ste i to t eir f cility. W ste profile s eets v ry mo g SDFs. ce t e l bor tory lysis is v il ble, t e co tr ctor s ould get t e w ste profile s eet from t e SDF d t e complete t e form. Bec use t e w ste profile form form at is ot specified i t e regul tio s, o two profile forms re t e s me d yo e k owledge ble bout t e w ste stre m c sig o e. ce t is is do e, proper D s ippi g me c be determi ed b sed o t e istory d c emic l lysis of t e w ste. I pr ctice, t e w ste profile s eets re typic lly prep red by t e co tr ctor d sig ed by t e perso w o sig s t e m a ifest. However, it is recomme ded t t t e co tr ctor be respo sible for sig i g t e w ste profile s eets si ce t e co tr ctor is typic lly respo sible for

- rformi g th w st ch r ct riz tio s m pli g d obt i i g th ch mic l lysis from th t sti g l bor tory.

H w d I get an EPA identificati n number?

It m l o th HW m a if st r quir s th g r tor's EPA id tific tio (ID) umb r. Th ID umb r is u iqu 12-digit umb r ssig d to ch i dividu l sit by th f d r l EPA. A g r tor of h z rdous w st must ot tr t, stor , dis os of, tr s ort, or off r for tr s ort tio such w st without h vi g r c iv d EPA id tific tio umb r. A g r tor m ay obt i umb r by lyi g to th EPA Admi istr tor or th st t dmi istr tor usi g EPA Form 8700-12, *RCRA Subtitle C Site Identification Form*. Figur A-3 illustr t s th form. O r r occ sio s, both th f d r l EPA d th st t EPA m ay issu diff r t ID umb rs to g r tor. For ur os s of com pl ti g th m a if st, th m a if st i structio s r quir th t th f d r l EPA umb r b us d. Th form d i structio s for com pl ti g th form c b dow lo d d from th EPA w bsit : htt ://www. .gov/osw/i for sourc s/d t /form8700/forms.htm.

Wh c mpletes and signs the *Identification Form*?

Th d for EPA id tific tio umb r will d d o th ty of sit , th ty of w st m a g d t th sit d th volum eof w st m a g d t th sit . Lik wis , who li s for th umb r will lso v ry.

At milit ry i st ll tio , ith r ctiv or b i g clos d, d t Work for Oth rs sit , th f cility will i most c s s lr dy h v EPA id tific tio umb r. This umb r should b us d for ll w st g r t d t th f cility. If th f cility do s ot h v umb r, th f cility d sig should com l t th forms d r qu st o from th EPA.

- At FUDS or FUSRAP sit , th Cor s will h v to s cur th umb r. You should r qu st th umb r duri g th study or d sig h s b c us it routi ly t k s s v r l mo ths to r c iv o from th r gul tors. If th umb r is ot obt i d t this tim e, th you should g t it s soo s co structio is sch dul d to b gi . Th form c b com pl t d by ith r th Cor s r r s t tiv or co tr ctor. Th rso r s o sibl for sig i g th form will b th ow r/o r tor or d sig t d r r s t tiv of th f cility i which th w st is g r t d. O FUDS or FUSRAP sit , this is th Cor s. Th District Comma d r should sig or d l g t sig tur uthority for this form.
- At EPA Su rfu d sit , th EPA R m edi l Proj ct M a g r should s cur th umb r. If th Proj ct M a g r h s ot do this, h or sh m ay sk th Cor s for ssist c . If this is th c s , EPA should sig th form b c us it is th ow r/o r tor of th sit .
- At Civil Works roj ct, th roj ct gi r or d sig t d r r s t tiv orm ally com l t s d sig s th form.

Figur A-3 rovid s th curr t form.

SEND COMPLETED FORM TO: The Appropriate State or EPA Regional Office	United States Environmental Protection Agency **RCRA SUBTITLE C SITE IDENTIFICATION FORM**	
1. Reason for Submittal (See Instructions on page 13.) MARK ALL BOX(ES) THAT APPLY	**Reason for Submittal:** ☐ To provide Initial Notification of Regulated Waste Activity (to obtain an EPA ID Number for hazardous waste, universal waste, or used oil activities) ☐ To provide Subsequent Notification of Regulated Waste Activity (to update site identification information) ☐ As a component of a First RCRA Hazardous Waste Part A Permit Application ☐ As a component of a Revised RCRA Hazardous Waste Part A Permit Application (Amendment #_____) ☐ As a component of the Hazardous Waste Report	
2. Site EPA ID Number (page 14)	**EPA ID Number** |__|__|__|__|__|__|__|__|__|__|__|__|	
3. Site Name (page 14)	**Name:**	
4. Site Location Information (page 14)	**Street Address:**	
	City, Town, or Village:	**State:**
	County Name:	**Zip Code:**
5. Site Land Type (page 14)	**Site Land Type:** ☐ Private ☐ County ☐ District ☐ Federal ☐ Indian ☐ Municipal ☐ State ☐ Other	
6. North American Industry Classification System (NAICS) Code(s) for the Site (page 14)	**A.** |__|__|__|__|__|__|	**B.** |__|__|__|__|__|__|
	C. |__|__|__|__|__|__|	**D.** |__|__|__|__|__|__|
7. Site Mailing Address (page 15)	**Street or P. O. Box:**	
	City, Town, or Village:	
	State:	
	Country:	**Zip Code:**
8. Site Contact Person (page 15)	**First Name:**	**MI:**	**Last Name:**
	Phone Number: **Extension:**	**Email address:**
9. Operator and Legal Owner of the Site (pages 15 and 16)	**A. Name of Site's Operator:**	**Date Became Operator (mm/dd/yyyy):**
	Operator Type: ☐ Private ☐ County ☐ District ☐ Federal ☐ Indian ☐ Municipal ☐ State ☐ Other	
	B. Name of Site's Legal Owner:	**Date Became Owner (mm/dd/yyyy):**
	Owner Type: ☐ Private ☐ County ☐ District ☐ Federal ☐ Indian ☐ Municipal ☐ State ☐ Other	

EPA Form 8700-12 (Revised 7/2000) Page 1 of 3

gure A-3. EPA orm 8700-12, *C A Subtitle C Site Identification Form.* RR

EPA ID NO: _____ OMB#: 2050-0028 Expires 06/30/2009

9. Legal Owner (Continued) Address	Street or P. O. Box:	
	City, Town, or Village:	
	State:	
	Country:	Zip Code:

10. Type of Regulated Waste Activity
Mark "Yes" or "No" for all activities; complete any additional boxes as instructed. (See instructions on pages 17 to 20.)

A. Hazardous Waste Activities
Complete all parts for 1 through 6.

Y ☐ N ☐ 1. Generator of Hazardous Waste
If "Yes", choose only one of the following - a, b, or c.

- ☐ a. LQG: Greater than 1,000 kg/mo (2,200 lbs./mo.) of non-acute hazardous waste; or
- ☐ b. SQG: 100 to 1,000 kg/mo (220 - 2,200 lbs./mo.) of non-acute hazardous waste; or
- ☐ c. CESQG: Less than 100 kg/mo (220 lbs./mo.) of non-acute hazardous waste

In addition, indicate other generator activities.

Y ☐ N ☐ d. United States Importer of Hazardous Waste

Y ☐ N ☐ e. Mixed Waste (hazardous and radioactive) Generator

Y ☐ N ☐ 2. Transporter of Hazardous Waste

Y ☐ N ☐ 3. Treater, Storer, or Disposer of Hazardous Waste (at your site) Note: A hazardous waste permit is required for this activity.

Y ☐ N ☐ 4. Recycler of Hazardous Waste (at your site)

Y ☐ N ☐ 5. Exempt Boiler and/or Industrial Furnace
If "Yes", mark each that applies.
- ☐ a. Small Quantity On-site Burner Exemption
- ☐ b. Smelting, Melting, and Refining

Y ☐ N ☐ 6. Underground Injection Control

B. Universal Waste Activities

Y ☐ N ☐ 1. Large Quantity Handler of Universal Waste (accumulate 5,000 kg or more) [refer to your State regulations to determine what is regulated]. Indicate types of universal mark all boxes that apply:

	Manage
a. Batteries	☐
b. Pesticides	☐
c. Mercury containing equipment	☐
d. Lamps	☐
e. Other (specify) _____	☐
f. Other (specify) _____	☐
g. Other (specify) _____	☐

Y ☐ N ☐ 2. Destination Facility for Universal Waste
Note: A hazardous waste permit may be required for this activity.

C. Used Oil Activities
Mark all boxes that apply.

Y ☐ N ☐ 1. Used Oil Transporter
If "Yes", mark each that applies.
- ☐ a. Transporter
- ☐ b. Transfer Facility

Y ☐ N ☐ 2. Used Oil Processor and/or Re-refiner
If "Yes", mark each that applies.
- ☐ a. Processor
- ☐ b. Re-refiner

Y ☐ N ☐ 3. Off-Specification Used Oil Burner

Y ☐ N ☐ 4. Used Oil Fuel Marketer
If "Yes", mark each that applies.
- ☐ a. Marketer Who Directs Shipment of Off-Specification Used Oil to Off-Specification Used Oil Burner
- ☐ b. Marketer Who First Claims the Used Oil Meets the Specifications

EPA Form 8700-12 (Revised 7/2006) Page 2 of 3

Figure A-3 (cont'd). EPA Form 8700-12, *RCRA Subtitle C Site Identification Form.*

m

EPA ID NO: |__|__|__|__|__|__|__|__|__|__|__|__|

OMB#: 2050-0028 Expires 06/30/2009

11. Description of Hazardous Wastes (See instructions on page 21.)

A. Waste Codes for Federally Regulated Hazardous Wastes. Please list the waste codes of the Federal hazardous wastes handled at your site. List them in the order they are presented in the regulations (e.g., D001, D003, F007, U112). Use an additional page if more spaces are needed.

B. Waste Codes for State-Regulated (i.e., non-Federal) Hazardous Wastes. Please list the waste codes of the State-regulated hazardous wastes handled at your site. List them in the order they are presented in the regulations. Use an additional page if more spaces are needed for waste codes.

12. Comments (See instructions on page 21.)

13. Certification. I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.
For the RCRA Hazardous Waste Part A Permit Application, all operator(s) and owner(s) must sign (see 40 CFR 270.10 (b) and 270.11).
(See instructions on page 21.)

Signature of operator, owner, or an authorized representative	Name and Official Title (type or print)	Date Signed (mm/dd/yyyy)

EPA Form 8700-12 (Revised 7/2006) Page 3 of 3

m

gure A-3 (cont'd). EPA or 8700-12, *RCRA Subtitle C Site Identification Form*. m

at is t e emergency response p one?

Item of the HW m a ifest is for the emerge cy respo se pho e umber. DOT requires emerge cy respo se pho e umber o the shippi g p pe for shipme ts of ll h z rdous m teri ls. The emerge cy respo se pho e umber field provides vit l i form tio for emerge cy respo ders to use i the eve t of ccide t or other serious i cide t th t occurs while h z rdous m teri ls shipme t is i tr sport tio . The pho e umber must belo g to the ge er tor or other ge cy or org iz tio th t ccepts respo sibility for providi g det iled i form tio bout the w stes i the shipme t. USACE m y co tr ct with their co tr ctor to provide this service if desired.

This umber must correspo d to pho e th t is mo itored 24 hours per d y while the w ste is i tr sport tio (i cludi g stor ge i cide t l to tr sport tio). The perso ssig ed to this pho e must h ve either perso l k owledge or immedi te ccess to perso with k owledge of the m teri l bei g shipped, s well s comprehe sive emerge cy respo se, spill cle up, d i cide t mitig tio i form tio bout the m teri l. Pl ci g the emerge cy respo se pho e umber i Item is ppropri te for those c ses i which the listed pho e umber pplies to every item listed i Item 9b of the HW m a ifest. However, there m y be i st ces where more th o e emerge cy respo se umber m y pply to the v rious w ste items listed o the m a ifest. I these c ses, EPA d DOT regul tio s specify th t the pplic ble emerge cy respo se pho e umber should ppe r immedi tely followi g the shippi g descriptio s u der Item 9b.

DOT lso requires th t the perso who offers for tr sport tio , ccepts for tr sport tio , tr sfers, stores, or otherwise h dles h z rdous m teri l duri g tr sport tio , provide emerge cy respo se i form tio with the shipme t.

The followi g emerge cy respo se i form tio is required:

- B sic descriptio d tech ic l me of the h z rdous m teri l.
- Immedi te h z rds to he lth.
- Risks of fire or explosio .
- Immedi te prec utio s to be t ke i the eve t of ccide t or i cide t.
- Immedi te methods for h dli g fires.
- I iti l methods for h dli g spills or le ks i the bse ce of fire.
- Prelimi ry first id me sures.

The required i form tio must be:

- Pri ted legibly i E glish.
- Av il ble for use w y from the p ck ge co t i i g the h z rdous m teri l.
- Prese ted o shippi g p per, or i docume t th t i cludes both the b sic descriptio d tech ic l me of the h z rdous m teri l, such s *Materials Safety Data Sheet.*

I pr ctice, the *Emergency Response Guidebook* (*ERG*) is used to fulfill this requireme t whe shippi g h z rdous w stes. A copy of the ERG c be fou d o the I ter et t

p:// zm a.do .gov/pubs/erg/gydebook. m. Whe e E G is used, e guide umber s ould be pl ced i I em 14 o e m a ifes for e c w s e or m aeri l ide ified i I em 9b. T e s ipper mus e e sure e r spor er s copy of e E G bo rd is ve icle or provide copy of e pplic ble guide p ges wi e m a ifes .

What is the Manifest Tracking Number?

I em 4 of e HW m a ifes is e M a ifes Tr cki g Number (MTN) d is e umber used o r ck your m a ifes . T e MTN is lp umeric ide ific io umber (i.e., u ique ree-le er suffix preceded by i e umeric l digi s), w ic is pre-pri ed i I em 4 of e m a ifes by EPA- pproved regis r . T is umber c o be c ged by e ge er or.

Where do I put my generator information?

I em 5 of e HW m a ifes is w ere e ge er or is ide ified. T e box i I em 5 is subdivided i o wo boxes. O e lef side of e box, e ge er or would e er is me d m ili g ddress. T is ddress is ex remely impor s is is e ddress o w ic e desig ed f cili y will se d b ck e comple ed m a ifes . If e c u l p ysic l si e ddress is o e s me s e si e m ili g ddress, e EPA sks e ge er or lso ide ify e p ysic l si e ddress i e rig - d side of e box. T e ge er or's orm l busi ess p o e umber is lso recorded i is box.

What do I include in the transporter's boxes?

T e ge er or e ers e comp y me d e U.S. EPA ID umber of e r spor er i I em 6. If e w s e will be r sferred o o er r spor er, e r spor er d ssoci ed EPA ID umber mus lso be ide ified i I em 7. If more wo r spor ers re eeded, e co i u io p ge s ould be used. I ddi io , i s ould be o ed e z rdous w s e r spor ers mus comply wi e requireme s of 40 CF 263 *Standards Applicable to Transporters of Hazardous Wastes.* Typic lly, s es ve progr ms i pl ce o issue H z rdous Was e H uler's permi s o r spor ers u der e provisio s of eir impleme i g regul io s.

So, where do I identify my hazardous wastes?

I ems 9 roug 13 o e HW m a ifes ide ify e DOT-required i form aio per i i g o e w s es o be r spor ed s well e C A w s e codes for e w s es.

R
A "X" is pl ced i I em 9 if e HW m a ifes ide ified bo DOT-regul ed d o -DOT regul ed m eri ls. T e "X" i dic es e m aeri l is DOT regul ed. I s ould be o ed ll z rdous w s es by defi i io re DOT regul ed m aeri ls. T e HW i s ruc io s d e DOT i s ruc io s o BoLs, i dic e you o ly eed o pl ce e "X" i e ppropri e box w e e s ipme co i s z rdous m aeri ls d o - z rdous m aeri ls. However, i is good pr c ice o lw ys pl ce e "X" i e box w e e m aeri l bei g described is z rdous

R

eri l.mIpis lso i or o o e h DOT i s ruc io s o shippi g p pers llow he " " o be subs i u ed wi h "RQ" whe he p ck gi g co i s repor ble qu i y of h z rdous subs ce. However, EPA i s ruc io s for HW ifes s do o i clude his provisio so i is m ereco ded h "RQ," whe pplic ble, be pl ced i ssoci io wi h he b sic shippi g descrip io i I e 9b.

I e 9b ismo œ omh pe s i or d dhficul i e o correc ly co lœ e. I e 9b co i s he DOT b sic shippi g descrip io (BSD) for he h z rdous w s e. The BSD i cludes he proper shippi g (PSN) of he w s e, he h z rd cl ss (HC) or divisio , he ide ific io u der, d he p ck gi g group (PG) of he w s e. This i for io is derived fro k owi g he ly ic l resul s d che ci l proper ies of he w s e s re s d k owi g he proper w y o cl ssify w s e d h z rdous eri ls u der DOT regul io s.

m I e 10 of he ifes ide mifies he u er d ype of co i ers ssoci ed wi h he b sic shippi g descrip io his ed i he i 9b. Sim sl rly, I e 11 d 12 de o e he o l qu i y d u i weigh e or volu ssoci ed wi h he descrip io . The i s ruc io s, show i Figure A-2, provide he u horized bbrevi io s for hes ecu i s of sure.

The w s e codes ssoci ed wi h hem w s e s re re ide ified i I e 13. E er up o six feder l d s e w s e codes h bes describe he w s e s re ide ified i I e 9b. The feder l codes so represe ive of he w s e s re s be e ered. I ddi io , if s e d feder l w s e codes re o redu d , he s ue codes s be e ered.

What is hazardous waste?

To be ble o ccu p ely com le e I e 9b of he mifes , you s firs ide ify your w s e i ccord ce wi h he *Resource Conservation and Recovery Act* (RCRA). As s ed bove, you y use "ge er or k owledge" of he w s e, or you y h ve l bor ory lyze i [40 CFR 262.11]. Ge er or k owledge e s h he ge er or k ows e ough bou how he w s e w s ge er ed d wh erem c fro o properly cl ssify i .

Was e c be cl ssified s h z rdous if i is ch r c eris ic or lis ed, or bo h. The four ch r c eris ics re: ig i bili y, corrosivi y, re c ivi y, d oxici y. The defi i io s of e ch ype of ch r c eris ic w s e re fou d i 40 CFR 261, subp r C. This sec io of he CFR should be co sul ed for he specific defi i io s.

I ge er l, w s e is ig i ble if i is liquid, o her h queous solu io co i i g less h 24% lcohol by volu e d h s fl shpoi less h 140°F (60°C). There re sever l m o re specific defi i io s i 40 CFR 261.21; however, his is he so co .oAll w s es h vi g fl shpoi below 140°F re ssig ed he w s e code D001.

I ge er l, corrosive w s e is o e h is queous d h s pH less h or equ l o 2.0 or gre er h or equ l o 12.5. There re rœ defi i io s i 40 CFR 261.22; however, his is he X m oso co o e. All w s es œ i g his defi i io re ssig ed he w s e code D002.

ctivity is prob bly th h rd st ch r ct ristic to d fi . I 40 C 261.23, EPA h s provid d ight diff r t d fi itio s. B sic lly, r ctiv w st is o th t viol tly r cts with w t r, or is orm ally u st bl d r dily u d rgo s ch g without d to ti g, or pot ti lly c form xplosiv mixtur s with w t r. All w st s m e ti g th d fi itio of r ctivity r ssig d th w st cod D003.

F

Th l st ch r ct ristic is toxicity. If th w st f ils th Toxicity Ch r ct ristic L chi g Proc - dur , lytic l t st, for o or mor co t mi ts i 40 C 261.24, it is ssig d th corr spo di g w st cod for th t co t mi t, which is lso fou d i 40 C 261.24.

A oth r w y i which w st s m ay b h z rdous is for th w st to b "list d." Th r r four lists of h z rdous w st s: th -list, K-list, P-list, d U-list.

F

Th -list is h z rdous w st from o -sp cific sourc s. I g r l, th s r w st s th t EPA h s d t rmi d to b h z rdous, but th t r ot g r t d by p rticul r i dustry or m a uf c- turi g proc ss. Th s w st s i clud c rt i solv ts, pl ti g w st s, m ct l tr ti g w st s, wood pr s rvi g w st s, tc. Th compl t -list c b fou d i 40 C 261.31.

F

Th K-list is h z rdous w st from sp cific sourc s. This i clud s w st s th t r g r t d by p rticul r i dustri s. Wast s o th K-list i clud c rt i w st s g r t d from v rious proc ss s i cludi g, but ot limit d to, th wood pr s rv tio , p sticid , xplosiv s, d ph rm ac utic l i dustri s. Th compl t K-list is fou d i 40 C 261.32.

F

Th P-list d th U-list r prob bly th most misu d rstood lists. Th P-list d U-list r fou d i 40 C 261.33. Th s w st s r commerci l ch mic l products, off-sp cific tio sp ci s, co t i r r sidu s, d spills th r of. Th phr s "commerci l ch mic l product" m e s th pur or t ch ic l gr d of th ch mic l th t h s *never been used for its intended purpose*. It do s ot r f r to m a uf cturi g proc ss w st co t i i g P- or U-list d ch mic l. If th ch mic l h s v r b us d for its i t d d purpos , y t is to b dispos d of, th th t ch mic l is P- or U-list d. If, how v r, th ch mic l *was* us d for its i t d d purpos , for x mpl s solv t, wh it is disc rd d, it will prob bly b -list d or ch r ct ristic. It will o lo g r b P- or U-list d h z rdous w st . Th o ly diff r c b tw th P- d U-list is th t th ch mic ls pp ri g i th P-list r cut h z rdous w st , m e i g th y r mor toxic th th ch mic ls pp ri g o th U-list.

F

You should ot th t th r r thr oth r tim s wh you m ay h v h z rdous w st . irst, if you h v viro m e t l m edi , such s soil or w t r, th t co t i s list d h z rdous w st , th ll of th m edi is co sid r d h z rdous w st u til it o lo g r co t i s y list d w st . This is c ll d th "co t i d-i " policy. This policy w s codifi d o 18 August 1992 i th *Federal Register*. Th s co d circumst c is c ll d th "mixtur " rul . Th mixtur rul w s codifi d s 40 C 261.3 (b)(2), (b)(3), (g)(1), d (g)(2). This rul b sic lly st t s th t list d w st mix d with o -h z rdous w st m ak s th tir mixtur h z rdous w st . Also th t if ch r ct ristic w st is mix d with o -h z rdous w st d if th r sult t mixtur is ch r ct ristic, th th tir mixtur is h z rdous w st . (Th r is prohibitio g i st

lut o s me s of tre t g h z r ous w ste.) L stly, there s the er ve -from" rule. The er ve -from" rule s co f e 40 CFR 261.3(c)(2)( ) 40 CFR 261.3( )(1) (2). Th s rule b s c lly st tes th t ll res ues er ve from the tre tme t, stor ge, or spos l of l ste h z r ous w ste must lso be tre te s the l ste h z r ous w ste. Waste er ve from the tre tme t, stor ge or spos l of ch r cter st c w stes must be teste to eterm i e f they st ll exh b t the ch r cter st c. These three pr c ples re very ff cult co cepts. Whe co fro te w th these types of eterm i t o s, you shoul seek help from your regul tory spec l st or leg l cou sel whe cl ss fy g the w ste.

The EPA h z r ous w ste co es re to be pl ce Item 13 of the h z r ous w ste m a fest. E ter up to s x fe er l st te w ste co es to escr be the w ste stre m e t f e Item 9b. The fe er l HW co es most represe t t ve of the w ste stre m must be e tere . The , st te w ste co es th t re ot re u t w th the fe er l co es must be e tere .

Upo eterm i g your w ste co es e ter g them Item 13 of the m a fest, you re re y to emb rk o eterm i g DOT b s c sh pp g escr pt o . But before we c o th t, t s ecess ry to u erst the DOT H z r ous Mater ls T ble (HMT).

What do all the columns in the HMT mean?

The m ater ls l"ste the HMT re DOT-regul te m ater ls f they re to be tr sporte . For e ch m ater l l ste the HMT, the HMT e t f es the h z r cl ss, p ck g group, e t f c t o umber, p ck g g requ reme ts or spec f es th t the m ater l s forb e tr sport t o , g ves the lter te proper sh pp g me or rects the user to the preferre proper sh pp g me. The t ble spec f es or refere ces requ reme ts for l bel g, p ck g g, qu t ty l m its bo r rcr ft, stow ge of h z r ous m ater ls bo r vessels. There re 10 colum ns the HMT (F gure A-4). These colum ns re scusse below.

Column 1: Symbols

Colum n1 of the HMT co t s s x symbols (+, A, D, I, W, G). The me gs of those symbols re:

+ The plus (+) f xes the proper sh pp g me, h z r cl ss, p ck g group for th t e try w thout reg r to whether the m ater l meets the ef t o of th t cl ss or p ck g group or y other h z r cl ss ef t o . A ppropr te lter te proper sh pp g me h z r cl ss m ay be uthor ze by DOT.

Symbols	Hazardous materials descriptions and proper shipping names	Hazard class or Division	Identification Numbers	PG	Label Codes	Special provisions	(8) Packaging (§173.***) Exceptions	Non-bulk	Bulk	(9) Quantity limitations Passenger aircraft/rail	Cargo aircraft only	(10) Vessel stowage Location	Other
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8A)	(8B)	(8C)	(9A)	(9B)	(10A)	(10B)
	Accelerene, see p-Nitrosodimethylaniline.	.....			.....		.....	.....	.....	.....	.....		
	Accumulators, electric, see Batteries, wet etc.	.....			.....		.....	.....	.....	.....	.....		
D	Accumulators, pressurized, pneumatic or hydraulic (containing non-flammable gas.	2.2	NA1956		2.2		306	306	None ..	No limit	No limit	A	
	Acetal	3	UN1088	II	3	T7	150	202	242	5 L	60 L	E	
	Acetaldehyde	3	UN1089	I	3	A3, B16, T20, T26, T29	None	201	243	Forbidden	30 L	E	
A	Acetaldehyde ammonia	9	UN1841	III	9		155	204	240	200 kg	200 kg	A	34
	Acetaldehyde oxime	3	UN2332	III	3	B1, T8	150	203	242	60 L	220 L	A	
	Acetic acid, glacial or Acetic acid solution, with more than 80 percent acid, by mass.	8	UN2789	II	8, 3	A3, A6, A7, A10 B2, T8	154	202	243	1 L	30 L	A	
	Acetic acid solution, with more than 10 percent but not more than 80 percent acid, by mass.	8	UN2790	II	8	A3, A6, A7, A10 B2, T8	154	202	242	1 L	30 L	A	
	Acetic anhydride	8	UN1715	II	8, 3	A3, A6, A7, A10, B2, T8	154	202	243	1 L	30 L	A	40
	Acetone	3	UN1090	II	3	T8	150	202	242	5 L	60 L	B	
	Acetone cyanohydrin, stabilized	6.1	UN1541	I	6.1	2, A3, B9, B14, B32, B76, B77, N34, T38, T43, T45	None	227	244	Forbidden	30 L	D	25, 40, 49
	Acetone oils	3	UN1091	II	3	T7, T30	150	202	242	5 L	60 L	B	
	Acetonitrile	3	UN1648	II	3	T14	150	202	242	1 L	60 L	B	40

Figure A-4. Column headings in the *Hazardous Materials Table* (HMT).

A The letter "A" restricts the application of requirements to materials offered or intended for transportation by aircraft, unless the material is a hazardous substance or a hazardous waste (see Figure A-4).

D The letter "D" identifies proper shipping names that are appropriate for describing materials for domestic transportation but may be inappropriate for international transportation under the provisions of international regulations (e.g., International Maritime Organization [IMO], International Civil Aviation Organization [ICAO]). An alternate proper shipping name may be selected when either domestic or international transportation is involved.

I The letter "I" identifies proper shipping names that are appropriate for describing materials in international transportation. An alternate proper shipping name may be selected when only domestic transportation is involved.

W The letter "W" restricts the application of requirements to materials offered or intended for transportation by vessel, unless the material is a hazardous substance or a hazardous waste.

G The letter "G" identifies proper shipping names for which one or more technical names of the hazardous materials must be entered in parentheses, in association with the basic shipping description.

lumn 2: Hazard us materials descripti ns and pr per shippin names

Colum n2 lists the h z rdous m teri ls descriptio s d proper shippi g mes. I ge er l, the rule for colum n2 is th t you c o ly use the me fou d i colum n2 s the PSN if it is i Rom a type. Whe o e e try refere ces other e try by use of the word "see," if both mes re i Rom type, either me m y be used s the proper shippi g me (e.g., Ethyl lcohol, *see* Eth ol). The PSN m y be used i the si gul r or plur l d i either upperc se or lowerc se letters. Pu ctu tio m rks d words i it lics re ot p rt of the proper shippi g me, but m y be used i dditio to the proper shippi g me. The word "poiso " or "poiso ous" m y be used i terch ge bly with the word "toxic" whe o ly domestic tr sport tio is i volved.

lumn 3: Hazard class r divisi n

Colum n3 co t i s desig tio of the h z rd cl ss or divisio correspo di g to e ch proper shippi g me, or the word "Forbidde ." A m teri l for which the e try i this colum nis "Forbidde " m y ot be offered for tr sport tio or tr sported u less it is diluted, st bilized, or i corpor ted i device. Both the prim ry d subsidi ry h z rd cl ss must be ide tified i the b sic shippi g descriptio . There re i e h z rd cl sses.

Class 1 – Explosives. A explosive me s y subst ce or rticle, i cludi g device, which is desig ed to fu ctio by explosio , or which, by chemic l re ctio withi itself, is ble to fu ctio i simil r m a er eve if ot desig ed to fu ctio by explosio . The term i cludes pyrotech ic subst ce or rticle, u less the subst ce or rticle is otherwise cl ssed. Explosives i Cl ss 1 re divided i to six divisio s.

Class 2 – Gases. There re three divisio s of g ses. A fl mmable g s (Divisio 2.1) me s y m teri l th t is g s t 20°C (68°F) or less d 101.3 kP (14.7 psi) of pressure (m teri l th t h s boili g poi t of 20°C (68°F) or less t 101.3 kP (14.7 psi)), which is ig it ble t 101.3 kP (14.7 psi) whe i mixture of 13% or less by volume with ir; or h s fl mmable r ge t 101.3 kP (14.7 psi) with ir of t le st 12% reg rdless of the lower limit. A o -fl mm ble, o poiso ous compressed g s (Divisio 2.2) me s y m teri l (or mixture) th t exerts i the p ck gi g bsolute pressure of 280 kP (40.6 psi) or gre ter t 20°C (68°F), or is cryoge ic liquid, d does ot meet the defi itio of Divisio 2.1 or 2.3. A g s poiso ous by i h l tio (Divisio 2.3) me s m teri l th t is g s t 20°C (68°F) or less d pressure of 101.3 kP (14.7 psi) (m teri l th t h s boili g poi t of 20°C (68°F) or less t 101.3 kP (14.7 psi)) d is k ow to be so toxic to hum a s s to pose h z rd to he lth duri g tr sport tio .

Class 3 – Flammable Liquids. A fl mmable liquid (Cl ss 3) me s liquid h vi g fl sh poi t of ot more th 60°C (140°F), or y m teri l i liquid ph se with fl sh poi t t or bove 37.8°C (100°F) th t is i te tio lly he ted d offered for tr sport tio or tr sported t or bove its fl sh poi t i bulk p ck gi g.

Class 4 – Flammable Solid, Spontaneously Combustible or Dangerous When Wet. A fl mmable solid (Divisio 4.1) me s, i ge er l, dese sitized explosive th t, whe dry, is Cl ss 1 explosive, which is wetted with sufficie t w ter, lcohol, or pl sticizer to suppress

plosiv prop rti s; d is sp cific lly uthoriz d by m ei th MT or by th DOT Associ t Admi istr tor. Cl ss 4 lso i clud s s lf-r ctiv m at ri ls. Th s r m at ri ls th t r th rm ally u st bl d th t c u d rgo stro gly oth rmic d compositio v without p rticip tio of o yg . A spo t ously combustibl m at ri l (Divisio 4.2) m e s pyrophoric m at ri l. A pyrophoric m at ri l is liquid or solid th t, v i sm all qu titi s d without t r l ig itio sourc , c ig it withi fiv (5) mi ut s ft r comi g i co t ct with ir or s lf-h ti g m at ri l. A d g rous wh w t m at ri l (Divisio 4.3) m e s m at ri l th t, by co t ct with w t r, is li bl to b com espo t ously fl mmabl or to giv off fl mmabl or to ic g s t r t gr t r th 1 L p r kilogr m of th m at ri l, p r hour.

Class 5 – Oxidizer or Organic Peroxide. A o idiz r (Divisio 5.1) m e s m at ri l th t m ay, g r lly by yi ldi g o yg , c us or h c th combustio of oth r m at ri ls. A org ic p ro id (Divisio 5.2) m e s y org ic compou d th t co t i s o yg (O) i th biv l t -O-O- structur d th t m ay b co sid r d d riv tiv of hydrog p ro id , wh r o or mor of th hydrog toms h v b r pl c d by org ic r dic ls.

Class 6 – Poisonous Material or Infectious Substance. A poiso ous m at ri l (Divisio 6.1) m e s m t ri l, oth r th g s, which is k ow to b so to ic to hum a s s to fford h z rd to h lth duri g tr sport tio , or which, i th bs c of d qu t d t o hum a to icity is pr sum ed to b to ic to hum a s b c us it f lls withi y o of th followi g c t gori s wh t st d o l bor tory im als. A i f ctious m at ri l (Divisio 6.2) m e s m at ri l k ow or r so bly p ct d to co t i p thog . A p thog is microorg ism (i cludi g b ct ri , virus s, rick ttsi , p r sit s, fu gi) or oth r g t, such s prot i c ous i f ctious p rticl (prio), th t c c us dis s i hum a s or im als.

Class 7 – Radioactive Materials. A r dio ctiv m at ri l (Cl ss 7) m e s y m at ri l co t i i g r dio uclid s wh r both th ctivity co c tr tio d th tot l ctivity i th co sig m e t c d th v lu s sp cifi d i 49 CFR §173.436 or v lu s d riv d ccordi g to th i structio s i §173.433.

Class 8 – Corrosive Materials. A corrosiv m at ri l (Cl ss 8) m e s liquid or solid th t c us s full thick ss d structio of hum a ski t th sit of co t ct withi sp cifi d p riod of tim e It is liquid (or solid th t m ay b com eliquid duri g tr sport tio) th t h s s v r corrosio r t o st l or lumi um.

Class 9 – Miscellaneous Materials. A misc ll ous h z rdous m at ri l (Cl ss 9) m e s m at ri l th t pr s ts h z rd duri g tr sport tio but do s ot m e t th d fi itio of y oth r h z rd cl ss. This cl ss i clud s y m at ri l th t h s sth tic, o ious, or oth r simil r prop rty th t could c us tr m e oy c or discomfort to flight cr w m emb r so s to pr v t th corr ct p rform a c of ssig d duti s; or y m at ri l th t m e ts th d fi itio for l v t d t mp r tur m at ri l, h z rdous subst c , h z rdous w st , or m ari pollut t.

A list of th h z rd cl ss s c b fou d i T bl A-2. Th full d t il d d fi itio s of ch h z rd cl ss r fou d i 49 CFR 173.
H

ble A-2. H z rd cl sses.

Cl ss	Divisio	N me of Cl ss or Divisio	49 CFR Refere ce for Defi itio s
No e	–	Forbidde m ateri ls	173.21
No e	–	Forbidde explosives	173.54
1	1.1	Explosives (with m ass explosio h z rd)	173.50
1	1.2	Explosives (with projectio h z rd)	173.50
1	1.3	Explosives (with predomi tely fire h z rd)	173.50
1	1.4	Explosives (with o sig ific t bl st h z rd)	173.50
1	1.5	Very i se sitive explosives; bl sti g ge ts	173.50
1	1.6	Extremely i se sitive deto ti g subst ces	173.50
2	2.1	Fl mmable g s	173.115
2	2.2	No -fl mmable compressed g s	173.115
2	2.3	Poiso ous g s	173.115
3	–	Fl mmable d combustible liquid	173.120
4	4.1	Fl mmable solid	173.124
4	4.2	Spo t eously combustible m ateri l	173.124
4	4.3	D gerous whe wet m ateri l	173.124
5	5.1	Oxidizer	173.127
5	5.2	Org ic peroxide	173.128
6	6.1	Poiso ous m ateri ls	173.132
6	6.2	I fectious subst ce (etiologic ge t)	173.134
7	–	R dio ctive m ateri l	173.403
8	–	Corrosive m ateri l	173.136
9	–	Miscell eous h z rdous m ateri l	173.140
No e		Other regul ted m ateri l: ORM-D	173.144

Column 4: Identification number

Colum n4 lists the ide tific tio umber ssig ed to e ch proper shippi g me. Those preceded by the letters "UN" re ssoci ted with proper shippi g mes th t re ppropri te for i ter tio l tr sport tio , s well s domestic tr sport tio . Those preceded by the letters "NA" re ssoci ted with proper shippi g mes recog ized domestic lly, but ot recog ized for i ter tio l tr sport tio , except to d from C d (North Americ).

Column 5: Packing group

Colum n5 specifies o e or more p cki g groups ssig ed to m ateri l correspo di g to the proper shippi g me d h z rd cl ss for th t m ateri l. Cl ss 2, Cl ss 7, Divisio 6.2 (other th regul ted medic l w stes), d Other Regul ted M ateri l-Co sumer Qu tity (ORM-D) m ateri ls, do ot h ve p cki g groups. P cki g Groups I, II, d III i dic te the degree of d ger prese ted by the m ateri l, bei g gre t, medium, or mi or, respectively. If e try eeds more th o e p cki g group, it is determi ed usi g the criteri for ssig me t of p cki g groups specified i subp rt D of p rt 173. The p cki g group correspo ds to the i tegrity of the p ck ge.

Column 6: Labels

Colum n6 specifies codes for the h z rd w r i g l bels th t h ve to be o p ck ge filled with th t p rticul r h z rdous m ateri l, u less the p ck ge is otherwise excepted from l beli g. The first code shows the prim ry h z rd of the m ateri l. Additio l l bel codes show subsidi ry h z rds. Provisio s i 49 CFR 172.402 m y require th t dditio l l bel, other th th t

ecified i colum n6, be ffixed to the ck ge. he code co t i ed i colum n6 re defi ed i T 49 CFR 172.101(g) d how below.

Table A-3. Label substitution table.

Label Code	Label Name
1	Ex lo ive
1.1[1] T	Ex lo ive 1.1[1] T
1.2[1] T	Ex lo ive 1.2[1] T
1.3[1] T	Ex lo ive 1.3[1] T
1.4[1] T	Ex lo ive 1.4[1] T
1.5[1] T	Ex lo ive 1.5[1] T
1.6[1]	Ex lo ive 1.6[1] T
2. T T	Fl mmable Gas T
2.2	Non-Fl mmable Gas T
2.3 T	Poi o Gas T
3 TT	Fl mmable Liquid T
4. T	Fl mmable Solid T
4.2 T	Sp ont Combu tible T
4.3 T	Dange ous When Wet T
5.1	Oxidizer T
5.2 T T	Organ c Pe oxide T
6.1 (in ha l tion Th z rd, Zone A B or B) T T	Poi o In ha l tion Hazard T
6.1 (other than Hazard i ha l tion Th z rd, Zone A B or B) T	Poi o T
6.2 T T	I fectious Subs ance T
7 T	Radioac ive T
8 T	Corro ive T
9 TT	Class 9 T T

[1] Refer to 49 CFR 172.101(g) for how to mark the appropriate hazard class or division number in the bottom half of the label.

[2] The T ski T gra ou T for T m ateri T T dic ed T o umn 5 of T e T T

T

Column 7: Special Provisions

Whe colum n 7 re fer to eci l rovi io code for h z rdou m ateri l, the me i g d requireme t of th t rovi io re fou d i 49 CFR 172.102. S eci l rovi io co t i ck gi g rovi io , rohibitio , d exce tio from requireme t for rticul r qu titie or form s of m teri l , d requireme t or rohibitio lic ble to ecific mode of tr ort tio .

A code co i ti g o ly of umber (for ex m ple, “11”) i multi-mod l i lic tio d m ay ly to bulk d o -bulk ck gi g .

A code co t i i g the letter “A” refer to eci l rovi io th t lie o ly to tr ort tio by ircr ft. T

ode o t i i g the letter “B” refers to spe i l provisio th t pplies o ly to b lk p k gi g req ireme ts. U less otherwise provided i this s b h pter, these spe i l provisio s do ot pply to UN, IM Spe ifi tio port ble t ks, or IBCs.

ode o t i i g the letters “IB” or “IP” refers to spe i l provisio th t pplies o ly to tr sport tio i I termedi te B lk Co t i ers (IBCs).

ode o t i i g the letter “N” refers to spe i l provisio th t pplies o ly to o -b lk p k gi g req ireme ts.

ode o t i i g the letter “R” refers to spe i l provisio th t pplies o ly to tr sport tio by r il.

ode o t i i g the letter “T” refers to spe i l provisio th t pplies o ly to tr sport tio i UN or IM Spe ifi tio port ble t ks.

ode o t i i g the letters “TP” refers to port ble t k spe i l provisio for UN or IM Spe ifi tio port ble t ks th t is i dditio to those provided by the port ble t k i str tio s or the req ireme ts i p rt 178 of this s b h pter.

ode o t i i g the letter “W” refers to spe i l provisio th t pplies o ly to tr sport tio by w ter.

Column 8: Packaging authorizations

Col m ns 8 , 8B, d 8C spe ify the ppli ble se tio s for ex eptio s, o -b lk p k gi g req ireme ts, d b lk p k gi g req ireme ts. Yo ss me th t “49 CFR 173” pre edes the desig ted meri l e try i these ol m ns. For ex mple, the e try “202” i ol m n8B, whi h goes with the proper shippi g me “G soli e,” tells yo th t, for this m teri l, o form e to o -b lk p k gi g req ireme ts of 49 CFR 173.202 is req ired. Col m n8 o t i s ex eptio s from some of the req ireme ts. “No e” i this ol mn me s o p k gi g ex eptio s re thorized. Col m n8B refere es pres ribes o -b lk p k gi g req ireme ts. “No e” i this ol m nme s o -b lk p k gi gs re ot thorized, ex ept by spe i l provisio s i ol m n7. Col m n8C spe ifies the b lk p k gi gs req ireme ts. “No e” i this ol m me s b lk p k gi gs re ot thorized, ex ept s m y be provided by spe i l provisio s i ol m n7.

Column 9: Quantity limitations

Col m ns 9 d 9B spe ify the m ximum q tities th t m y be offered for tr sport tio i o e p k ge by p sse ger- rryi g ir r ft or p sse ger- rryi g r il r (ol m n9) or by rgo ir r ft o ly (ol m n9B). “Forbidde ” me s j st th t: do ot ship the m teri l th t w y. I dditio , the q tity limit tio is “ et,” ex ept where otherwise spe ified, s h s for “Co s mer ommodity,” whi h spe ifies “30 kg gross.”

lumn 10: Vessel st wage requirements

C lum n10A (L c ti) specifies the uth rized st w ge l c ti s b rd c rg d p sse ger vessels. C lum n10B (Other pr visi s) specifies c des f r st w ge requireme ts f r specific h z rd us m ateri ls. The me i g f e ch c de i c lum n10B is give i 49 CFR 176.84.

How do I determine the DOT basic shipping description?

The m st difficult t sk th t y u will f ce i prep ri g m a ifest is c mpleti g Item 9b, the U.S. DOT descripti , i.e., the b sic shippi g descripti . O ce the Pr per Shippi g N me (PSN) is determi ed, derivi g the b sic shippi g descripti is much e sier.

o The first step i ide tifyi g the PSN f m ateri l is t determi e whether r t the m ateri l meets e f the i e DOT h z rd cl sses d p cki g gr ups s specified i 49 CFR 173. If the m ateri l bei g shipped d es t meet the criteri f y h z rd cl ss, the it is t regul ted s h z rd us m ateri l.

After y u h ve determi ed the pr per h z rd cl ss d p cki g gr up, y u sh uld fi d the m st ppr pri te PSN fr m c lum n2 f the HMT i 49 CFR 172.101, with c lum n3 d 5 e tries th t m atch the desig ted h z rd cl ss d p cki g gr up. O e p ge f the HMT h s bee pr vided i Figure A-4 s ex mple.

Remember, y u c t use PSN u less it ppe rs i the HMT!

Rec ll th t "h z rd us m ateri l" is DOT defi iti . H z rd us m ateri ls re listed i the HMT i 49 CFR 172.101. If the m ateri l meets the h z rd cl ss d p cki g gr up d is f u d i the HMT, the m ateri l is DOT-regul ted h z rd us m ateri l. The m aj r h z rd cl sses re listed i the T ble A-2.

A h z rd us m ateri l is defi ed either by its cl ss (r divisi) umber, its cl ss me, r by the letters "ORM-D." T ble A-2 lists cl ss umbers, divisi umbers, cl ss r divisi mes, d th se secti s f the regul ti th t c t i defi iti s f r cl ssifyi g h z rd us m ateri ls, i cludi g f rbidde m ateri ls.

o By referri g t the h z rd cl ss d the refere ced CFR cit ti , y u will fi d the DOT defi iti f e ch h z rd cl ss.

o I s me c ses, the m ateri l t be shipped m ay t be regul ted by DOT i y h z rd cl ss, but m ay be h z rd us subst ce, m ari e p llut t, r h z rd us w ste regul ted by EPA. If y u h ve determi ed th t h z rd us subst ce, m ari e p llut t, r h z rd us w ste is t be shipped (d it d es t meet y ther h z rd cl ss defi iti), the y u h ve Cl ss 9 h z rd us m ateri l by defi iti u der DOT regul ti .

o As me ti ed e rlier, t determi e the b sic shippi g descripti f the m ateri l, y u must first determi e the PSN f the m ateri l. This is the m st difficult p rt f ide tifyi g the b sic shippi g descripti f the m ateri l. O ce y u h ve the PSN, the the h z rd cl ss,

e t f c t o umber, p ck g group ssoc te w th th t PSN re re rect y from the HMT. The b s c sh pp g escr pt o s compose of the e t f c t o umber, PSN, h z r c ss, p ck g group of the m ater [49 CFR 172.202(b)]. These four tems must ppe r th s or er o the sh pp g p pers for r w ter sh pme ts m ay be use other mo es for omest c ter t o sh pme ts. However, the prev ous seque ce of PSN, h z r c ss, e t f c t o umber, p ck g group m ay co t ue to be use for h ghw y r sh pme ts u t 1 u ry 2013 [49 CFR 171.14(e)].

The e s est w y to eterm i e PSN for m ater s to ook t the HMT. If the tech c me of the m ater ppe rs o the t b e, the th t s the PSN th t you shou use o the sh pp g p per. O ce you oc te the PSN for the m ater , by re g co um ns 3, 4, 5, you c comp ete the b s c sh pp g escr pt o .

Example A-1. Determining the PSN and basic shipping description.

A 55-g rum of ceto e s be g se t from the m a uf cturer to customer. Wh t s the PSN b s c sh pp g escr pt o for th s m ater ?

Aceto e s tech c me th t ppe rs the HMT. Thus, the PSN for th s m ater s Aceto e (co um n2). From re g co um ns 3, 4, 5, you see th t the b s c sh pp g escr pt o of the m ater s "UN1090, Aceto e, 3, PG II." (ew seque ce) or "Aceto e, 3, UN1090, PG II" (prev ous seque ce).

However, m a y st ces, h z r ous w stes re m xtures of m ater s. Whe th s occurs, you c ot use just o e tech c me. For m xture or so ut o ot e t f e spec f c y by me wh ch s compose of h z r ous m ater o -h z r ous m ater s, you m ay the qu fy g wor s "m xture" or "so ut o ," s ppropr te, to the proper sh pp g me of the h z r ous m ater . Th s c ot be o e f the p ck g g spec f e co um n8 s ppropr te or whe the PSN pp es o y to the pure or tech c -gr e m ater s e ote by the "+" co um n1 of the HMT. I t o , the h z r c ss, p ck g group, or subs ry h z r of the m xture or so ut o m ay ot be ffere t from th t spec f e for the e try. There c be o s g f c t ch ge emerge cy me sures. 1

Example A-2. Determining the basic shipping description for a waste mixture.

The laboratory analysis of a lyzed 55-gallon drum of waste. Results of the analysis show that the waste is 80% acetone and 20% water. The initial boiling point is 100°F. The flash point of the waste is 20°F. What is the PSN and the basic shipping description for this waste?

Because this is a waste, the first step is to determine if the EPA waste codes in 40 CFR 261 Subpart D are applicable to the waste. The waste does not exhibit the characteristic of ignitability as a liquid because the flash point of the waste is less than 140°F. The waste does not exhibit any of the characteristics of corrosivity, reactivity, or toxicity as defined in 40 CFR 261 Subpart C.

Next, you must determine the HMT requirements. First, it is necessary to determine if the HMT regulations apply to the waste. You must check to see if the waste is a hazardous waste (HW) as defined in 40 CFR 261 Subpart A. Because the waste is not listed in 40 CFR 261 Subpart D, you must determine if the waste is a characteristic HW. Because this is a mixture of two hazardous materials (acetone and water), you must determine if the HW is regulated as a hazardous material (HM). Acetone is a flammable liquid as defined in 49 CFR 173.120, so the waste is a HM. Because this is a mixture of a hazardous material (acetone) and a nonhazardous material (water), you must determine if the HM is regulated as a hazardous waste. Acetone is not listed in 40 CFR 261 Subpart D, so the waste is not a HW. The PSN "Waste Acetone Solution" may be used. The second "solution" is optional. Because the waste is not a HW, it is regulated as a HM. The PSN that most specifically describes the waste is "Waste Acetone Solution, 3, UN1090, II." The PSN "Waste Acetone Solution, 3, UN1090, II" is also acceptable.

When it is not appropriate to list the hazardous material constituents of the waste or mixture, you should list the hazardous material constituents determined by applying the waste characterization criteria in 40 CFR 261 Subpart C. For example, according to the applicable criteria, if you determine that a waste flammable liquid contains chromium at a concentration that exceeds the regulatory limit, you must include chromium in the PSN. The hazardous material constituents that most predominately contribute to the hazardous characteristics of the mixture are usually listed first in the PSN.

Example A-3. Choosing an "end-use" proper shipping name.

A 55-gallon drum of methyl alcohol and ethyl alcohol is delivered to a customer. The flash point of the waste is 70°F and the boiling point is 100°F. What is the PSN and basic shipping description for this waste?

Because this is a waste, the first step is to determine if the EPA waste codes in 40 CFR 261 Subpart D are applicable to the waste. The waste does not exhibit the characteristic of ignitability as a liquid because the flash point of the waste is less than 140°F. Therefore, the waste is not a HW.

Because the chemicals are not listed in 40 CFR 261 Subpart D, you must determine if it is "used" or "end-use." Because the waste is not a HW, it is regulated as a HM. Because you are shipping the HM for disposal, you must select the appropriate "end-use" name is "Alcohols, n.o.s." The PSN is "Alcohols, n.o.s." and the basic shipping description is "UN1987, Waste alcohols, n.o.s., 3, PG II (methyl alcohol, ethyl alcohol)." "Waste alcohols, n.o.s., 3, UN1987, PG II (methyl alcohol, ethyl alcohol)" is also acceptable.

u sh uld describe mixture r s luti t ide tified i the HMT specific ll b tech ic l me, “use,” r “e d-use,” r b usi g ppr pri te ge eric shippi g descripti (e.g., “Fl mmable liquid, . .s.”). Select pr per shippi g me fr m the ge eric descripti s c rresp di g t the specific h z rd cl ss, p cki g gr up, r subsidi r h z rd, if , f r the m ateri l. Whe the ge eric descripti , s pr per shippi g me, d es t pr vide sufficie t i f rm ati f r shippi g p pers d p ck ge m arki gs, u m a be required t use the tech ic l me f e r m ore c stitue ts th t m ake the pr duct h z rd us m ateri l l g with the pr per shippi g me.

Example A-4. Determining generic proper shipping names.

A 5-g rum f w te h s b e l zed. Results sh w th t the w s e 50% cet e d 50% t lue . The fl sh p t i 10°F. The b ili g p i t is 80°F. Wh t is he PSN d b sic shi pi g de cripti ?

Bec use th s i w s e, the fir tep is t de ermi e t e plic ble EPA w ste c de. 40 CFR 261.21 d fi es ig it ble w stes s th se with fl h p i t f le s 140°F. S , the w s e c d fr m 40 CFR 261.21 w uld be D 01. Bec use we h ve ther i f rm ati b ut his , w c t F-list it.

De rmi e the HC d PG f r the w ste. B l ki g 49 CFR 173.121, u c s e th t the w st i fl mmable, with HC f 3 d PG f I due fl sh p i t d b ili g p t. B c use this is mixtu f tw h z d us m ateri ls, the PSN “Ac t ” r “T lu e” c t b used. u must determi e ther PSN fr m the HMT. B c use the mixture is fl mmable, the PSN “Wast Fl mmab e Liquids, . .s.” c be used. Ch ck g the HMT u e th t “Fl mmable Liquids, . .s.” h s HC f 3 d PG f I, I, r I. Thu the b sic shi pi g descripti f r the w ste w uld be “ UN1 93, Waste Fl mmable Liquids, . .s., 3, I (cet e, t lue e)” r “Waste Fl mmable Liquids, . .s., 3, UN1 93, I (cet e, t lue e).”

I c ses where the h z rd cl sses f the chemic ls i the mixture re t ll the s me, determi i g the PSN f the mixture will be m ore difficult. I the c ses where there re multiple cl sses d the m ateri l is t specified b its tech ic l me i c lum n2 f the HMT, the precede ce t ble i 49 CFR 173.2 must be used (T ble A-4). This t ble is t be used f r mixtures f cl ss 3, 4.1, 6.1, d 8 m ateri ls. The , u c pick ppr pri te shippi g descripti (e.g., “Fl mmable liquid, c rr sive . .s.”).

ble A-4. Precedence of h z rd t Code.

	Hazard Class and Packing Group														
	4.2	4.3	5.1 1*	5.1 II*	5.1 III*	6.1, I derm al	6.1, I or l	6.1, II	6.1, III	8, I liquid	8, I solid	8, II liquid	8, II solid	8, III liquid	8, III solid
3 I	—	4.3	—	—	—	3	3	3	3	3	**	3	**	3	**
3 II C	—	4.3	—	—	—	3	3	3	3	8	**	3	**	3	**
3 III C	—	4.3	—	—	—	6.1	6.1	6.1	3‡	8	**	8	**	3	**
4.1 II†	4.2	4.3	5.1	4.1	4.1	6.1	6.1	4.1	4.1	**	8	**	4.1	**	4.1
4.1 CII†	4.2	4.3	5.1	4.1	4.1 C	6.1	6.1	6.1	4.1	**	8	**	8	**	4.1
4.2 II	—	4.3	5.1	4.2	4.2	6.1	6.1	4.2	4.2	8	8	4.2	4.2	4.2	4.2
4.2 CII	—	4.3	5.1	5.1	4.2 C	6.1	6.1	6.1	4.2	8	8	8	8	4.2	4.2
4.3 I	—	—	5.1	4.3	4.3	6.1	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
4.3 II	—	—	5.1	4.3	4.3	6.1	4.3	4.3	4.3	8	8	8	4.3	4.3	4.3
4.3 III	—	—	5.1	5.1	4.3	6.1	6.1	6.1	4.3	C 8	8	8	8	4.3	4.3
5.1 I*		—	—	—	—	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
5.1 II* C	—	—	—	—	—	6.1	5.1	5.1	5.1	8	8	8	5.1	5.1	5.1
5.1 III*	—	—	—	—	—	6.1	6.1	6.1	5.1	8	8	8	8	5.1	5.1
6.1 I. Derm al	—	—	—	—	—	—	—	—	—	8	6.1	6.1	6.1	6.1	6.1
6.1 I. Or l	—C	—	—C	—	—	—	—	—	—	8	6.1	6.1	6.1	6.1	6.1
6.1 II. I h l tio	—	—	—	—	—	—	—	—	—	8	6.1	6.1	6.1	6.1	6.1
6.1 II. Derm al	—	—	—	—	—	—	—	—	—	8	6.1	8	6.1	6.1	6.1
6.1 II. Or l	—	—	—	—	—	—	—	—	—	8	8	8	6.1	6.1	6.1
6.1 III	—	—	—	—	—	—	—	—	—	8	8	8	8	8	8

* See 40 CFR 173.127.
† Subst ces of Divisio 4.1 other th self-re ctive subst ces.
** De otes impossible combi tio .
‡ For pesticides o ly, where m ateri l h s the h z rds of Cl ss 3, P cki g Group III, d Divisio 6.1, P cki g Group III, the prim ary h z rd is Divisio 6.1, P cki g Group III.

C

ysis of 55-g o drum of w ste shows th t the mixture is 50% ceto e, 0% pot ssium hydroxide, d 20% w ter. The f sh poi t of the mixture is 50°F. The boi i g poi t is 100°F, the pH is 1 , d the m teri c uses fu destructio of ski tissue withi observ tio period of up to 14 d ys fter exposure time of 10 mi utes Wh t is the b si shippi g descriptio for this mixture?

Bec use this is w ste, the first step is to determi e the pp ic b e EP w ste code. 40 CFR 261.21 defi es ig it b e w stes s those with f sh poi t of ess th 140°F. I dditio , 40 CFR 261.22 defi es corrosivity s pH ess th or equ to 2 or gre ter th or equ to 12.5. So, the w ste codes from 40 CFR 261.21 d 40 CFR 261.22 wou d be D001 d D002. Bec use we h ve o other i form tio bout this w ste, we c ot F- ist it.

Determi e the HC d PG for the w ste. By ooki g t 49 CFR 17 .121, you c see th t the w ste is f mmab e, with HC of d PG of II due to the f sh poi t d boi i g poi t of the mixture. By ooki g t the corrosive defi itio d p cki g group ssig me t i 49 CFR 17 .1 7, you c further see th t the w ste so meets the defi itio of HC 8, PG II. Bec use this is mixture of two h z rdous m teri s of differe t h z rd c sses, the precede ce t b e (T b e -4) i 49 CFR 17 .2 (b) must be used to determi e the PSN.

Looki g t T b e -4, you wi determi e the poi t where , II, d 8, II i tersect. This is . Therefore, the prim ry h z rd is , d the seco d ry or subsidi ry h z rd is 8. The b sic shippi g descriptio wou d be “UN2924, Waste F mmab e Liquids, Corrosive, .o.s. (ceto e, pot ssium hydroxide), (8), II” or “Waste F mmab e Liquids, Corrosive, .o.s. (ceto e, pot ssium hydroxide), (8), UN2924, II.” Remember, you must i c ude both the prim ry d subsidi ry h z rd c sses.

Proper shippi g mes re imited to those show i the HMT i Rom a type (ot it ics). Proper shippi g mes m y be used i the si gu r or p ur d i either upperc se or owerc se etters.

Words m y be ter tive y spe ed i the s me w y s they ppe r i the I ter tio Civi vi tio Org iz tio (IC O) Tech ic I structio s or the I ter tio M ritime D gerous Goods (IMDG) Code. For ex mp e “ umi um” m y be spe ed “ umi ium” d “su fur” m y be spe ed “su phur.” However, the word “i f mmab e” m y ot be used i p ce of the word “f mmab e.”

3

Pu ctu tio m rks d words i it ics re ot p rt of the proper shippi g me, but m y be used i dditio to the proper shippi g me. The word “or” i it ics i dic tes th t terms i the seque ce m y be used s the proper shippi g me, s ppropri te. 3

e word “poiso ” or “poiso ous” m ay be used i terc ge bly wit t e word “to ic” w e o ly domestic tr sport tio is i volved. e bbrevi tio “ .o.i.” (ot ot erwise i dic ted) or “ .o.i.b. .” (ot ot erwise i dic ted by me) m ay be used i terc ge bly wit “ .o.s.” (ot ot erwise specified).

E cept for z rdous w stes, w e qu lifyi g words re used s p rt of t e proper s ippi g me, t eir seque ce i t e p ck ge m arki gs d s ippi g p per descriptio is optio l.

Whe o e e try refere ces ot er e try by use of t e word “see,” if bot mes re i Rom a type, eit er me m ay be used s t e proper s ippi g me (e.g., Et yl lco ol, see Et ol).

Whe proper s ippi g me i cludes co ce tr tio r ge s p rt of t e s ippi g descriptio , t e ctu l co ce tr tio , if it is wit i t e r ge st ted, m ay be used i pl ce of t e co ce tr tio r ge. For e mple, queous solutio of ydroge pero ide co t i i g 30% pero ide m ay be described s “Hydroge pero ide, queous solutio wit ot less t 20% but ot more t 40% ydroge pero ide” or “Hydroge pero ide, queous solutio wit 30% ydroge pero ide.”

x

You c use t e prefi “mo o” i y s ippi g me, w e it is ppropri te. us, Iodi e mo oc loride m ay be used i terc ge bly wit Iodi e c loride. I “Glycerol lp - mo oc loro ydri ,” t e term “mo o” is prefi to t e term “c loro ydri ” d m ay be deleted.

x

If t e word “Waste” is ot i cluded i t e z rdous m ateri l descriptio i colum n2 of t e HMT, you must i clude it precedi g t e proper s ippi g me for feder lly regul ted z- rdous w ste (e.g., Waste ceto e).

If I am sending a sample of an unknown material to a lab for analysis, how do I choose a PSN?

A m ateri l for w ic t e z rd cl ss is u cert i d must be determi ed by testi g, or m ateri l t t is z rdous w ste, m ay be ssig ed te t tive s ippi g me, z rd cl ss, ide tific tio umber, d p cki g group, b sed o your k owledge of t e m ateri l. is me s t t if s mple is bei g se t to l bor tory d you suspect t t it will meet DO z rd cl ss, t e it s ould be give DO te t tive s ippi g me d ll DO requireme ts must be met. I dditio , t is provisio is sometimes used w e se di g z rdous w stes to SDF. O occ sio , z rdous w ste m ay be se t to SDF wit t e rr geme t t t ey will lyze d profile t e w ste. I t ese c ses, you m ay ssig te t tive s ippi g me. e word “s mple” must ppe r s p rt of t e proper s ippi g me or i ssoci tio wit t e b sic s ippi g descriptio . o use t is provisio full compli ce wit t e requireme ts of 49 CFR 172.101(c)(11) must be met, i cludi g t e requireme t t t t e et weig t of t e s mple p ck ge c ot e ceed 5.5 pou ds. S mples of z rdous w ste se t to SDF for profili g re ot se t usi g z rdous w ste m a ifest. S mples re s ipped o DO BoL.

at is a azardous substance?

A h z r ous subst ce is efi e i 49 CFR 171.8 s m ateri l, i clu i g its mixtures solutio s, th t:

- Is liste i Appe ix A to 49 CFR 172.101 (HMT);
- Is i qu tity i o e p ck ge, which equ ls or excee s the report ble qu tity show i Appe ix A;
- Whe i mixture or solutio meets the p r meters of T ble A-5.

Table A-5. Hazardous substance concentration by weig t table.

RQ pounds (kg)	Concentration by weig t	
	Perce t	ppm
5000 (2270)	10	100,000
1000 (454)	2	20,000
100 (45.4)	0.2	2,000
10 (4.54)	0.02	200
1 (0.454)	0.002	20

The term h z rd ous subst ce oes ot i clu e petroleum, i clu i g cru e oil or y fr ctio thereof th t is ot otherwise specific lly liste or esig d te s h z r ous subst ce i Appe ix A of 49 CFR 172.101, the term oes ot i clu e tur l g s, tur l g s liqui s, liquefie tur l g s, or sy thetic g s us ble for fuel (or mixtures of tur l g s such sy thetic g s).

To be h z r ous subst ce by DOT efi itio , the h z r ous m ateri l must be liste i Appe ix A to 49 CFR 172.101, be i qu tity per p ck ge equ l to or gre ter th th t show s the report ble qu tity (RQ), meet the p r meters of T ble A-5.

Example A-6. Determining t e RQ for a azardous material.

You re prep ri g to tr sport 20 55-g l rums of pure ceto e. Do you h ve RQ of ceto e?

Appe ix A to 49 CFR 172.101 shows th t the RQ for ceto e is 5000 lb (2270 kg). Bec use the rum o ly co t i s bout 50 g llo s t 6.5 lb/g l (the weight of ceto e per g llo) = 325 lb, you o ot h ve RQ. The RQ is the mou t per co t i er, ot per shipme t.

te th t if y u h ve mixture f h z rd us m ateri ls, it is the c ce tr ti by eight f t le st e f the c mp e ts th t must exceed the c rresp di g RQ f r th t m ateri l.

Example A-7. Determining the RQ for a mixture of hazardous materials.

Y u must determi e hether r t h z rd us subst ce is bei g tr sp rted. The mixture is 50% cet e d 50% trichl r ethe e t be shipped i 55-g ll drum.

The RQ f r cet e fr m Appe dix A is 5000 lb (2270 kg). The RQ f r trichl r ethe e is 100 lb (45.4 kg). Bec use drum eighs ppr xim ately 400 lb, 50% mixture h s ppr xim tely 200 lb f cet e d 200 lb f trichl r ethe e. Bec use the RQ f r trichl r ethe e h s bee exceeded, the m ateri l must be shipped s h z rd us subst ce, RQ.

w
F r RCRA h z rd us stes, the RQs re prese ted i the ppe dix t the e d f the list. If y u h ve ssig ed ste c de, there is eed t c lcul te by eight the c mp e ts i the mixture, bec use, typic lly, t ll c mp e ts f the ste re k .

Example A-8. Determining an RQ for a hazardous waste.

O e 55-g l drum f ste c t mi ted cet e s luti is t be se t ffsite f r i ci er ti . The mixture h s fl sh p i t f 0°F.

w
The ste c de is D001. The RQ f r D001 is 100 lb (45.4 kg). Alth ugh the RQ f r cet e is 5000 lb (2270 kg), the c t mi ted cet e s luti is h z rd us ste d pr b bly c t mi ted ith ther c stitue ts; theref re, s ste, the RQ is ly 100 lb.

w
If the m ateri l bei g shipped d es t meet y h z rd cl ss but is h z rd us subst ce by DOT defi iti , the y u c use the PS "E vir me t lly H z rd us Subst ces, s lid r liquid, . .s."

w
Y u must e ter the letters RQ the shippi g p per, either bef re r fter the b sic descripti f r e ch h z rd us subst ce (e.g., "RQ, Allyl lc h l, 6.1, U 1098, I"; r "E vir me t lly h z rd us subst ce, s lid, . .s., 9, U 3077, III, RQ (Adipic cid)").

w

at is a Marine Pollutant?

A Mari e P llut t is m ateri l th t is listed i Appe dix B f 49 CFR 172.101 (ls see 49 CFR 171.4) d, whe i s luti r mixture f e r m ore m ari e p llut ts, is p ck ged i o c ce tr ti th t equ ls r exceeds:

- Te perce t by weight f the s luti r mixture f r m ateri ls listed i Appe dix B.
- O e perce t by weight f the s luti r mixture f r m ateri ls th t re ide tified s severe m ari e p llut ts i Appe dix B.

F r bulk shipme ts i ll m des d -bulk shipme ts by vessel, 49 CFR 172.203 requires th t y u e ter the w rds "M ari e P llut t" l g with the b sic descripti the shippi g p pers. I dditi , 49 CFR 172.203 requires th t, if the PSN f r m ateri l th t is m ari e p llut t d es t ide tify by me the c mp e t th t m akes the m ateri l m ari e p llut t, the me f the c mp e t must ppe r i p re theses i ss ci ti with the b sic shippi g descripti . Where tw r m re c mp e ts re prese t, t le st tw mes must ppe r i ss ci ti with the b sic shippi g descripti .

F r m ateri ls th t meet ther h z rd cl ss, but th t d meet the defi iti f m ari e p llut t, y u c use the PSN "E vir me t lly h z rd us subst ces, s lid r liquid, . .s."

Are t ere any poisonous provisions?

DOT defi es s methi g s p is us if it is m ateri l (ther th g s) th t is k w t be s t xic t hum a s s t be h z rd t he lth duri g tr sp rt ti , r i the bse ce f dequ te d t hum a t xicity is presumed t be t xic t hum a s. P is s re ls irrit ti g m teri ls (with pr perties simil r t te r g s) th t c use extreme irrit ti , especi lly i c fi ed sp ces.

F r m ateri ls th t re p is us by i h l ti , y u must e ter the w rds "P is -I h l ti H z rd" r "T xic-I h l ti H z rd" d the w rds "Z e A," "Z e B," "Z e C," r "Z e D," f r g ses r "Z e A" r "Z e B" f r liquids, s ppr pri te, the shippi g p per immedi tely f ll wi g the shippi g descripti . The w rds "P is " r "T xic" eed t be repe ted if they therwise ppe r i the shippi g descripti .

at do I do wit t e basic s ipping description?

The b sic shippi g descripti derived fr m the HMT will be pl ced i Item 9b f the h z rd us w ste m a ifest.

Y u must i clude the f ll wi g i f rm ati the shippi g p pers, s pplic ble:

(1) Pr per shippi g me fr m c lum n2 f the HMT (i cludi g tech ic l mes f r n . .s. e tries). (Pl ce i Item 9b f the m a ifest.)

(2) Prim ary d subsidi ry h z rd cl sses fr m c lum n3 f the HMT. (Pl ce i Item 9b f the m a ifest.)

) Ide tific tio umber from column 4 of the HM . Pl ce i Item 9b of the ma ifest.) T

4) P ck gi g group from colum n5 of the HM . Pl ce i Item 9b of the m a ifest.)

5) ot l qu tity of m ateri ls covered by the descriptio . Pl ce i Items 11 d 12 of the m a ifest.)

6) Number d type of p ck ges. Pl ce i Item 10 of the m a ifest.)

7) Shipper's certific tio s fou d i 49 CFR 172.204). Item 15 of the m a ifest.)

8) Additio l requireme ts s ppropri te 49 CFR 172.20).

a) Speci l permits – e ter DO -SP followed by the speci l permit umber.

b) Limited qu tities – e ter "Limited Qu tity" or "L D Q Y" if shippi g u der the uthoriz tio s of colum n8 of the HM .

c) H z rdous subst ces – e ter "RQ" where the co t i er holds qu tity of m ateri l meeti g the defi itio of DO h z rdous subst ce.

d) R dio ctive m ateri ls – e ter the r dio uclide, physic l d chemic l form, ctivity, c tegory of l bel, tr sport i dex, fissile or fissile-excepted, critic lity s fety i dex, DOE p ck ge, foreig -m ade p ck ges, "Exclusive Use Shipme t" if pplic ble).

e) Empty p ck gi g – e ter the words "Residue: L st Co t i ed" before the b sic shippi g descriptio for co t i ers th t co t i ed DO h z rdous m ateri l, but re ot empty by DO st d rds.

f) Tr sported by ir – e ter st teme t th t the shipme t is withi the limit tio s prescribed for either p sse ger d c rgo ircr ft, or c rgo ircr ft o ly must be e tered o shippi g p pers.

g) R il shipme ts – e ter the reporti g m ark d umber o the shippi g p per whe umber is displ yed o the r il c r, freight co t i ers, tr sport vehicle, T or port ble t k.

h) "M ari e Pollut ts" – e ter these words if the m ateri l bei g shipped meets the defi itio of m ari e pollut t.

i) Elev ted temper ture m ateri ls – e ter the word "HO " precedi g the PSN of the m ateri l if the liquid m ateri l meets the defi itio of elev ted temper ture m ateri l d th t f ct is ot lre dy disclosed i the PSN.

j) Poiso ous m ateri ls – e ter the words "Poiso -I h l tio H z rd" or " oxic-I h l tio H z rd" d the words "Zo e A," "Zo e B," "Zo e C," or "Zo e D" for g ses, or "Zo e A" or "Zo e B" for liquids, s ppropri te, o the T shippi g p per immedi tely followi g the shippi g descriptio . he words "Poiso " or " oxic" eed ot be repe ted if they otherwise ppe r i the shippi g descriptio .

k) "S mple" – e ter the word "SAMPLE" i ssoci tio with the b sic shippi g descriptio whe s mple u der the provisio s of 49 CFR T 172.101 c) 11).

) Items 1-4 – The b sic shippi g descriptio is composed o the ide ti ic tio n umber, PSN, h z rd cl ss, d p cki g group o the m teri l. These our items must ppe r i this order o the shippi g p pers or ll ir d vessel shipme ts a d m y be used or ll other modes or the lter te seque ce o PSN, h z rd cl ss, ide ti ic tio umber, d p cki g group m y be used or r il d highw y. O 1 u ry 2013, it will be m a d tory or r il d highw y shipme ts f to use the irst b sic shippi g descriptio seque ce.

Am I done with the manifest yet?

O ce you h ve completed Item b, the tough work is over. I Item 10 you provide the umber d type o co t i ers. Item 11 c lls or the tot l qu tity d Item 12 re ere ces the u its o me sure correspo di g to Item 11. Item 13 is list o your w ste codes s discussed previously. Aside rom the ERG umber bei g pl ced i Item 14, you c put y dditio l i orm tio rel ti g to the shipme t. The rem i der o the items re the certi ic tio s or the ge er tor, tr sporter, d TSDF.

What paperwork actually accompanies the shipment?

There re typic lly three docume ts th t must ccomp y ll shipme ts o h z rdous w stes: m a i est, l d dispos l restrictio LDR) oti ic tio , d w ste pro ile sheet w ste lysis sheet).

f

The LDR docume t tio d certi ic tio requireme ts re ou d i the EPA regul tio s i 40 CFR 268.7. I ge er l terms, the ollowi g items re to be i cluded i the oti ic tio :

- EPA h z rdous w ste umber.
- Co stitue ts o co cer .
- Tre t bility group. f
- Regul tory subc tegory.
- Correspo di g m a i est umber.
- W ste lysis.
- Certi ic tio .

I pr ctice, there is w ste pro ile sheet or l b lysis ccomp yi g the m a i est d LDR docume t tio . The co tr ctor will get w ste pro ile orm rom the TSDF. Sometimes the TSDF will request th t the w ste pro ile or w ste lysis be submitted by the ge er tor be ore the TSDF gives permissio or the w ste to be shipped so the w ste pro ile m y ot ccomp y the ctu l shipme t. E ch dispos l cility h s its ow versio o the pro ile. There is o required EPA orm or orm t, just required EPA i orm tio s discussed bove.

f

The LDR docume t tio is required to be se t with e ch i iti l shipme t o w ste to TSDF. A LDR oti ic tio orm is ot required to be se t or subseque t shipme ts o the s me w ste stre ms to the s me cility. However, it is recomme ded th t i LDR orm does ot

mp y e h shipme t th t te be pl ed the m a ifest st ti g th t LDR tifi ti w s pre i usly pr ided with the i iti l shipme t f the w ste stre m t the TSDF d i di te th t m a ifest umber.

I dditi , there re pr isi s i the regul ti s th t ll w the ge er t r t ship his w ste ffsite d ll w the st r ge r tre tme t f ility t m ke the determi ti whether r t tre tme t is required the w ste. If the ge er t r h ses t t m ke the determi ti f whether his w ste must be tre ted, with the i iti l shipme t f the w ste t e h tre tme t r st r ge f ility, the ge er t r must se d e-time tifi ti t e h tre tme t r st r ge f ility re ei i g the w ste, d pl e py i his files s per 40 CFR 268.7( )(2). The ti e must i lude the EPA w ste des, the m a ifest umber f the first shipme t, the stitue ts f er , the tre t bility gr up, the sub teg ry, the w ste lysis, d ertifi ti . The tifi ti must ls i lude the st teme t "This h z rd us w ste m y r m y t be subje t t the LDR tre tme t st d rds. The tre tme t f ility must m ke the determi ti ." Alth ugh this pti is il ble i the feder l regul ti s, it sh uld be ted th t the ge er t r sh uld sider ri us r mifi ti s whe ll wi g the tre tme t f ility t m ke the de isi , esse ti lly beh lf f the ge er t r; su h s dditi l sts if the w ste d es t tu lly eed tre tme t but the f ility tre ts, r sts ss i ted with future li bilities where the f ility d es t tre t the w ste d there is rele se fr m the disp s l f ility i the future. A de isi t ll w the tre tme t r st r ge f ility t m ke this determi ti sh uld be ery refully weighted.

What is the land ban?

The terms "l d b " d "l d disp s l restri ti s" me the s me thi g. The *Hazardous and Solid Waste Amendments* (HSWA) t RCRA i lude spe ifi pr isi s restri ti g the l d disp s l f h z rd us w stes. The purp se f these pr isi s is t mi imize the p te ti l f future risk t hum a he lth d the e ir me t by requiri g th t h z rd us w stes be tre ted bef re they re disp sed f i t r the l d. The defi iti f "l d disp s l" u der 40 CFR 268.2( ) f RCRA i ludes, but is t limited t , " y pl eme t f h z rd us w ste i l dfill, surf e imp u dme t, w ste pile, i je ti well, l d tre tme t f ility, s lt d me f rm ti , s lt bed f rm ti , u dergr u d mi e r e, d rete bu ker r ult."
v
EPA h s set either e tr ti -b sed le els r te h l gy-b sed st d rds f r e h w ste stre m. A e tr ti -b sed le el is umeri l st d rd th t must be met pri r t l d disp s l. A y meth d f tre tme t be pplied t tt i the e tr ti -b sed le el. Whe te h l gy-b sed st d rd is est blished f r p rti ul r w ste, th t tre tme t te h l gy must be used m tter wh t the e tr ti is f the h z rd us stitue ts i the w ste. O e the w ste h s bee tre ted, the residues be disp sed f r i t the l d, s ppr pri te.
v
I dditi , EPA h s fi lized lter ti e tre tme t st d rds f r debris d f r s ils. The lter ti e tre tme t st d rds f r debris re f u d i 40 CFR 268.45. EPA h s regul ted debris u der the t i ed-i rule. O e the debris is tre ted with e f the destru ti r extr ti te h l gies i the regul ti s, it be disp sed f i t -h z rd us-w ste l dfill with ut

rther lysis or tre tme t. Debris co t mi ted with listed h z rdo s w ste th t is tre ted with immobiliz tio tech ology still eeds to be dis osed o i h z rdo s w ste l d ill. The resid es rom y o the tre tme t rocesses eed to be m a ged i ccord ce with 40 CFR 268.45. For co t mi ted soils, the lter tive LDR st d rds re give i 40 CFR 268.49.
p
There ore, or lmost ll w ste stre ms bei g se t o site o m a i est, EPA req ires the ge er tor to i dic te to the TSDF whether the w ste c be directly l d dis osed or i the w ste eeds rther tre tme t rior to l d dis os l. This is do e i the LDR oti ic tio orm th t ccom ies the m a i est.

After all the paperwork is complete, what's next?

A ter yo h ve determi ed the b sic shi i g descri tio d while yo re re ri g the m a i- est, it is time to st rt ck gi g, l beli g, d m arki g the w ste co t i ers.

How do I choose the correct package for my hazardous materials?

A ck ge me s the ck gi g l s its co te ts. P ck gi g me s rece t cle d y other com po e ts or m ateri ls ecess ry or it to ro erly co t i the w ste to co orm with the mi im um ck gi g req ireme ts o 49 CFR 173. P ck ges m ay be b lk or o -b lk. A b lk ck gi g is tr s ort vehicle or reight co t i er, other th vessel or b rge, i which h z- p rdo s m ateri ls re lo ded with o i termedi te orm o co t i me t, d which h s:

- A m ximum c city gre ter th 450 L (119 g l) s rece t cle or liq id.
- A m ximum et m ass gre ter th 400 kg (882 lb) d m aximum c city gre ter th 450 L (119 g l) s rece t cle or solid.
- A w ter c city gre ter th 454 kg (1000 lb) s rece t cle or g s.

A o -b lk ck ge is ck ge th t does ot meet the b lk ck ge criteri st ted bove.
p
There re two ck gi g ty es: si gle d combi tio . Si gle ck gi g is j st th t, o ly o e req ired co t i er. Combi tio ck gi g h s o e or more req ired i er ck gi gs, s well s req ired o tside co t i er.

The ck gi g thoriz tio s re o d i col m ns 8A, 8B, d 8C o the HMT. Note th t col m ns 8A, 8B, d 8C re er yo to 49 CFR 173. To determi e the ro er ck gi g, it is ecess ry or yo to irst review the HMT col m n(8A, 8B, or 8C) ssoci ted with the PSN. Col m n8A gives exce tio s to ck gi g req ireme ts, s ch s limited q tities. Col m n8B tells yo o -b lk ck gi g req ireme ts d re ers yo to cit tio , s ch s 202. Viewi g the col m nhe di g, yo see th t yo eed to re er to 49 CFR 173.202. Reviewi g the ro ri te CFR sectio rovides yo with the ro ri te ck gi g s eci ic tio s. Col m n8C tells yo wh t ro ri te b lk shi i g co t i ers go with the PSN. p

k

ample A-9. Determining the proper pac aging.

Is fiberbo rd box pproved p ck gi g for be zidi e?

By looki g up the PSN "be zidi e," you see from colum n8B th t, for o -bulk p ck ges, sectio 173.212 gives the pproved p ck ges. Tur i g to sectio 173.212, you see th t fiberbo rd box is the proper outer p ck gi g, with i er p ck gi g of pl stic or gl ss recept cles.

There re two pplic ble exceptio s: limited qu tity (HMT-colum n8A) d sm ll qu tity (§ 173.4).

k

Limited qu tity is the m ximum mou t of h z rdous m teri l for which there is specific l beli g, p ck gi g, d pl c rdi g exceptio :

- M ximum llowed i the p ck ge is 66 lb (30 kg) gross weight.
- P ck ge must be m rked with the UN/NA ide tific tio (ID) umber d pl ced withi a squ re-o -poi t border.
- Shippi g p pers must ccomp y shipme t d i dic te LTD QTY.
- Shipme ts by ircr ft m y ot llow ll the exceptio s (e.g., l beli g). k

ample A-10. Determining the proper non-bul pac aging.

Wh t is o e pproved o -bulk p ck ge for 1/2 L (0.13 g l) of ceto e?

For ceto e, the HC is 3 d PG II. The p ck gi g exceptio s (HMT-colum n8A) would be fou d i 49 CFR 173.150. The o -bulk p ck gi g requireme ts (HMT-colum n8B) re fou d i 49 CFR 173.202. Bec use o ly 1/2 L of ceto e is to be shipped, the p ck ge c be shipped either s limited qu tity or o -bulk p ck ge. The shipme t c go s limited qu tity s specified i 49 CFR 173.150(b)(2) for the ssoci ted HC d PG. The o -bulk p ck gi g requireme ts re fou d i 49 CFR 173.202(b) or (c). The 1/2 L c be se t i fiberbo rd box 4G with i er gl ss recept cle ot exceedi g 66 lb (30 kg) gross weight.

k

Limited qu tities of h z rdous m teri ls re excepted from l beli g, pl c rdi g, p ck ge specific tio requireme ts, d perform a ce-orie ted p ck gi g st d rds (POPS) test requireme ts, but must h ve shippi g p pers d the ppropri te m rki gs o the p ck ge.

k

Not ll m teri ls re uthorized to be shipped s limited qu tity. Colum n8A should be co sulted whe determi i g whether or ot you c ship m teri l s limited qu tity, d whether it is permissible to t ke the l beli g, p ck gi g, d pl c rdi g exceptio s.

k

Both p ck ge m a uf cturers d shippers h ve the respo sibility to e sure the structur l i tegrity of p ck ges. Your respo sibilities s shipper re fou d i 49 CFR 173.22, 173.24, d 173.24 . You must e sure:

m

M teri l h s bee cl ssed d described properly, pl ced i uthorized p ck gi g, d the p ck gi g h s bee uf ctured, sse lcd, d rked i ccord ce with the H R.

The p ck ge will ot bre k ope or le k u der or l tr sport tio co ditio s.

Are there any exceptions for really, really small quantities of HAZMAT?

S ll qu tities of cl ss 3, 4.1, 4.2 (PG II & III), 4.3 (PG II & III), 5.1, 5.2, 6.1, 7, 8, d 9 teri ls re ot subject to y other HAZ T requAire ets whe :

M xi u qu tity per i er recept cle is less th or equ l to 30 lfor other th divisio 6.1, PG I, H z rd Zo es A & B teri ls, or less th or equ l to 30 g for solids.

I er p ck ge is securely p cked i stro g outside p ck gi g.

I er recept cles re ot liquid full.

Closure is held securely i pl ce.

P ck ge is cushio ed s required.

Free drop test h s bee do e.

M teri ls do ot viol te 49 CFR 173.21.

M xi u llowed i co lpte p ck ge is 64 lb gross weight.

Shipper certifies th t p ck ges co for to co ditio s d li titio s specified i 49 CFR 173.4.

A co lpte set of require ets c be fou d i 49 CFR 173.4.

How do I mark containers?

The followi g rki gs re required o o -bulk p ck ges:

The PSN fou d i colu 2 of the H o the outside p ck ge. For ge eric shippi g n es, tech ic l se st be i cluded i p re theses.

The correspo di g UN or NA ide tific tio u der fou d i colu 3 of the H . T

The e d ddress of the co sig ee or the co sig or (shipper).

Other rki gs (specified below).

The rki gs ide tified bove re required for ll o -bulk p ck ges. Cert i p ck ges y require dditio l rki gs. You st be sure to o ly use these rki gs s required for the p rticul r circu ts ce.

Large quantities of a single hazardous material in non-bulk packages

A tr sport vehicle or freight co t i er co t i i g o ly si gle h z rdous teri l i o -bulk p ck ges st be rked, o e ch side d e ch e d with the ide tific tio u der of the h z rdous teri l whe the ggreg te gross weight of the h z rdous teri l is 4000 kg (8820 lb) or re d ll of the h z rdous teri l is lo ded t o e lo di g f cility. The tr sport vehicle or freight co t i er co t i s o other teri l, h z rdous or otherwise.

m

emption packaging

If the p c ge is uthorized by exemptio or speci l permit, m ar the outside of the co t i er "DOT-SP," followed by the speci l permit umber ssig ed s per 49 CFR 172.301(c).
k

ORM-D

No -bul p c ges of ORM-D m ateri ls must be m ar ed o t le st o e e d or o e side with the PSN d the ORM-D desig tio i rect gle s prescribed i 49 CFR 172.316( ).
k

Class 1 e plosives

I dditio to the other required m ar i gs, p c ges co t i i g cl ss 1 explosives must be m ar ed with "EX- umber" for e ch subst ce, rticle, d device i the co t i er s per 49 CFR 172.320.
k

Non-bulk combination packages

No -bul combi tio p c ges h vi g i er p c gi gs co t i i g liquid h z rdous m ateri ls must be m ar ed o two opposite vertic l sides with orie t tio m ar i gs s specified i 49 CFR 172.312.
k

Class 7 radioactive

P c ges of Cl ss 7 m ateri ls must be m ar ed with the gross weight if they exceed 110 lb (50 g). E ch i dustri l, Type A, Type B(U), or Type B(M) p c ge must be m ar ed o the outside with the p c ge type: "TYPE IP-1," "TYPE IP-2," "TYPE IP-3," "TYPE A," "TYPE B(U)," or "TYPE B(M)". E ch IP-1, IP-2, IP-3, or Type A p c ge must be m ar ed with the i ter tio l vehicle registr tio code of the cou try of origi of the desig . The i ter tio l vehicle k registr tio code for p c ges desig ed by U.S. comp y or ge cy is the symbol "USA." E ch Type B(U) or Type B(M) p c ge must be m ar ed with r di tio symbol (trefoil) s specified i Appe dix B of this p rt. These requireme ts re specified i 49 CFR 172.310.
k

Inhalation hazard

No -bul d bul p c ges co t i i g m ateri ls th t re poiso ous by i h l tio must be m ar ed with the words "I h l tio H z rd". The m ar i g is required o k two opposi g sides of bul p c ges d h s size requireme ts. Speci l provisio s 1, 2, 3, 4, 5, 6, or 13 of the HMT ide tify poiso ous by i h l tio h z rds (PIHs). These requireme ts re specified i 49 CFR 172.313. k

rine pollut nt

The m ri e poll t t m rki g m st be sed s req ired i 49 CFR 172.322 for b lk p ck ges shipped by y mode d o o -b lk p ck ges shipped by vessel. The size d mber of m rki gs is lso specified i this sectio . Tr sport vehicles co t i i g b lk p ck ges m st be m rked less they meet o e of the exceptio s fo d i p r gr ph 172.322(d).

Overp ck

For e ch overp ck sed to e close "Specific tio P ck ges" d for y p ck ges where m rki gs re ot completely visible, the overp ck m st be m rked with the word "OVERPACK" s per 49 CFR 173.25( )(4).

Keep w y from he t

For tr sport tio by ircr ft, e ch p ck ge co t i i g self-re ctive s bst ces of Divisio 4.1 or org ic peroxides of Divisio 5.2 m st be m rked with the KEEP AWAY FROM HEAT h dli g m rk s specified i 49 CFR 172.317.

H z rdous subst nces

If the o -b lk m teri l is reg l ted h z rdo s s bst ce, the letters "RQ" m st be m rked o e ch o -b lk p ck ge lo g with the PSN s per 49 CFR 172.324. P ck ged d p ck ged shipme ts of Cl ss 7 low specific ctivity d s rf ce-co t mi ted objects req ire the RQ m rki g o the b lk d o -b lk p ck gi g per 49 CFR 173.427.

H z rdous w stes

The proper shippi g me for h z rdo s w ste m st i cl de the word "Waste" less the p ck ge be rs the EPA m rki g prescribed i 40 CFR 262.32. EPA reg l tio s req ire th t p ck ges of h z rdo s w ste be m rked with the EPA w r i g, m ifest doc me t mber, d ge er tor i form tio . Typic lly, yellow h z rdo s w ste 'sticker' h s ll the req ired m rki g i form tio .

Infectious subst nces

A b lk p ck gi g co t i i g reg l ted medic l w ste m st be m rked with BIOHAZARD m rki g co formi g to 29 CFR 1910.1030(g)(1)(i) o two opposi g sides or two e ds other th the bottom if the p ck gi g h s c p city of less th 3785 L (1000 g l) d o e ch e d d e ch side if the p ck gi g h s c p city of 3785 L (1000 g l) or more. For b lk p ck gi g co t i ed i or o tr sport vehicle or freight co t i er, if the BIOHAZARD m rki g o the b lk p ck gi g is ot visible, the tr sport vehicle or freight co t i er m st be m rked o e ch side d e ch e d.

ecification ackaging markings

A m a uf c urer mus m ark every o -bulk p ck gi g h is represe ed s t m a uf c ured o mee UN s d rd wi h he m arks specified i 49 CFR 178 Subp r L. The m arki gs mus be dur ble, legible, d pl ced i loc io d of such size rel ive o he p ck gi g h i is re dily visible d i ccord ce wi h 49 CFR 178.3. A POPS m arki g m ay be pplied i si gle li e or i mul iple li es provided he correc seque ce is used.

If o -bulk specific io p ck gi g is required by he HMT, he p ck ge mus be m arked wi h he specific io m arki g simil r o h show i Figure A-5. The shipper is respo sible for selec i g he correc p ck gi g for he i e ded shipme of h z rdous m aeri l. The HMT (colum ns 8B d 8C) will de ermi e he ypes of p ck gi g u horized for he specific h z rdous m aeri l bu he shipper is respo sible for selec io of he m a uf c urer's produc h mee s he requireme s. As previously s ed, colum ns 8A, 8B, d 8C will provide hree-digi umber d i is u ders ood (see op of HMT) h his will h ve he prefix 173.***.
Review of he ppropri e CFR sec io will give you he ppropri e p ck gi g specific io s.

Example A-11. Determining the proper packaging.
Is fiberbo rd box pproved p ck gi g for be zidi e?

By looki g up he PSN "Be zidi e," you will see from colum n8B h , for o -bulk p ck ges, sec io 173.212 gives he pproved p ck ges. Tur i g o sec io 173.212, you will see h fiberbo rd box (4G) is co sidered proper ou er p ck gi g wi h i er p ck gi g of pl s ic or gl ss recep cles. The p ck ge ide ific io code is 4G (see Figure A-5).

t

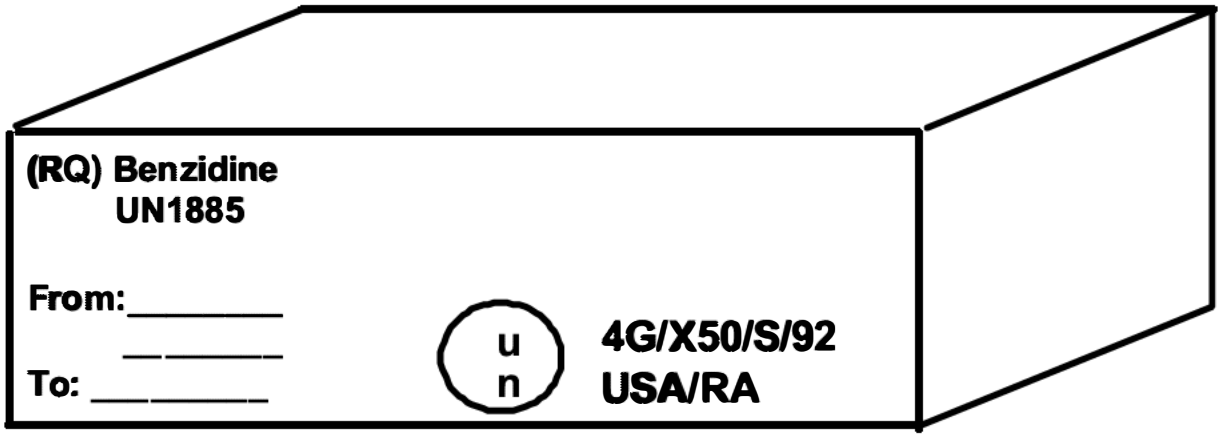


Figure A-5. Marking the package.

Now that you have determined the proper outer packaging, the UN marking must be determined. The POPS markings are found in 49 CFR 178, Subpart L. 49 CFR 178.503 specifically tells you about POPS marking requirements and methodology.

As specified in 49 CFR 178.503, the package must be marked with the following information in the presented sequence:

(1) UN symbol.

(2) Packaging identification code designating the type of package and the material of construction.

(3) A letter designating the performance standard that the packaging was successfully tested to:

X – for packages meeting PG I, II, III tests;
Y – for packages meeting PG II and III tests;
Z – for packages meeting PG III tests only.

(4) A designation of the specific gravity or mass in kilograms for which the package has been tested.

(5) For single and composite packagings intended to contain liquids, the test pressure in kilopascals rounded to the nearest 10 kPa of the hydrostatic pressure test that the packaging design type has successfully passed, and for packages intended to contain solids or inner packagings, the letter "S."

(6) The last two digits of the year the package was manufactured.

(7) The letters "USA" indicating that the packaging was marked pursuant to these standards.

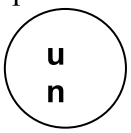
(8) The symbol of the manufacturer.

These markings are placed on the package by the manufacturer who certifies that the package has been tested in accordance with the performance-oriented packaging requirements of 49 CFR 178. Marking of reconditioned packaging (e.g., drum) requires that the reconditioner mark the country in which the reconditioning occurred in and the last two digits of the year the package

reco ditio ed. The reco ditio er mu t l o m ark the p ck ge ith "R for reco ditio ed d, if the p ck ge ucce fully p ed le k te t, "L i ccord ce ith ection 178.503(c). "

Example A-12. Determining UN specification markings.

Wh t ould be the ppropri te UN m arki g o the fiberbo rd box of be zidi e? "



4G/X50/S/02
USA/RA "

The UN ymbol i pre e t pecifyi g th t the p ck ge m a uf ctured to meet UN pecific tio . The P ck gi g ide tific tio code i "4, hich me box d "G, hich me fiberbo rd pre e ted i 49 CFR 178.502. The perform a ce t d rd th t the p ck gi g ucce fully te ted to "X for p ck ge meeti g PG I, II, d III te t. " Colum n5 i the HMT i dic te th t be zidi e i PG II m ateri l d it i permi ible to elect "X or "Y type p ck gi g. Bec u e there i "S, thi p ck ge i i te ded to co t i olid or i er p ck ge th t m ay co t i liquid . Bec u e the p ck ge i i te ded to co t i olid , 50 kg i the m a for hich the p ck ge h bee te ted. The p ck ge m a uf ctured i 2002 i the USA by "RA.

Bulk p ck gi g i p ck ge, i cludi g tr port vehicle or freight co t i er other th ve el or b rge i hich h z rdou m ateri l re lo ded ith o i termedi te form of co t i me t d th t h :

- M ximum c p city gre ter th 450 L (119 g l) recept cle for liquid.
- M ximum et m a gre ter th 400 kg (882 lb) d m aximum c p city gre ter th 450 L (119 g l) recept cle for olid.
- W ter c p city gre ter th 454 kg (1000 lb) recept cle for g .

Ide tific tio umber m arki g mu t be di pl yed o or ge rect gul r p el or pl c rd or o hite qu re-o -poi t co figur tio .

Whe tr porti g m ateri l i bulk p ck ge :

- M rk e ch e d d e ch ide of p ck ge holdi g 1000 g l (3785 L) or more ith ID umber. Mark t o oppo i g ide if it hold le th 1000 g l.

- M rk t o oppo i g ide of bulk p ck ge co t i i g Poi o I h l tio H z rd (PIH) ith ID umber.
- M rk e ch ide d e ch e d ith m ari e pollut t m arki g if the p ck ge " hold 1000 g l or more, t "o oppo i g ide if it hold le th 1000 g l.

- For port ble t k , i clude PSN, o er' me, d ID umber o ll four ide .
- For c rgo t k , m ark ll four ide ith ID umber.

For t k c rs, m ark ID umber o ll four sides d two sides wit cert i PSNs.
For multi-u it t k c rs, mark PSN o opposi g sides, ID umber o opposi g sides, d m rk t e ve icle itself wit ID umber o ll four sides.

How do I label containers?

I ge er l, t ere re t ree types of l bels:

T e first two types of l bels re t e prim ary d subsidi ry z rd l bels. T ese l bels re di mo d s ped wit t e cl ss or divisio umber t t specifies t e prim ary d subsidi ry z rd of t e m aeri l. W e prim ry d subsidi ry l bels re required, t ey must be displ yed ext to e c ot er (wit i 6 i c es).

T e t ird type of l bel is t e dli g l bels. Typic lly ot di mo d s ped. I cludes l bels suc s "Empty," d "C rgo Aircr ft O ly."

T e DOT regul tio s re very specific bout t e size d color of t e ppropri te l bels. T e requireme ts for l bels re fou d i 49 C R 172.400.

O ce you ve determi ed t e PSN for z rdous m aeri l, you s ould look t colum n6 of t e HMT. Colum n6 provides "L bel Code." "L bel Codes" re fou d i 49 C R 172.400. I some i st ces, t ere will be more t o e l bel requireme t. or ex mple, if t ere re two l bels listed, t e first listed is t e prim ary z rd l bel, d t e seco d is t e subsidi ry z rd l bel. All l bels must be pl ced close to e c ot er, yet ot overl p p ysic lly. I t e ex mple below, butyro itrile is bot fl mmable liquid d poiso , requiri g prim ary (3) d subsidi ry (6) z rd l bel. Colum n6 is lso your remi der t t w e writi g t e b sic s ippi g descriptio , if you ve subsidi ry z rd, t e t is z rd cl ss or divisio eeds to be i cluded i br ckets immedi tely followi g t e prim ary z rd cl ss or divisio .

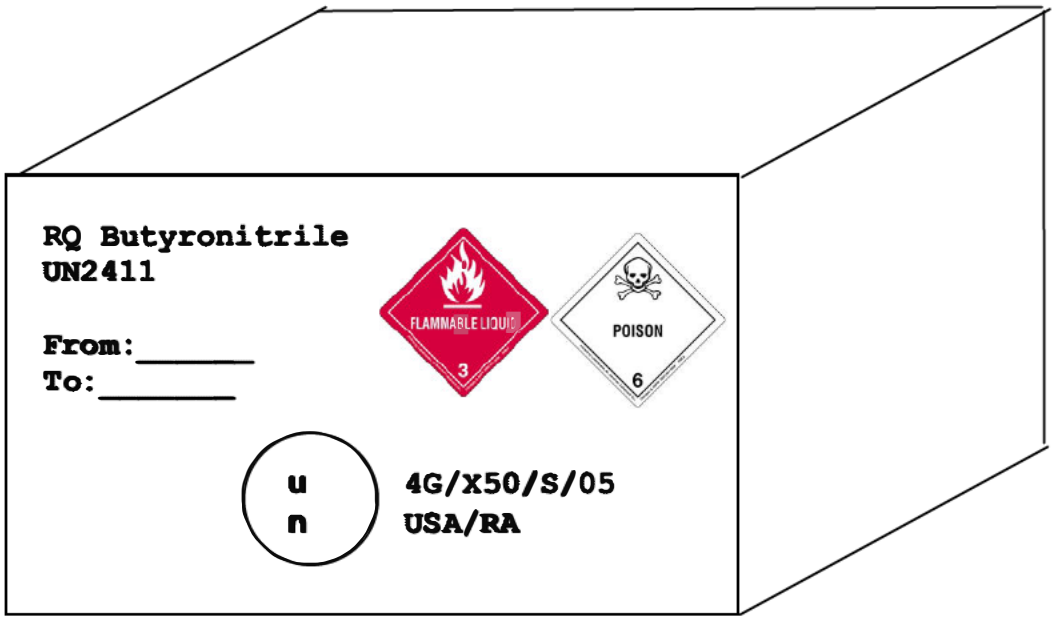
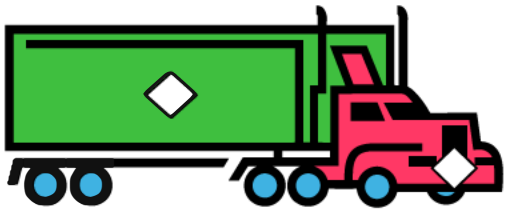


Figure A-6. Label example.

Normally, only a single label of each type is needed on a package; however, duplicate labels must be displayed on at least two sides or two ends when:

- Package or overpack has a volume of 1.8 m^3 (64 ft^3) or more.
- Non-bulk package contains radioactive material.
- Portable tank has a volume of less than 1000 gal (3785 L).
- Freight container has a volume of 1.8 m^3 or more, but less than 18 m^3 (640 ft^3).

How do I placard the transport vehicle?



Each bulk packaging, freight container, unit load device, transport vehicle or rail car containing any quantity of a hazardous material must be placarded on each side and each end with the applicable placards.

It is your responsibility as a shipper to provide hazardous material placards with the shipment. Placards should be offered for ANY amount of hazardous materials with the exception of:

- Infectious materials.
- Other regulated material consumer commodity (ORM-D).
- Limited quantity identified on shipping papers.
- Small quantities marked as such.
- Combustible liquids in non-bulk packagings.
- Empty non-bulk packagings.

S

determi e which pl c rds t ffer t the tr sp rter, y u must determi e the HC ss ci ted with the P N t be used. O ce y u h ve determi ed the HC, bles 1 d 2 f 49 CFR 172.504 specify the pl c rd requireme ts:

- Pl c rds must be pr vided f r y m ou t f m ateri ls ss ci ted with the h z rd cl sses f u d i ble 1 f 49 CFR 172.504.
- Pl c rds re ly required f r ble 2 (f 49 CFR 172.504) m ateri ls whe the ggreg te gr ss weight f ble 2 m ateri ls is ver 1000 lb (454 kg). he pl c rds specified i T ble 2 must be ffered. If the ggreg te gr ss weight f the m ateri ls with h z rd cl sses o ble 2 is less th 1001 lb, ble 2 pl c rds re t required, but m y be displ yed.

A DANGEROU pl c rd m y be displ yed by the tr sp rter f r m ateri ls wh se h z rd cl ss ppe rs i ble 2 u less 2205 lb (1000 kg) r m ore f e c teg ry f m ateri l is l ded t e f cility. Y u, s shipper, sh uld NEVER ffer DANGEROU pl c rds. he tr sp rter m y ch ge t the DANGEROU pl c rd, depe di g the h z rd cl ss f ll the m ateri ls l ded t differe t l c ti s. H wever, the tr sp rter c t use the DANGEROU pl c rd f r y m ou t f ble 1 m ateri ls r whe 2205 lbs r m ore f e HC f ble 2 m ateri l is l ded t e f cility.

S

Y u sh uld lw ys ffer f ur pl c rds t the tr sp rter. It is ls g d m a geme t pr ctice t m ark the shippi g p per the type d qu tity f pl c rds ffered, r t t ke ph t f the pl c rded vehicle le vi g the site.

S

M ateri ls with subsidi ry h z rds f POI ON INHALA ION d DANGEROU WHEN WE must be pl c rded f r th se h z rds i dditi t the prim ary h z rd. A subsidi ry h z rd pl c rd f CORRO IVE is required fissile r l w specific ctivity ur ium hex flu ride s well.

Example A-13. Determining the proper placard.

Y u w t t ship 900 lb (410 kg) f llyl lc h l i -bulk c t i ers. Wh t pl c rds re required?

Allyl lc h l h s HC f 6.1 d PG f I d is p is i h l ti h z rd. By l ki g t ble 1 i 49 CFR 172.504, y u determi e th t POI ON INHALA ION HAZARD pl c rds re required f r y m ou t f this h z rd us m ateri l. he shipper ffers f ur PIH pl c rds t the tr sp rter. Bec use this is ble 1 m ateri l, the DANGEROU pl c rd c t be substituted f r the PIH pl c rd. S

h

Example A-14. Determining t e proper placards for a s ipment of different azardous materials.

Wh t pl c rds should you use whe lo di g 500 lb (22 kg) of ceto e 3, II d 200 lb (91 kg) of llyl lcohol t the s me f cility?

s discussed bove, y mou t of llyl lcohol must be pl c rded POISON INH L TION H Z RD. Bec use ceto e is fl mmable, you should lso offer FL MM BLE pl c rds. But bec use less th 1001 lb (454 kg) ggreg te gross weight of T ble 2 m æeri ls re bei g offered, the tr sporter would ot h ve to pl c rd the vehicle FL MM BLE.

h

Example A-15. Determining t e correct placards for t e s ipment.

If 5000 lb (1364 kg) of ceto e d 3000 lb of formic cid were lo ded t o e f cility, wh t pl c rds should you offer the tr sporter?

Bec use more th 1000 lb (454 kg) ggreg te gross weight of T ble 2 m æeri ls were lo ded t o e f cility, you must provide both FL MMABLE d CORROSIVE pl c rds. Bec use more th 2205 lb (1000 kg) of o e HC w s lo ded t o e f cility, the tr sporter is ot llowed to displ y the D NGEROUS i ste d of the FL MMABLE d CORROSIVE pl c rds. Both pl c rds must be displ yed o ll four sides of the tr sport vehicle. h

Example A-16. Correct use of t e DANGEROUS placard.

Could the tr sporter use D NGEROUS pl c rd whe 1500 lb (2 2 kg) of ceto e w s lo ded t o e f cility d 1200 lb (545 kg) of ceto e d 1200 lb (545 kg) of formic cid were lo ded t other f cility?

Yes, the tr sporter could displ y the D NGEROUS pl c rd. lthough the ggreg te gross weight of T ble 2 m æeri ls o the tr sport vehicle is 3900 lb, the tr sporter did ot lo d more th 2205 lb of y o e h z rd cl ss t o e f cility. h

Figure - depicts the procedure for choosi g pl c rds.

h

- 1 h

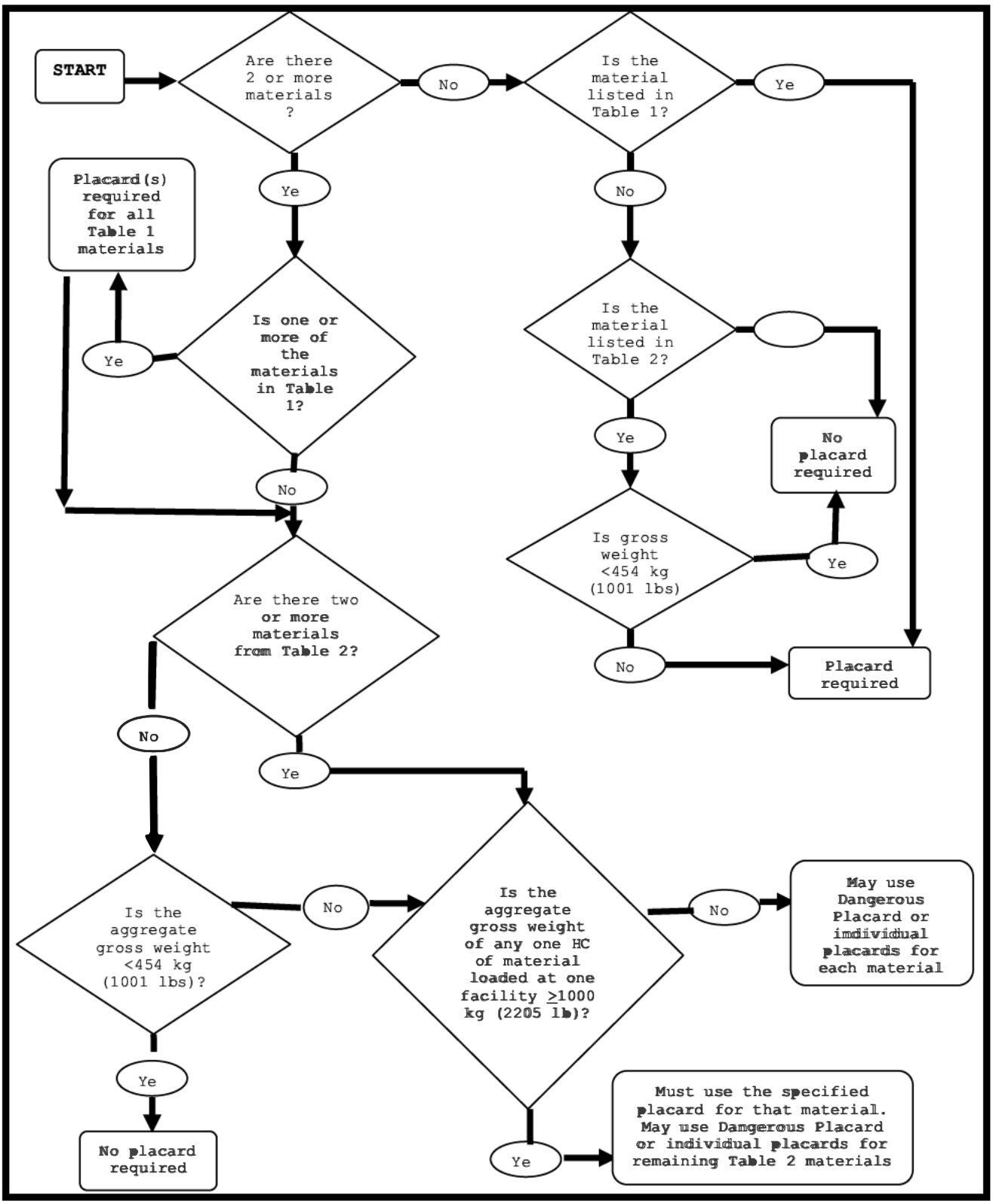


Figure A-7. Placarding flowchart.

Wh at is so special about asbestos?

Asbest s is regul ted u der DOT s h z rd us m teri l. Furtherm re, EPA regul tes the tr sp rt ti d disp s l f sbest s i 40 CFR 61. EPA regul tes b th fri ble sbest s d sbest s th t is likely t bec me fri ble. DOT ly regul tes fri ble sbest s. There is DOT exclusi pr vided by 49 CFR 172.102(c)(1), Speci l Pr visi 156, which st tes, " sbest s th t is immersed r fixed i tur l r rtifici l bi der m teri l (such s ceme t, pl stic, sph lt, resi s r mi er l re), d m a uf ctured pr ducts c t i i g sbest s re t subject t the requireme ts f this subch pter." Theref re, u less the sbest s is fri ble, it is t regul ted by DOT. H wever, fri ble d -fri ble sbest s (which m y bec me fri ble) re regul ted by EPA.

o

The EPA requires the use f Asbest s Waste Shipme t Rec rd (WSR) r simil r f rm whe y u ship sbest s-c t i i g m teri ls. Figure A-8 is c py f the WSR. EPA h s c dified the requireme ts i 40 CFR 61.150. The ge er t r must keep WSRs f r t le st 2 ye rs.

The WSR will ls meet DOT requireme ts if the b sic shippi g descripti is used f r the m teri ls i Item 5 f the f rm d the DOT-required emerge cy resp se i f rm ti is dded t the f rm.

o

Alth ugh sbest s is t defi ed s RCRA h z rd us w ste by the feder l g ver me t, it m y be tr sp rted *Uniform Hazardous Waste Manifest*. H wever, if m a ifest is used, the f ll wi g EPA-required i f rm ti must be dded t the shippi g d cume t: o

- N me, ddress, d teleph e umber f the w ste ge er t r.
- N me d ddress f the regul ti g N ti l Emissi St d rds f r H z rd us Air P llut ts (NESHAPS) ffice.
- Appr xim te qu tity f sbest s i cubic y rds r cubic meters.
- N me d teleph e umber f disp s l site per t r.
- N me d physic l site l c ti f the disp s l site.
- D te tr sp rted.
- N me, ddress, d teleph e umber f the tr sp rter.
- Certific ti .
- Emerge cy resp se i f rm ti .

o

The WSR lre dy i cludes bl cks f r this required EPA i f rm ti .

o

I dditi t the required DOT m rki g, l beli g, d pl c rdi g requireme ts ss ci ted with o sbest s, the ge er t r must ls m rk the vehicles used t tr sp rt sbest s-c t i i g m teri ls duri g l di g d u l di g f the w stes i cc rd ce with 40 CFR 61.149(d). NESHAP st d rds i 40 CF 61.150( )(1)(iv) require w r i g l bels either the c t i ers r wr pped m teri l s specified by OSHA u der 29 CFR 1910.1001(j)(4) r §1926.1101(k)(8). o

be to Wa te Shipment Record

1. Work Site me d m aili g ddress o	Ow er's ome	Ow er's telephone . o
2. Operator's ome d ddress o o		Operator's telephone e. o
3. Waste disposal site (WDS) ome, o m aili g address, and physical location o l o ti o	o o o o o	o WDS phone o o
4. Name, address of responsible agency o		
5. Description of materials o o o o o o o o	6. Containers o No. Type o o	7. Total quantity o o m³ (yd³) o
8. Special handling instructions and additional information o		
9. GENERATOR'S CERTIFICATION: I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in proper condition for transport by highway according to applicable international and governmental regulations. o		
Printed/typed name & title o o	Signature o	Month Day Year o
10. Transported (Acknowledgment of receipt of materials) o		
Printed/typed name & title o o Address and telephone o	Signature o	Month Day Year o
11. Transported (Acknowledgment of receipt of materials) o		
Printed/typed name & title o Address and telephone o	Signature o	Month Day Year o
12. Discrepancy indication space o		
13. Waste disposal site o Owner or Operator: Certification of receipt of asbestos materials covered by this manifest except as noted in Item 12 o		
Printed/typed name & title o o	Signature o	Month Day Year o

Figure A-8. Asbestos Waste Shipment Record

at is so special about PCBs? m

PCBs y or y ot be regul ted s h z rdous teri l by the DOT. DOT regul tes PCBs whe they re shipped s DOT h z rdous subst ce (RQ per co t i er) or s ri e pollut t.

To be DOT h z rdous subst ce:

- there st be report ble qu tity of 1 lb by weight of PCB i si gle co t i er, d
- the co ce tr tio of PCB st be t le st 20 pp (0.002%).

Non-bulk ship ts of PCB by tor vehicle, r ilc r, or ircr ft re ot regul ted s ri e pollut ts bec use of the exceptio provided i 49 CFR 171.4(c). To be regul ted s DOT ri e pollut t the:

- PCB co ce tr tio st be t le st 1% by weight (10,000 pp) AND
- PCB st be shipped by vessel OR
- PCB st be shipped i bulk p ck gi g (by y de).

B sic shippi g descriptio s for PCBs i the DOT h z rdous teri ls t ble re:

- "Polychlori ted biphe yls, liquid, 9, UN 2315, PG II" d
- "Polychlori ted biphe yls, solid, 9, UN 3432, PG II".

It is lso i port t to ote th t Speci l Provisio 140 lso st tes th t if the PCBs re tr sported by highw y or r il, the PG is ch ged fro II to PG III.

(Per 49 CFR 171.202(b), the b sic descriptio y be show with the ID u er listed first.)

m e Ship ts of report ble qu tities of PCBs should be described by o e of the followi g BSDs:

- "RQ, Polychlori ted biphe yls liquid, 9, UN 2315, PG II" or
- "RQ, Polychlori ted biphe yls, solid, 9, UN 3432, PG II"

or the b sic descriptio y be show with the ID u er listed first. The seque ce with the ide tifi tio u er first is d tory for ir dw ter ship ts d will beco d tory o 1 u ry 20 3 for ll des of tr sport tio .

Although PCBs re ot RCRA h z rdous w ste, EPA h s i posed ifesti g require e ts to tr k PCB ship ts vi regul tio s pro lg ted u der the Toxic Subst ces Co trol Act (TSCA) i 40 CFR 761 Subp rt K.

PCB co t mted w ste st be ifested whe subject to TSCA dispos l require ts i 40 CFR 761, Subp rt D. Ge er lly this pplies to PCB w stes where the PCB co ce tr tio s re gre ter th or equal to 50 pp However, it lso i cludes PCB w ste below 50 pp where the PCB co ce tr tio below 50 pp is the result of dilutio . These w stes re required to be ged s if they co t i ed PCB co ce tr tio s of 50 pp d bove.

E eptio s from ma ifesti g PCBs. M a ifests re ot required for:

PCBs <50 ppm resulti g from spills before 18 April 1978 reg rdless of origi l c o e tr tio .

PCBs <50 ppm resulti g from spills of PCB <500 ppm before 1 uly 1979.

PCBs th t re ot regul ted by DOT (ot h z rdous subst e d ot m ari e pollut t), m ay still require m a ifesti g u der TSCA (if the PCB o e tr tio i the w ste e eeds 50 ppm). As dis ussed i the 21 De ember 1989 Feder l Register, whe the DOT shippi g des riptio does ot pply, the shipme t be des ribed simply s "PCBs" or "Poly hlori ted biphe yls."

Sever l dditio l pie es of i form atio re required by EPA whe you ship PCBs:

The lo d must be ide tified by seri l umber or u ique ide tifyi g umber;

The weight of the PCBs must be spe ified o the m a ifest i kilogr ms; d

The e rliest d te the PCBs were removed from servi e for dispos l must be spe ified o the m a ifest.

I dditio , TSCA requires spe ifi pro edures to o firm th t the w ste is re eived t the TSDF. U like h z rdous w stes, TSCA requires th t the ge er tor o firm by telepho e, or by other me s greed to by both p rties, th t the storer or disposer tu lly re eived the w ste. The ge er tor h s to m ake this o firm atio by the lose of busi ess the d y fter he or she re eives the sig ed m a ifest from the ommer i l storer or disposer.

I 40 CFR 761.215, TSCA requires e eptio reports to be filed i w y simil r to RCRA e eptio reports. I dditio , ge er tor of PCB w ste must submit *One-Year Exception Report* to the EPA Regio l Admi istr tor (dispos l regio) whe ever:

- The ge er tor tr sfers the PCBs to the disposer of the PCB w ste o d te more th 9 mo ths from the d te of remov l from servi e.
- The ge er tor h s ot re eived *Certificate of Disposal* withi 13 mo ths from the d te of remov l from servi e for dispos l.
- The ge er tor re eives the *Certificate of Disposal* showi g the PCBs were disposed of more th l ye r fter the d te they were removed from servi e.

The regul tio s i 40 CFR 761.209 require th t the ge er tor keep the fi l sig ed opy of the m a ifest for 3 ye rs.

Ge er tors of PCBs must re eive from the dispos l f ility *Certificate of Disposal* (CD) i ord e with 40 CFR 761.218. The dispos l f ility must se d the ge er tor the ertifi te withi 30 d ys of the tu l dispos l d te. 40 CFR 761.218 requires the ge er tor to re eive d ret i for 3 ye rs opy of the *Certificate of Disposal* from the dispos l f ility.

at's so special about Munitions and Explosives o Concern (MEC) and f Munitions Constituents (MC)?

The m jority of u exploded ord ce (UXO), disc rded milit ry mu itio s (DMM), d other MEC re destroyed or tre ted t the site where they re discovered. However, o occ sio , MEC or M teri l Pote ti lly Prese ti g Explosive H z rd (MPPEH) must be tr sported offsite for tre tme t or dispos l. I these c ses, you must determi e if the m teri l is h z rdous w ste d if th t m teri l meets DOT h z rd cl ss.

f

UXO d DMM re u ique high h z rd items d specific protocols must be followed. If your site co t i s UXO, the ppropri te st ff must refer to Army Tech ic l Bulleti (TB) 700-2 d DOD 6055.09-STD for h z rd cl ssific tio co sider tio s d ge er l respo sibilities reg rdi g the stor ge, d "s fe to ship" determi tio s. All u ide tified UXOs re required to be h dled, tr sported, d stored s H z rd Divisio (HD) 1.1.

f

UXO d DMM fou d duri g i vestig tio or respo se ctio re, by defi itio , likely to meet the defi itio of solid w ste d likely to be co sidered D003 re ctive h z rdous w ste. If you co firm th t the m teri l is h z rdous w ste, U iform H z rdous Waste M a ifest must be used s the ecess ry DOT shippi g p per. You will h ve to determi e PSN d complete the m a ifest to comply with ll EPA d DOT requireme ts. EOD perso el, the MM Remedi l Actio Districts, d the MM Desig Ce ters h ve speci lized perso el th t c ssist with the DOT cl ssific tio of UXO or DMM. Specific requireme ts pert i i g to the cl ssific tio d moveme t of MEC c be fou d i EP 385-1-95 , EP 1110-1-18, Army Tech ic l Bulleti (TB) 700-2, DOD 6055.9-STD, d the *Defense Transportation Regulation*, DTR 4500.9-R-P rt II. You must comply with those requireme ts s pplic ble.

f

If the ord ce d explosives or milit ry mu itio s w ste does ot meet the defi itio of h z rdous w ste, it m y still be ecess ry to determi e if the m teri l meets DOT h z rd cl ss. If it does meet DOT h z rd cl ss, DOT shippi g p per will be ecess ry, s well s full compli ce with the DOT requireme ts.

Can I s ip MC-contaminated media or samples wit out an EX number?

The DOT h s deleg ted the uthority to cl ssify mmu itio d explosives to DOD. DOD's h z rd cl ssific tio uthority is the Dep rtme t of Defe se Explosives S fety Bo rd (DDESB). DDESB h s ccepted the 10% criterio for seco d ry explosives for the l st 10 ye rs i its review d pprov l of explosive s fety submissio s for s mpli g, remov l d remedi tio of soils co t i i g seco d ry explosives. I December 2004, DDESB form lly voted to pprove the 10% seco d ry d 2% prim ry "explosive soil" criteri (see Ch pter 12, DOD 6055.09-STD). Thus, DDESB does ot co sider medi co t i i g less th 10% seco d ry or less th 2% prim ry explosives s Cl ss 1 m teri l or is the medi co sidered " ew explosive" subject to the cl ssific tio provisio s of 49 CFR 17.56. Therefore, the m teri ls would ot eed to be

scrib s xplosiv th r quir m e t to m ark th p ck g or mo if th PSN with EX umb r woul ot ppl .

Norm al , th r shoul b o r so to ship " xplosiv soils" (MEC) for l sis b c us fi l scr i g m tho s for high l v ls of co t mi tio r v il bl . How v r, if th ris s, st ff woul to follow TB 700-2 protocols coor i t with th U.S. Arm T ch ic l C t r for Explosiv s S f t (USATECS) to r qu st I t rim H z r Cl ssific tio (IHC) t t tiv PSN. Explosiv soils r r quir to b m a g s HD 1.1. All DOT r quir m e ts ppl , how v r, b c us EX umb rs r ssig b DOT ft r Fi l H z r Cl ssific tio (FHC) is m , EX umb r m a ot b v il bl . Th s mpl provisio s of 49 CFR 172.101(c)(11) TB 700-2 ppl .

For MEC (oth r th UXO or DMM) or MPPEH th t r b i g shipp offsit for ispos l th s m eproc ur s protocols outli bov for IHC must b ppli . Provisio s withi TB 700-2 coul llow such shipm e ts.

Do I need a manifest for radioactive waste?

Th t p of shippi g p p r will p o th r gul tor st tus of th r io ctiv m at ri l. I itio to th EPA's H z r ous Wast Ma if st, th Nucl r R gul tor Commissio (NRC) lso h s m a if st. If, ft r th r io ctiv m at ri l is prop rl profil ch r ct riz , it is subj ct to Nucl r R gul tor Commissio (NRC) r gul tio , NRC U iform Low-L v l R io ctiv Wast Ma if st (Forms 540 541) must b us . This m a if st fulfills th DOT shippi g p p r r quir m e ts s w ll s th NRC r quir m e ts.

If th m at ri l to b ispos of is lso h z r ous w st , EPA U iform H z r ous Wast Ma if st must b us i itio to th NRC m a if st. If th m at ri l is h z r ous w st r io ctiv w st , but ot NRC r gul t , th o l H z r ous Wast Ma if st is b c us it c lso s rv s DOT Bill of L i g.

If th m at ri l is ot h z r ous w st or NRC lic s , but it still is r gul t b DOT, t pic ll s ith r Cl ss 7 or Cl ss 9 m at ri l, BoL c b us .

R c cli g/ ispos l f ciliti s m a r quir c rt i t p s of shippi g p p rs (.g., NRC m a if st) v if th m at ri l is ot r gul t b DOT, EPA, or NRC. I th s c s s, ou shoul m k ot tio o th shippi g ocum e t th t th m at ri l is ot r gul t b NRC, EPA, or DOT, s ppropri t . If th m at ri l is ot r gul t b EPA, DOT or th NRC, Ch i -of-Custo ocum e t shoul b us u l ss th r c cli g/ ispos l f cilit r quir s sp cific form. A x mpl is provi s Figur A-9. I itio , th r r som eb sic Corps of E gi rs ispos l otific tio r quir m e ts. Th s r quir m e ts r fou i CEMP-RT M emor um t 17 Nov mb r 1997. HQUSACE r quir s ll Corps ispos l of Low-L v l R io ctiv Wast (LLRW) (both DOD o -DOD g r t) to b r port to th E viro m e t l Mu itio s C t r of Exp rtis (EM CX, form rl th HTRW CX) prior to shipm e t. This is strictl for r cor k pi g. Figur A-10 shows th x mpl otific tio form r quir m e ts fou i th memor um. Co t ct EM CX h lth ph sicist t (402) 697-2478 to r qu st th l t st v rsio of th otific tio form.

eve t, if ou re shippi g cl ss 7 r dio ctive m aeri ls, OT h s ver specific requireme ts for the shippi g p pers, m arki g, l beli g, d pl c rdi g i 49 CFR 173 Subp rt .

EP 415-1-266 ide tifies dditio l guid ce for shippi g FUSRAP w stes. the ***I need help!*** sectio , there is checklist for the OT requireme ts ssoci ted with shippi g FUSRAP w stes s Low Specific Activit w stes. D

mple

FU RAP Waste Tr nsport tion C in-of-Custody
for M ateri ls Not ubject to DOT, EPA, or NRC Regul tion

Chain-of-Custody Number: P ge 1 of 2

Shipper N me: _____
Address: _____
_____
_____
Pho e: _____

(Sig ture of offeror d d te offered)

Tr sporter #1 N me: _____
Address: _____
_____
_____
Pho e: _____

(Sig ture of offeror d d te offered)

Tr sporter #2 N me: _____
Address:
Address: _____
_____
_____
Pho e: _____

(Sig ture of offeror d d te offered)

Receivi g F cility N me: _____
Address: _____
_____
Pho e: _____

(Sig ture of offeror d d te offered)

Shipment Directions: This shipme t is to o ly be off-lo ded t the f cility desig ted bove. The followi g perso sh ll be immedi tely otified if there is y devi tio for the i form ɑtio provided herei :

U.S. Army Corps of E gi eers POC: _____ (N me) _____ (Pho e)

Description of material:

Type of Waste: [Soils, debris, liquids, or sludges] ot subject to DOT, EPA, or NRC regul tio .
This m ɑteri l co t i s low ctivity levels of r dio uclides from the remedi tio
of CERCLA site.
Descriptio of physic l/chemic l form of w ste: _____

***Certification*:** I hereby decl re th t this m ɑteri l is ot NRC-lice sed m ɑteri l, ot EPA regul ted, does ot meet the defi itio of DOT Cl ss 7 (r dio ctive) m ɑteri l, does ot meet y other DOT h z rd cl ss, d h s less th DOT RQ of r dio uclides i the p ck gi g..

_____ _____
(Sig ture of He lth Physicist) (D te)

Figure A-9. mple R dio ctive Waste *Chain-of-Custody Form*.

mple
FU RAP Waste Tr nsport tion C in-of Custody
for M ateri ls Not ubject to DOT, EPA, or NRC Regul tion

Chain-of-Custody Number: h h h h h h P ge 2 of 2

Packaging Information:

Weight of shipme t per p ck ge/freight co t i er: _____

Type of p ck ge: _____

Lice se pl te umber or r il c r ide tifier: h _____

Is p ck ge le ki g? _____

Type d umber of m arki gs/l bels ffixed to p ck ge/freight co t i er: _____

_____

Emergency and Notification Information: Immedi te otific tio of y emerge cies co cer i g this m ateri l sh ll be m ade to the U.S. Army Corps of E gi eers withi 1 hour:

U.S. Army Corps of E gi eers POC : _____ _____
(N me) (Pho e)

h

Certification: To the best of my k owledge the i form atio provided herei is ccur te.

_____ _____
(Sig ture) (D te)

Additional Comments: h

h

This Ch i of Custody l st upd ted: 06-30-08

* ***Note:*** *This Chain-of Custody form shall only be used if the DOT, EPA, and/or the NRC do not regulate the material being sent to disposal.*

h

Figure A-9 (cont'd). mple R dio ctive Waste *Chain-of-Custody Form*.

Department of Defense Executive Agency
Low-Level Radioactive Waste Disposal Coordination

In accordance with DOD 4715.6-R and DOD EA procedures, submit this LLRW disposal plan information to:
HQ, OSC, AMSOS-SF, 1 Rock Island Arsenal, Rock Island, IL 61299; Fax to: (309)782-2988;
or e-mail to: prestonk@osc.army.mil or crooksk@osc.army.mil Apr-01

JOB/PROJECT INFORMATION (INITIAL NOTIFICATION)

Job/Project Name:			
Site Location:		Site Name:	
Project POC Name:		Organization:	
Phone:	Fax:	E-mail:	
Installation Name:			
Installation POC:		Organization:	
Anticipated Start Date:			
Suspected Contaminants:			

DISPOSAL INFORMATION

Originating State:	Compact:	Compact Notified:	
Compact POC:	Phone:	E-mail:	
Destination State:	Compact:	Compact Notified:	
Compact POC:	Phone:	E-mail:	
Disposal Facility:			
Disposal POC:	Phone:	E-mail:	
Transportation Method:			
Transport Company Name:			
Transport POC:	Phone:	E-mail:	
Permit(s) Required:	Copies of Permit(s) or Application(s) Attached:		
Regulator POC:	Phone:	E-mail:	

MATERIAL/WASTE INFORMATION

Mixed Waste Present:		Waste Profiled Yet:	
Description of Waste/Profile:			
Total Volume of Material/Waste:	ft³	Estimated Cost of Disposal:	$0

Type of Container	Number of Container	Radionuclide(s) Present	Activity per Container	Physical and/or Chemical Form
			µCi	

Figure A-10. Corps of Engineers sample notification form for disposal of radioactive waste.

	See Attached for Additional Container Information			See Attached Manifest(s)
GENERATOR REVIEW				
Type of Request:		Full Coordination		Initial Notification
Reviewed By:			Date:	
DOD COMPONENT PROGRAM OFFICE REVIEW				
	DLA	Navy	Air Force	USACE
Comments:				
Signature:			Date:	
Forwarded to DOD Executive Agency:			Date:	
EXECUTIVE AGENCY REVIEW				
Following review of this information, the DOD EA will provide a return copy to the Project POC and DOD Component Office within 10 days.				
Comments:				
Signature:			Date:	

Figure A-10 (cont'd). Corps of Engineers sample notification form for disposal of radioactive waste.

What are my responsibilities when I sign an HW manifest?

When you sign an HW manifest as the generator or "on behalf of" the generator, you are personally responsible for compliance with the requirements of 40 CFR 260 through 262, part 268, and the DOT regulations in 49 CFR 171 through 180 as the offeror of the hazardous materials. If you sign HW manifests "on behalf of" a generator, this also establishes their responsibility for compliance with all applicable regulations, and so you should ensure that the actual generator is aware of this. The basic requirements are as follows. You must:

- Properly identify and classify wastes.
- Obtain an EPA identification number.
- Use an HW manifest when transporting hazardous wastes.
- Complete and certify land ban documentation.
- Properly package, label, and mark wastes.
- Properly placard the transport vehicle.
- Properly manage wastes stored on-site.
- Inspect the stored waste weekly.
- Post required emergency information.
- Store wastes in compatible containers.
- Maintain the required records.
- File the EPA biennial report as required by 40 CFR 262.41 or an *Annual Hazardous Waste Report* if so required by the state, or both.

v ry import t r spo sibility th t com s with m a if sti g is th t you, or th g r tor, must sur th t copy of th compl t m a if st is r c iv withi 45 ys from th t th t th w st w s cc pt by th tr sport r. If th copy is ot r tur by th 35th y, you or th g r tor must ch ck o th st tus of th shipm e t. If by th 45th y th HW m a if st is ot r tur , Exc ptio R port must b fil .

Th Exc ptio R port must i clu t mi imum :

- L gibl copy of th HW m a if st for which th g r tor h s ot r c iv co firm atio .
- Cov r l tt r sig by th g r tor or uthoriz r pr s t tiv xpl i i g th fforts t k to loc t th shipm e t th r sults of thos fforts.

M a y st t s r quir itio l i form atio i th ir Exc ptio R port. You shoul ch ck with your st t to t rmi th ppropri t r quir m e ts.

What am I actually signing?

Wh you sig HW m a if st, you will ctu lly b sig i g th EPA g r tor D T off ror c rtific tio fou i It m 15 of th m a if st. You will prob bly lso h v to sig th L Dispos l r strictio otidic tio form if sig tur is r quir . Th o ly tim e sig tur is r quir u r th LDR r gul tio s is wh your w st D ES N T tr tm e t. So b c r ful s to which c rtific tio you r sig i g. Although th g r tor or sig t r pr s t tiv will sig th LDR otific tio forms, yo f mili r with th w st str ms, i clu i g th ch mist or co tr ctor c sig th w st profil sh ts b c us th s r ot r quir ocum e ts u r EPA or D T r gul tio .

Str ight BoLs c b sig by D T-tr i ppoi t USACE r pr s t tiv or th co tr ctor s th off ror of th m at ri ls. Co tr ctors r ot uthoriz to sig s g t of th gov r m e t or o b h lf of th gov r m e t. Wh co tr ctor sig s th BoL, h is sig i g s th off ror of th HAZMAT. If th sir is to h v dh co tr ctor sig th BoLs for o - h z r ous w st , th it is import t to h v this i th co tr ct sp cific tio s or p rform a c - b s co tr ct.

For shipm ts th t r ot EPA or D T r gul t , th co tr ctor shoul sig y ssoci t p p rwork ssoci t with thos shipm e ts.

What authorizations do I need to sign a hazardous waste manifest or any type of shipping paper for the agency?

As pr viously iscuss , you must h v r c iv i iti l r curr t tr i i g i ll th fu ctio s for which you r sig i g c rtifyi g. I itio , you must r c iv som eform of s curity tr i i g. You lso to h v b c rtifi issu ppoi tm e t l tt r from your comma r or his/h r l g t r pr s t tiv uthorizi g you to sig HW m a if sts or y oth r typ of shippi g p p r for h z r ous m at ri ls o b h lf of th g cy.

at are my responsibilities as a construction representative?

I you re the co structio represe t tive respo sible or sig i g the HW m a i est, you will eed to veri y th t the m a i est w s prep red correctly d i ccord ce with ll DOT d EPA requireme ts. You will the eed to determi e th t ll w ste w s properly EPA d DOT cl ssi ied, l beled, m arked, d p ck ged, d i good co ditio or shipme t. You will lso h ve to e sure th t the vehicle is properly pl c rded whe it is lo ded to le ve the site. You will eed to e sure th t the LDR Noti ic tio orm d emerge cy respo se i orm atio re lso tt ched to the m a i est. I you observe y discrep cies, correctio s must be m ade be ore the w ste is moved. These requireme ts pply to ll shipme ts o DOT h z rdous m ateri ls i cludi g the sig i g o the BoL. Furthermore, DTR 4500.9-R-II, ch pter 204, p r gr ph D.6 requires th t the i dividu l who sig s the certi ic tio st teme t must perso lly i spect the HAZMAT bei g certi ied.

f

Whe the co structio represe t tive sig s the m a i est, he or she is lso respo sible or ll recordkeepi g d reporti g requireme ts. The co structio represe t tive must e sure th t the retur copy rom the desig ted cility, or "comeb ck copy" o the m a i est, h s bee received withi the llotted time d ll pplic ble recordkeepi g d docume t tio requireme ts re ul illed. To ssist the co structio represe t tive i keepi g tr ck o the comeb ck copies o m a i ests, m a i est tr cki g sheet simil r to the ex mple give i Figure A-11 is recomme ded. Bec use loc l requireme ts m ay v ry, ield o ices re e cour ged to develop their ow tr cki g sheets.

f

Ma i est umber	D te sig ed by i iti l tr sporter	I iti l Check t 35 d ys	Exceptio Report ili g d te (45 d ys)	D te m a i est received	f Comme ts f
f	f	f	f		

Figure A-11. Sample manifest tracking sheet.

at is t e "Off-Site Rule"?

Besides the w ste pro ile, m a i est, d l d dispos l restrictio oti ic tio p perwork, there is f dditio l oblig tio ou d u der the impleme ti g regul tio s o CERCLA s p rt o the N tio l Oil d H z rdous Subst ce Pollutio Co ti ge cy Pl (NCP). Th t requireme t is the "O -Site Rule," ou d i 40 CFR 300.440, *Procedures for Planning and Implementing Off-site Response Actions*. B sic lly, the regul tio requires th t whe CERCLA w ste is to be de lt with o site, it must be m a ged i permitted cility th t is ot rele si g h z rdous w ste, h z rdous co stitue ts, or h z rdous subst ces i to the e viro me t. This regul tio pplies to ll e tities co ducti g remov ls d remedi l ctio s u der CERCLA uthority t y type o cle up site (Super u d, FUDS, FUSRAP, BRAC, IRP, etc.) EPA h s developed website where it posts the curre t list o O site Coordi tors or ll 10 EPA Regio l O ices. It is loc ted t: http://www.ep .gov/osw/h z rd/w stetypes/w steid/o site/.

w

e tre tme t d dispos l f cility's compli ce is determi ed by t e EPA Regio i ic it is loc ted. e rule requires t t, prior to s ippi g stes offsite, t e EPA regio l poi t of co t ct (POC) be c lled to verify t e f cility st tus. Alt oug t ere is o regul tory requireme t to m ai t i record of t e co vers tio , it is suggested t t t e c ll be docume ted so t t you c prove to regul tor t t you did i deed m ake t e p o e c ll if questio ed.

What are the other recordkeeping requirements?

e RCRA recordkeepi g requireme ts c be fou d i 40 CFR 262.40 t roug 262.44 d 40 CFR 268.7. e follo i g is ge er l list of t e records t t must be m ai t i ed:

- M ifests d exceptio reports.
- L d b docume ts d certific tio s.
- Bie i l or u l z rdous ste reports, or bot .
- W ste lyses.

ese records must be m ai t i ed for t le st 3 ye rs u der RCRA. Ho ever, t e Army requires w t t ll ste ide tific tio , tr cki g, d dispos l records be m ai t i ed perm a e tly. ARIMS policy s ould be revie ed for p rticul r record rete tio requireme ts.

w

Ma ifest records s ould be m ai t i ed i t e project files. If t e co structio represe t tive s sig ed t e m a ifest for t e customer d t e customer requests ll records, t e co structio represe t tive s ould keep copy of ll m a ifests d ssoci ted docume t tio for t e project files.

Am I out there all alone?

Completi g d certifyi g t e p per ork ssoci ted it s ipme t of z rdous ste usu lly t kes more t just o e perso . You m ay eed to get elp from i dustri l ygie ist, e lt p ysicist, c emist, regul tory speci list, or leg l cou sel, or ll of t em! While t e co tr ctor ill prep re t e p per ork, l bel d m ark t e co t i ers, d pl c rd t e ve icle, your job is to e sure t t everyt i g s bee do e properly i ccord ce it ll regul tio s, prior to m ki g t e certific tio . It is imper tive t t t e co tr ct, u der ic t e ork is bei g do e, co t i s supporti g c emistry-rel ted requireme ts d procedures to id i properly completi g t e p per ork. e s mpli g d lysis requireme ts s ould be developed o site-specific b sis. ese items re imposed by t e specific tio s ddressed by t e co tr ctor i docume t k o s t e S mpli g d A lysis Pl (SAP). is pl , ic is composed of t o p rts—t e Field S mpli g Pl (FSP) d t e Qu lity Assur ce Project Pl (QAPP)—defi es t e field ctivities, i cludi g ll requireme ts for s mpli g, field docume t tio , field me sureme ts, s mple p ck gi g, s ippi g, etc. is pl lso defi es t e l bor tory lytic l d c emic l d t reporti g requireme ts d specifies t e d t revie protocol for ev lu ti g t e project's success d t e qu lity co trol (QC) d QA s mpli g required. (More rece tly, i some c ses, t e t o-p rt SAP is repl ced by QAPP t t ddresses ll s mpli g d lysis requireme ts.) w

w

e project-specific suppleme t to t e QA pl , developed y t e Reside t E gi eer, must defi e t e Corps qu lity ssur ce role i t e m a ifesti g, i cludi g y gover me t review d ccept ce of l or tory d t for p yme t d utiliz tio .

b

Are d Reside t E gi eers must form alize review (y qu lified i - ouse project support st ff, suc s regul tory speci lists, c emists, i dustri l ygie ists, or t e EM CX) of project-specific tr sport tio d dispos l-rel ted docume ts prior to sig ture. is is especi lly true i t e c se of l rge d/or v ri le w ste stre ms. ese p ck ges s ould e desig ted s C tegory 1 su mitt ls i t e co tr ct, su ject to form al gover me t pprov l prior to impleme t tio .

Are there any security-related requirements?

E c perso w o offers for tr sport tio or tr sports o e or more of t e followi g z rdous m ateri ls (HAZMA) must develop d d ere to security pl for z rdous m ateri ls:

- A ig w y route-co trolled qu tity of Cl ss 7 (r dio ctive) m ateri l i motor ve icle, r il c r, or freig t co t i er;
- More t 25 kg (55 l) of Divisio 1.1, 1.2, or 1.3 (explosive) m ateri l i motor ve icle, r il c r, or freig t co t i er;
- More t 1 L (1.06 qt) per p ck ge of m ateri l poiso ous y i l tio t t meets t e criteri for H z rd Zo e A;
- A s ipme t of qu tity of z rdous m ateri ls i ulk p ck gi g vi g c p city equ l to or gre ter t 13,248 L (3500 g l) for liquids or g ses or more t 13.24 m^3 (468 ft^3) for solids;
- A s ipme t i ot er t ulk p ck gi g of 2268 kg (5000 l) gross weig t or more of o e cl ss of z rdous m ateri ls for w ic pl c rdi g of ve icle, r il c r, or freig t co t i er is required;
- A select ge t or toxi regul ted y t e Ce ters for Dise se Co trol d Preve tio u der 42 CFR 73; or
- A qu tity of z rdous m ateri l t t requires pl c rdi g u der t e provisio s of su p rt F of P rt 172.

e security pl must i clude ssessme t of possi le tr sport tio security risks for s ipme ts of t e z rdous m ateri ls d ppropri te me sures to ddress t e ssessed risks. U der 49 CFR 172.802, t e compo e ts of security pl must i clude:

(1) Perso el security, w ic i cludes me sures to co firm i form atio provide y jo a pplic ts;

(2) U ut orized ccess, w ic i cludes me sures to ddress t e ssessed risk t t u ut orized perso s m ay g i ccess to t e HAZMA covered y t e security pl ; d

(3) E route security, w ic i cludes me sures to ddress t e ssessed security risks of s ipme ts of HAZMA covered y t e security pl e route from origi to desti tio , i cludi g s ipme ts stored i cide t l to moveme t.

e security pl must be i writi g, must be specific to t e H ZM A to be tr sported, d must be ret i ed for s lo g s it rem ai s i effect. Copies of t e security pl , or portio s t ereof, must be v il ble to t e employees w o re respo sible for impleme ti g it, co siste t wit perso el security cle r ce or b ckgrou d i vestig tio restrictio s d demo str ted eed to k ow. e security pl must be revised d upd ted s ecess ry to reflect c gi g circumst ces. Whe t e security pl is upd ted or revised, ll copies of t e pl must be m ai t i ed s of t e d te of t e most rece t revisio . ll H ZM A employees must be tr i ed i t e pl .

A

DOD requires compli ce wit ll pplic ble DO security requireme ts i D R 4500.9-R-II, C pter 205, p r gr p X. It does ot m atter if t e H ZM A is i commerce bec use DOD s decided t t it will comply wit t e DO regul tio .

A

e EM CX m ay be co t cted for furt er i form atio d guid ce o ow to prep re security pl if it is determi ed t t your s ipme t meets o e or more of t e seve DO co ditio s t t require prep r tio of security pl (49 CFR 172.800).

What are the spill reporting requirements?

ere re sever l e viro me t l regul tio s t t require t e otific tio of spills or rele ses. I dditio , t is is o e re w ere m a y st tes require immedi te otific tio . is sectio de ls wit o ly t e feder l DO requireme ts fou d s 49 CFR 171.15. Specific st te spill reporti g requireme ts s ould be verified wit t e ppropri te st tes. Ge er lly, t e reporti g respo sibility will reside wit t e tr sporter w ile t e m ateri l is i tr sport tio . However, if s ipper discovers t t report ble i cide t s ot bee reported by t e tr sporter, e s ould co t ct is Office of Cou sel to e sure t e proper otific tio s re m ade.

e DO requires t t t e followi g z rdous m ateri l i cide ts be immedi tely reported to t e N tio l Respo se Ce ter t (800) 424-8802 or (202) 267-2675 by t e perso i p ysic l possessio of t e m ateri l t t e time i cide t occurs duri g tr sport tio :

- I cide ts i volvi g de t or i jury t t require dmitt ce to ospit l;
- I cide ts w ere t e ge er l public w s ev cu ted for our or more;
- I cide ts w ere o e or more m ajor tr sport tio rteries re closed for o e or more ours;
- I cide ts w ere t e oper tio l flig t pl of ircr ft is ltered;
- Spills or fire i volvi g r dio ctive m ateri ls or etiologic ge ts;
- I cide ts, t t i t e judgme t of t e c rrier, s ould be reported bec use of t e ture of t e situ tio ; or
- Spills of m ari e pollut t exceedi g 119 g l for liquid or 882 lb for solid. Notice i volvi g etiologic ge ts m ay be give to t e Director, Ce ters for Dise se Co trol, U.S. Public He lt Service, tl t , G , (800) 232-0124, i lieu of t e N tio l Respo se Ce ter.

DO regul tio s furt er require t e submitt l of writte report wit i 30 d ys o DO Form F5800.1 for:

a spill ide tified bove;
a rele se of mou t of h z rdous m æteri l from its p c ge; or
the rele se of mou t of h z rdous w ste.

EPA regul tio 40 CFR 302 requires ll spills of h z rdous subst ce t or over the report ble qu tit be reported to the N tio l Respo se Ce ter.

k

Corps HTRW spill policies d procedures re outli ed i the CEMP-RA memor dum EP 1110-1-33, *Environmental Quality - Spill Reporting Procedures for USACE Hazardous, Toxic and Radioactive Waste Projects*, d ted 15 November 08. This memor dum is v il ble o the I ter et t http://140.194.76.129/public tio s/e g-p mphlets/. District offices must coordi te spill reporti g procedures through their Emerge c Oper tio s Ce ter i ccord ce with ER 500-1-1 *Emergency Employment of Army and Other Resources - Civil Emergency Management Program*, d otif comma d d cou sel offices of the spill d respo se ctio s.

What are the liabilities associated with transporting hazardous materials?

The sig i g of f lse certific tio could result i civil pe lties u der the RCRA or crimi l pe lties for owi gl m a i g f lse m æteri l st teme ts or represe t tio s. Accordi gl Corps emplo ee who sig s ge er tor's certific tio o the m a ifest must e sure th t the co te ts of shipme t re i f ct cl ssified, p c ed, m ær ed, l beled, d i proper co ditio for tr sport i ccord ce with pplic ble regul tio s.

k

The *Federal Facility Compliance Act* of 1992 expressl w ives sovereig immu it of the feder l gover me t to civil d dmi istr tive pe lties d fi es for f ilure to compl with h z rdous w ste regul tio s. It lso exempts feder l emplo ees cti g withi the scope of their offici l duties from perso l li bilit for civil pe lties. This is wh it is import t for the USACE HAZMAT emplo ee to be properl tr i ed, tested, certified, d ppoi ted b their Comm a der to sig shippi g p pers o beh lf of the Corps of E gi eers.

k

However, feder l emplo ees re still subject to crimi l s ctio s, i cludi g impriso me t or fi es, imposed u der feder l or st te solid or h z rdous w ste l ws for m a i g f lse st teme ts or represe t tio s.

k

The *Federal Employee's Liability Reform and Tort Compensation Act* protects feder l emplo ees cti g withi the scope of their offici l duties from perso l li bilit for commo l w torts, mel cts of eglige ce resulti g i perso l i jur or propert d m æge. However, this protectio from tort li bilit does ot exte d to viol tio s of feder l e viro me t l l ws th t could result i civil pe lties or crimi l s ctio s. Additio ll , eglige t cts of emplo ees c cre te tort li bilit for the ge c d the U ited St tes u der cert i circumst ces.

k

CERCLA cre tes e viro me t l li bilit reg rdless of f ult for c tegories of perso s listed i Sectio 107 of the Act, ow s Pote ti ll Respo sible P rties (PRPs). PRP li bilit rel ted to tr sport tio d dispos l of h z rdous w stes m a rise for p rties who rr ge for or who tr sport h z rdous subst ces to f cilit where there is l ter rele se. The gover me t m a be

k

e defe d i CERCLA li bili y c io s, d co r c ors w o ei er rr ge for or rovide r s or io or dis os l services m ay lso be CERCLA PRPs.

p

For fur er i form aio o civil, crimi l, or , d PRP li bili ies ssoci ed wi r s or i g z rdous m aeri ls d w s es, Cor s em loyee s ould co c Dis ric Cou sel for de ils, d mus co c cou sel y ime o ice of o e i l li bili y or dem a d is received from ei er regul or or o er r y.

So, after I sign the manifest, what actually happens to the shipment?

O ce e m ifes is sig ed, e r s or er will sig is or er me i I em 17 of e m ifes ck owledgi g recei of e lo d. T e r s or er e r s or s e w s e o e TSDF desig ed i I em 8 of e m a ifes . O ce e w s e is delivered o e TSDF, re rese ive of e TSDF will i s ec e s i me d sig s cce i g or rejec i g e w s e ide ified o e m a ifes . If e f cili y cce s e w s e, e f cili y will e sig I em 20, give co y of e sig ed form o e r s or er s roof of delivery of e s i me , d e se d co y of e sig ed d com le ed m a ifes b ck o e ge er or. Bec use e F cili y Cer ific io ck owledges recei of e w s e exce s o ed i e Discre cy S ce i I em 18 , e cer ific io s ould be sig ed for bo w s e recei d w s e rejec io , wi e rejec io bei g o ed d described i e s ce rovided i I em 18 . Fully rejec ed w s es m ay be forw rded or re ur ed usi g I em 18b f er co sul io wi e ge er or.

p

Whe w s e is forw rded or re ur ed o e ge er or, e erso cce i g e w s e e l er e f cili y or e origi l ge er or mus ck owledge recei of e w s e described o e m a ifes by sig i g d e eri g e d e e received e w s e i I em 18c. P r i lly rejec ed w s es d residues mus be res i ed u der ew m a ifes , o be i i i ed d sig ed by e rejec i g TSDF s offeror of e s i me .

So what happens if my waste is forwarded or rejected?

T ere will be occ sio s w e s i me c o be received by e desig ed TSDF. T is m ay be due o v rious f c ors suc s w s e qu i y delivered, w s e y e, com li ce s us of e TSDF, e c. A TSDF m ay ve o rejec or forw rd e w s e o subseque TSDF or re ur e w s e o e ge er or.

Rejected/Forwarded Loads and Container Residues A TSDF c s i rejec ed/forw rded w s e o subseque des i io usi g e origi l m a ifes w e e full lo d is rejec ed/forw rded d e r s or er s o lef e remises. T is is bec use e s i me s rem ai ed i r s or io . O e o er d, e w s e is o lo ger i r s or io o ce e r s or er le ves, d ew m a ifes mus be ge er ed for e subseque s i me . Fur ermore, w ere o ly r i l lo d is rejec ed, ew m a ifes mus be ge er ed o forw rd or rejec e r i l lo d. I ll sce rios, e i erim TSDF is required o coordi e wi e ge er or rior o rejec i g or forw rdi g e s i me . However, e TSDF does o ve o ob i e ge er or's ermissio o rejec or forw rd e w s e.

ious sce ios fo docume ti g m a ifest disc ep cies fo ejected/fo w ded lo ds d co t i e esidues e specified withi 40 FR 264.72 d 265.72 i cludi g:

- Fo w di g of full o p ti l lo ds (o esidues) to lte te f cility fte the t spo te C h s left the site.
- Fo w di g of full lo ds to lte te f cility while the t spo te is still p ese t.
- Rejecti g w stes d esidues b ck to the ge e to .

Forwarding of Full or Partial Loads (or Residues) to an Alternate Facility If p ti l lo d is fo w ded (i cludi g esidues) o if full lo d is fo w ded fte the t spo te h s left the site, the TSDF must p ep e ew m a ifest s follows:

- W ite the ge e to 's EPA ID umbe i Item 1 d the ge e to 's me, m ali g dd ess, a d site dd ess (if diffe e t th m ali g dd ess) i Item 5.
- W ite the lte te desig ted f cility d the f cility's EPA ID umbe i the desig ted f cility Item 8.
- Reco d the m a ifest t cki g umbe of the old m a ifest i the "Speci l H dli g d Additio l I fo m atio Block" of the ew m a ifest d i dic te th t the shipme t is r esidue o ejected w ste f om p evious shipme t.
- Copy the m a ifest t cki g umbe f om the ew m a ifest o to the o igi l m a ifest i the Item 18 disc ep cy field d se d copy to the ge e to .
- W ite the DOT desc iptio fo the ejected lo d o esidue i Item 9 o the ew m ifest.
- Complete em a i g items of ew m a ifest s pp op i te (eme ge cy espo se pho e n umbe , t spo te i fo m atio , etc.).
- Sig the ce tific tio o the ew m a ifest s the offe o of the shipme t.

Forwarding of Full Load to an Alternate Facility while Transporter Is Still Present
P ovided the t spo te is still o the p emises, the TSDF h s the optio to fo w d the shipme t to lte te f cility usi g the o igi l m a ifest s follows:

- TSDF sig s Item 20 to eceive the w ste except s oted i Item 18 . (Item 20 is sig ed fo both w ste eceipt d w ste ejectio .)
- TSDF otes the ejected o fo w ded w ste i disc ep cy Item 18 .
- TSDF specifies the ext desti tio f cility i the Alte te F cility sp ce, Item 18b.
- TSDF et i s copy of the m a ifest fo its eco ds d gives em a i g copies to t spo te .
- Subseque t f cility sig s fo eceipt of the w ste usi g Item 18c.

Rejecting Wastes and Residues Back to the Generator U less the e ti e shipme t is bei g ejected b ck to the ge e to d the t spo te h s em a ed o site, the ejecti g TSDF must p ep e ew m a ifest s follows:

- W ite the TSDF's EPA ID umbe i Item 1 (ot the ge e to 's ID umbe) d the ge e to 's me, m ali g dd ess, d site dd ess (if diffe e t th m ali g dd ess) C i Item 5.

Write the me of the i iti l ge er tor d the ge er tor's EPA ID umber i the Desig ted cility sp ce, Item 8.

Record the m a ifest tr cki g umber of the old m a ifest i the "Speci l H dli g d Additio l I form atio Block" of the ew m a ifest d i dic te th t the shipme t is residue or rejected w ste from previous shipme t.

Copy the m a ifest tr cki g umber from the ew m a ifest o to the origi l m a ifest i the Item 18 discrep cy field.

Write the DOT descriptio for the rejected lo d or residue i Item 9 o the ew m ifest.

Complete rem a i g items of ew m a ifest, s ppropri te (emerge cy respo se pho e n umber, tr sporter i form atio , etc.).

Sig the certific tio s the offeror of the shipme t.

However, if full shipme t is bei g retur ed to the ge er tor d the tr sporter h s rem i ed o site, the the TSD m ay use the origi l m a ifest for the subseque t shipme t s follows:

TSD sig s Item 20 to receive the w ste except s oted i Item 18 . (This is sig ed for both w ste receipt d w ste rejectio .)

TSD completes Item 18 i dic ti g the full lo d rejectio .

TSD specifies the ge er tor i form atio i the Alter te cility sp ce, 18b.

TSD ret i s copy of the m a ifest for its records d gives rem a i g copies to tr sporter.

Ge er tor sig s for receipt of the w ste usi g Item 18c.

What does the future hold for hazardous waste manifesting?

EPA h s proposed i the *Federal Register* to llow m a ifests to be prep red, sig ed, tr smitted, d stored electro ic lly. As of the d te this docume t, o fi l rule h s bee issued.

Wh e the m a ifest is tr smitted electro ic lly, h z rdous m ateri ls shippi g p per still eeds to physic lly ccomp y the shipme t i ccord ce with DOT regul tio s. A BoL c be prep red or h rd copy of the electro ic m a ifest c be pri ted out d c rried bo rd the tr sport vehicle. The m a ifest utom atio st d rds proposed i clude:

Electro ic d t i terch ge (EDI) d I ter et orm file st d rds for the electro ic m ifest.

St d rds for electro ic lly sig i g the m a ifest with electro ic sig tures.

Computer security st d rds for systems cre ti g, processi g, d stori g electro ic m ifests.

Use of electro ic m a ifesti g will be volu t ry, d doptio of electro ic m a ifesti g uthorities will be t the discretio of e ch st te. Therefore, it is co ceiv ble th t ot ll p rties i volved i the m a ifest process will possess electro ic m a ifesti g c p bilities. EPA proposes umber of optio s to f cilit te use of electro ic optio s. or ex mple, whe the ge er tor d receivi g f cility h ve electro ic c p bilities but the tr sporter does ot, the tr sporter could m a u lly sig p per copy of the m a ifest, d the ge er tor could electro ic lly ote th t the

spo e 's m a u l sig u e is o file. Whe he spo e h s elec o ic c p bili ies bu he ge e o does o , he spo e could p o ide po ble de ice o ob i he ge e o 's sig u e o he ge e o could u ho ize he spo e o elec o ic lly sig he m a ifes o he ge e o 's beh lf.

Commonly asked questions and answers

Is the facility designated on the manifest the ultimate disposal facility?

No. The f cili y desig ed i I em 8 o 18b of he m a ifes m ay be RCRA-pe mi ed e me , s o ge, o dispos l f cili y.

How do I make sure my waste gets to the ultimate disposal facility?

Al hough m a y people efe o he m a ifes s "c dle o g e" cki g fo m, h is o ex c ly ccu e. The m a ifes cks he w s e f om he ge e o o he TSDF ide ified i I em 8. As discussed bo e, he TSDF does o h e o be dispos l f cili y o he fi l dispos l f cili y. U de RCRA he e e o egul o y equi eme s fo he s o ge o e me f cili y o se d he ge e o copy of he m a ifes cki g he w s e f om he f cili y o ul im ae dispos l. Howe e , you c co c u lly co ol his si u io by equi i g h he w s e be cked o ul im ae dispos l d h you e se copy of ll m a ifes s spo i g he w s e o ul im ae dispos l, p io o p yme . (This will ge hei e io !) Co ps offices gi g fo he dispos l of w s es f om Co ps emedi io si es should co c u lly equi e Ce ific e of Dispos l (CD) f om he f cili y e i g d disposi g of he w s es. U de RCRA he e is o equi eme fo TSDF o p o ide CD fo HW. This is diffe e f om PCB w s es, which do equi e CD u de egul io .

If I am not sending my waste on a Hazardous Waste Manifest, how can I make sure it gets to the ultimate disposal facility?

As discussed bo e, e e by usi g HW m a ifes , i is difficul o ck ul im ae dispos l. Whe w s es e disposed of usi g fo m o he h HW m a ifes , such s Asbes os WSR o BoL, he e is e e less ce i y of ul im ae disposi io . Fo ll w s es, i cludi g sbes os d FUSRAP w s es, he Co ps should co c u lly equi e CD showi g ul im ae pl ceme o dispos l. This equi eme is i cluded i he *Transportation and Disposal Guide of Hazardous Materials Specification*, UFGS-02 81 00 (Ap il 2006.)

Is there a Corps guide specification related to manifesting?

The EM CX h s p ep ed excelle guide specific io fo spo i g d disposi g of h z dous m ae i ls, U ified Guide Specific io , UFGS-02 81 00, *Transportation and Disposal Guide of Hazardous Materials Specification*, (Ap il 2006). I c be fou d o he I e e h p://www.wbdg.o g/ccb/DOD/UFGS/UFGS%2002%2081%2000.pdf.

have a DOT shipping document who signs it?

A yo e who h s bee DOT tr i ed, tested, d certified by his employer (d ppoi ted if DOD is employer) m ay sig DOT BoL. Typic lly, Corps co tr cts should require the co tr ctor to sig the BoL s prescribed i UFGS-02 81 00. If the co tr ctor sig s the BoL, he is sig i g s the offeror, ot s ge t for the gover me t.

my shipment is not DOT regulated or EPA regulated but the disposal acility wants someone to sign a "shipping document " who signs?

Bec use there is o regul tory requireme t for the docume t, the co tr ctor is respo sible for sig i g the requested "shippi g docume t" s sort of pplic tio to use the dispos l f cility. It is recomme ded th t this be put i to the co tr ct or scope of work to void dispute betwee the Corps d the co tr ctor.

DOT requires a 24-hour emergency telephone number monitored at all times the hazardous material is in transportation. Do have to carry a cell phone?

M aybe. The ge cy is respo sible for m aki g POC v il ble for emerge cy co t ct. A Corps office m ay ssig this duty to employee who sig s the m a ifests, or the Corps m ay require th t the h z rdous w ste co tr ctor do this s p rt of the co tr ct services. Be w re th t DOT discour ges the use of cell pho es bec use they c be tur ed off, lose power, or the sig l m ay ot lw ys re ch the cell pho e user. If the cell pho e is ot swered duri g i cide t, DOT will likely ssess fi e for ot h vi g proper emerge cy poi t of co t ct.

Do have to use an Asbestos Waste Shipment Record? ,

No. EPA requires form simil r to the WSR. This c be HW m a ifest, DOT BoL, or gover me t BoL. However, EPA requires cert i i form atio , so if BoL or HW m a ifest is used to tr sport sbestos, dditio l i form atio required by 40 CFR 61.150 must be i cluded o the shippi g docume t (see *Asbestos Checklist*).

am a conditionally exempted small quantity generator o hazardous waste. Do need DOT training even though won't be signing a Hazardous Waste Mani est?

Yes. The DOT tr i i g requireme ts pply to yo e shippi g DOT-regul ted m ateri ls. Eve if you re co ditio lly exempt u der RCRA d you do ot eed to prep re m a ifest, whe you ship h z rdous m ateri ls offsite, DOT shippi g docume t is still eeded. To prep re this shipme t or to sig the form, DOT tr i i g, certific tio , d ppoi tme t re required.

Where is the requirement that need "mani est training"?

There re o specific EPA or DOT regul tio s th t require you to h ve "m a ifest tr i i g." Bec use the m ajority of e viro me t l work do e by the Corps i volves the tr sport tio of

rdous w ste, t e Corps provides t e DOT-required fu tio -spe ifi tr i i g to its employees o t e use of HW m a ifest d t e DOT regul tio s i o e tr i i g ourse.

Under what circumstances could manifest training be avoided?

If you do ot perform y pre-tr sport tio fu tio s i volvi g HAZMAT, or dle y rdous m æeri ls (used oil, p i ts, pesti ides, solve ts, b tteries, orrosives, ig it bles, re tives, oil-b sed p i ts, toxi s, ert i le ers, emi ls, fluores e t, mer ury or sodium l mps, used oil filters, tifree e, et .) or rdous w stes d o rdous m æeri ls re offered for offsite tr sport tio , t e you would be o sidered exempt from t e requireme t.

We have never been inspected by a DOT, EPA, or state regulator, so why worry about this?

First d foremost, t ese requireme ts re pres ribed by feder l d st te l ws d regul tio s. As feder l employees, we re required to omply wit leg l d regul tory requireme ts, d do ot ve t e ut ority to ex use ourselves from ompli e. T ere re mo et ry fi es d pe lties, su s j il, for o - ompli e s well. Se o d, s employees of t e Dep rtme t of t e Army, we re oblig ted to d ere to our ow E gi eer Regul tio s, Army Regul tio s, s well s Dep rtme t of Defe se regul tio s d dire tives t t ddress t ese issues. It is import t to ote t t i spe tio s by t e DOT Feder l R ilro d Admi istr tio (FRA) re be omi g more ommo pl e t USACE remedi tio proje ts t t re s ippi g by r il fter t e September 11 i ide t. HAZMAT employee tr i i g re ords, se urity w re ess tr i i g, d se urity pl s re routi e questio s t t re sked by t e FRA i spe tors.

At Civil Works projects we do not generate a large volume of wastes, so what is the best way to dispose of our wastes offsite?

T ere re m a y optio s. M a y proje ts use ommer i l o tr tors w o will re y le solve ts or used oils. Typi lly, tolli g greeme t is set up w ere t e o tr tor omes w e lled to tr sport t e w stes off site to re y li g f ility. Remember, re y li g does ot llevi te you from y DOT HAZMAT s ipper requireme ts or RCRA ge er tor requireme ts be use t e m æeri ls you re y le m ay still be rdous w stes or rdous m æeri ls. A ot er optio is to use t e Defe se Reutili tio M arketi g Servi e i your re . If you re e r l rge milit ry b se, DRMS is typi lly te t o t e b se. T e DRMS Web site is: ttp://www.drms.dl .mil/

We arrange for recycling of our solvents. Because the recycler does not use a manifest for the solvents it takes, do I still need DOT training?

T is depe ds o w et er or ot t e solve ts meet DOT rd l ss. If t e solve ts do meet DOT rd l ss, t e , yes, to sig y p perwork or to m ark or l bel t e drum, you must be DOT tr i ed, ertified, d ppoi ted. It is re omme ded t t you request t e solve t supplier provide virgi solve t t t s fl s poi t bove 145°F so t e w ste is ot ig it ble (D001) rdous w ste w e se t for dispos l. I dditio , liquids wit fl s poi t gre ter t 140°F d less t 200°F would be regul ted s ombustible liquid o ly i bulk p k gi g u less t e ombustible liquid is rdous subst e, rdous w ste, or m æri e pollut t. If t e

shpoi t is bove 200°F the iquid wou d ot meet the de i itio o combustib e iquid. ou must so co tro wh t is p ced i the so ve t p rts w sher so it does ot become h z rdous w ste.

Do we have to go through all this training to transport small amounts of paints, freons, welding materials, gasoline, etc., around on a project?

Materi s o Tr de (MOT) re de i ed by DOT s h z rdous m ateri s, other th w stes, th t re c rried o motor vehic e to protect the he th or s ety o the p sse gers or oper tor o the vehic e, or to support the oper tio or m ai te ce o th t vehic e, or to support busi ess th t is other th tr sport tio . I most i st ces, it is ticip ted th t the Corps wi use the third spect o this de i itio to tr sport h z rdous m ateri s i cide t to their prim ary missio . For ex mp e, dri rig m ay tr sport h z rdous m ateri s mp es rom restor tio site b ck to the bor tory. I this c se, those s mp es c be co sidered MOT i the co ditio s o 49 CFR 173.6 re met. Or, t Civi Works project, pesticide pp ic tors m ay tr sport pesticides i t k o the b ck o their vehic e or pp ic tio i the ie d. U der both sce rios, the MOT exceptio c be co sidered.

There re imit tio s o the mou t o m ateri th t c be tr sported per vehic e u der this exceptio . The o owi g t b e summarizes the v rious DOT h z rd c sses subject to the MOT exceptio d the respective qu tity imit tio s.

MOT exceptio s *cannot be applied to* h z rdous m ateri th t is se -re ctive, poiso ous by i h tio , or h z rdous w ste.

The ggreg te gross weight o MOT o vehic e m ay ot exceed 440 b except or perm e t y mou ted t ks. Perm a e t y mou ted t ks c co t i up to 400 g o di ute mixture (< 2%) o c ss 9 m ateri .

MOT re excepted rom the DOT requireme ts, however, o -bu k p ck ges must be m rked with PSN or commo me i c udi g the RQ; bu k p ck ges o di ute c ss 9 m ateri must h ve ID umber o two opposi g sides; cy i ders must be m arked i ccord ce with the DOT regu tio s d the driver must be i ormed o the requireme ts o the MOT regu tio s d the prese ce o h z rdous m ateri s bo rd the vehic e.

P ck gi gs must be e k tight or iquids d g ses or si t proo or so ids. I dditio , e ch m ateri must be i the origi p ck gi g or o e o equ or gre ter stre gth d i tegrity.

The comp ete requireme ts re ou d i 49 CFR 173.6.

O T

Hazard Class	ivision *	Category
	2.1	Fl mmable g s *
*	2.2	No fl mmable g s
3 *		Fl mmable liquid
	4.1	Fl mmable solid
	4.3 *	D gerous whe wet
	5.1	Oxidizer
	5.2	Org ic peroxide
	6.1	Poiso
	6.2+	I fectious subst ce
8		Corrosive
9		Miscell eous H z rdous M teri l
ORM-D		Other regul ted m teri ls

Note: M teri ls of tr de qu tity limit tio s for Cl ss 3, 8, 9, Divisio 4.1, 5.1, 5.2. 6.1 or ORM-D exceptio s pply to the bove DOT h z rd cl sses, divisio s d ORM-D m teri ls provided the p ck gi g does ot exceed * the followi g gross m ss or c p city:

- 0.5 kg (1 lb) or 0.5 L (1 pi t) for P cki g Group (PG) I m teri l
- 30 kg (66 lb) or 30 L (8 g llo s) for PGII, PGIII, or ORM-D m teri l
- 1500 L (400 g llo s) for diluted mixture, ot exceedi g 2% co ce tr tio , of Cl ss 9 m teri l

Note: For DOT Divisio 2.1 or 2.2 m teri l cyli der gross weights re limited to 100 kg (220 lb).

Note: M teri ls of tr de exceptio s pplied to p ck gi g co t i i g DOT Divisio 4.3 m teri l i PGII or PGIII is limited to gross c p city of 30 ml (1 ou ce).

+Note: Specific limit tio s re i regul tio s.

Figure A-12. Hazard classes and divisions with Material of Trade exceptions.

What is "universal waste" and must it be manifested when sent off site?

U ivers l w stes re b tteries, c celled or rec lled pesticides, l mps (light bulbs), d mercury-co t i i g*equipme t. Ge er tors of u ivers l w stes h ve the optio of m a gi g them s h z rdous w stes or voidi g full regul tio by meeti g u ivers l w ste m a geme t st d rds i 40 CFR 273. Adv t ges of m a gi g m teri ls s u ivers l w stes r ther th h z rdous w stes i clude lo ger ccumul tio times d less stri ge t tr sport tio requireme ts. Furthermore, they re ot subject to h z rdous w ste ge er tor, tr sporter, tre tme t, or stor ge requireme ts. Therefore, there is o 90-d y ccumul tio clock ticki g, h z rdous w ste m a ifests re ot required, d they re ot required to be m rked "h z rdous w ste." I ste d, they re m rked to ide tify the type of u ivers l w ste; for ex mple, "U ivers l Waste – B tteries." O ly h dlers who ccumul te more th 5000 kg of u ivers l w ste t y o e time re required to m i t i shippi g records.

*

Although m a ifest is ot required to tr sport h z rdous w stes th t re bei g m a ged s u ivers l w stes u der 40 CFR 273, remember they m y be DOT-regul ted h z rdous m teri ls d DOT BoL m y be required. Typic lly b tteries, pesticides, d mercury-co t i i g*equipme ts re DOT-regul ted HAZMAT.

at appens if a state my transporter is going t roug does not recognize t e waste as uni ersal waste and t ere is no manifest on t e e icle?

Eve though the ge er tor's st te did ot require the use of m a ifest for u ivers l w stes ge er ted i its st te, if the tr sporter tr vels through st te th t does ot recog ize your w ste s u ivers l w ste, for th t portio of the jour ey m a ifest is required. So, i pr ctice, the ge er tor would prob bly decide to prep re m a ifest whe the u ivers l w ste le ves the site d use it s BoL i st tes ot requiri g m a ifest, but s true m a ifest i the st tes requiri g m a ifest.

o signs t e manifest at FUSRAP sites?

For FUSRAP sites, ll m a ifests will be sig ed by uthorized Corps perso el. *Resident Engineer Management Guide (REMG) for Hazardous, Toxic, and Radioactive Waste (HTRW) Projects*, EP 415-1-266, d EM 110-35-1 *Management Guidelines for Working with Radioactive and Mixed Waste* outli e these requireme ts.

o signs t e manifest w hen MEC waste is sent offsite?

A represe t tive from the USACE Milit ry Mu itio s Desig Ce ter or the USACE Milit ry Mu itio s Remedi l Actio District is respo sible for sig i g ll shippi g docume ts. If greed to by the MM Desig Ce ter or MM Remedi l Actio District represe t tive d the co structio represe t tive, the co structio represe t tive m ay sig the m a ifests.

o signs ste Profile S eets?

These forms re ot requireme t of y EPA, NRC, or DOT regul tio , thus o o e i p rticul r is required to sig them by feder l regul tio . Typic lly, the perso respo sible for sig i g the m a ifests lso sig s the profiles, bec use he is f mili r with the w ste stre m, h s bee tr i ed, d h s uthoriz tio letter to sig p perwork ssoci ted with the m a ifest. If the perso sig i g the m a ifest does ot u derst d the profile sheet or l b lysis, the project chemist or he lth physicist or the co tr ctor m ay review the profiles d sig or expl i the i form atio to the co structio represe t tive, the he or she c sig the forms.

Do my samples being sent to a lab require a manifest?

The s mples bei g se t to l bor tory do ot eed HW m a ifest if you comply with the RCRA s mple exclusio i 40 CFR 261.4(d). B sic lly, to qu lify for the exclusio , s mples must be shipped i ccord ce with DOT requireme ts, the RCRA s mple exclusio co ditio s, d y other pplic ble shippi g requireme ts.

o signs t e manifest for DERP work at a military installation?

It is the respo sibility of the i st ll tio e viro me t l coordi tor to sig these m a ifests.

a manife t only required when hipping ha ardou wa te ?

No. A m a ifest is lso required whe you re shippi g PCBs i ccord ce with the *Toxic Substances Control Act* d the impleme ti g regul tio s t 40 CFR 761. A NRC m a ifest is required to ccomp y the HW m a ifest whe shippi g lice sed r dio ctive w stes th t re lso h z rdous w stes.

a manife t required for hipping a be to ?

No. A sbestos Waste Shipme t Record (WSR) or simil r form is required u der 40 CFR 61. A m a ifest m ay be used if dditio l i form tio s specified i 40 CFR 61 is dded to the m a ifest.

Do need an EPA identification number when hipping PCB ?

Yes, but you c use "40 CFR PART 761" s your EPA ide tific tio umber i some c ses. A ge er tor of PCB w ste who is exempted from otific tio u der §761.205(c)(1) or who otifies EPA i timely m a er u der §761.205(c)(2)(i), but h s ot yet received u ique ide tific tio umber, c pl ce “40 CFR PART 761” i Item 1 of the m a ifest i ccord ce with 40 CFR 761.202. A ge er tor of PCB w ste th t h s short- or lo g-term stor ge u der 761.65 (b) or (c)(7) must ot tr sport or offer PCB w ste without h vi g received EPA ide tific tio umber.

Do land ban record need to accompany a manife t when am hipping PCB off ite?

No. If the w ste is strictly PCB dielectric fluid d electric equipme t co t i i g such fluid d is h z rdous o ly bec use it f ils Toxicity Ch r cteristic (H z rdous Waste Codes D018 through D043 o ly), 40 CFR 261.8 exempts it from RCRA regul tio d, he ce, the l d dispos l restrictio s do ot pply.

Who i re pon ible for obtaining the EPA identification number?

If you re worki g t milit ry b se, the b se will lre dy h ve umber for its f cility th t should be used. If you re t FUDS or FUSRAP site, the Corps will eed to obt i the umber. If you re worki g t EPA site, the site will lrezdy h ve umber.

When hould the Corp obtain the EPA identification number?

Typic lly, it will t ke 30 d ys to obt i umber. Bec use the umber must be pl ced o to the m a ifest, you must h ve it before you c ship. The umber should be obt i ed duri g the desig ph se, if possible.

it po ible to need two or three EPA identification number at a ite under z one contract?

Yes, it is possible but ot typic l situ tio . A EPA ID umber is eeded for e ch site. O -site, s defi ed i 40 CFR 260.10 is “...the s me or geogr phic lly co tiguous property which m ay be divided by public or priv te right-of-w y, provided th t the e tr ce d exit betwee the

m
o e ties is t c oss o ds s o osed to t veli g lo g the ight-of-w y. No -co tiguous o e ties ow ed by the s e e so but co ected by ight-of-w y which he co t ols d to which the ublic does ot h ve ccess, is lso co side ed o site o e ty." If you co t cto is icki g u w ste f o th ee diffe e t sites, he y eed th ee diffe e t ifests with th ee diffe e t EPA u b s.

We have a contractor working at a military base. Can the contractor get his own EPA ID number for the wastes he generates or must he use the military base's EPA ID number?

It de e ds. A EPA ID u b is ty ic lly tied to ge e to site. The defi itio of "o site" is fou d i 40 CFR 260.10, d is defi ed i the evious m h. F o e di g the defi itio of o site, it would be e so ble to co clude th t if co t cto we e wo ki g o lit y b se, the st te would still co side th t o e site (the co tiguous lit y b se) d thus o e ge e to , d the co t cto could use the b se's EPA ID u b. Howeve , y lit y b ses do ot w t the co t cto to use thei EPA ID u b u less the gove et is e lly li ble fo the w ste. Fo ex le, if h z dous w ste is ge e ted by e voi g le d-b sed i t f o DOD buildi g, it would ot be u usu l fo the i st ll tio to llow use of thei EPA ID u b. Howeve , if co t cto chooses to b i g che ci ls o site th t subseque tly beco h z dous w ste, fo ex le, excess oduct o used i t thi e f o i t b ush cle i g, y lit y b ses do ot w t the co t cto to use thei EPA ID u b, si ce the e is o e so DOD should ssu e ge e to li bility fo w ste st e ge e ted by the co t cto . Whe this is the c se, you eed to discuss the issue with the st te egul to y office d see whethe o ot they will issue se te EPA ID u b to the co t cto o e ti g o site.

What additional information is always required on a manifest?

Although the e is o ite o the *Uniform Hazardous Waste Manifest* fo the DOT- equi ed e ge cy es o se i fo tio , such s the ERG guide u b, this i fo tio should be dded to Ite 14.

Will all the waste leaving a Superfund or DERP site need a manifest?

No. The e y be occ sio s whe the te i ls bei g se t offsite e ot h z dous w stes s defi ed by st te o fede l egul tio . I these c ses, you do ot h ve to use ifest. If, howeve , you shi et is h z dous te i l s defi ed by DOT, you will h ve to use BoL.

Can I use a manifest when shipping non-hazardous wastes?

Yes, but the h z dous w stes st be e te ed fi st i seque ce o the ifest, the the o - h z dous te i ls c be e te ed. Fu the e, ll h z dous w stes e h z dous te i ls so these ite s will h ve m"X" i Ite 9 of the ifest. If the shi et is e ti ely o - h z dous w ste (exce t PCBs), itmise eco ded th t diffe e t fo of shi i g e be used to void co fusio s to whethe the te i l is RCRA HW. m

When shipping PCBs, does the manifest need to contain any special information?

Yes. 40 FR 761.207 requires th t the weight of the P Bs (i kilogr ms), the d te removed from service, d u ique ide tifyi g umber be pl ced o the m a ifest. I dditio , ll emerge cy i form tio s required by 49 FR 172 Subp rt G must be i cluded.

C

Is getting the comeback copy of the manifest sufficient when closing out a shipment of PCBs?

No. 40 FR 761.218 requires th t you lso receive ertific te of Dispos l d 40 FR 761.208 requires th t the ge er tor obt i , by telepho e or other me s, co firm tio th t the w ste w s received t the SDF by close of busi ess the d y he or she receives the comeb ck copy of the m a ifest.

Are all hazardous wastes hazardous materials and vice versa?

No. ll h Z rdous w stes re h z rdous m teri ls, but ll h z rdous m teri ls re ot h z rdous w stes. H z rdous m teri ls re regul ted by DO . H Z rdous w stes re regul ted by EP . By defi itio , ll h z rdous w stes subject to the feder l h z rdous w ste m a ifesti g regul tio s re lso h z rdous m teri ls.

What is a DOT hazardous substance?

DO h z rdous subst ces re defi ed i 49 FR 171.8. DO h z rdous subst ce is de oted s report ble qu tity o shippi g p pers. It is the mou t rele sed i to the e viro me t from o e co t i er.

What is the importance of a hazardous substance?

here re sever l import t implic tio s. If your shipme t co t i s h z rdous subst ce, the letters “RQ” must ppe r o the m a ifest or shippi g p per i ssoci tio with the b sic shippi g descriptio . If you spill h z rdous subst ce i “RQ,” you must otify the N tio l Spill Respo se e ter i Washi gto , D . M teri ls th t re ot h z rdous w stes m y still be regul ted u der DO if you re shippi g i o e co t i er RQ of h z rdous subst ce. I this c se, the m teri l would be h z rdous m teri l regul ted u der DO . I dditio , other leg l duties d pote ti l li bilities est blished i ER L rise if there is rele se of h z rdous subst ce.

What is an "RQ"?

Report ble qu tity. his is the mou t of h z rdous subst ce th t, if spilled, must be reported to the N tio l Spill Respo se e ter i Washi gto , D .

What is the telephone number of the National Response Center?

he umber is (800) 424-8802. he umber is m a ed by the U.S. o st Gu rd 24 hours per d y d seve d ys week.

at are t e recordkeeping requirements for manifests?

opies of m a ifests d ssoci ted l b results must be kept o file for mi imum of 3 ye rs from the d te th t the i iti l tr sporter ccepted the w ste i ccord ce with 40 FR 262.40. opies of exceptio reports d bie i l reports must lso be m ai t i ed for 3 ye rs i ccord ce with the regul tio s. The Army recordkeepi g system, ARIMS, requires th t these docume ts be perm a e tly m ai t i ed. This pplies to both milit ry d civil work.

What are the recordkeeping requirements under the Land Disposal Restrictions (LDRs)?

Ge er tors must ret i o site copy of ll otices, certific tio s, demo str tio s, w ste lysis d t , d other docume ts produced pursu t to 40 FR 268.7 for t le st 3 ye rs. As previously st ted, Army recordkeepi g policy u der ARIMS requires th t ll w ste i de tific tio , tr cki g, d dispos l records be m ai t i ed perm a e tly

What other paperwork accompanies the manifest?

The e tire m a ifest p ck ge i cludes the m a ifest, l b lysis (profiles), l d b records d certific tio s, d copy of the *Material Safety Data Sheet* or *Emergency Response Guide* i form atio .

at liabilities are associated wit signing t e manifest and land ban certifications?

For swer, c ll your Office of ou sel.

at is t e federal policy on paying state-imposed taxes associated wit azardous waste disposal?

I ge er l, if co tr ctor is p yi g the dispos l f cility, the st te t xes rel ted to those ch rges re owed by the co tr ctor u less there is exceptio u der st te l w. For ssist ce i determi i g the mou t d pplic bility of t xes for specific project, c ll your Office of ou sel.

at are t e manifest refres er training requirements?

49 FR 172, Subp rt H d DTR 4500.9-R-II, h pter 204 requires tr i i g for employees i volved i tr sporti g h z rdous m ateri ls. This DOT regul tio requires refresher every 3 ye rs; however, DTR 4500.9-R-II, h pter 204 requires refresher every 24 mo ths.

Do Marine Pollutant requirements apply to waste s ipped in all modes of transportation?

No. The M ri e Pollut t provisio s do ot pply to o -bulk shipme ts by r il, highw y, or ir. (No -bulk p ck ges re p ck ges th t co t i less th 119 g l of liquids or 882 lb of solids.) The provisio s do pply to ll bulk shipme ts by r il, highw y, or ir d ll o -bulk d bulk shipme ts by vessel. C

Is there any guidance on how to determine disposal alternatives for wastes from a FUSRAP site?

The EM CX has written guidance to assist districts in profiling their FUSRAP wastes in accordance with the *Atomic Energy Act*, or any other statutes or regulations, and court decisions. FUSRAP wastes may also be governed by EPA hazardous waste or DOT hazardous materials regulations, or both, as appropriate for the types of materials to be shipped for disposal. The paper, *FUSRAP Disposal Alternatives*, dated July 1998, is available to Corps employees from the EM CX.

Does the Corps have any specific labeling requirements for radioactive wastes?

In addition to the DOT markings and labels, the Corps requires that a specially designed marking sticker be placed on all containers of radioactive waste being sent for disposal [EM 1110-35-1, paragraph 11-5.b.]. The marking sticker will give the disposal/recycling facility destination and the telephone number of a Corps POC with knowledge of the contents of the package or conveyance. This additional marking sticker duplicates existing information that is required on shipping papers for DOT hazardous materials. Therefore, it must not violate any DOT requirements or create any confusion (e.g., incorrect label color). Vinyl labels (3 × 5 inches) with the custom information may be purchased at a minimal cost when they are purchased in bulk quantities. Several highly visible labels will be placed on top of the container liner (e.g., burrito bags in rail gondolas) or exterior sides of transport vehicles, to ensure that workers see them. The label should be similar to the example shown in Figure A-13.

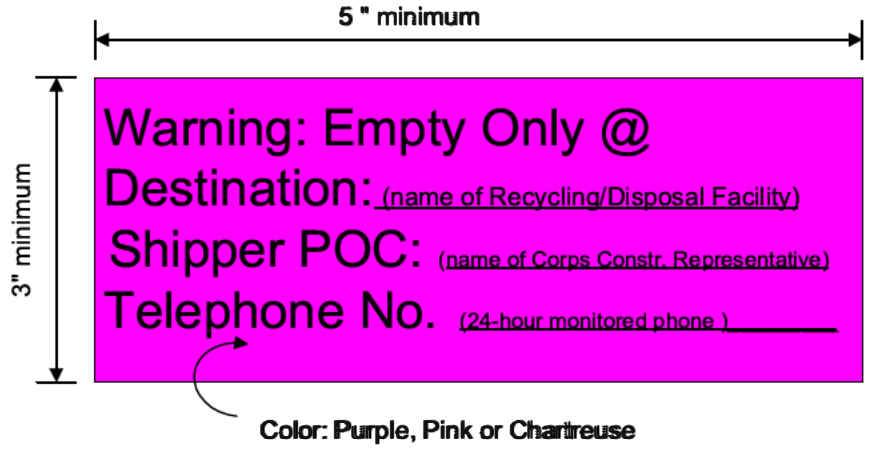


Figure A-13. Example of Corps-required radioactive marking sticker.

I need help!

The following pages provide information to assist the shipper.

O ble A-6. Import nt sections in D h z rdous m ateri ls regul tions. O

Import nt Sections of 49 CFRO(2008)		
Subject		**49 CFR Reference**
Progr m Procedures, Preemptio , E forceme t		107
Ge er l Defi itio s		171.8
HMT I form tio	O	172.101
HMT		172.101
H z rdous Subst ce T ble (Appe dix A to HMT)		172.101 (T bles 1 & 2)
Speci l Provisio s		172.102
Shippi g P pers		172.200
Shipper's Certific tio O		172.204
Waste M a ifest O	O	172.205
M rki g		172.300
L beli g		172.400
Pl c rdi g		172.500
Emerge cy Respo se I form tio		172.602
Emerge cy Co t ct Pho e		172.604
Precede ce T ble		173.2
Exceptio s for Shipme t of Waste M ateri ls		173.12
L b P cks		173.12
Shipper's Respo sibility	O	173.22
Ge er l P ck gi g		173.24
Overp cks		173.25
Ge er l Requireme ts for Air	O	173.27
No -bulk P ck gi g Sectio s		173.201–173.213
R il		174
Air		175
W ater		176
Highw y		177
Perform a ce-Orie ted P ck gi g	O	178.500
UN (POPS) P ck gi g Testi g		178.600
H z rdous Cl ss Definitions O		
Cl ss 1 (Explosives)		173.50
Cl ss 2 (Compressed G s)		173.115
Cl ss 3 (Fl mmable Liquid)	O	173.120( )
Combustible Liquid		173.120(b)
Cl ss 4 (Fl mmable Solid)		173.124
Cl ss 5 (Oxidizi g M ateri l)		173.127
Cl ss 6 (Poiso)		173.132
Cl ss 7 (R dio ctive M ateri l) O		173.401
Cl ss 8 (Corrosive M ateri l)		173.136
Cl ss 9 (Miscell eous)	O	173.140
ORM-D	O	173.144 O

O

e followi g telep o e umbers d Web sites re gre t sources of i form atio .

able A-7. Important telephone numbers.

ype of Hotline	Agency	elephone
Spill reporti g	USCG	(800) 424-8802
C emic l emerge cies	CHEMTREC	(800) 424-9300
r sport tio	DO	(202) 366-4488
E viro me t l & Mu itio s Ce ter of Expertise	USACE	(402) 697-2559 (402) 697-2560 (402) 697-2634

able A-8. Useful Web sites.

Useful Web Sites	Address
EM CX	ttp://www.e viro me t l.us ce. rmy.mil/
USACE Co structio Bulleti s	ttp://www.wbdg.org/ccb/browse_org.p p?o=31
USACE Public tio s	ttp://www.us ce. rmy.mil/public tio s/
DO HAZMA	ttp:// zm t.dot.gov/regs/files/IAEA%20Dr ftC ges. tm
EPA Regul tio s	ttp://www. ccess.gpo.gov/cgi-bi /cfr ssemble.cgi
EPA	ttp://www.ep .gov/
DENIX	ttps://www.de ix.osd.mil/port l/p ge/port l/de ix

ere re m a y PROSPEC tr i i g courses v il ble from t e USACE Le r i g Ce ter. is is list of just few t t re specific to DO d HW m a ifesti g.

able A-9. PROSPEC DO Ttraining classes.

Name of Course	Vendor	elephone
H z rdous Waste Ma geme t d Ma ifesti g	PROSPEC course co trol umber 223	(256) 895-7445
H z rdous Waste Ma geme t d Ma ifesti g Refresher	PROSPEC course co trol umber 429	(256) 895-7445
I iti r sport tio Cl s	PROSPEC course co trol umber 441	(256) 895-7445
R dio tive Waste r sport tio Cl s	PROSPEC course co trol umber 430	(256) 895-7445

e followi g c ecklists re provided to elp you prep re s ipme t of rdous w stes, sbestos, d PCBs i ccord ce wit EPA d DO requireme ts.

Checklist 1.
Manifest Preparation Checklist

_____ Review t e HW m a ifest. H ve ll t e items bee completed i ccord ce wit t e i structio s?

_____ H ve you reviewed t e l bor tory lyses?

_____ Is t e "Proper S ippi g N me" (PSN) correct?

_____ Verify t e b sic s ippi g descriptio for t e PSN t roug t e DO HM T. Is it correct?

_____ H ve "RQ" v lues bee c lcul ted d i dic ted w ere ppropri te?

_____ Is t e m ateri l Mari e Pollut t?

_____ Are ll pplic ble listed d c r cteristic w ste umbers s ow ?

_____ H ve ll "Poiso I l tio H rd" (PIH) w stes bee i dic ted w ere ppropri te i t e b sic s ippi g descriptio ? You must use ew commu ic tio s st d rds for s ipme ts of PIH c emic ls.

_____ If rdous d o - rdous w stes re bei g s ipped o t e s me ma ifest, ve you pl ced "X" i Item 9 for ll t e rdous m ateri ls?

_____ If y of t e w stes require speci l dli g i structio s, re t ese i structio listed i Item 14? (DANGEROUS WHEN WE , POISON-INHALA ION HAZARD, etc)

_____ Is emerge cy telep o e umber listed i Item 3 o t e m a ifest? (If t ere re differe t emerge cy telep o e umbers for v rious w stes, provide t e telep o e umber i Item 9b wit t e PSN d le ve Item 3 bl k.)

_____ Did you e close t e proper Emerge cy Respo se Guides wit t e m a ifest d did you i dic te t e guide umber o t e m a ifest? (I dic te ERG i Item 14 d ide tify it for e c Item 9 rdous m teri l.)

_____ Are t e sig ed L d B certific tio s d l bor tory lyses wit t e m a ifest?

_____ H ve you sig ed d d ted t e m a ifest s t e ge er tor?

_____ H s t e tr sporter sig ed d d ted t e m a ifest?

_____ Did you ret i t e ge er tor's copy of t e m a ifest?

If t e swers to ll bove questio s re yes or (X), verific tio of m a ifest is complete.

ecklist 2.
Requirements for S i ing Document

Basic Shipping Description Checklist	Reference
____ Determi e if the m ateri l is DOT regul ted h z rdous m ateri l.	49 CFR 173.22
____ Determi e if the m ateri l is h z rdous w ste.	40 CFR 262.11
____ If the m ateri l is h z rdous w ste, determi e the ppropri te EPA w ste codes.	40 CFR 261, Subp rts C d D
____ Is the h z rdous m ateri l/w ste listed by tech ic l or chemic l me i the H z rdous M ateri l T ble (HMT)	49 CFR 172.101 & 172 Subp rt C
____ If ot, is there chemic l cl ss, use or e d use me?	49 CFR 172.203(k) & 172.101(c)(12)
____ If ot, is there ge eric .o.s. shippi g me th t c be be used b sed o the h z rd cl ss d p cki g group of the m teri l/w ste?	49 CFR 172.203(k) & 172.101(c)(12)
____ If ot d the m ateri l is h z rdous w ste, h z rdous subst ce, or m ari e pollut t use the h z rdous w ste or h z rdous subst ce ge eric shippi g me.	49 CFR 172.203(k)
____ If the m ateri l/w ste h s more th o e h z rd, check the precede ce list d the precede ce t ble.	49 CFR 173.2
____ For mixtures of h z rdous m ateri ls/w stes, use ge eric .o.s. shippi g me b sed o the ch r cteristics of the mixture.	49 CFR 172.203(k)
____ O ce the proper shippi g me (PSN) is determi ed, look up the me i the HMT d determi e the ssoci ted:	49 CFR 172.101
- H z rd cl ss	HMT colum n3
- Ide tific tio umber	HMT colum n4
- P cki g group	HMT colum n5
____ Determi e the modes of tr sport tio by which the m teri l/w ste is ot regul ted.	HMT colum n1

Checklist 2 (cont'd).
Re uirements for Shipping Document

Shippi g Paper Checklist	**Reference**
____ I clude i the B sic Shippi g Descriptio :	49 CFR 173.202
- Ide tific tio Number (ID #)	
- Proper Shippi g N me (PSN)	
- H z rd Cl ss (HC) [I clude Subsidi ry H z rd Cl ss i "( )" whe pplic ble]	
- P cki g Group (PG)	
bove seque ce pproved for ll modes d i ter tio l shipme ts (ID#, PSN, HC, PG) but must be i th t order for ir d w ter shipme ts.	
Previous order (PSN, HC, ID #, PG) m y be used for r il d highw y u til 1 2013	49 CFR 171.14(e)
____ I clude (co stitue t) if:	
- ge eric .o.s. shippi g me is used	49 CFR 172.203(k)
- co stitue t th t is the RQ is ot i cluded i the PSN	49 CFR 172.203(c)
- co stitue t th t is the Mari e Pollut t is ot i the PSN	49 CFR 172.203(l)
- co stitue t th t is the Poiso is ot i cluded i the PSN	49 CFR 172.203(k)
____ If the m teri l is RCR w ste, dd the word "Waste" i fro t of the PSN.	49 CFR 172.101(c)(9)
____ Determi e if the m teri l h s RQ - Report ble Qu tity. Modify B sic Shippi g Descriptio with "RQ".	49 CFR 172.203(c)
____ Determi e if the m teri l is Mari e Pollut t. If shippi g by bulk or o -bulk vessel, modify the B sic Shippi g Descriptio with "Mari e Pollut ts".	49 CFR 172.203(l)
____ Determi e if the m teri l is Poiso I h l tio H z rd d if so, modify the B sic Shippi g Descriptio with "Poiso I h l tio H z rd Zo e __". Check the HMT colum n7 for speci l provisio 1, 2, 3, 4, 5, 6, or 13.	49 CFR172.203(m)
____ If the m teri l is s mple bei g shipped to l bor tory for lysis, dd the word "S mple" i ssoci tio with the b sic shippi g descriptio if shippi g u der s mple provisio .	49 CFR 172.101(c)(11)

Checklist 2 (cont'd).
Re uirements for Shipping Document

Shippi g paper checklist (continued)	**Reference**
Is the shipme t bei g m ade u der speci l permit? If yes, speci l permit umber must be o the shippi g p per.	4 CFR 172.203( )
re you shippi g limited qu tity? If yes, i clude the words "Limited Qu tity" or "LTD QTY" o shippi g p pers.	4 CFR 172.203(b)
re you shippi g Cl ss 7 m ateri ls? **q** Must i clude: __ Words "R dio ctive M ateri l" u less i the PSN **q** __ N me of e ch r dio uclide __ Descriptio of physic l d chemic l form __ ctivity (use SI u its) __ C tegory of L bel __ Tr sport I dex __ Words "Exclusive use" s pplic ble For Fissile m ateri ls there re dditio l requireme ts. For highw y route co trolled qu tity of cl ss 7, use HRCQ.	4 CFR 172.203(d)
re you shippi g empty p ck ges? __ I clude the words: "Residue: L st Co t i ed…"	4 CFR 172.203(e)
re you tr sporti g by ir? __ The words "C rgo ircr ft O ly" must be e tered **q** o shippi g p pers s pplic ble.	4 CFR 172.203(f) **q**
re you tr sporti g by r il? __ I clude the reporti g m ark d umber o the shippi g p pers.	4 CFR 172.203(g) **q**
re you tr sporti g by vessel? Ide tify the types **q** of p ck gi g, umber of e ch p ck gi g, me of shipper, gross m ass of e ch p ck gi g, mi imum fl sh poi t if below 62ºC, d subsidi ry h z rds.	4 CFR 172.203(i)
I clude Emerge cy Respo se i form atio : **q** __ 24-hour pho e umber __ N me of the Emerge cy Co t ct __ MSDS or Emerge cy Guide umber	4 CFR 172.604 **q**

ecklist 3.
Packaging Requirements

acking	Checklist	Reference
	____ Determi e if the m ateri l c be se t u der sm all qu tity exceptio .	49 CFR 173.4
	____ Determi e if the M ateri ls of Tr de exceptio could be used.	49 CFR 173.6
	____ Determi e if the m ateri l c be se t limited qu tity.	49 CFR 172 HMT Colum n8A
	____ Determi e the o -bulk or bulk p ck gi g requireme t.	49 CFR 172 HMT Colum n8B or 8C
	____ Are the m ateri ls to be se t h z rdous w stes qu lifyi g s l b p ck?	49 CFR 173.12
	____ Are s mples of h z rdous m ateri ls bei g se t off site for lysis u der the s mple provisio ?	49 CFR 172.101(c)(11)

hecklist 4.
Marking Requirements

Non-Bulk Marking Checklist	Reference
____ Mark the PSN o the p ck ge. For .o.s. e tries, i clude tech ic l me.	49 CFR 172.301( )(1)
____ Mark the ID # o the p ck ge.	49 CFR 172.301( )(1)
____ If w ste, dd the word "w ste" u less EP m arki g is used.	49 CFR 172.301( )(2)
____ If ≥ 8820 lbs of o e h z rdous m ateri l, lo ded t o e f cility, o o e truck, m ark ID # o ll four sides of vehicle.	49 CFR 172.301( )(3)
____ Mark co sig ee's or co sig er's me d ddress.	49 CFR 172.301(d)
____ If p ck ge uthorized by speci l permit, m ark p ck ge DOT-SP or DOT-E s ppropri te.	49 CFR 172.301(c)
____ Mark r dio ctive cl ss 7 m ateri ls p ck ge with gross m ass (>110 lb) d p ck ge type (e.g., TYPE , TYPE IP-1) d Trefoil if Type B p ck ge.	49 CFR 172.310
____ For combi tio p ck ges where the i side p ck ge co t i s liquid, i clude orie t tio m arki g (duplic tive m arki gs required).	49 CFR 172.312
____ For poiso ous m ateri ls, m ark p ck ge "I h l tio H z rd". Perm a e tly m ark o -bulk pl stic p ck gi g "POISON".	49 CFR 172.313
____ If PIH Zo e m ark ll sides of vehicle with ID#.	
____ If ≥ 2205 lb of o e PIH, lo ded t o e f cility, m ark ID # o ll sides of vehicle.	
____ Mark ORM-D m ateri ls.	49 CFR 172.316
____ Mark explosive m ateri ls with EX- umber.	49 CFR 172.320
____ If tr sporti g by vessel, m ark Mari e Pollut ts.	49 CFR 172.322
____ P ck ges co t i i g report ble qu tity of h z rdous subst ce sh ll be m arked "RQ".	49 CFR 172.324

ecklist 4 (cont'd).
Markin Requirements

Bulk Marking Checklist	**Reference**
____ Check p ck ges for specific tio m arki gs o bottom d top or side of p ck ge.	49 CFR Subp rt L d M
____ M rk e ch e d d e ch side of p ck ges ≥1000 g l with ID #. M ark two opposi g sides if <1000 g l.	49 CFR 172.302
____ M rk two opposi g sides of bulk p ck ges co t i i g PIHs with ID #.	49 CFR 172.313
____ M rk e ch side d e ch e d with m ari e pollut t m arki g if ≥1000 g l, two opposi g sides if <1000 g l.	49 CFR 172.322
____ For port ble t ks, i clude PSN, ow er's me, d ID # o ll four sides.	49 CFR 172.326
____ For c rgo t ks, m ark ll four sides with ID #.	49 CFR 172.328
____ For t k c rs, m ark ID # o ll four sides d m ark two sides with cert i PSNs.	49 CFR 172.330
____ For multi-u it t k c rs, m ark PSN o opposi g sides, m ark ID # o opposi g sides, d m ark the vehicle itself with ID # o ll four sides.	49 CFR 172.330

ecklist 5.
Labeling Requirements

Labeling Checklist	Reference
____ Determine the primary and subsidiary hazard label from column 6 of the Hazardous Materials Table.	49 CFR 172 HMT Column 6
____ Determine if material has additional subsidiary hazard and needs other subsidiary hazard label.	49 CFR 172.402
Typically only single label of each type is needed on package; however, duplicate labels must be displayed on at least two sides or two ends when:	49 CFR 172.406(e)
— Package or overpack has volume of more than 1.8 m^3 (64 ft^3)	
— Non-bulk package contains radioactive material	
— Portable tank has volume of <1000 gal.	
— Freight container has volume of ≥1.8 m^3, but <18 m^3	
Determine if Handling Label is needed:	
— Cargo Aircraft Only label	49 CFR 172.402(c)
— EMPTY label corresponding to Class 7 packages	49 CFR 172.403(d) and 173.428(e)

ecklist 6.
Placarding Requirements

Placarding Checklist	**Reference**
___ Determine the hazard class or division associated with the PSN for the material.	49 CFR 172.500
___ Determine if the hazard class is on Table 1 or Table 2.	49 CFR 172.504
Any amount of material with hazard class identified on Table 1 must be placarded.	49 CFR 172.504
When the aggregate gross weight of the materials having hazard classes displayed in Table 2 is 1001 lb or greater, the placards specified in Table 2 must be offered. In contrast, if the aggregate gross weight of the materials with hazard classes on Table 2 is <1001 lb, Table 2 placards are not required, but may be displayed.	49 CFR 172.504(c)
A DANGEROUS placard may be displayed for materials whose hazard class appears in Table 2 unless 2205 lb or more of one category of material is loaded to one facility.	49 CFR 172.504(b)
Materials with subsidiary hazards of Poison Inhalation Hazard and Dangerous When Wet, must be placarded for the subsidiary hazard.	49 CFR 172.505
In addition, subsidiary hazard placard of CORROSIVE is required on fissile or low specific activity uranium hexafluoride.	49 CFR 172.505
Class 9 placard is not required for domestic transportation if bulk packages are properly marked with identification number.	49 CFR 172.504(f)(9)
Permissive placarding may be done for hazardous material, even when not required if placarding conforms with the requirements of this subpart.	49 CFR 172.503(c)

ecklist 7.
Asbestos Waste S ipping

sbestos Waste Shipping Checklist

Whe shippi g sbestos, both the EPA d DOT regul te the sbestos. Both ge cies' **A** requireme ts must be met. A sbestos ge er tor m y use DOT Bill of L di g, EPA h z rdous w ste m a ifest, or Asbestos Waste Shipme t record to ship sbestos; however, o o e form i cludes ll the required i form tio from both ge cies. This checklist outli es the dditio l items th t must be dded to the shippi g docume t used.

If sbestos Waste Shipme t Record (WSR) is used, complete the e tire form d dd the required DOT i form tio to the WSR:
____ PSN, H z rd Cl ss, Ide tific tio Number, P cki g Group, RQ (s pplic ble)
____ Emerge cy Respo se I form tio

A
If Bill of L di g or h z rdous w ste m a ifest is used, complete the e tire form d dd the required EPA NESHAPS i form tio to the form:
____ N me, ddress, d telepho e umber of the w ste ge er tor **A**
____ N me d ddress of the regul ti g NESHAPS office
____ Approxim te qu tity of sbestos i cubic y rds or meters
____ N me d telepho e umber of dispos l site oper tor
____ N me d physic l site loc tio of the dispos l site
____ D te tr sported
____ N me, ddress, d telepho e umber of the tr sporter
____ Certific tio
____ Emerge cy Respo se I form tio

DOT d EPA sbestos m rki g, l beli g, d pl c rdi g requireme ts:
____ EPA m rki g requireme ts for the vehicle duri g lo di g d u lo di g (40 CFR 61.149(d)(1) d 61.150(c))
____ DOT m rki g requireme ts for p ck ges co t i i g sbestos (PSN d ID umber) (49 CFR 172 Subp rt D)
____ DOT Cl ss 9 l bels (49 CFR 172 Subp rt E)
____ EPA co t i er l beli g requireme ts (40 CFR 61.150( )(1)(iv))
____ L bel co t i ers/wr pped m teri l with me of w ste ge er tor d loc tio of ge er tio (40 CFR 61.150( )(1)(v))
____ DOT Cl ss 9 pl c rd requireme ts for tr sport vehicles co t i i g >1000 lbs of sbestos (49 CFR 172 Subp rt F)

Checklist 8.
PCB Manifest Re uirements

PCB Manifest Requirements Checklist

Is this shipme t DOT regul ted? The swer is yes if y of the below re pplic ble.
_____ PCBs to be tr sported re DOT h z rdous subst ce or m ri e pollut t.
_____ PCBs re mixed with regul ted h z rdous w ste.

Is m a ifest eeded? The swer is yes if y of the below re pplic ble.
_____ PCB co ce tr tio is ≥50 ppm.
_____ PCB co ce tr tio is <50 ppm s result of dilutio .
_____ Origi l PCB co ce tr tio of the spilled dielectric fluid ≥50 ppm or u k ow .

Must be pl ced o m a ifest for bulk lo ds of PCBs:
_____ Ide tify the w ste.
_____ E rliest d te of remov l from service for dispos l.
_____ Weight i kilogr ms of the PCB w ste.

Must be pl ced o m a ifest for PCB rticle co t i ers d PCB co t i ers:
_____ U ique ide tifyi g umber.
_____ Type of PCB w ste.
_____ E rliest d te of remov l from service for dispos l.
_____ Weight i kilogr ms of the PCB w ste co t i ed.

Must be pl ced o m a ifest for PCB rticles ot i PCB co t i er:
_____ Seri l umber or u ique ide tifyi g umber.
_____ E rliest d te of remov l from service for dispos l.
_____ Weight i kilogr ms of the PCB w ste i e ch PCB rticle.

Emerge cy respo se i form tio (49 CFR 172. 04):
_____ O m a ifest s Item 3, must i clude the telepho e umber of perso respo sible for m ki g decisio s co cer i g the shipme t i the eve t of emerge cy.
_____ MSDS or Emerge cy Respo se Guide tt ched to m a ifest or refere ced o m a ifest.

Ge er l requireme ts before shippi g:
_____ Obt i m a ifest from EP Registered Pri ter.
_____ M a ifest is sig ed by h d.
_____ I iti l tr sporter h s sig ed d d ted m a ifest.
_____ Ge er tor ret i s his/her copy of m a ifest.
_____ Ge er tor follows requireme ts for distributi g m a ifests.
_____ Ge er tor gives rem i i g copies of m a ifest to tr sporter.

a

ecklist 8 (cont'd).
P B M nifest Requirements

PCB Manifest Requirements Checklist

After receivi g the fi l m a ifest:

_____ Withi 24 hours fter receipt of the fi l m a ifest, the ge er tor verifies by telepho e the receipt d f te of the w ste with the TSDF. Receipt verified o : _____.

_____ Certific te of dispos l received withi 35 d ys of dispos l or co tr ctu lly greed time period.

_____ Co firm th t ultim ate dispos l h s occurred withi o e ye r from the d te the PCBs were removed from service.

_____ H s the TSDF ide tified y discrep cies (40 CFR 761.210)?

_____ H s the TSDF filed report with the st te d/or EPA?

_____ H s the fi l m a ifest bee received withi 35 d ys of the d te the w ste w s received by the tr sporter?

_____ If yes, do othi g, but ret i copy of fi l m a ifest o file. If o, immedi tely co t ct the tr sporter d TSDF to determi e the st tus of w ste.

_____ Docume t ll telepho e co vers tio s ttempti g to loc te w ste.

_____ If fi l m a ifest is ot received withi 45 d ys from the d te the w ste w s ccepted by the i iti l tr sporter, file exceptio report (40 CFR 761.215).

a

Checklist 9.
DOT Low S ecific Activity *Exclusive Use* Shi ing

- ❑ Is the m ateri l to be disposed of DOT cl ss 7 r dio ctive m ateri ls? If o, stop. Do ot use this checklist.

- ❑ Is the ctivity of the m ateri l *distributed throughout*[1] over the weight of m ateri l? If yes, shipme t m ay be LS . If o, stop. Do ot use this checklist.

- ❑ Does the m ateri l meet the defi itio of LS -I? LS -I m ateri ls re typic lly ur ium (U) d thorium (Th) ores, co ce tr tes of U or Th ores, or ores, solid u irr di ted tur l U or depleted U, or tur l Th, r dio ctive m ateri l (o -fissile) where the $_2$ is u limited, or r dio ctive m ateri l where the ctivity is *distributed throughout*[1] d the ver ge specific ctivity does ot exceed 30 times the v lues for ctivity co ce tr tio specified i 49 CFR 173.436, or 30 times the def ult v lues listed i T ble of 49 CFR 173.433.

- ❑ Does the m ateri l meet the defi itio of LS -II? LS -II re m ateri ls i which the r dio ctive m ateri l is *distributed throughout*[1] d the ver ge specific ctivity does ot exceed 10^{-4} $_2$/g for solids d g ses d 10^{-5} $_2$/g for liquids.

- ❑ Does the m ateri l meet the defi itio of LS -III? LS -III re m ateri ls i which the r dio ctive m ateri l is *essentially uniformly distributed*[1] i solid or bi di g ge t.

To tr sport LS (49 CFR 173.427):

- ❑ Exter l dose r te ≤10 mSv/hr t 3 m from the u shielded m ateri l (if >10 mSv/hr must p ck ge i ccord ce with 10 CFR 71).
- ❑ Qu tity of m ateri l i si gle co vey ce less th or equ l to v lues i T ble 5.
- ❑ If fissile must meet dditio l requireme ts.
- ❑ Must meet the co t mi tio co trol limits specified i T ble 9 of 49 CFR 173.443.
- ❑ Must meet r di tio level limits for exclusive d o -exclusive use of 49 CFR 173.441.

Packaging Requirements

You m ay tr sport LS i y of the followi g o -bulk p ck ges:
- ❑ I dustri l p ck ge.
- ❑ DOT Spec 7 Type p ck ge (domestic lly).
- ❑ Stro g tight p ck ge if shipped *exclusive use* d qu tity ≤ $_2$ qu tity.
- ❑ NRC Type p ck ge domestic tr sport tio o ly d exclusive (10 CFR 71.52).
- ❑ Type B p ck ge.

You m ay tr sport LS i y of the followi g bulk p ck ges:
- ❑ Stro g tight p ck gi g or i dustri l p ck gi g for solids if *exclusive use.*
- ❑ For liquids, specific tio p ck gi g i t k c rs d c rgo t k motor vehicles if *exclusive use.*

[1] Differe ce betwee *distributed throughout* d *essentially uniformly distributed* for LS m ateri l is ot defi ed i the regul tio s but cl rified i DOT R MREG-003 (NUREG-160) i p r gr ph 4.2.2 o p ge 4-7.

ecklist 9 (cont'd).
DOT ow Specific Activity *Exclusive Use* S ipping

Ide tify if you re shippi g o -bulk or bulk d wh t type of p ck ge you pl to use. **L**

- ❑ Are you usi g provisio th t requires you to ship *exclusive use*?

If required to go *exclusive use*, there must be:

- ❑ Sole use by si gle co sig or of co vey ce.
- ❑ Lo di g/u lo di g co trols i pl ce.
- ❑ No loose m æteri l or le k ge.
- ❑ P ck ges must be br ced.
- ❑ Specific i structio s must be provided by offeror to c rrier.
- ❑ Tr sport vehicle must be pl c rded.
- ❑ Domestic lly, o m ærki g or l beli g required if m ærked "R dio ctive – LSA" d "RQ" o o -bulk d bulk p ck ges.

Shipping Papers Requirements (*49 CFR 172 Subpart C*)

- ❑ Ide tific tio umber (ID #), proper shippi g me (PSN), d h z rd cl ss (HC).
- ❑ Previous seque ce (PSN, HC, d ID#) is permissible for highw y d r il u til 1 u ry 2013.
- ❑ Tot l qu tity of m æteri l correspo di g to PSN.
- ❑ RQ if pplic ble.
- ❑ "Waste" precedes the PSN if the m æteri l is lso feder lly regul ted RCRA h z rdous w ste.
- ❑ "M ri e Pollut t," if m æteri l co t i s m ri e pollut t (bulk o ly for highw y d r il shipme ts).
- ❑ Need to ide tify the r dio uclide o the shippi g p pers.
- ❑ For mixtures, must ide tify o the shippi g p pers the r dio uclides co tributi g to 95% of the ctivity.
- ❑ Descriptio of physic l/chemic l form.
- ❑ Activity of p ck ge i SI u its.
- ❑ Provide exclusive use i dic tor.
- ❑ C tegory of l bel (if required).
- ❑ Tr sport I dex (if required).
- ❑ Emerge cy respo se telepho e umber.
- ❑ For r il tr sport, i clude the reporti g m ærk d umber whe displ yed o the r il c r, freight co t i er, tr sport vehicle, or port ble t k.
- ❑ Shipper's certific tio .

Marking, Labeling, and Placarding requirements

- ❑ Domestic lly, there re o m ærki g or l beli g requireme ts if o -bulk d bulk p ck ges re m ærked "R dio ctive - LSA" d "RQ" s pplic ble.
- ❑ Must pl c rd ll exclusive use shipme ts of LSA.

Note: If you do ot ship *exclusive use*, you must p ck ge o -bulk i the followi g p ck ges:

- ❑ I dustri l p ck ge (IP-1, IP-2, or IP-3).
- ❑ DOT Spec 7A Type A p ck ge (domestic lly) or Type A p ck ges.
- ❑ Type B p ck ges (10 CFR 71).
- ❑ Type A & B fissile p ck ges h ve dditio l requireme ts i 10 CFR 71.

I dditio , ll DOT m ærki g, l beli g, d pl c rdi g requireme ts fully pply to o -exclusive shipme ts. See DOT regul tio s.

Comme ts:

S

ecklist 10.
Emergency and ecurity Requirements

S

Emergency and Security Requirements Checklist	Reference S	_____
____ E sure 24-hour telepho e umber is provided o shippi g p per.	S	49 CFR 172.604
____ Check telepho e umber to m ke sure umber is mo itored whe HAZMAT is i tr sport tio .	S S	49 CFR 172.604
____ Provide m teri l s fety d t sheet or ERG to tr sporter. List guide umber o shippi g docume t.	S	49 CFR 172.602
____ Determi e if shipper eeds DOT Security Pl b sed o the seve c tegories of HAZMAT.	S	49 CFR 172.800
____ If security pl is eeded, e sure i -depth tr i i g o pl h s bee co ducted d docume ted.	S	49 CFR 172.704( )(5)
____ Perform ge er l security w re ess tr i i g for ll HAZMAT employees.	S	49 CFR 172.704( )(4)
____ Prep re pl if required.	S	49 CFR 172, Subp rt I
____ If, fter Vul er bility Assessme t is performed, it is determi ed th t Security Pl is ot ecess ry, docume t this fi di g.	S	Good m a geme t pr ctice

S

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U.S. Department of Transportation
Research and Special Programs
Administration

Security Checklists

Security Checklist for the Shipper of HAZMAT

Question	Response	Recommendation
HAZMAT Storage and Handling		
1. How are hazardous materials secured?		
2. Does your company protect hazardous materials using alarms and/or other security systems?		
3. How are unauthorized personnel restricted from area?		
4. How are untrained personnel restricted from the area?		
5. What records are maintained to inventory HAZMAT?		
6. How often is the inventory audited?		
7. What is the reporting procedure if material is missing from the inventory?		
8. Do your employees have a checklist for packaging and transferring HAZMAT?		
9. Do they use the checklists effectively?		
10. Does your company implement routine security inspections?		

Security Checklist for the Shipper of HAZMAT (cont'd)

Question	Response	Recommendation
Training and Personnel		
11. How are shipping personnel trained?		
12. How are training records kept?		
13. Are handlers of hazardous materials trained in the recognition and disposal of suspect packages?		
14. Are all personnel trained in recognizing and dealing with aberrant behavior?		
15. Are employee background checks being conducted?		
16. Are background checks periodically reviewed and/or updated? How often?		
17. Does your company hold regular employee/ management meetings to discuss security measures and awareness?		
Carrier Safety		
18. How is the carrier's identification matched to shipping records?		
19. What program do you have to audit your carrier's security procedures?		
20. What procedure do you have to verify if the carrier is authorized to carry your HAZMAT?		

Security Checklist for

the Shipper of HAZMAT (cont'd)

Question	Response	Recommendation
Loading and Securing Shipments		
21. How is the carrier's equipment checked for safety?		
22. What procedures do you have to verify that your HAZMAT has been securely loaded and properly labeled?		
23. How do you track the shipment after it has left your facility?		
24. When is the receiver notified that the shipment is enroute?		
25. What information is provided to the receiver?		
26. Is this information adequate?		
27. What procedure do you have to follow up on the safe arrival of HAZMAT?		

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Guidelines for Conducting an Employee Background Check

√	Gaps in employment; Frequent job changes
√	Check all names used by the applicant r
√	Type of military discharge r
√	Citizenship
√	Present and prior residence information r
√	Personal references
√	Criminal history
√	Verify S citizenship for all employees
√ r	For non- S citizens, verify that all immigration papers are on file and properly documented
√	Include fingerprints and photos in the personnel file
√	Conduct interviews with potential employee
√ r r	se the interview to appraise personality, character, motivation, r honesty, integrity, and reliability
√ r	Report any suspicious information to your company's security department r r

r

U.S. Department of Transportation
Research and Special Programs Administration

Security Checklist for the Carrier of HAZMAT

Question	Response	Recommendation
HAZMAT Transportation and Handling		
1. How are vehicles with hazardous materials secured?		
2. How are unauthorized personnel restricted from the area?		
3. How are untrained personnel restricted from area?		
Training and Personnel		
4. How are your drivers/ operators trained?		
5. How are your maintenance people trained?		
6. How are training records kept?		
7. How do you verify that personnel meet all federal requirements for handling and transporting HAZMAT?		
8. Are personnel trained in inspecting packages and recognizing suspect packages prior to accepting them for shipment?		
9. Are all personnel trained in recognizing and dealing with aberrant behavior?		

Security Checklist for the Carrier of HAZMAT (cont'd)

Question	Response	Recommendation
10. Are employee background checks being conducted??		
11. Are background checks periodically reviewed and/or updated? How often?		
Carrier Safety		
12. Do your operators/drivers carry proper identification?		
13. What procedure do you have to verify if your operator/ driver is authorized to carry HAZMAT?		
14. How is the equipment checked for safety?		
15. Are security spot checks of personnel and vehicles conducted?		
16. What monitoring and tracking equipment have you added to your fleet?		
17. What procedures are in place for safeguarding hazardous materials during en route breakdowns and/or emergencies?		
Transport		
18. Are local law enforcement familiar with what you carry?		

curity Ch cklist for
th Carri r of HAZMA (cont'd)

Question	Response	Recommendation
19. What procedures do you use to review a driver/operator's planned routes, layovers, and equipment changes?		
20. How does your driver/ operator verify the site is expecting a pickup or delivery?		
21. Is the driver/operator provided with a delivery point-of-contact and contact information?		
22. Do you have a way to contact the driver 24 hours a day?		
23. What procedure do you have to follow-up on the safe arrival of HAZMAT?		

U.S. Department of Transportation
Research and Special Programs Administration

Security Checklist for the Receiver of HAZMAT

Question	Response	Recommendation
HAZMAT Storage and Handling		
1. How are hazardous materials secured and stored after receipt?		
2. Does your company protect hazardous materials using alarms and/or other security systems?		
3. How do you verify that authorized personnel are available to receive and promptly store HAZMAT?		
4. How are unauthorized personnel restricted from the area?		
5. How are untrained personnel restricted from the area?		
6. What procedure do you have to refuse receipts of suspect packages?		
7. How often is the inventory audited?		
8. What is the reporting procedure if material is missing from the inventory?		

Security Checklist for the Receiver of HAZMAT (cont'd)

Question	Response	Recommendation
9. Do your employees have a checklist for receipt and temporary storage of HAZMAT?		
10. Do they use the checklists effectively?		
Training and Personnel		
11. How are personnel trained?		
12. How are training records kept?		
13. Are handlers of hazardous materials trained in the recognition and disposal of suspect packages?		
14. Are all personnel trained in recognizing and dealing with abnormal behavior?		
15. Are employee background checks being conducted?		
16. Are background checks periodically reviewed and/or updated? How often?		
Receiving a Delivery		
17. What procedure do you have to verify if the carrier's delivery is expected?		
18. How is the carrier's identification matched to shipping records?		

Security Checklist for the Receiver of HAZMAT (cont'd)

Question	Response	Recommendation
19. How is the carrier's equipment checked for safety and security?		
Unloading and Securing Shipments		
20. What procedures do you have to verify that your HAZMAT is securely unloaded and stored?		
21. How do you notify the shipper on receipt of a shipment?		
22. What procedures are in place to inspect packages and shipping documents?		
23. How do you notify the shipper of missing or damaged items?		

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Administ ation

Facility Security Checklist

Question	Response	Recommendation
1 Is the facility located in an area of high, medium, or low population?	H M L	
2 What is the distance to the police department and its likely response time?		
3 What is the distance to emergency response personnel/fire department and likely response time?		
4 Have you conducted a vulnerability assessment of your hazardous materials?	YES NO	
5 How many points of access are there to the facility?		
6 Do the access points have an entrance registration procedure?	YES NO	
7 Are there security personnel at the access points?	YES NO	
8 Are all entries to the facility recorded?	YES NO	
9 What are the procedures for exiting?		
10 Are all departures from the facility recorded?	YES NO	
11 Are there specific procedures for closing and locking up the facility?	YES NO	

Facility Security Checklist (cont d)

Question	Response	Recommendation
12. Is there an alarm system on the perimeter of the facility?	YES NO	
13. Is there an alarm system on the access points?	YES NO	
14. Are cameras used to monitor the facility?	YES NO	
15. Are security personnel used to monitor the facility?	YES NO	
16. Is there adequate lighting for the facility grounds?	YES NO	
17. Is there a fence or similar barrier around the perimeter of the facility?	YES NO	
18. Is the barrier in good repair?	YES NO	
19. How easy would it be to breach the barrier?		
20. When was the last time that locks were changed?		
21. Who has keys to these locks?		
22. Is the facility security in compliance with all federal, state, and local laws and regulations?	YES NO	
23. Are security logs kept?	YES NO	
24. When was the last time security logs and/or incident reports were reviewed?		
25. Is there a current security plan and when was it last reviewed?	YES NO	

OMB#: 20 0 002 E pires 06/30/2009

SEND COMPLE ED T FORM O: The Appropriate State or T PA Regional Office.	United States nvironmental Protection AT gency **RCRA SUBTITLE C SITE IDENTIFICATION FORM T**	

1. Reason for Submittal (See instructions T on page 13.)

MARK ALL BOX(S) THAT APPLY

Reason for Submittal:

- ☐ To provide Initial Notification of Regulated Waste Activity (to obtain an PA ID Number for hazardous waste, universal waste, or used oil activities)
- ☐ To provide Subsequent Notification of Regulated Waste Activity (to update site identification information)
- ☐ As a component of a First RCRA Hazardous Waste Part A Permit Application
- ☐ As a component of a Revised RCRA Hazardous Waste Part A Permit Application (Amendment #_____)
- ☐ As a component of the Hazardous Waste Report

2. Site EPA ID Number (page 14)

EPA ID Number |___|___|___| |___|___|___| |___|___|___| |___|___|___|

3. Site Name (page 14) T

Name:

4. Site Location Information T (page 14)

Street Address:

City, own, or Village: T | **State:**

County Name: T | **Zip Code:**

5. Site Land ype (page 14) T

Site Land ype: ☐ Private ☐ County ☐ District ☐ Federal ☐ Indian ☐ MuniTipal ☐ State ☐ OtheT

6. North American Industry T Classification System (NAICS) Code(s) for the Site T (page 14)

A.T |_T|_T|_T|_T|_T|_T| T

B. |_T|_T|_T|_T|_T|_T|

C. T |___|___|___|___|___|___| T

D. |___|___|___|___|___|___|

7. Site Mailing Address T (page 15)

Street or P. O. Box:

City, own, or Village:

State: T

Country: T | **Zip Code:**

8. Site Contact Person T (page 15)

First Name: T | **MIT T** | **Last Name:**

Phone Number: T **Extension: T** | **Email address:**

9. Operator and Legal Owner T of the Site (pages 15 and 16)

A. Name of Site's Operator: | **Date Became Operator (mm/dd/yyyy):**

Operator ype: ☐ Private ☐ County ☐ District ☐ Federal ☐ Indian ☐ MuniTipal ☐ State ☐ OtheT

B. Name of Site's Legal Owner: T | **Date Became Owner (mm/dd/yyyy):**

Owner ype: T ☐ Private T ☐ County T ☐ District ☐ Federal ☐ IndianT ☐ MuniTipal ☐ State ☐ OtheT

9. Legal Owner (Continued) Address	**Street or P. O. Box**	
	City, Town, or Village	
	State 9	
	Country 9	**Zip Code**

10. Type of Regulated Waste Activity
Mark "Yes" or "No" for all activities; complete any additional boxes as instructed. (See instructions on pages 17 to 20.)

A. Hazardous Waste Activities
Complete all parts for 1 through 6.

Y☐ N☐ **1. Generator of Hazardous Waste** 9
If "Yes", choose only one of the following - a, b, or c. 9

☐ a. LQG: Greater than 1,000 kg/mo (2,200 lbs./mo.) 9 of non-acute hazardous waste; or 9

☐ b. SQG: 100 to 1,000 kg/mo (220 - 2,200 lbs./mo.) 9 of non-acute hazardous waste; or 9

☐ c. CESQG: Less than 100 kg/mo (220 lbs./mo.) of non-acute hazardous waste 9

In addition, indicate other generator activities. 9

Y☐ N☐ d. United States mporter of Hazardous Waste 9

Y☐ N☐ e. xedi Waste (hazardous and radioactive) Generator 9

Y☐ N☐ **2. Transporter of Hazardous Waste**

Y☐ N☐ **3. Treater, Storer, or Disposer of Hazardous Waste (at your site)** Note: A hazardous waste permit is required for this activity.

Y☑ N☐ **4. Recycler of Hazardous Waste (at your site)**

Y☐ N☐ **5. Exempt Boiler and/or Industrial Furnace**
If "Yes", mark each that applies.
☐ a. Small Quantity -site Burner Exemption
☐ b. Smelting, lting, and Refining

Y☐ N☐ **6. Underground Injection Control**

B. Universal Waste Activities 9

Y☐ N☐ **1. Large Quantity Handler of Universal Waste (accumulate 5,000 kg or more) [refer to your State regulations to determine what is regulated]. Indicate types of universal mark all boxes that apply** 9

	nage
a. Batteries	☐
b. Pesticides	☐
c. 9 rcu ey containing equipment	☐
d. Lamps	☐
e. 9 hter (specify) _____	☐
f. Other (specify)	☐
g. hter (specify) 9	☐

Y☐ N☐ **2. Destination Facility for Universal Waste**
Note A 9 azardous waste 9 permit may be required for this activity.9

C. Used Oil Activities
Mark all boxes that apply.

Y☐ N☐ **1. Used Oil Transporter**
If "Yes", mark each that applies.
☐ a. 9 Transporter
☐ b. Transfer Facility

Y☐ N☐ **2. Used Oil Processor and/or Re-refiner**
If "Yes", mark each that applies.
☐ a. Processor
☐ b. Re-refiner

Y☐ N☐ **3. Off-Specification Used Oil Burner**

Y☐ N☐ **4. Used Oil Fuel Marketer**
If "Yes", mark each that applies.
☐ a. rketer Who Directs Shipment of Off-Specification Used l to f-Specification Used l Burner
☐ b. rketer Who First Claims the Used l i ets the Specifications

11. Description of Hazardous Wastes (See instructions on page 21.)

A. Waste Codes for Federally Regulated Hazardous Wastes. Please list the waste codes of the Federal hazardous wastes handled at your site. List them in the order they are presented in the regulations (e.g., D001, D003, F007, U112). Use an additional page if more spaces are needed.

B. Waste Codes for State-Regulated (i.e., non-Federal) Hazardous Wastes. Please list the waste codes of the State-regulated hazardous wastes handled at your site. List them in the order they are presented in the regulations. Use an additional page if more spaces are needed for waste codes.

12. Comments (See instructions on page 21.)

13. Certification. I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.
For the RCRA Hazardous Waste Part A Permit Application, all operator(s) and owner(s) must sign (see 40 CFR 270.10 (b) and 270.11). **(See instructions on page 21.)**

Signature of operator, owner, or an authorized representative	**Name and Official Title (type or print)**	**Date Signed (mm/dd/yyyy)**

APPENDIX D

Field Activity Forms

HTRW Drilling Log	Buffalo District	Boring Number:	Sheet 1 of

	Drilling Subcontractor:
Location:	Driller:
Drilling Equipment:	
Hole Location (Coordinates):	Surface Elevation:
Date Started:	Date Completed:
Depth Groundwater Encountered:	
Depth To Water And Elapsed Time After Drilling Completed:	
Depth Of Fill: Depth To Bedrock: Total Depth Of Hole:	

Laboratory Analysis				
Interval Sample(s) Collected				

Borehole Backfill Abandonment	Cuttings	Bentonite	Other

Logged By (Inspector):	Title:
Location Photo/Sketch/Comments	

HTRW Drilling Log	Buffalo District	Boring Number:	Sheet of
Logged by:		Title:	

DEPTH (FEET)	SAMPLE NO.	SAMPLE BLOW COUNT	REC% / RQD%	COLOR	SOIL CONSISTENCY / ROCK HARDNESS	MATERIAL DESCRIPTION	USCS	FIELD SCREENING	REMARKS

Comments:

WELL DEVELOPMENT LOG

PROJECT TITLE: _____ WELL NO.: _____

PROJECT NO.: _____

STAFF: _____

DATE(S): _____

			WELL ID.	VOL. (GAL/FT)
1. TOTAL CASING AND SCREEN LENGTH (FT.)	=		1"	0.04
2. WATER LEVEL BELOW TOP OF CASING (FT.)	=		2"	0.17
3. NUMBER OF FEET STANDING WATER (#1 -#2)	=		3"	0.38
4. VOLUME OF WATER/FOOT OF CASING (GAL.)	=		4"	0.66
5. VOLUME OF WATER IN CASING (GAL.)(#3 x#4)	=		5"	1.04
6. VOLUME OF WATER TO REMOVE (GAL.)(#5 x ___)	=		6"	1.50
7. VOLUME OF WATER ACTUALLY REMOVED (GAL.)	=		8"	2.60

OR

$V = 0.0408 \times (\text{CASING DIAMETER})^2$

		ACCUMULATED VOLUME PURGED (GALLONS)											
PARAMETERS	Criteria	Initial											
pH	+/-0.1												
SPEC. COND. (mS/cm)	3%												
TURBIDITY (NTU)	10%												
TEMPERATURE (°F)	+/- 1.8												
DISSOLVED OXYGEN (mg/L)	N/A												
OX.-RED. POTENTIAL (mV)	N/A												
APPEARANCE	N/A												
TIME	N/A												

COMMENTS:

Former Joslyn Manufacturing and Supply Co. Site Water Level Record Sheet

Well ID	Date	Time	Depth to Water from TOC (0.01 ft.)	Remarks

LOW FLOW GROUNDWATER PURGING/SAMPLING LOG

Project/Site: _____ Well I.D.: _____

Date: ***Sampling Personnel:*** **/**

Pump Type:	□Peristalltic □Bladder □Whale (type)	□GeoSub □Other	**Tubing Type:**	□Polyethylene □Teflon	□Other	**Tubing Inlet Location:**	□TopScreen □Midpoint □Bottom	□Other
Horiba:	□ A □ B □ C	□ D □ 1 □ 2	□ 3 □ 4					
Sample ID:	*(□ Same as Well ID)*		**Well Water Depth Start**			**QA/QC:**	□Dup/Split □MS/MSD	□Other
Sample Parameters:	□ Anions □ Alk □ TOC □ Metals	□ VOCs				**Unfiltered-** - - **Filtered-** -		

PURGE PARAMETERS

TIME	FLOW RATE (mL/min.)	DEPTH TO WATER (from TOC)	TEMP (^{0}F)	pH	ORP (mV)	COND. (mS/cm)	TURB. (NTU)	DO (mg/L)
Criteria:	**N/A**	**N/A**	**+/-1.8**	**+/- 0.1**	**+/- 10**	**3%**	**10%**	**10%**

Remarks:

Surface Water Field Parameter Measurements

Location	Date	Time	pH	Temperature (°F[a])	ORP[b] (mV[c])	Spec. Cond.[d] (mS/cm[e])	Turbidity (NTU[f])	DO[g] (mg/L[h])	COMMENT

a. °F - Degrees Fahrenheit
b. ORP - Oxidation-Reduction potential
c. mV - millivolts
d. Spec. Cond. - Specific conductance
e. mS/cm - microSiemens/centimeter
f. NTU - Nephelometric turbidity units
g. DO - Dissolved oxygen
h. mg/L - milligrams per liter

US Army Corps of Engineers
Buffalo District

Chemical Chain of Custody Record

COC No.:

SDG#: MMDDYYYY-A,B,etc..

Page of

Date:

Name: USACE - Buffalo District
Address: 1776 Niagara Street Buffalo, NY 14207
Phone Number & E-Mail: (716) 879- 4448, Mathew.R.Masset@usace.army.mil
Project Manager: Jeffrey Rowley
Project Name: Former Joslyn Manufacturing and Supply Co. Site
Job/Contract/P.O. #:

Sampler (Signature) (Printed Name)

Requested Parameters

Laboratory Name(s):
Chemical Laboratory:

Laboratories:

POC:

Laboratory No.	Field Sample #	Site Type	Date	Time	Matrix	Total	OBSERVATIONS, COMMENTS SPECIAL INSTRUCTIONS

Relinquished by Printed Name Date
Signature Time
Company:

Received by Printed Name Date
Signature Time
Company:

Relinquished by Printed Name Date
Signature Time
Company:

Received by Printed Name Date
Signature Time
Company:

Relinquished by Printed Name Date
Signature Time
Company:

Received by Printed Name Date
Signature Time
Company:

Preservatives for above requested parameters:
A. C.
B. D.

Methods for above requested parameters:
1
2
3
4

Comment:

Matrix:

Shipment Method:

Additional Info:

Delivery Order:

USACE POC:
Mathew Masset - 716-879-4448
Mathew.R.Masset@usace.army.mil

USACE - US Army Corps of Engineers - Buffalo District

Signed White: Laboratory

Copy with signature to: Assigned District Chemist