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June 29, 2016

U.S. Army Engineering & Support Center, Huntsville
Attn: Ms. Becky Terry, CEHNC-MM-DC
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Contract: Contract No. W912DY-10-D-0014
Task Order #0009

Subject: Final Landfill Areas 1 and 3 Remedial Investigation/ Feasibility Study Work Plan Former Lee Field Naval Air Station Green Cove Springs, Florida

Dear Ms. Terry:

Enclosed please find the electronic file for the Final Landfill Areas 1 and 3 Remedial Investigation/Feasibility Study Work Plan, Former Lee Field Naval Air Station, Green Cove Springs, Florida, for regulatory review. Copies have been forwarded as indicated on the enclosed distribution list. In addition, an electronic copy of the document will be placed on the Lee Field sharepoint site. If you have any questions concerning this document, please contact me at (865) 692-3585.

Sincerely,

Kenneth A. Cunningham, P.G.
Project Manager

Enclosures

Final Distribution List

U.S. Army Corps of Engineers, Jacksonville District Attn: Ms. Diana Martuscelli, Project Manager (PM) 701 San Marco Blvd Jacksonville, FL 32207	8 copies; 8 CDs (Including 2 copies for FDEP; 2 copies for CCP; 1 copy For The Colinas Group)
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U.S. Army Corps of Engineers
South Atlantic Division

FINAL
Landfill Areas 1 and 3
Remedial Investigation / Feasibility Study Work Plan
Former Lee Field Naval Air Station
Green Cove Springs, Florida

FUDS Project No. I04FL0085

In Support of
FUDS HTRW Program

Prepared for:
U.S. Army Corps of Engineers, Jacksonville District
701 San Marco Boulevard
Jacksonville, Florida 32207

Contract: W912DY-10-D-0014
Task Order: 0009

June 2016

Review Signature Page

Title. Final Landfill Areas 1 and 3 Remedial Investigation/Feasibility Study Work Plan, Former Lee Field Naval Air Station, Green Cove Springs, Florida, June 2016.

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List of Acronyms

ABS	absorption factor
AF	soil-to-skin adherence factor
ALM	Adult Lead Methodology
amsl	above mean sea level
APP	accident prevention plan
AR	analysis request
ARARs	applicable or relevant and appropriate requirements
BAF	bioaccumulation factor
BERA	baseline ecological risk assessment
bgs	below ground surface
BHHRA	baseline human health risk assessment
BSV	background screening value
CB&I	CB&I Federal Services LLC
CCP	Clay County Port, Inc.
°C	degrees Celsius
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm/hour	centimeters per hour
cm^2	square centimeter
COC	contaminant of concern
COPC	contaminant of potential concern
COPEC	contaminant of potential ecological concern
CQCR	contractor quality control report
CSEM	conceptual site exposure model
D&M	Dames & Moore, Inc.
DA	dose absorbed
DCE	dichloroethene
DDE	dichlorodiphenyldichloroethene
DFW	definable feature of work
DID	Data Item Description
DoD	U.S. Department of Defense
DPT	direct-push technology
Eco-SSL	ecological soil screening level
ECSM	ecological conceptual site model
EPA	U.S. Environmental Protection Agency

List of Acronyms (continued)

EPC	exposure-point concentration
ESV	ecological screening value
ET	exposure time
°F	degrees Fahrenheit
F.A.C.	Florida Administrative Code
FADL	field activity daily log
FDEP	Florida Department of Environmental Protection
FS	feasibility study
GCTL	groundwater cleanup target level
HI	hazard index
HQ	hazard quotient
IDW	investigation-derived waste
ILCR	incremental lifetime cancer risk
IRIS	Integrated Risk Information System
kg	kilogram
kg/mg	kilograms per milligram
K_p	permeability coefficient
L/cm^3	liters per cubic centimeter
L/day	liters per day
LANL	Los Alamos National Laboratory
LFNAS	former Lee Field Naval Air Station
LOAEL	lowest-observed-adverse-effects level
MDC	maximum detected concentration
m^3/day	cubic meters per day
m^3/hr	cubic meters per hour
m^3/kg	cubic meters per kilogram
µg/L	micrograms per liter
µg/m^3	micrograms per cubic meter
m^2	square meter
m^3	cubic meter
mg/cm^2	milligrams per square centimeter
mg/cm^2-event	milligrams per square centimeter per event
mg/day	milligrams per day
mg/kg	milligrams per kilogram

List of Acronyms (continued)

mg/kg-day	milligrams per kilograms per day
mg/L	milligrams per liter
mg/m^3	milligrams per cubic meter
mL	milliliter
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no-observed-adverse-effects level
NTU	nephelometric turbidity unit
OAE	oral absorption efficiency factor
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PEF	particulate emission factor
PID	photoionization detector
PPRTV	provisional peer-reviewed toxicity value
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
QSM	Quality Systems Manual
RfC	reference concentration
RfD	reference dose
RfD_i	inhalation reference dose
RI	remedial investigation
RME	reasonable maximum exposure
SCTL	soil cleanup target level
SF	slope factor
Shaw	Shaw Environmental, Inc.
SLERA	screening-level ecological risk assessment
SQAG	sediment quality assessment guidelines
SSHP	site safety and health plan
SSO	Site Safety Officer
SVOC	semivolatile organic compound
SWCTL	surface water cleanup target level
TCE	trichloroethene

List of Acronyms (continued)

TDS	total dissolved solids
TPMC	TerranearPMC, LLC
TRPH	total recoverable petroleum hydrocarbons
TRV	toxicity reference value
UCL	upper confidence limit on the arithmetic mean
UR	unit risk factor
USACE	U.S. Army Corps of Engineers
VOA	volatile organic analysis
VOC	volatile organic compound
WERS	Worldwide Environmental Remediation Services Contract
WRS	Wilcoxon Rank Sum
ZOD	Zone of Discharge

1.0 Introduction

The U.S. Army Corps of Engineers (USACE) has authorized CB&I Federal Services LLC (CB&I) to conduct a remedial investigation (RI) and feasibility study (FS) at the former Landfill Areas 1 and 3 within the former Lee Field Naval Air Station (LFNAS) (Figure 1-1), Green Cove Springs, Florida. The LFNAS is a formerly used defense site (FUDS) within the USACE Jacksonville, District; the designated FUDS property number is I04FL0085. The Army is the lead agent for the program which the USACE executes on behalf of the Army and the U.S. Department of Defense (DoD) following the requirements set forth in USACE Engineering Manual ER 200-3-1, FUDS Program Policy. The RI/FS for the former Landfill Area 1 and 3 will be conducted under Contract No. W912DY-10-D-0014, Task Order 0009, issued by the USACE to CB&I. This work plan was prepared in accordance with Data Item Description (DID) Worldwide Environmental Remediation Services (WERS)-001.01 and other applicable DIDs for sub plans, EM 1110-1-4009 as guidance, EM 385-1-1, EP 385-1-97, applicable Federal, State, or Army guidance and regulations, as appropriate. Government project management and technical oversight will be provided by the USACE.

1.1 Objective

The RI activities completed to date at Landfill Area 1 and Landfill Area 3 have described exceedances of applicable environmental threshold values in various environmental media, such as soil, sediments, surface water, and groundwater, within and proximal to sites. The objective of this RI/FS is to utilize the supplemental data set in combination with existing data to accurately delineate the chemical footprint of each landfill, update human health and ecological risk assessments, and to obtain sufficient data within the footprint of each landfill to define the nature and extent of Department of Defense (DoD) contaminants of concern (COC) exceedances and their potential for off-site migration. The existing and supplemental data sets will also support the FS, which will develop and evaluate appropriate remedial alternatives for residual contaminants in site media at Landfill Area 1 and Landfill Area 3.

1.2 Site Description

LFNAS occupies approximately 1,560 acres along the St. Johns River in Clay County, Florida, within the city of Green Cove Springs (Figure 1-1). The area known as Lee Field was initially developed by the DoD in 1940 and was used as a pilot training base during World War II. The installation contained extensive docking facilities (with access to the St. Johns River), a railroad system, multiple aircraft runways, and supporting structures. Following the war, the facility was used as a Naval Station to mothball shallow-draft fleet ships. In 1963, the ownership of Lee Field

was transferred from the DoD to the City of Green Cove Springs. Shortly thereafter, the City of Green Cove Springs began developing Lee Field into an industrial park property (Reynolds Industrial Park), and site development has continued. Businesses currently or formerly operating at Reynolds Industrial Park include a railroad refurbisher, a truck driver training school, an aircraft maintenance facility, a brake testing facility, a fiberglass pipe manufacturing facility, and an airstrip for small planes (USACE, 1999).

Climate. The climate in Clay County Florida is described as "moderate" by the U.S. Soil Conservation Service (U.S. Department of Agriculture [USDA], 1989). The summers are long, hot, and humid, and the winters are cool. The coolest month is January with a mean daily temperature of 53.2 degrees Fahrenheit (^{o}F), and the warmest is July with a mean daily temperature of 81.3 ^{o}F. The average annual rainfall is 53 inches, the majority of which falls from June through September. Tropical storms can affect the area from early June through mid-November, but hurricane-force winds are rare because of the county's inland location. However, the heavy rains associated with tropical systems can cause flooding in low-lying areas.

Topography. The LFNAS lies within the Eastern Valley of the Coastal Lowland Province in Northern Florida. The Eastern Valley physiographic region consists of mostly swamps and flatwoods (nearly level, poorly drained soils characterized by open woods of pine, saw palmetto, and pineland threeawn) (USDA, 1989) and ranges from 0 to 30 feet above mean sea level (msl) within Clay County. The Eastern Valley near the site grades into a broad, shallow regional valley approximately 15 to 20 miles wide, which slowly deepens northward until the St. Johns River drops to sea level (ESE, 1988). The Eastern Valley is bordered on the east by the Atlantic Coastal Ridge, which ranges from 25 to 30 feet above msl (ESE, 1988). West of the Eastern Valley is the Duval Upland, which ranges from 30 to 100 feet above msl.

The LFNAS facility is located on a series of beach ridge deposits associated with higher sea levels during the Late Pleistocene epoch. Topographic relief is low, with elevations gently decreasing northeastward toward the river. The central portions of the facility lie 20 to 25 feet above msl, while the northern portions of the site lie less than 10 feet above msl. The average elevation of Three Mile Swamp, located south of the facility is less than 10 feet above msl.

Geology. Eastern Clay County is characterized by poorly drained land consisting mostly of woods and swamps. The site lies within the Sapelo-Meadowbrook-Leon general soil map unit (USDA, 1989). These soils consist of nearly level, poorly drained soils that are sandy to depths of 40 to 79 inches below ground surface (bgs), and that are found in the flatwoods. Some are

characterized by loamy subsoil; some have sandy subsoil underlain by loamy subsoil; and others are sandy throughout, with subsoil coated with organic matter.

Soils of the southern and southwestern portions of the facility, including the landfill sites, consist of Leon fine sand, Osier fine sand, Allanton and Rutledge mucky fine sands (depressional), Goldhead fine sand, Plummer fine sand, and Meggett fine sandy loam (USDA, 1989). All of these soil units are described as nearly level and poorly drained.

Clay County is underlain by a thick sequence of sediment associated with the Atlantic Coastal Plain Province. Units underlying the area range in age from Recent to Jurassic and are more than 18,600 feet thick. Because of their occurrence at great depths, little is known about the Jurassic age rocks. The oldest rocks described as of 1986 are the Taylor and Navarro units of Late Cretaceous age. Taylor rocks consist of light gray chalk or argillaceous chalk with thin layers of dolomite. Navarro rocks consist of tan to white, soft, friable, limestone. These units are 200 to 1,300 feet thick, respectively. The top of the Navarro occurs at depths of approximately 2,000 to 2,500 feet bgs in Clay County (Miller, 1986).

The Cretaceous rocks are overlain by Tertiary Paleocene age carbonate-evaporite rocks. The primary unit of the Paleocene rocks is the Cedar Keys Formation. The lower two-thirds of the Cedar Keys consists of fine to microcrystalline dolomite with interbedded anhydrite. This lower unit comprises the lower confining unit of the Floridan Aquifer System. The upper part of the formation consists of coarsely crystalline dolomite. The Paleocene rocks are approximately 500 feet thick in the Clay County area (Miller, 1986).

Three rock units comprise Eocene age rocks in the vicinity of Clay County. The Oldsmar Formation of Early Eocene age overlies the Cedar Keys Formation. The Oldsmar is composed mostly of micritric to finely granular limestone with interbedded fine to medium crystalline dolomite. The Oldsmar Formation is overlain by the middle Eocene Avon Park Formation. This formation is a soft to well indurated, pelletal to locally micritic limestone. The limestone is thin to thickly interbedded, fine to medium crystalline, slightly vuggy dolomite. The Avon Park Formation is exposed at the surface in Citrus and Levy Counties, representing the oldest rock outcropping in Florida. The Avon Park Formation is overlain by the late Eocene Ocala Limestone. This unit consists of an upper soft, somewhat friable, porous coquina, and a lower soft to semi-indurated, fossiliferous limestone. The Ocala is one of the most permeable units within the Floridan Aquifer as a result of karst dissolution of the rock. The total thickness of the Eocene age rocks underlying Clay County is approximately 800 feet (Miller, 1986).

A thin unit of Oligocene age rock, the Suwannee Limestone, is shown in cross-section by Miller, (1986) to be present in Clay County. The Suwannee Limestone is described as consisting of two rock types: (1) crystalline, vuggy limestone and (2) finely pelletal limestone in a micritic to finely crystalline limestone matrix. This unit is 0 to 100 feet thick and forms the uppermost rock unit of the Floridan Aquifer.

The Miocene age Hawthorn Group overlies the Eocene and Oligocene rocks in the Clay County area. The Hawthorn in Clay County is composed of three formations: (1) the basal Penny Farms Formation, (2) the middle Marks Head Formation and, (3) the upper Coosawhatchie Formation. The group ranges from approximately 75 to 90 feet thick and forms the upper confining unit of the Floridan Aquifer System (Scott, 1988).

The Penny Farms Formation consists of a lower carbonate member and an upper siliciclastic member. The carbonate member is composed of variably sandy, phosphatic, clayey dolostones with interbedded sand and clay. The upper member of the Penny Farms Formation consists of olive gray, fine to coarse grained, variably phosphatic, dolomitic, silty, clayey sands and sandy clays with interbedded carbonates. The phosphate content can reach the point of being classified as a phosphorite sand (50 percent or greater phosphate grains).

The Marks Head Formation is the most complex in the Hawthorn Group. The Florida portion of the unit consists of interbedded sand, clay, and dolostone. The sands are light to dark gray, and generally fine to medium grained, dolomitic, silty, clayey, and phosphatic. The clays are greenish to olive gray, sandy, silty, dolomitic and phosphatic. The clay beds can comprise a large portion of the formation. The dolostone portions of the formation are yellowish to olive gray, micro to finely crystalline, sandy, phosphatic, and clayey.

The Coosawhatchie Formation is similar in lithology to the Marks Head, consisting of quartz sands, clays and dolostones. The sands are phosphatic with percentages of phosphate ranging from a trace to more than 20 percent. The Coosawhatchie sediments range from light gray to greenish and olive gray in color (Scott, 1988).

Overlying the Hawthorn Group is the late Tertiary age Cypresshead Formation. The Cypresshead Formation consists of fine to coarse quartz sand. The sand is moderate to well sorted and contains some quartz gravel. Clay is commonly present in minor amounts. Mica is common in minor percentages, especially in finer sands. The Cypresshead Formation is the oldest surficial unit in Clay County, outcropping in the central portion of the county (Scott, 1992).

Overlying the Cypresshead Formation in the western portion of Clay County is the Pleistocene age Trail Ridge sands. This beach ridge and dune deposit is comprised of fine to medium grained sands. Peat beds and pieces of wood are common. The Trail Ridge sands contain ore grade concentrations of heavy minerals (Scott, 1992).

The surficial unit in eastern Clay County consists of undifferentiated Quaternary sediments. These sediments are composed of sands, clayey sands, and clays occasionally containing limited numbers of mollusk shells. This package may contain reworked Cypresshead. Lowlands along the St. Johns River and tributaries are mapped as Holocene fluvial sediments. This alluvial deposit is composed of quartz sands, silt, clay, and marls (poorly consolidated, variably sandy, clayey, shelly carbonate sediments). Peat and other organic-rich sediments are often present. This unit is common below 10 feet above msl (Scott, 1992).

Hydrology. Clay County is underlain by a shallow unconfined and a deeper confined aquifer. The upper unconfined aquifer is contained in the Quaternary Cypresshead and recent undifferentiated sediments. The top of the shallow aquifer was encountered at depths ranging from less than 1 foot to approximately 6 feet bgs during Base-wide field activities at the LFNAS. The upper unconfined aquifer consists of approximately 75 feet of unconsolidated, undifferentiated sand, sandy clay, and shell material. Groundwater moves in this aquifer from high to low piezometric areas (under water table conditions), which generally coincides with the ground surface. Consequently, the groundwater in the unconfined aquifer generally flows toward the St. Johns River. However, due to the shallow depth to water locally and low topographic relief, frequent variations in the groundwater flow patterns are observed.

A hydrologic divide is apparently present in the west-central portion of the facility, northeast of Landfill Area 2. Groundwater flow north of the divide is to the north toward the St. Johns River. South of the divide, flow is south toward Three Mile Swamp and east toward the drainage ditch along the eastern boundary of the LFNAS. Hydraulic gradients across the facility range from 0.003 feet/foot to the north to 0.005 feet/foot to the southwest.

The clay-rich Hawthorn Group separates the surficial aquifer from the deeper, confined Floridan Aquifer. The Hawthorn functions as the upper confining layer for the Floridan Aquifer, although the Hawthorn also has permeable zones that yield substantial quantities of water. These zones are usually in the Lower Hawthorn and are often included as part of the Floridan Aquifer System (Miller, 1986).

The Floridan Aquifer System is defined by Miller (1986) as a vertically continuous sequence of carbonates rocks of generally high permeability that are mostly of middle to late Tertiary age.

The rock units within the system are hydraulically connected in varying degrees and the permeability is one to several orders of magnitude greater than the upper and lower bounding (confining) units of the system. The Floridan Aquifer is divided into an upper and lower unit by a middle, discontinuous, confining to semi-confining unit. The main part of the Floridan Aquifer consists of middle to late Eocene, highly porous and permeable carbonate rocks capable of producing large quantities of water. The Floridan Aquifer consists of the following formations from oldest to youngest: the Eocene age Lake City Limestone, Avon Park Limestone, Ocala Group Limestone, and the lower permeable zones of the Miocene age Hawthorne Group. Groundwater flow in the Floridan Aquifer in the vicinity of the LFNAS is regionally from west to east (ESE, 1988).

Drainage. The St. Johns River flows northward along the eastern boundary of Clay County. Its entire reach along the county is tidally influenced, and the river stage rises and falls with each change of tide (USDA, 1989). Tides on the St. Johns River fluctuate approximately 1 foot from low to high. During times of severe storms, such as nor'easters or hurricanes, rises in ocean level can cause a significant rise in river levels and cause reverse flow in the St. Johns River as far south as Lake St. George (SJRWMD, 2000). The mean water level of the river is at sea level.

Several drainage ditches are present at the LFNAS site; some drain into the surrounding swamps and others drain into the St. Johns River. Three Mile Swamp is located in the southern portion of the facility. The area is a mature cypress swamp with an average surface elevation of less than 9 feet above msl. The water level of the swamp fluctuates, but averages 9 to 10 feet above msl based on staff gauge measurements at Landfill Area 1. The large drainage ditch located along the eastern boundary of the LFNAS was a pre-existing creek that was the discharge outlet for Three Mile Swamp prior to development of the Base.

1.2.1 Landfill Area 1

Landfill Area 1 covers approximately 6.2 acres of land near the southeastern corner of the LFNAS property. Today, the site is an inactive, heavily vegetated parcel bordered to the north by Wildwood Road and a drainage swale paralleling the road; to the south and east by a cypress wetland area (Three Mile Swamp); and to the west by a low, flat, wooded area that contains standing water during the rainy season and connects with Three Mile Swamp (Figure 1-2).

Currently, the landfill is completely covered with vegetation of different types. The surface of the eastern one-half to two-thirds of the landfill is generally mounded with abundant debris approximately 8 to 15 feet above the surrounding topography. In this portion of the landfill, the

debris is generally covered with a thin layer of soil, which supports mostly grasses, scrub vegetation, and few trees. Various types of debris, such as fiberglass pipes, concrete, and brush/timber piles, are present on the surface or are visible through the soil cover. There is a leveled and clear-cut open area of approximately ¼ acre in the northeastern portion of the site. This area has previously been used for temporary storage of local law enforcement equipment such as service patrol vehicles. This area was re-graded in 2010 by the property owner (Clay County Ports, Inc. [CCP]) to allow for further use of the site as a temporary storage location (no new fill material was utilized for the regrading). However, the site is currently not utilized by local law enforcement. The eastern edge of the landfill slopes downward to the east and south toward the wetland area, which is dominated by cypress trees and low vegetation common to wetlands in the southeastern U.S. The eastern portion of the landfill contains debris such as concrete culverts, drummed materials, and (reportedly) power poles.

The southwestern area of the landfill is low and relatively flat as the ground surface slopes downward to the east and south from the high central portion of the landfill. The southeastern and southwestern edges of the landfill are covered mostly with grasses and low vegetation common near wetland areas. The south-central part of the landfill is densely vegetated with cypress trees and vines. The central and west-central portions of the landfill are dominated by thick vegetation such as trees, brush, and scrub and are essentially inaccessible by foot and most equipment. Mounded debris is common here, including concrete, fiberglass materials, rusted drums (some labeled “acetone”), and other miscellaneous debris. The western portion of the landfill is fairly flat and contains a dense canopy of trees, but it is accessible. Surface debris is common here, especially to the south. The northern edge of the landfill slopes downward to the north from the center to Wildwood Road. Most of the debris observed at the surface is known to be related to post-DoD activities.

Historical LFNAS records indicate that activity at the area known as “Landfill Area 1” was initiated in 1947 to reportedly store compost and creosote-treated power poles and materials removed from the mothballed ship fleet that could not be incinerated were dumped at this area during the years when the Navy operated the base. Post-DOD activity at the landfill was documented by aerial photographs from approximately 1971 through 1990. During that time period, the width of LF1 was expanded to encompass part of the surrounding wetland area. No landfill activity is now occurring at this site.

Topography and Drainage. The topography of Landfill Area 1 varies depending upon location. The eastern and southern edges and western portion of the landfill are relatively flat, with little relief. Just inside the eastern and southeastern boundaries, debris is mounded

approximately 10 feet higher than the surrounding land surface for a distance of approximately 100 feet. The landfill surface slopes upward as you traverse toward the center. The maximum relief is approximately 12 feet from the top of the landfill to the surrounding wetland areas. The elevation of the site averages approximately 10 feet above msl, with a high elevation of approximately 20 feet above msl.

Drainage for Landfill Area 1 occurs in a radial pattern away from the high central part of the landfill. Three Mile Swamp accepts runoff from the southern, eastern, and to a lesser extent, the western portions of the landfill. Due to the relief of the site, rainwater generally does not pond on the surface. The exception is the western portion of the landfill which collects water during heavy rain events. During the wet season, the western part of the landfill contains standing water that often merges with Three Mile Swamp. Runoff flowing north from the top of the landfill drains into the drainage ditch located just north of Wildwood Road. The drainage swale and portion of Three Mile Swamp that borders the landfill generally contain water for approximately 8 months of the year.

Geology. The subsurface geology was determined by the installation of piezometers, monitoring wells, and lithologic borings. A total of six monitoring wells (5 shallow and 1 deep) were installed at the site during the RI field work. Soil borings were drilled to a maximum depth of 40 feet bgs adjacent to each piezometer location to determine the subsurface lithology and determine if a continuous confining unit was present beneath the site. Lithologic information obtained during the drilling activities was used to construct cross-sections for the site.

All borings encountered undifferentiated sediments of sand, silty sand, clayey sand, and some clay. The different sediment types formed irregular and discontinuous lenses found at the perimeter of the landfill. Several borings such as LF1PZ06, LF1PZ05, and LF1PZ03 encountered clay layers; however, these units appear to represent discontinuous lenses. Therefore, there is no true confining unit present at depth. Sand zones were typically gray to brown to greenish-gray-colored, fine grained, and well sorted with mica or phosphate. Deep lithologic borings were drilled as close as possible to the edge of the landfill due to the uncertain nature of possible debris types. On the south and east sides of the landfill, borings had to be placed on the landfill due to the surrounding wetland area. Landfill material such as fiberglass, paper, and metal was encountered to depths of 6 to 8 feet bgs in borings located along the southern edge of the site (LF1MW04, -MW05, LF1DW01, and LF1PZ04.)

In the deep well, a surface casing was set at 20 feet in a clayey sand to reduce the possibility of cross contamination of the aquifer above and below the clay layer. This unit represents a

localized aquitard. Below 26 feet, alternating layers of sand and clayey sand units were encountered to the total depth of the deep well.

The grain size analysis of ten surface soil samples indicated that an average of 86.7 percent of soil collected was finer than 0.425 millimeter (mm) (#40 sieve) and 23.4 percent was finer than 0.149 mm (#100 sieve). Therefore, the surface soil is predominantly a poorly sorted fine to medium grained sand, with a small percentage of coarse and very fine-grained sand.

Geotechnical parameters such as bulk soil density, total soil porosity, air-filled and water-filled porosity, particle density and fractional organic carbon were also reported for five vadose subsurface soil samples. In addition, two shallow and one deep saturated soil samples were analyzed for grain size, moisture, bulk density, porosity, and vertical conductivity.

Hydrology. Five new shallow wells and one deep well were installed in the vicinity of Landfill Area 1 during the RI. The five new shallow wells were screened from approximately 2 to 12 feet bgs. The pre-existing shallow wells are screened from approximately 4 to 14 feet bgs. The deep monitoring well is located adjacent to LF1MW04 and is screened from 24 to 29 feet bgs.

Groundwater in the upper portion of the aquifer is contained under water table conditions in undifferentiated sand, silt, and clayey sand layers. No horizontally continuous confining clay layer was encountered to 40 feet bgs to separate the surficial aquifer from lower water-bearing zones.

The water table at Landfill Area 1 has been encountered at approximate depths of 1 to 4 feet bgs during the previous drilling activities and subsequent water level monitoring events. As indicated from the water table elevations, groundwater generally flows away from the high central portion of the landfill in a radial pattern. The average gradient across the site is approximately 0.00111 feet/foot.

Aquifer testing in the form of slug tests were performed to determine hydraulic properties of the aquifer in the immediate vicinity of the test wells. Rising head slug tests were conducted in the two pre-existing 2-inch diameter monitoring wells (LF1W-6-86 and LF1W-7-86) in January 2001. At least two tests were run in each well for quality control (QC) purposes. Average conductivities of 1.02×10^{-3} feet/min and 9.78×10^{-4} feet/min were calculated for wells LF1W-6-86 and LF1W-7-86, respectively. A groundwater flow velocity of 0.008 feet/day or 2.9 feet/year was calculated based on an average hydraulic conductivity of 1.00×10^{-3} feet/min.

1.2.2 Landfill Area 3

Landfill Area 3 covers approximately 7.4 acres of land at the southern edge of the LFNAS property. The landfill is bounded on the north, west, and east by a thick cover of trees (Figure 1-3). Three Mile Swamp lies approximately 400 feet east and northeast of the landfill. The southern edge of Landfill Area 3 is bordered by a dirt access road that connects County Road 209 with Wildwood Road. The remnants of 6-inch-by-6-inch wooden posts from a previous boundary fence are located around the perimeter of the landfill.

Currently, the landfill is heavily wooded with trees and undergrowth. Prior to the end of 2001, the eastern edge of Landfill Area 3 was cleared of larger timber from the bend in the access road to the northeast. The removal of timber in these areas has provided more sunlight, which allowed the growth of grasses and thick scrub vegetation. Portions of the landfill where this has occurred are now nearly impenetrable, as is the northeast corner of the landfill where cutting debris has been piled.

Overall, the landfill area is relatively flat; however, three mounded areas are located within the estimated boundaries of Landfill Area 3. Two of the mounds are located near monitoring well LF3W-5-86. The third mound is located just west of well LF3MW04. The mounds are approximately 3 to 5 feet high, and their origin is unknown. Scattered debris, including bottles, cans, and miscellaneous metal items, is observed at the surface from the south-central portion of the landfill to the east and northeast. From the surface, there are no other indications that a landfill is present.

There are two small ponds on site, and a seasonably wet ditch area with intermittent standing water located approximately 120 feet southeast of the landfill boundary. These two ponds have a combined area of less than 0.1 acre.

Historical LFNAS records indicate that the area known as Landfill Area 3 was referred to as a “Sanitary Land Fill” on a map dated 1957. The area was reportedly used to dispose of domestic waste, refuse, and medical waste. No other details concerning historical use of the site were available. A review of historical aerial photographs first indicated landfill-related activity at Landfill Area 3 in 1951. Activity at the landfill continued through at least 1958. The next available aerial photo (1969) indicates some activity occurred between 1958 and 1969 on the northeast portion of the site, but it is unknown whether this activity occurred prior to the closure of LFNAS or post-DOD. No other activity was observed at Landfill Area 3 after approximately 1969. No landfill activity is now occurring at this site.

Topography and Drainage. The topography of Landfill Area 3 is relatively flat with a slight slope toward Three Mile Swamp to the east and northeast. The elevation of the site averages approximately 15 feet above msl. Three mounded areas are present in the central portion of the landfill and along the eastern boundary. These are isolated mounds that range in height from 3 to 6 feet above the surrounding ground surface.

Drainage for Landfill Area 3 is generally toward the east into Three Mile Swamp, which is the nearest downgradient receptor. Locally, water drains into the drainage swale/ditch and pond in the south-central portion of the landfill. The swale is generally dry except during the rainy season or during heavy rain events. The ponds on-site generally remain wet year round.

Geology. The subsurface geology was determined by the installation of piezometers, monitoring wells, and lithologic borings. All borings encountered undifferentiated sediments of sand, silty sand, clayey sand, and minor clay. The different sediment types formed irregular and discontinuous lenses found at the perimeter of the landfill. The predominant sediment type observed was a fine-medium grained, white to greenish gray to brown sand. The sand units ranged from poorly to well sorted. Minor lenses of silt and clay were encountered, but they were not continuous across the site. Deep lithologic borings were generally not drilled in the interior of the presumed landfill area due to the uncertain nature of possible debris types. Landfill material was encountered to a depth of approximately 6 feet bgs in LF3W-5-86.

The grain size analysis of ten surface soil samples indicated that 96.6 percent of soil collected was finer than 0.425 millimeter (mm) (#40 sieve) and 35.7 percent was finer than 0.149 mm (#100 sieve). Therefore, the surface soil is predominantly poorly sorted, fine-grained sand, with a small percentage of medium and very fine-grained sand and silt. The grain size of the shallow saturated zone was determined based on two soil samples collected from 6 to 10 feet bgs. The soil collected averaged 98.5 percent finer than a #40 sieve with only 25.4 percent finer than #100 indicating moderately sorted fine-grained sand. The saturated soil sample collected from 26 to 31 feet bgs in the aquifer is predominantly fine grained sand, but also has grain sizes ranging from medium to silt and is poorly sorted.

Hydrology. Six new shallow wells and two deep wells were installed in the vicinity of Landfill Area 3 during the RI. The six new shallow wells were screened from approximately 2 to 12 feet bgs. The pre-existing shallow wells are screened from approximately 9 to 19 feet (LF3W-4-86) and 5 to 15 feet (LF3W-5-86) bgs. Deep monitoring well LF3DW01 is located adjacent to LF3MW04 and is screened from 29 to 34 feet bgs. A second deep monitoring well was installed downgradient of the chlorinated solvent detection at the southeast corner of the landfill.

Groundwater in the upper portion of the aquifer is contained under water table conditions in undifferentiated sand, silt, and clayey sand layers. No clay confining unit is present in the upper 40 feet to separate the surficial aquifer from lower water-bearing zones.

The water table at Landfill Area 3 was encountered at approximate depths ranging from 1 to 4 feet bgs during previous drilling activities. Groundwater generally flows toward the east-northeast and the gradient across the site is approximately 0.00495 feet/foot.

Aquifer testing in the form of slug testing was performed to determine hydraulic properties of the shallow aquifer in the immediate vicinity of the test wells. Rising head slug tests were conducted in the two pre-existing 2-inch diameter monitoring wells (LFW-4-86 and LF3W-5-86) in January 2001. At least two tests were run in each well for QC purposes. Average conductivities of 3.04 X 10^{-5} feet/min and 3.82 X 10^{-4} feet/min were calculated for wells LFW3-4-86 and LF3W-5-86, respectively. A groundwater flow velocity of 0.004 feet/day or 1.4 feet/year was calculated based on average hydraulic conductivity of 2.06 x 10^{-4} feet/min.

A 100-min pumping and recovery test was conducted for deep well LF3DW01 to determine the characteristics of the deeper portion of the shallow aquifer. The average conductivity and transmissivity values for the drawdown and recovery test were 0.0026 feet/min and 8,976.5 gallons per day/foot.

The porosity of the shallow and deep saturated aquifer zones was measured in the laboratory from two undisturbed soil samples collected at 6 to 10 feet and one sample collected from 26 to 31 feet bgs. The total effective porosity measured ranges from 38.0 to 44.7 percent in the shallow zone and 41.8 percent in the deep saturated zone.

1.3 Summary of Previous Investigations at Landfill Area 1

There have been several investigations conducted in the past for Landfill Area 1. The first of these investigations were limited in scope and were conducted to determine if further investigation was warranted. Analytical tables from all previous investigations are included as Appendix A. Historical sampling locations are shown on Figure 1-2, except in those instances where the reports describing the findings of these investigations do not provide scaled drawings or survey coordinates for the soil samples.

1.3.1 Preliminary Assessments

The U.S. Environmental Protection Agency (EPA), Region IV conducted a site screening assessment at Landfill Area 1 in November 1985 (EPA, 1985). Samples of surface and subsurface soil, sediment, and surface water were collected in the vicinity of Landfill Area 1.

These data were subjected to only a limited quality assurance (QA) review and should be considered qualitative.

In November 1986, the Mobile District USACE installed two permanent monitoring wells outside the estimated boundaries of Landfill Area 1. Well W-6-86 (now LF1W-6-86) was placed northeast of Landfill Area 1 in what was believed to be a downgradient direction, based on the location of the St. Johns River. Well W-7-86 (now LF1W-7-86) was installed southwest of Landfill Area 1 in the assumed upgradient direction. (USACE,1986).

A preliminary investigation at the LFNAS was completed in September 1987 with the objective of determining the presence or absence of contaminants at multiple LFNAS sites (Environmental Science and Engineering [ESE], 1988). The investigation at Landfill Area 1 included the collection of groundwater samples from the two existing monitoring wells, the collection of two subsurface composite soil samples (LFSS6 and LFSS7) from within the estimated landfill boundaries, and the collection of three surface water samples (LFSW1, LFSW2, and LFSW3). Lead was detected at a concentration of 47 micrograms per liter (μg/L) in the groundwater sample collected from W-6-86 (LF1W-6-86). At that time, the groundwater standard for lead was 50 μg/L. The soil samples were collected from a depth of approximately 2 feet bgs to the shallow water table (approximately 3 feet bgs). Low concentrations of several metals, petroleum hydrocarbons, and bis(2-ethylhexyl)phthalate were detected in the two soil samples. Polychlorinated biphenyl (PCB) Aroclor 1260 (210 micrograms per kilogram [μg/kg]) was also detected in soil sample LFSS6. Silver was detected in surface water sample LFSW2 (25 μg/L) in excess of surface water standards.

Monitoring wells W-6-86 and W-7-86 (LF1 W-6-86 and LF1 W-7-86) were resampled in December 1991 (Dames and Moore [D&M], 1992). Barium was detected in the samples collected from both wells; lead was also detected in the sample collected from W-6-86. The concentrations detected did not exceed the Florida Groundwater Guidance Concentrations (FGGC) at that time.

Four soil samples were re-analyzed using a different digestion method in 1993 to determine if the metals concentrations reported as contamination in the LFNAS samples might be naturally occurring. An evaluation of the results found that the detected concentrations of metals in the samples were below regulatory limits and likely naturally occurring (Southern Chemists Laboratories [SCL], 1993).

1.3.2 Site Investigation

In 1998, the EPA oversaw a site investigation of several suspected waste disposal sites at the former Lee Field, including Landfill Area 1 (Black & Veatch, 2000). Samples of groundwater (RP-TW-03), surface soil (RP-SS-02 and -03), and subsurface soil (RP-SB-02 and -03), and sediment (RP-SD-02 and -03) were collected at Landfill Area 1 and analyzed for volatile organic compounds (VOC), semivolatile organic compounds (SVOC), metals, pesticides, PCBs, dioxins, and furans. The groundwater sample was collected from a temporary well placed on the western portion of Landfill Area 1, outside the burial area. This location coincided with surface and subsurface soil samples SS and SB-03. Soil samples SS and SB-02 were collected from approximately the east-central portion of the landfill burial area. Sediment samples SD-02 and SD-03 were collected from the western and eastern sides of Landfill Area 1, respectively. No compounds were detected above Federal Drinking Water Standards in the groundwater sample. Concentrations of PCBs in surface soil sample RP-SS-03 and both subsurface soil samples exceed residential soil cleanup target levels (SCTL). Sample RP-SB-02 also contains barium and lead concentrations exceeding the SCTLs. Concentrations of lead, zinc, and PCBs in sediment sample RP-SD-02 and nickel, zinc, and PCBs in sample RP-SD-03 exceed screening values. The sample locations shown on Figure 1-2 are approximate as no survey data was provided.

1.3.3 Remedial Investigations

A RI for Landfill Area 1 was conducted from September 2000 to October 2002 (Shaw Environmental, Inc. [Shaw], 2004a). The RI consisted of a historical records search, historical aerial photograph review, test pit excavations, piezometer and monitoring well installation, surface and subsurface soil sampling, sediment and surface water sampling, groundwater sample collection, comparison of Landfill Area 1 data to established LFNAS upper-bound background soil and groundwater concentrations (as described in *Final Installation-Wide Background Chemical Data Study Report, Former Lee Field Naval Air Station, Green Cove Springs, Florida, Revision 1* [Shaw, 2004b]), a complete statistical/geochemical evaluation of soil and groundwater with respect to LFNAS background, and completion of a baseline human health risk assessment (BHHRA) and screening-level ecological risk assessment (SLERA).

During the RI, four test pits were excavated on the western edge of the presumed landfill for boundary delineation purposes (Figure 1-2). In addition, 26 permanent barhole probes were installed around the perimeter of the landfill area and were monitored for landfill gas, with none detected. Surface emissions monitoring for methane was also conducted, with no detections.

Groundwater samples were collected by direct-push technology (DPT) from two approximate depths of 20 feet bgs and 40 feet bgs at six piezometer locations (Figure 1-2). Following installation of a downgradient deep well, conversion of one piezometer (LF1PZ02) located within the presumed landfill boundary to a permanent monitoring well, and installation of four shallow wells near the landfill perimeter, groundwater samples were collected from all existing wells. The direct-push results indicated that bis(2-ethylhexyl) phthalate and fluoranthene concentrations exceeded State of Florida groundwater cleanup target level (GCTL) in three locations located within the presumed landfill boundary, LF1PZ01 (10.5 µg/L), LF1PZ04 (10 µg/L), LF1PZ05 (6.6 J µg/L), and from one location outside the presumed landfill boundary, LF1PZ-06 (8.6 µg/L). Analysis of groundwater samples from the monitoring wells contained concentrations of vinyl chloride in the deep well (LF1DW01, 2.1 µg/L) and chlorobenzene in one shallow well (LF1MW02, 157 µg/L) at levels that exceeded their GCTLs of 1 and 100 micrograms per liter (µg/L), respectively. Total inorganics iron and manganese were detected exceeding GCTLs in all Landfill Area 1 wells (Shaw, 2004a).

Surface soil samples from within the landfill boundaries (Figure 1-2) contained various constituents at concentrations in excess of soil quality standards (Chapter 62-777, Florida Administrative Code [FAC]), including arsenic, PCBs, chromium, copper, lead, TRPH, polynuclear aromatic hydrocarbon (PAHs), and dieldrin. Surface soil samples were collected from 20 locations within and outside the presumed landfill boundary. Because the landfill is directly adjacent to Three Mile Swamp on the east and south sides, some of the soil samples planned for outside the landfill boundaries were collected from inside the landfill boundaries. The analytical results indicated the presence of five SVOCs, two PCB compounds, one pesticide, eight inorganics, and TRPH at concentrations exceeding background concentrations and residential soil cleanup target levels (SCTL) at 13 sample locations.

Subsurface soil samples were collected from locations coinciding with eight of the surface samples, outside or near the perimeter of the landfill boundary (Figure 1-2). The results indicate the presence of five SVOCs, one PCB compound, one pesticide, five inorganics, and TRPH at concentrations exceeding background and residential SCTLs at three locations. These locations are widely separated, but all occur in the south-central or southeast portion of Landfill Area 1.

Exceedances for inorganics were compared to background concentrations established during the background chemical data study (Shaw, 2004b). The data sets were subjected to statistical tests; if necessary, geochemical evaluations were performed to determine if the elevated inorganic concentrations in the site samples were naturally occurring. Site-to-background comparison for soil (surface and subsurface) indicated anomalously high concentrations of antimony in two site

samples, which may reflect contamination. Site-to-background comparison for sediment and surface water indicated that the inorganics detected in the Landfill Area 1 samples were either within the background range or naturally occurring. Arsenic, iron, and manganese concentrations in specific groundwater samples were elevated as a result of reductive dissolution as a secondary effect of the organic contamination. The zinc concentration in one groundwater sample was anomalously high and may contain a component of contamination (Shaw, 2004b).

The BHHRA identified antimony, PCBs, dieldrin, several PAHs, and TRPH as contaminants of potential concern (COPC) for surface soil at Landfill Area 1. The COPCs for total soil are similar to those for surface soil, except that PCB and PAH concentrations are higher in the subsurface soil. COCs identified in soil include the PAHs benzo(a)pyrene (BaP), benzo(a)anthracene, and dibenz(a,h)anthracene. Arsenic, iron, and BaP were selected as COPCs for the sediment. For surface water, only TRPH was selected as a COPC. The groundwater evaluation identified the following COPCs: iron, manganese, TRPH, and several VOCs. COCs for groundwater include several VOCs, TRPH, and manganese.

The SLERA identified 26 contaminants of potential ecological concern (COPEC) (14 inorganics, 4 PAHs, 6 pesticides, and 2 PCBs) for surface soil; 10 inorganic analytes were selected as COPECs for surface water and 7 COPECs (4 inorganic compounds, 1 pesticide, and 2 PCBs) for sediment. Based on the results of the SLERA, the following constituents and associated environmental media were found to warrant further investigation/evaluation to determine their potential ecological risk: surface soil (BaP, fluoranthene, phenanthrene, pyrene, dieldrin, Aroclor 1254, and Aroclor 1260) and sediment (DDE, Aroclor 1254, and Aroclor 1260). Inorganics identified as COPEC were determined to be naturally occurring and were excluded as a concern.

Additional groundwater samples were collected in January and July 2005 as part of two semiannual monitoring events at Landfill Area 1 (Shaw, 2005a). Vinyl chloride was again detected at deep well LF1DW01 (1.1 µg/L) above it's GCTL of 1.0 µg/L (Shaw, 2005b). Well LF1DW01 is located within the presumed footprint of the landfill boundary. Other compounds detected, but not in excess of GCTLs, were TRPH and cis-1,2-dichloroethene (DCE).

Four sediment samples and four surface water samples were collected adjacent to the landfill (Figure 1-2). Sediment samples were collected from three locations in the drainage swale north of Wildwood Road and from one location in the creek/wetland area east of Landfill Area 1. All four sediment samples contained concentrations of various constituents exceeding the sediment quality assessment guidelines. Exceedances included pesticides (4,4'-DDE) and PCBs (Aroclor 1254 and 1260), and three inorganics (copper, lead, and mercury). Elevated concentrations of

copper, lead, mercury, zinc, PCBs, and 4,4-dichlorodiphenyldichloroethene (DDE) were detected in one sediment sample.

Surface water samples were collocated with the sediment samples and analyzed for the same parameters. Concentrations of beryllium, mercury, silver, and thallium exceeding surface water standards were detected in the four surface water samples collected north and east of Landfill Area 1.

A supplemental RI was undertaken in 2013 TerranearPMC, LLC (TPMC) to address requirements for the potential close-out of Landfill Area 1 in accordance with the *Guidance for Disturbance and Use of Old Closed Landfills or Waste Disposal Areas in Florida, Version 2.1 Final* (FDEP, 2011) and groundwater Zone of Discharge (ZOD) requirements specified in Florida Administrative Code (F.A.C.) Chapters 62-520.200 and 62-520.462 (TPMC, 2014). Because the waste in the dump area of Landfill Area 1 will remain in place and undisturbed, the emphasis of this investigation was to focus on the potential for a ZOD in groundwater. Groundwater investigation activities presented in the supplemental RI were undertaken to assess current conditions and to address FDEP comments regarding potential site-related constituents in the shallow groundwater surrounding the old waste disposal site comprising Landfill Area 1. Disposal activity was initiated in this area in 1947, and surface disturbances are visible in aerial photography until 1990. No landfilling operations have taken place at this site since 1983.

Groundwater sampling around the perimeter of the landfill was performed in 2013 to characterize conditions in areas where previous investigation indicated that there was the potential for site-related constituents to be present in shallow groundwater. Groundwater results identified that only one organic constituent, chlorobenzene in a well located on the upgradient boundary of the landfill, exceeded the GCTL in a single well. There are no records or other data to indicate the specific source of the detected chlorobenzene in this upgradient area along the northern boundary of Landfill Area 1.

Total dissolved solids (TDS), iron, or manganese exceeded the GCTL in 14 of the 15 perimeter wells sampled. Groundwater in only six wells exceeded the background concentration for iron and nine wells exceeded the background concentration for manganese. The consistency of these constituents' concentrations between the upgradient and downgradient perimeter of the landfill suggests that these concentrations could be indicative of local shallow aquifer conditions (TPMC, 2014).

FDEP comments on 28 March 2014 on the supplemental RI acknowledged the findings of the report and recommended active remediation of chlorobenzene the groundwater in the vicinity of

monitoring well LFNAS-LF1MW02 (located within the presumed landfill boundary), where chlorobenzene has been detected at concentrations greater than GCTLs in 2001 and 2013. Pending completion of the RI/FS, no action has been taken regarding this recommendation.

1.4 Summary of Previous Investigations at Landfill Area 3

There have been several investigations conducted in the past for Landfill Area 3. The first of these investigations were limited in scope and were conducted to determine if further investigation was warranted. Analytical tables from all previous investigations are included as Appendix A. Historical sampling locations are shown on Figure 1-3, except in those instances where the reports describing the findings of these investigations do not provide scaled drawings or survey coordinates for the soil samples.

1.4.1 Preliminary Assessments

The Mobile District USACE installed two permanent monitoring wells outside the estimated boundaries of Landfill Areas 3 during November, 1986. Well W-4-86 (now LF3W-4-86) was placed near the southern edge of Landfill Area 3 in what was believed to be an upgradient direction, based on the location of the St. Johns River. Well W-5-86 (now LF3W-5-86) was installed in the north-central portion of Landfill Area 3 in an assumed downgradient direction. (USACE, 1986).

A preliminary investigation at the LFNAS in September 1987 with the objective of determining the presence or absence of contaminants at multiple LFNAS sites (ESE, 1988). The investigation at Landfill Area 3 included sampling the two existing monitoring wells and the collection of two subsurface composite soil samples (LFSS4 and LFSS5) from within the estimated landfill boundaries. The soil samples were collected from approximately 2 feet bgs to the shallow water table (approximately 3 feet bgs). Concentrations of 46 μg/L chromium, 44 μg/L lead, and 37.6 μg/L methylene chloride were detected in groundwater collected from well W-4-86. Both chromium and lead were also detected in well W-5-86 at concentrations of 103 μg/L and 62 μg/L, respectively. At that time, the groundwater standard for both chromium and lead were 50 μg/L. Low concentrations of several metals and bis(2-ethylhexyl)phthalate were detected in soil sample LFSS4. Due to their age, these data were excluded from the risk assessments background calculations.

Monitoring wells W-4-86 and W-5-86 (LF3 W-4-86 and LF3 W-5-86) were resampled in December 1991 (D&M, 1992). Chlorobenzene was detected at a concentration of 21 μg/L in the sample collected from W-5-86. The QA/QC check indicated that chloroform contamination by the laboratory may have resulted in an anomalous reading of compounds

containing chloroform, such as chlorobenzene. Other compounds detected in the samples collected from wells W-4-86 and W-5-86 include several metals, 1,4-dichlorobenzene, and acenaphthene.

1.4.2 EPA Expanded Site Inspection of 1998

In 1998, the EPA oversaw a site investigation of several suspected waste disposal sites at the former Lee Field, including Landfill Area 1 and Landfill Area 3 (Black & Veatch, 2000). At Landfill Area 3, one surface (RP-SS-04) and one subsurface (RP-SB-04) soil sample were collected from within the presumed landfill boundary and analyzed for volatile organic compounds (VOC), semivolatile organic compounds (SVOC), metals, pesticides, PCBs, dioxins, and furans. No compounds were detected in the surface or subsurface soil samples that exceed SCTLs.

1.4.3 Remedial Investigations

The initial RI for Landfill Area 3 was conducted in several phases from September 2000 to October 2002 (Shaw, 2004a). This investigation consisted of a historical records search, historical aerial photograph review, test pit excavation, piezometer and monitoring well installation, surface and subsurface soil sampling, sediment and surface water sampling, groundwater sample collection, comparison of Landfill Area 3 data to established upper-bound background soil and groundwater concentrations, a complete statistical/geochemical evaluation of soil and groundwater with respect to LFNAS background (Shaw, 2004b), completion of a BHHRA, and completion of a SLERA.

In addition to the aerial photo review, a total of 24 excavated test pits were used to determine the approximate landfill boundaries. Debris was encountered in four test pits at depths ranging from the ground surface to approximately 7 feet bgs. Subsurface debris encountered included gas masks, cartridges, glass, trash cans, mufflers, and other miscellaneous debris. No landfill gas was detected from in surface soil emissions or in barhole probes installed around the landfill perimeter.

The results of the RI indicated:

- Concentrations in surface soil of the PAHs BaP and dibenz(a,h)anthracene exceeded the lower of the residential SCTL or leachability standards based on groundwater.
- Sediment samples contained concentrations of PAHs and PCB exceeding State of Florida sediment quality assessment guidelines (SQAG).
- A grab DPT groundwater sample contained trichloroethene (TCE), cis- and trans-1,2-DCE, and vinyl chloride at concentrations greater than the GCTL.

- The BHHRA established soil and groundwater as the only media of concern due to the presence of PAHs in soil and VOCs and manganese in groundwater.
- The SLERA identified that concentrations of iron and Aroclor 1260 could pose a potentially unacceptable risk.

During the RI, groundwater samples were collected by direct-push technology (DPT) from six piezometer locations. The piezometers were placed on the perimeter of the landfill to determine the groundwater flow direction and to collect groundwater quality screening samples. Concentrations of chlorinated hydrocarbons in excess of the State of Florida groundwater cleanup target levels (GCTLs) were detected at depth in one piezometer (LF3PZ02). During a Phase II investigation, additional groundwater samples were collected by DPT to define the extent of chlorinated hydrocarbons detected previously. The Phase II sampling indicated that the contaminant plume is localized. Two of the piezometers were converted to permanent monitoring wells. In addition, four shallow monitoring wells and two double-cased deep monitoring wells were installed. Groundwater samples were collected from all existing wells. Analysis of groundwater samples from the monitoring wells identified concentrations of chlorinated hydrocarbons in excess of the GCTLs in well LF3MW06, which replaced destroyed piezometer LF3PZ02 (destroyed by land clearing operations after it was initially sampled). Five inorganics were also detected at concentrations that exceeded GCTLs in well LF3MW06 (Shaw, 2004a).

Surface soil samples were collected from 20 locations within and outside the presumed landfill boundary. Concentrations of polynuclear aromatic hydrocarbons (PAH) exceeding the lower of the residential soil cleanup target levels (SCTL) or leachability standards based on groundwater were detected in surface soil at LF3SS02, LF3SB05, and LF3SS11. Methylene chloride was detected in the surface soil at SS01 and at SS07 through SS12. Surface water samples LF3SW01, LF3SW02, and LF3SW03 contained semi-volatile organic compounds (SVOC) and various metals, including aluminum, beryllium, iron, silver, and mercury. Sediment samples LF3SD02 and LF3SD03 contained concentrations of polychlorinated biphenyls (PCB) exceeding sediment quality assessment guidelines (SQAG).

Subsurface soil samples were collected from locations coinciding with eight of the surface samples, outside or near the perimeter of the landfill boundary. The results identified detectable concentrations of VOC, SVOCs, inorganics, and TRPH, but not in excess of background, as proposed by the background study (Shaw, 2004b) and residential or leachability-based SCTLs.

Sediment samples were collected from four locations within Landfill Area 3. One sample contained concentrations of five PAHs (benzo(a)anthracene, benzo(a)pyrene, chrysene, fluoranthene, and pyrene), PCBs (Aroclor 1260), and mercury that exceeded the State of Florida SQAGs. The other three samples also exceed the State of Florida SQAGs for PCBs.

Surface water samples were collocated with the sediment samples and analyzed for the same parameters. The SVOC bis(2-ethylhexyl)phthalate was present in three of the surface water samples at concentrations exceeding the surface water cleanup target level (SWCTL). Seven inorganics were detected above the SWCTLs in one location.

Exceedances for inorganics were compared to proposed site-specific background concentrations established during the background study (Shaw, 2004b). The data sets were subjected to statistical tests; if necessary, geochemical evaluations were performed to determine if the elevated inorganic concentrations in the site samples were naturally occurring. Site-to-background comparison for soil (surface and subsurface) indicated anomalously high concentrations of cadmium, copper, lead, mercury, nickel, silver, and zinc in specific site samples, which may reflect contamination. Anomalously high arsenic and iron concentrations were detected in one sediment sample and may contain a component of contamination. Evaluation of the surface water data indicated that the inorganic detections were either within the background range or naturally occurring. Barium, chromium, iron, nickel, and manganese concentrations in specific groundwater samples were anomalously high and may reflect contamination. Iron in one groundwater sample may have been elevated because of reductive dissolution as a secondary effect of the organic contamination.

The BHHRA identified copper, mercury, and two PAHs as COPCs for surface soil at Landfill Area 3. The COPCs for total soil are identical to those for surface soil, with higher concentrations in the surface soil. COCs identified in soil consist of benzo(a)anthracene and dibenz(a,h)anthracene. COPCs identified in sediment consist of arsenic, iron, and BaP. For surface water, only TRPH was selected as a COPC. COCs in groundwater consist of manganese, acetone, 1,2,4-trimethlybenzene, cis- and trans-1,2-DCE, TCE, vinyl chloride, and TRPH.

The SLERA identified 19 COPECs (11 inorganics, 5 PAHs, 2 SVOCs, and 1 VOC) for surface soil, 13 COPECs (11 inorganics, 1 VOC, and 1 SVOC) for surface water, and 20 COPECs (12 inorganic analytes, 2 VOCs, 4 PAHs, 1 SVOC, and 1 PCB) for sediment. Based on further evaluation, the following constituents and associated media warrant further investigation/evaluation to determine their potential ecological risk: sediment (iron and Aroclor 1260). None of the

constituents identified as COPECs for the soil and surface water were deemed a potential ecological risk (Shaw, 2004a).

Groundwater samples were collected from the 10 existing monitoring wells in January 2005 and July 2005 as part of the semiannual monitoring events at Landfill Area 3. Metals detected above the GCTLs at Landfill Area 3 during the semiannual monitoring events consisted of aluminum, iron, and manganese. Although they exceed their respective GCTLs, aluminum, iron, and manganese were not found to be contaminant related, based on a geochemical evaluation in the Landfill Areas 1 and 3 RI report (Shaw, 2004a). The VOCs trans-1,2-DCE, TCE, and vinyl chloride exceeded their respective GCTLs in one well located on the south side and cross/upgradient of the central portion of Landfill Area 3 within which evidence of disposal activities has been noted. No other inorganics, VOCs, or SVOCs were detected above the GCTLs. Additional discussion of the results is included in the second monitoring report (Shaw, 2005b).

The nature and extent of COPCs previously identified in sediment, soil, surface water, and groundwater contamination at this former landfill site were further investigated during a supplemental RI conducted in October and December 2011 by TPMC and Shaw. This investigation collected site-specific characterization information to support the evaluation of the potential close-out of Landfill Area 3 in accordance with the *Guidance for Disturbance and Use of Old Closed Landfills or Waste Disposal Areas in Florida, Version 2.1 Final* (FDEP, 2011) and groundwater ZOD requirements specified at F.A.C. Chapters 62-520.200 and 62.520.462. These activities included soil sampling, surface water and sediment sampling, monitoring well installation, monitoring well development, and monitoring well groundwater sample collection (TPMC and Shaw, 2012).

The detected concentrations of aluminum and iron exceeding the SWCTLs in surface water were lower than the proposed background concentrations (Shaw, 2004b) for groundwater. As a result, these concentrations in both the total and dissolved sample fractions of the surface water were likely associated with the ambient groundwater quality rather than an indicator of chemical impacts from the former landfilling activities at this site.

Detected constituent concentrations in the collocated sediment samples were below screening criteria, and therefore do not identify the presence of site impacts.

The BaP and total BaP-equivalents exceeded the residential direct exposure SCTL in two samples collected from a single boring; however, neither sample exceeded the industrial direct exposure SCTL (TPMC and Shaw, 2012).

VOCs were detected in six groundwater samples. Detected concentrations of cis-1,2-DCE, trans-1,2-DCE, toluene, and vinyl chloride exceeded their respective GCTLs. Exceedances of GCTLs were localized in an area to the southeast of the area historically designated as Landfill Area 3, in the same area where these constituents were detected in the 2000 and 2005 RIs (TPMC and Shaw, 2012).

Three inorganic constituents (aluminum, iron, and manganese) exceeded their respective GCTLs for several samples collected from several monitoring wells. However, these detected concentrations were similar to the sitewide background concentrations and were not considered to be representative of landfill releases. Similarly, TDS exceeded the GCTL in two locations; however, concentrations were close to the cleanup level and similar to concentrations in the groundwater elsewhere within LFNAS.

The source of the observed stable concentrations of DCE and vinyl chloride in groundwater to the south-southeast of the historically designated landfill burial area has not been identified. Additional disposal activities may have occurred in areas along the eastern edge of the access road that have resulted in the identified VOC concentrations in this area. In addition, the impacted area is not fully defined laterally or vertically, and warrants further investigation to define those limits, and the formal boundaries of Landfill Area 3 redesignated to include areas underlain by impacted groundwater (TPMC and Shaw, 2012).

1.5 Work Plan Organization

This work plan is organized as follows:

- Chapter 1.0, Introduction
- Chapter 2.0, Technical Management Plan
- Chapter 3.0, Field Investigation Plan
- Chapter 4.0, Baseline Human Health Risk Assessment
- Chapter 5.0, Screening-Level Ecological Risk Assessment
- Chapter 6.0, Feasibility Study
- Chapter 7.0, Quality Control Plan
- Chapter 8.0, Environmental Protection Plan
- Chapter 9.0, Site Safety and Health Plan

- Chapter 10.0, References
- Appendix A, Task Order Scope of Work and Historical Data
- Appendix B, Points of Contact
- Appendix C, Accident Prevention Plan
- Appendix D, Forms/Procedures
- Appendix E, Contractor Personnel Qualifications Certification Letter
- Appendix F, Uniform Federal Policy-Quality Assurance Project Plan and Quality Assurance Surveillance Plan

2.0 Technical Management Plan

This chapter describes the approaches, methods, and operational procedures to be used during the Landfill Area 1 and Landfill Area 3 RI/FS.

2.1 Technical Scope of Work at Landfill Area 1

The scope of work necessary to achieve the project objective consists of the following:

- Hold a kickoff meeting with CB&I personnel, USACE, FDEP, and Clay County Port, Inc. (CCP) prior to mobilization.
- Using geographic information system (GIS) sample location coordinates loaded into a Global Positioning System (GPS), CB&I sampling personnel will locate and stake proposed sample locations (see Section 3.0, Figure 3-1) with wooden stakes marked with the sample location identifier.
- Collect one surface soil sample (0 to 0.5 foot bgs) and three subsurface soil samples (0.5 to 2.0 feet bgs; 2.0 to 4.0 feet bgs; 4.0 to 6.0 feet bgs [or first encountered groundwater]) at 10 locations. These samples will be analyzed for VOCs, SVOCs with PAHs, TRPH, pesticides, and TAL metals.
- Collect collocated surface water and sediment samples at three locations. These samples will be analyzed for VOCs, SVOCs with PAHs, TRPH, pesticides, and TAL metals (total and dissolved for surface water only).
- Drill six DPT soil borings near existing monitoring wells LF1MW02 and LF1DW01. Five DPT soil borings will be installed to horizontally and vertically delineate previously identified GCTL exceedances in well LF1MW02. One DPT soil boring will be installed to vertically delineate previously identified GCTL exceedances in groundwater in deep well LF1DW01.
- Collect DPT groundwater samples from the six DPT soil borings (see Section 3.0). Samples will be analyzed for VOCs, SVOCs with PAHs, TRPH, pesticides, TAL metals (total and dissolved).
- Install one deep monitoring well (40 feet bgs) to define the vertical extent of previous GCTL exceedances in well LF1MW02.
- Collect groundwater samples from newly installed monitoring well and 13 existing monitoring wells. Analyze groundwater for VOCs, SVOCs with PAHs, TRPH, TAL metals (total and dissolved), and geochemical parameters (i.e., anions [chloride, sulfate, nitrate, phosphate, fluoride], methane alkalinity, ammonia, orthophosphate, TDS, and total suspended solids).

- Analytical results will be compared to FDEP SCTLs (residential and leachability to groundwater) and GCTLs. Surface water analytical results will be compared to the State of Florida Freshwater Surface Water Cleanup Target Levels (FSWCTL). Sediment analytical results will be compared to the State of Florida SQAGs.

The Landfill Area 1 fieldwork is tentatively scheduled for 2015. However, this schedule is subject to change based on regulatory approval and/or conditions in the field.

2.2 Technical Scope of Work at Landfill Area 3

The scope of work necessary to achieve the project objective consists of the following:

- Hold a kickoff meeting with CB&I personnel, USACE, FDEP, and CCP prior to mobilization.

- Using geographic information system (GIS) sample location coordinates loaded into a Global Positioning System (GPS), CB&I sampling personnel will locate and stake proposed sample and test pit locations (see Section 3.0, Figure 3-2) with wooden stakes marked with the sample location identifier.

- Perform exploratory test pit excavations at three mounds identified during previous investigations to verify the type and extent of waste/debris buried within them.

- Collect one surface soil sample (0 to 0.5 foot bgs) and two subsurface soil samples (0.5 to 2.0 feet bgs; 2.0 to 4.0 feet bgs [or first encountered groundwater]) at three locations. These samples will be analyzed for VOCs, SVOCs with PAHs, TRPH, pesticides, PCBs, and TAL metals.

- Collect one surface water and one sediment sample at one collocated location. These samples will be analyzed for VOCs only.

- Drill ten vertical profile soil borings to delineate the extent of previously identified VOC GCTL exceedances in groundwater along the southeastern portion of the landfill area..

- Collect DPT groundwater samples (see Section 3.0) from the ten vertical profile soil borings. Samples will be analyzed for VOCs only.

- Install four shallow monitoring wells (15.0 feet bgs) and four deep monitoring wells (35.0 feet bgs) to define the horizontal and vertical extent of previous GCTL exceedances.

- Collect groundwater samples from 8 newly installed monitoring wells and 12 existing monitoring wells. Analyze groundwater for VOCs, SVOCs with PAHs, TRPH, pesticides, PCBs, TAL metals (total and dissolved), and geochemical parameters.

- Analytical results will be compared to the FDEP SCTLs (residential and industrial) and GCTLs. Surface water analytical results will be compared to the State of Florida

FSWCTL. Sediment analytical results will be compared to the State of Florida SQAGs.

The Landfill Area 3 RI fieldwork is tentatively scheduled for 2015 and will be conducted concurrent with field activities Landfill Area 1. However, this schedule is subject to change based on regulatory approval and/or conditions in the field.

2.3 Daily Project Reporting

Daily status reports will be completed to track and report progress of the field work. Daily and weekly contactor quality control reports (CQCR) will include specific operational results completed for each task. The original CQCR will be provided to the USACE and will be made available to the Project Team upon request. All CQCRs will be maintained at the LFNAS site office and the Knoxville, Tennessee, office until project closeout.

3.0 Field Investigation Plan

The field component of this RI at Landfill Area 1 and Landfill Area 3 consists of surface and subsurface soil sample collection; surface water and sediment sample collection; drilling of vertical profile soil borings; DPT groundwater sample collection; and monitoring well installation, development, and sampling.

The intent of this RI is to utilize the supplemental data set in combination with existing data to accurately delineate the chemical footprint of each landfill, update human health and ecological risk assessments, and to obtain sufficient data within the footprint of each landfill to define the nature and extent of DOD COC exceedances and their potential for off-site migration

This chapter details the planned RI activities at Landfill Area 1 and Landfill Area 3. The planned RI samples, analysis, and holding times are summarized in Tables 3-1 and 3-2 and illustrated in Figures 3-1 and 3-2.

3.1 Kickoff Meeting

Prior to the initiation of the RI activities, a kickoff meeting will be held at LFNAS. The kickoff meeting will review the details of planned field activities, health and safety procedures, and the RI schedule.

3.2 Mobilization/Demobilization

To support the RI field activities, CB&I proposes to mobilize two environmental technicians and a subcontracted DPT drill rig and crew. Support equipment requirements include health and safety supplies and equipment, such as personal protective equipment and air monitoring equipment (e.g., lower explosive limit/oxygen meters and photoionization detectors [PID]) and other miscellaneous supplies (e.g., wooden stake, pin flags). Most equipment and material will be procured through equipment vendors and scientific supply vendors and shipped directly to the site.

Mobilization activities will occur at the CB&I Knoxville office and at the CB&I LFNAS field office in Greene Cove Springs, Florida. Knoxville office mobilization activities include the procurement of rental items and assembling and packing equipment and supplies for ground transportation to the site. After field mobilization, CB&I personnel will attend a kickoff meeting and safety orientation to review the proposed approach and sequence of work to ensure that clear lines of communication are established. All necessary site-specific safety training will be

conducted at this time. Demobilization will primarily consist of decontamination, disassembly, packing, and return of rental equipment to suppliers and travel for personnel.

3.3 Static Groundwater Elevation Survey

Synoptic groundwater level measurements will be collected from the monitoring wells to be sampled within a 24-hour period prior to a groundwater sampling event at a given site. Water level measurements will be obtained with an electric water level tape.

During the collection of synoptic water level measurements, the depth to groundwater and total depth of the well from the surveyed reference mark on the well casing (casing notch if present) will be measured and recorded to the nearest 0.01 foot. Measurements will be recorded in a field logbook or on a field sampling log. The groundwater elevation will be calculated as the difference between the top-of-casing elevation and the depth to water.

3.4 Brush Clearing and Tree Removal

As necessary for access to project sites or sampling locations, CB&I will clear brush or trees covering investigation areas. Additionally, a small area within a project site, or adjacent to a site may also be cleared to facilitate a laydown yard or staging area. It is expected that manual and mechanical (e.g., chainsaw, line trimmer, heavy equipment) means will be used to accomplish the brush clearing task. Cleared brush will be chipped on site and used for erosion control/soil cover, or will be disposed of off-site as nonhazardous waste at a Subtitle D landfill, per coordination with CCP. CB&I will also coordinate with the appropriate CCP personnel to arrange for the removal if any large-diameter (more than 6 inches) trees, as necessary, for completion of the investigation activities.

3.5 Test Pit Excavation

Observational test pits will be utilized to investigate the nature and extent of buried waste/debris in three previously identified mounds. Observation test pits will be excavated consistent with EPA SOP SS-6 (*Test Pit Excavation*) (Appendix F). All test pits will be excavated with a backhoe that uses a 2- to 3-foot wide bucket capable of efficient excavation to the appropriate depth into the mounds. Observation test pits will be excavated utilizing cuts of 1- to 2-foot depths, and stockpile the material on the downwind or downslope side of the trench. Ample space will be maintained (a minimum of 2 feet) between the stockpiled material and test pit to maneuver excavation equipment. All material excavated from the test pit will be field screened for the presence of organic vapors using a hand-held organic vapor monitor. Excavated material will be placed on plastic and isolated from contact with surface soil to the extent practical. During test pit excavation, personnel will stand upwind of the excavation area to the extent

possible. To facilitate surveying, the location of the pit will be marked with stakes after it has been backfilled. Stakes will be placed at the ends of the test pit and at any significant bend or corner, as appropriate. All excavated soil will be returned to the pit from which they were excavated.

3.5.1 Test Pit Excavation at Landfill Area 3

Three observational test pits will be excavated at three mounds identified during previous investigations to verify the type and extent of waste/debris buried within them (Figure 3-2). Test pits will be advanced through the three mounds down to the surrounding ground surface elevation. Test pit materials will be visually observed and described with respect to depth and location within the individual mounds. Photographs of the excavation and of the removed soil/debris will be taken and referenced by location for future use.

3.6 Surface Water and Sediment Sampling

Each sediment sample will be collected using a single-use disposable spoon or scoop. Sediment sampling will be performed consistent with Florida DEP-SOP-001/01 FS 4000 (*Sediment Sampling*) (Appendix F). Sediment sampling will progress from the most downstream locations to the most upstream locations to eliminate potential mixing of sediment between individual sampling locations via suspension and subsequent redeposition. Sediment samples will be transferred from the single-use disposable spoon or scoop directly into the appropriate container for each requested analysis.

All sediment samples will be field screened for the presence of organic vapors using a hand-held organic vapor monitor. Sediment samples will be placed in the appropriate sample containers, labeled for proper identification, and packed in a cooler on ice, and chilled to 2 to 6 degrees Celsius (^{o}C) from the time of collection until receipt by the laboratory for analysis. A sample collection log will be completed for each sample collected and will provide the following information about the sample: sample location and identity, sampling team members, sample number, screening results, sample depth interval, analytical parameters, sample containers, quality assurance (QA)/quality control (QC) information, and any comments or observations. Sediment analytical results will be compared to the State of Florida SQAGs.

Each surface water sample will be collected using a Teflon® or stainless-steel water grab-sampling device that allows the technician to submerge a sample collection vessel just beneath the surface so that surface water flows into the collection device. Sample handling requirements will be generally the same as for groundwater samples (Section 3.9). Surface water sampling will be performed consistent with Florida DEP-SOP-001/01 FS 2100 and DEP-SOP-001/01 FD 1000

(*Surface Water Sampling and Documentation*) (Appendix F)**.** At the time of sampling, after collection of the sample for chemical analysis, a second sample will be collected and analyzed for water quality parameters (including pH) and the field data recorded on the sample collection log. Sample containers will be completely filled with water, wiped clean and dry, labeled with a preprinted label for proper identification, packed in a cooler on ice, and chilled to 2 to 6°C from the time of collection until receipt by the laboratory for analysis. A sample collection log will be completed for each sample collected and will provide the following information about the sample: sample location and identity, sampling team members, sample number, water quality parameter results (i.e., temperature, pH, conductivity, turbidity), analytical parameters sample containers, QA/QC information, and any comments or observations. Surface water results will be compared to the FDEP SWCTLs and the Federal Water Quality Criteria (WQC).

In cases where sediment and surface water samples are to be collected at the same sampling location, the surface water sample will be collected first, followed by the sediment sample, to avoid disturbing the sediment and possibly biasing the surrounding surface water with suspended sediment. The location, identity, sampling method, analytical requirements, and sample collection observations will be recorded using the sample collection log.

3.6.1 Surface Water and Sediment Sampling at Landfill Area 1

Three surface water and sediment samples will be collected at six collocated locations (LF1SW/SD05 – LF1SW/SD07) to investigate the surficial extent of contaminant impacts outside the eastern limits of Landfill Area 1 (Figure 3-1). Samples will be analyzed for VOCs by EPA Method 8260B, SVOCs with PAHs by EPA Method 8270C/8270C LL, TRPH by FL-PRO, pesticides by 8081/8081B, and TAL metals (dissolved and total for surface water only) by EPA Method 6020/7470A/7471B.

3.6.2 Surface Water and Sediment Sampling at Landfill Area 3

One surface water and one sediment sample (LF3SW/SD07) will be collected at one collocated location to investigate the surficial extent of DCE and vinyl chloride impacts outside the southeastern limits of the landfill (Figure 3-2). Both surface water and sediment samples will be analyzed for VOCs by EPA Method 8260B.

3.7 Surface and Subsurface Soil Sampling

Soil sampling will follow the State of Florida requirements (F.A.C. Chapter 62-780.600 (4)(c)1); sample intervals will include 0 to 0.5 feet, 0.5 to 2.0 feet, 2.0 to 4.0 feet bgs, and 4.0 to 6.0 feet bgs (or first encountered groundwater). Subsurface soil samples will not be collected at or below the groundwater table. Surface and subsurface soil sampling will be performed consistent with

Florida DEP-SOP-001/01 FS 3000 and DEP-SOP-001/01 FD 1000 (*Soil and Documentation*) (Appendix F).

Surface soil from 0 to 0.5 feet bgs will be collected using a single-use disposable spoon or scoop. Surficial ground debris, such as vegetative material, rubble, etc., will be cleared from the immediate area before collecting surface soil samples. Subsurface soil samples from 0.5 to 2.0 feet bgs, 2.0 feet to 4.0 feet bgs, and 4.0 to 6.0 feet bgs (or first encountered groundwater) will be collected manually using a stainless-steel hand auger. All surface and subsurface soil samples collected for chemical analysis will be placed in the appropriate sample containers, labeled for proper identification, and packed in a cooler with ice pending shipment to the laboratory.

All surface and subsurface soil samples will be field screened for the presence of organic vapors using a hand-held organic vapor monitor. Soil samples will be placed in the appropriate sample containers, labeled for proper identification, and packed in a cooler on ice, and chilled to 2 to 6°C from the time of collection until receipt by the laboratory for analysis. A sample collection log will be completed for each sample collected and will provide the following information about the sample: sample location and identity, sampling team members, soil boring number, sample number, screening results, sample depth interval, analytical parameters, sample containers, QA/QC information, and any comments or observations. The soil samples will be shipped to an off-site laboratory for the requested analysis. Analytical results will be compared to State of Florida cleanup target levels for residential and commercial/industrial soil.

3.7.1 Surface and Subsurface Soil Sampling at Landfill Area 1

Surface and subsurface soil samples will be collected from 10 soil boring locations (LF1SB13 – LF1SB22) to redefine the contact exposure risks associated with the potential presence of near surface contaminants in the regraded areas (Figure 3-1). Ten surface soil samples will be collected from 0 to 0.5 foot bgs at all 10 locations. Thirty subsurface soil samples will be collected from the 0.5 to 2.0 feet bgs, 2.0 to 4.0 feet bgs, and 4.0 to 6.0 feet bgs intervals (or first encountered groundwater). Soil samples will be analyzed for VOCs by EPA Method 8260B, SVOCs with PAHs by EPA Method 8270C/8270C LL, TRPH by FL-PRO, pesticides by 8081, and TAL metals by EPA Method 6020/7471B.

3.7.2 Surface and Subsurface Soil Sampling at Landfill Area 3

Surface and subsurface soil samples will be collected at three locations (LF3SB17– LF3SB19) to define the horizontal and vertical extent of SCTLs exceedances within the footprint of the landfill area (Figure 3-2). Three surface soil samples will be collected from 0 to 0.5 feet at all three sample locations. Six subsurface soil samples will be collected from the 0.5 to 2.0 feet bgs

and 2.0 to 4.0 feet bgs intervals (or first encountered groundwater). Soil samples will be analyzed for VOCs by EPA Method 8260B, SVOCs with PAHs by EPA Method 8270C/8270C LL, TRPH by FL-PRO, pesticides by 8081, PCBs by EPA Method 8082A, and TAL metals by EPA Method 6020/7471B.

3.8 Soil Borings and DPT Groundwater Sampling

Soil borings are important in delineating potential confining subsurface horizonation and evaluating the COC concentration distribution in groundwater beneath known impacted areas. The results of the information gathered from these borings are intended provide a general understanding of the depth intervals in which specified contaminants may be migrating. Soil borings deeper than 5 feet bgs required during this investigation will be performed using DPT drilling techniques. Vertical profile borings will be advanced using DPT drilling techniques at each location to the proposed depth or refusal, whichever is encountered first. The DPT system is a less expensive alternative to drill rig-installed soil borings and has the capability of collecting both soil and groundwater samples from the same sample location. Because the soil probe is pushed pneumatically to depth, the DPT produces little investigation-derived waste (IDW) and, therefore, reduces associated disposal costs.

Standard DPT groundwater sampling methods will be used. These methods will include using extended tip and “dual wall” screen approaches to gain access to the groundwater for sampling. Before sampling, groundwater in the extend tip and “dual wall” screen will be purged until water clarity improves and at least approximately one pipe volume of water has been removed. Purging and sampling will be accomplished using Teflon-lined tubing and a peristaltic pump. If the site’s hydrogeologic conditions warrant and the location is not producing an adequate volume of water to sample quickly, a temporary DPT groundwater sampling point may be installed into the boring as an alternative. This point will consist of a 1-inch-diameter polyvinyl chloride (PVC) riser pipe and 5-foot screen. If necessary, a prepacked well screen may be used to prevent excessive formation materials from entering the wellpoint. After the wellpoint has been installed, the upper 2 feet of the hole will be filled with bentonite and topped with a few inches of grout to prevent surface water from entering the screen. Groundwater samples will be collected within 24 hours of the installation if possible. This time should be sufficient to allow groundwater to accumulate in the wellpoint. Before sampling, stagnant groundwater in the point will be purged until water clarity improves and at least approximately one pipe volume of water has been removed. Purging and sampling of the well point will be accomplished using Teflon-lined tubing and a peristaltic pump. Sample collection, documentation, and packing will be performed using the same general procedures as monitoring well groundwater samples (Section 3.9).

All screening-level DPT groundwater samples will be placed in the appropriate sample containers, labeled for proper identification, packed in a cooler on ice, and chilled to 2 to 6°C from the time of collection until receipt by the laboratory for analysis. A sample collection log will be completed for each sample collected and will provide the following information about the sample: sample location and identity, sampling team members, DPT boring number, sample number, sample depth interval, analytical parameters, sample containers, QA/QC information, and any comments or observations. The screening-level DPT groundwater samples will be shipped to an off-site laboratory for the requested analysis. Analytical results will be compared to State of Florida GCTLs.

Boreholes installed using the DPT techniques will be decommissioned in accordance with FDEP methodology contained in Section 7.2 of the *Monitoring Well Design and Construction Guidance Manual* (FDEP, 2008a). The boreholes will be abandoned once the DPT groundwater samples have been collected. DPT borings will be abandoned by backfilling the borehole with compacted clay, bentonite-cement grout, or hydrated bentonite pellets.

3.8.1 Soil Borings and DPT Groundwater Sampling at Landfill Area 1

A total of six DPT soil borings will be installed at Landfill Area 1. Five DPT soil borings (LF1DP01 – LF1DP05) will be installed to horizontally and vertically delineate previously identified VOC GCTL exceedances in groundwater in shallow well LF1MW02. One DPT soil boring (LF1DP06) will be installed to vertically delineate previously identified GCTL exceedances in groundwater in deep well LF1DW01. (Figure 3-1). Additionally, the lithologic data obtained from these DPT borings are critical to identifying potential discontinuous clay lenses that may or may not influence vertical migration of certain constituents, such as vinyl chloride. DPT groundwater samples will be collected at each vertical profile boring from the 8 to 12 feet bgs, 16 to 20 feet bgs, and 26 to 30 feet bgs intervals. A DPT groundwater sample will also be collected at vertical profile boring LF1DP06 from the 36 to 40 feet bgs interval to define the vertical extent of previous vinyl chloride GCTL exceedances at deep well LF1DW01. The DPT groundwater samples will be analyzed for VOCs by EPA Method 8260B, SVOCs with PAHs by EPA Method 8270C/8270C LL, TRPH by FL-PRO, pesticides by EPA Method 8081B, TAL metals (total and dissolved) by EPA Method 6020/7470A.

3.8.2 Soil Borings and DPT Groundwater Sampling at Landfill Area 3

A total of ten DPT soil borings (LF3DP08 – LF3DP17) will be installed to delineate the extent of previously identified VOC GCTL exceedances in groundwater along the southeastern portion of the landfill area (Figure 3-2). Additionally, the lithologic data obtained from these DPT borings are critical to identifying potential discontinuous clay lenses that may or may not influence

vertical migration of certain constituents, such as vinyl chloride. DPT groundwater samples will be collected at each vertical profile boring from the 8 to 12 feet bgs, 16 to 20 feet bgs, 26 to 30 feet bgs, 36 to 40 feet bgs, and 46 to 50 feet bgs intervals. The DPT groundwater samples will be analyzed for VOCs by EPA Method 8260B only.

3.9 Monitoring Well Installation and Development

Monitoring Well Installation. Monitoring wells will be installed by a Florida-licensed drilling subcontractor using DPT drilling equipment. Wells will be constructed in accordance with USACE EM 1110-1-4000, *Monitoring Well Design, Installation, and Documentation at Hazardous, Toxic, and Radioactive Waste Sites* (USACE, 1998) and the FDEP *Monitoring Well Design and Construction Guidance Manual* (FDEP, 2008a). Well placement will conform to the requirements of *Design, Installation, and Placement of Monitoring Wells*, FDEP Standard Operating Procedures PCS-006 (FDEP, 2005a). If confined aquifers exist and the deeper aquifers will be penetrated, double-cased wells will be installed.

For wells, lithological soil samples will be collected continuously at 5-foot intervals (or as otherwise deemed necessary) to provide a detailed lithologic log. A geologist and/or soil scientist will supervise the drilling of each borehole and will maintain a record of the drilling and soil conditions encountered. The geologist/soil scientist will maintain continuous, detailed subsurface hazardous, toxic, and radiological waste logs by examining drill cuttings, recording the collection of samples/cores, and noting first-encountered groundwater level for each borehole as per USACE specifications. Daily field notes will be kept and will include sufficient information to reconstruct the progress of drilling operations, such as problems encountered, and well installation procedures. After completion of site work and report writing, original copies of field forms and documents will be archived in the project files at the CB&I offices in Knoxville.

After completion of the borings, well installations will be performed in conformance with USACE and FDEP requirements. The screened interval for new wells will be placed in a representative depth and will not extend deeper than the expected contamination interval. The monitoring wells will be constructed with 1-inch-inner diameter PVC and prepacked well screens (ASTM International, 2010). Shallow wells will be installed with the DPT drill rig and constructed with 10 feet of prepacked well screens. Select deep wells will be constructed with 5 feet of prepacked well screens. Following the pre-drilling utility clearance process at each proposed drilling site, the first 5 feet of each monitoring well borehole will be cleared again for potential underground utilities using a hand auger. Monitoring wells will be constructed by placing less than a 1-foot layer of sand in the borehole below the screen and bringing the sand pack to at least 2 feet above the top of screen.

An annular seal will be formed above the filter pack with either fine sand or bentonite pellets. If the top of the filter pack is in the unsaturated zone, then a layer of fine sand approximately 3 feet thick will be placed on top of the filter pack, assuming there is adequate distance between the top of the filter pack and ground surface. If not, then sufficient fine sand will be emplaced to bring the annular materials to within 0.5 foot of ground surface. A cement grout will be used to seal the borehole above the fine sand. If less than 3 feet of the fine sand seal was used, then the initial grout mixture will be sufficiently viscous to prevent significant penetration into the fine sand. If the top of the filter pack is below the water table, then a bentonite seal approximately 3 feet thick will be emplaced on top of the filter pack. The remaining annulus will be grouted continuously from the top of the hydrated bentonite seal to ground surface.

A stainless-steel warning plaque will be permanently affixed to the outer protective casing or within the flush-mount structure upon completion. The plaque will be inscribed with a warning stating the well is not for drinking water and will also show pertinent information such as well identification, date installed, total well depth, screen length, borehole size, and who installed the well.

A well installation diagram will be included in the RI report for each site. This diagram will illustrate the depth of the boring, screen location, sand filter pack material, seals, grout, height above or below ground surface of the wellhead, pumping hardware installed, and other pertinent data.

Monitoring Well Development. Following construction of the monitoring wells, each new monitoring well will be developed consistent with USACE EM 1110-1-4000, *Monitoring Well Design, Installation, and Documentation at Hazardous, Toxic, and Radioactive Waste Sites* (USACE, 1998) and the FDEP *Monitoring Well Design and Construction Guidance Manual* (FDEP, 2008a) requirements.

Each well will be developed by pumping or bailing as soon as practical, but no sooner than 48 hours nor longer than 7 calendar days after the placement of the surface pad and outer protective casing. The well will be developed by bailing, pumping and surging, or by a closed air-lift system. During development, the pump inlet will be moved through the entire screened interval or the bailer will be lifted from different depths in the well. The development procedure will continue until the following conditions are met:

- Water is clear to the unaided eye, free of sand, and free of drilling fluids.
- Thickness of the accumulated sediment in the well is less than 5 percent of the length of the well screen.

- Temperature, pH, turbidity, and specific conductance values stabilize.
- A volume of water equal to five times the volume of standing water in the well and annular space has been removed from the well. For well development purposes, one well volume will be taken to be the sum of the volume of water within the annulus, assuming 30 percent porosity in the annulus and using the height of the water column in the well at the time just prior to development.

If all development criteria are not achieved after two attempts to develop a well, the USACE will be notified for further direction.

3.9.1 Monitoring Well Installation at Landfill Area 1

One deep monitoring well (LF1DW02) will be installed to define the horizontal and vertical extent of previous GCTL exceedances detected in groundwater at well LF1MW02 (Figure 3-1). The deep monitoring well will be installed within a deep sand layer by DPT to a total depth of 40 feet bgs and will consist of a 1-inch PVC prepacked 5-foot screen with stick-up surface completion (total well depth may be revised based on DPT groundwater results).

All federal and state drilling, lithological sampling and logging, and well installation procedures will follow those described in Section 3.7.

3.9.2 Monitoring Well Installation at Landfill Area 3

Four shallow monitoring wells (LF3MW08 – LF3MW11) and four deep monitoring wells (LF1DW03 – LF1DW06) will be installed (Figure 3-2) to define the horizontal and vertical extent of previous DCE and vinyl chloride GCTL exceedances. The four shallow monitoring wells will be installed by DPT to a total depth of 15 feet bgs and will consist of 1-inch PVC pre-packed 10 foot screens with stick-up surface completion. Four deep monitoring wells will be installed by DPT to a total depth of 35 feet bgs and will consist of 1-inch PVC prepacked 5 foot screens with stick-up surface completion (total depths of select deep wells may be revised based on DPT groundwater results).

All federal and state drilling, lithological sampling and logging, and well installation procedures will follow those described in Section 3.7.

3.10 Monitoring Well Purging and Groundwater Sampling

Prior to the initiation of monitoring well purging and sample collection, water levels will be measured at all newly installed and existing monitoring wells. Synoptic water levels will be measured from a marked, survey point at the top of the well casing to the nearest 0.01 foot with an electronic water level meter.

Monitoring well purging and sample collection methods from monitoring wells at the LFNAS will be consistent with Florida DEP-SOP-001/01 FS 2200 and DEP-SOP-001/01 FD 1000 (*Groundwater Sampling and Documentation*) (FDEP, 2008b). The groundwater sampling SOP provides specific procedures on how the monitoring wells will be purged and groundwater samples collected using a low-flow peristaltic pump, a submersible pump, or a disposable bailer.

The following procedures will be followed when collecting groundwater samples from monitoring wells:

- Purging techniques will be performed consistent with Florida DEP-SOP-001/01 FS 2200 (*Groundwater Sampling*); well pumping and recharge rate balance will be attempted by pumping at as slow a rate as less than 100 milliliters (mL)/minute, if necessary. Purging may be performed using one of four techniques:

  - Wells with fully submerged screen and intake tube placed within the screened interval: Purge until the water level has stabilized (< 4.0-inches of fluctuation), then purge one volume of the pump, tubing, and flow-through cell before collecting stabilization measurements. Measurements may be no sooner than two minutes apart. At least three volumes of the pump, tubing, and flow container must be removed.

  - Wells with partially submerged well screen: Purge until the water level has stabilized, then purge a minimum of one well volume prior to collecting stabilization measurements. Measurements may be no sooner than two minutes apart.

  - If purging at a very low rate (less than 100 mL/minute) is not able to achieve water level stabilization or if a well has previously consistently purged dry, then the well will be purged with very small diameter tubing placed within the screen interval and pumped at the lowest possible rate (less than 100 mL/minute) to withdraw at least two volumes of the pump, tubing, and flow container. Then stabilization parameters will be measured once and samples will be collected.

- Where recharge rates permit, the well will be purged by low-flow peristaltic or submersible pump or by using a bailer. Purging shall continue until the parameters have stabilized within the ranges described in Florida DEP-SOP-001/01 FS 2212 (*Groundwater Sampling, Well Purging Techniques*). Where recharge rates are low, wells will be purged until dry and allowed to recharge as described above. Physical parameters will be measured at least once each tubing volume.

- Water quality stabilization parameters to be measured in the field during purging include pH (± 0.1 standard units), temperature (± 1.0 degree Celsius), conductivity (± 3 percent of readings), dissolved oxygen (± 10 percent of readings), turbidity (± 10 percent of readings), and oxidation-reduction potential (± 10 percent of readings). These parameters will be measured with meters mounted to a flow-through cell.

- Either an adjustable flow rate peristaltic pump or bladder pump will be used for sampling groundwater, depending on the depth to groundwater and the depth to the well screen. Single-use, disposable Teflon-lined, low-density polyethylene tubing will be used for the groundwater discharge line of the pump for each well. When the peristaltic pumps are being utilized, a small section of silicone tubing will be used in the pump head to facilitate the pump operation. If bladder pumps are used, new Teflon-lined low-density polyethylene tubing will be used for both the air line and groundwater discharge line of the pump for each well. Small diameter tubing is used for discharge to help ensure it remains liquid filled when operating at low pumping rates. If a submersible pump is used, then the pump will be decontaminated between sampling locations and operated so that it does not force air through the water column to generate pressure (this may strip volatiles from the sampled matrix). Groundwater samples will be collected with a low-flow peristaltic pump whenever possible. If pumps of this type are not available or are unusable due to an encountered condition, a single-use polyethylene bailer will be used. When collecting samples with a bailer, caution will be used in filling and emptying the bailer to avoid VOC loss through volatilization.

- For those samples collected with a peristaltic or bladder pump, aliquots for VOCs will be collected last. The pump fill-and-drain technique will be used to drain water from the tubing into the volatile organic analysis (VOA) vials, consistent with Florida DEP-SOP-001/01 FS 2221 (*Groundwater Sampling, Sampling Wells without Plumbing*).

- When sampling for VOCs, double sample volume should be collected from each location. VOC samples will be collected consistent with Florida DEP-SOP-001/01 FS 2004 (*General Aqueous Sampling, Volatile Organics*). Sample containers should always be 40-mL septum VOA vials equipped with screw caps and Teflon-lined silicone disks in the cap to prevent contamination of the sample by the cap. The disks should be mounted in the caps by the manufacturer prior to laboratory purchase. Hydrochloric acid preservative will also be added by the laboratory during bottle preparation for shipment to the field. During sampling, the VOC vials will be completely filled with no headspace to prevent volatilization, and extreme caution should be exercised when filling a vial to avoid any turbulence that could also produce volatilization. As a rule, it is best to gently pour the last few drops into the vial so that surface tension holds the water in a "convex meniscus." The cap is then carefully applied and, although some overflow may be lost, air space in the bottle is eliminated. Immediately after collection, the pre-labeled samples should be sealed and volatile samples should be checked for headspace. If bubbles less than 5 millimeters are observed in the VOA vials, the sample should be submitted for analysis; if a bubble greater than 5 millimeters is present, the VOA vial will be discarded and a new one will be filled.

All groundwater samples will be placed in the appropriate sample containers, labeled for proper identification, packed in a cooler on ice, and chilled to 2 to 6°C from the time of collection until receipt by the laboratory for analysis. A sample collection log will be completed for each sample

collected and will provide the following information about the sample: sample location and identity, sampling team members, monitoring well identification, sample number, sample depth interval, analytical parameters, sample containers, QA/QC information, and any comments or observations. The groundwater samples will be shipped to an off-site laboratory for the requested analysis. Analytical results will be compared to State of Florida GCTLs.

3.10.1 Groundwater Sampling at Landfill Area 1

Groundwater samples will be collected from the newly installed monitoring well LF1DW02 and 13 existing monitoring wells (Figure 3-1). All groundwater sampling will follow all federal and state procedures outlined in Section 3.8. The following water quality parameters will be measured during groundwater sampling: pH, temperature, conductivity, dissolved oxygen, turbidity, salinity, and oxidation-reduction potential. Groundwater samples will be analyzed for VOCs by EPA Method 8260B, SVOCs with PAHs by EPA Method 8270C/8270C LL, TRPH by FL-PRO, TAL metals (total and dissolved) by EPA Method 6020/7470A, and geochemical parameters.

3.10.2 Groundwater Sampling at Landfill Area 3

Groundwater samples will be collected from the 8 newly installed monitoring wells and 12 existing monitoring wells (Figure 3-2). All groundwater sampling will follow all federal and state procedures outlined in Section 3.8. The following water quality parameters will be measured during groundwater sampling: pH, temperature, conductivity, dissolved oxygen, turbidity, salinity, and oxidation-reduction potential. Groundwater samples will be analyzed for VOCs, SVOCs with PAHs, TRPH, pesticides, PCBs, TAL metals (total and dissolved), and geochemical parameters. VOCs by EPA Method 8260B, SVOCs with PAHs by EPA Method 8270C/8270C LL, TRPH by FL-PRO, pesticides by EPA Method 8081B, PCBs by EPA Method 8082A, TAL metals (total and dissolved) by EPA Method 6020/7470A, and geochemical parameters.

3.11 Decontamination of Equipment

Decontamination of nondisposable equipment (e.g., sampling equipment) will be performed to ensure chemical analyses reflect actual concentrations at sampling locations by maintaining the quality of samples and preventing cross contamination. General specifications for equipment decontamination will be performed in a manner that is consistent with Florida DEP-SOP-001/01 FC 1000 (*Cleansing/ Decontamination Procedures*) (Appendix F).

Nondisposable sampling and monitoring equipment will be decontaminated prior to and between sample collection. Cleaning procedures are specific to the equipment that requires

decontamination and the analytical suites that will be sampled with the equipment. The following decontamination steps will be followed:

- After the required samples have been properly prepared at a given sampling location, residual visible soil will be removed as much as possible from the sampling equipment by scraping.
- Following the recovery of the sampling equipment to the decontamination area, the equipment will be rinsed with tap water and then undergo a vigorous brushing with laboratory-grade, phosphate-free detergent in water and will then be rinsed with tap water to remove visible particulates.
- Rinse decontaminated equipment with deionized analyte-free water. The water used should be certified as analyte-free by the manufacturer and prepared using filters, an activated carbon bed filtration apparatus, and deionizing resin columns. For all water sources, verify that the same lot or batch that has been documented as analyte-free is consistently used or that documentation exists for multiple lots.
- Prepare decontaminated equipment for storage by draining all residual deionized water from the equipment, then allowing equipment to air dry (if possible) or towel dry. Wrap sampling surfaces in layers of aluminum foil (if applicable) and store in a designated storage location, free from sources of contamination. Apply outer protection such as sealing in a resealable plastic bag or plastic basin/tub with a lid to avoid dust.

3.12 Sample Preservation, Packaging, and Shipping

Table 3-1 summarizes the containers, preservation methods, and holding times for the proposed analysis of this Landfill Area 1 and Landfill Area 3 RI. Completed analysis requests (AR)/chains-of-custody will be secured and included with each shipment of coolers to:

Gulf Coast Analytical Laboratories
7979 GSRI Avenue
Suite C-15
Baton Rouge, Louisiana
Contact: Casey A. Anderson
Telephone: (931) 636-1019

Completed AR/COCs for QA samples will be secured and included with each shipment of coolers to:

Eurofins Lancaster Laboratories
2425 New Holland Pike
Lancaster, Pennsylvania
Telephone: (717) 656-2300

3.13 Sample Analysis

Table 3-2 presents a summary of proposed soil and groundwater samples with pre-planned sample designations and QA/QC samples. The laboratory will provide sampling containers and preservatives in accordance with Table 3-1.

All regular and QC samples will be analyzed off site by Gulf Coast Analytical Laboratories using the prescribed EPA methods and the DoD Quality Systems Manual (QSM), Version 5.0. Detailed procedures are outlined in the Uniform Federal Policy-Quality Assurance Program Plan (Appendix F).

All QA split samples will be analyzed offsite by Eurofins Lancaster Laboratories using the prescribed EPA methods and the DoD Quality Systems Manual (QSM) Version 5.0. Detailed procedures are outlined in the UFP-QAPP (Appendix F).

3.14 Investigation-Derived Waste Management and Disposal

The IDW expected to be generated during RI activity will include minor soil cuttings, groundwater from well development and purging, decontamination fluids, and used personal protective equipment. IDW will be disposed of within 90 days of the receipt of applicable sample data.

3.15 Land Surveying

All new monitoring well and soil sampling locations will be surveyed by a Florida licensed professional surveyor to determine horizontal coordinates referenced to the Florida State Plane Coordinate System. Ground surface and top of casing elevations will be surveyed to the nearest 0.01 foot and referenced to the 1983 North American Vertical Datum.

All newly installed monitoring wells will be surveyed by a Florida licensed professional surveyor to determine horizontal coordinates referenced to the Florida State Plane East Coordinate System. Horizontal control will be based in feet and referenced to North American Datum of 1983. Ground surface and top of casing elevations will be surveyed to the nearest 0.01 feet and referenced to the 1988 North American Vertical Datum. The surveyor will provide Northing and Easting (X,Y) for control points, sample points, and any boundaries or closures that may be present; data will be transmitted in the report electronically or via a certified letter or map. Survey standard of care will adhere to the concepts contained in EM 1110-1-1005 and DID WERS 007.01 (Appendix F).

All sampling locations, DPT boring locations, and any designated site features will be documented using Global Positioning System technology. Soil boring, sediment, and/or surface

water sampling locations, DPT boring locations, and any designated site features will be established in the field by the field coordinator or site geologist. Each location, once sampled or designated, will be clearly marked with a stake, pin, or similar item until it can be surveyed. The sample location identifier will be written in waterproof ink on each marker.

Geospatial data generated during the course of this project will be incorporated into the project Geographic Information System. This section was drafted using the general instructions outlined in DID WERS-007.01, *Geospatial Information and Electronic Submittals*.

Existing permanent control monuments will be used. If existing permanent control monuments are unavailable in the vicinity of Landfill Area 1 and Landfill Area 3, new control monuments will be provided after consultation with the USACE. Each new control monument will be located horizontally to the nearest 0.1 foot. The elevation of each monument will be measured to the nearest 0.01 foot and referenced to the 1988 North American Vertical Datum. Horizontal control will be based in feet and referenced to North American Datum of 1983. Each monument will consist of a standard 4-inch-diameter brass or aluminum monument embedded permanently in concrete. The identification, elevation, and coordinates will be inscribed on the monument. Control monument data will be included with other surveying data in the final report

4.0 Baseline Human Health Risk Assessment

4.1 Introduction

This BHHRA work plan was prepared to describe the protocol for evaluating human health risks associated with environmental media at the Landfill Area 1 and Landfill Area 3 sites. The primary objective of the BHHRA is to provide risk-based information for site management decisions involving the environmental media at the site. Specifically, this includes:

- Identify and evaluate baseline risks (i.e., risks that may exist if no remediation or institutional controls were to be applied) associated with environmental media.
- Identify and evaluate uncertainties associated with potential risks.

Information from the BHHRA is intended to be used by decision-makers to 1) provide a basis for determining whether further study and/or a response action is appropriate, and 2) provide a basis for developing human health risk-based cleanup levels in the feasibility study.

The BHHRA will be prepared consistent with the previous BHHRAs performed for the Landfill Area 1 and Landfill Area 3 sites (Shaw, 2004a), but updated to reflect current risk assessment guidance and toxicological values that had been unavailable when the previous Landfill Area 1 and Landfill Area 3 BHHRAs were submitted. The methodologies and assumptions described by this work plan are consistent with current EPA and FDEP guidance.

A separate BHHRA will be performed for Landfill Area 1 and for Landfill Area 3. Descriptions of these two sites are presented in Chapter 2.0 of this RI work plan.

The BHHRA will present the methods used, results generated, and the interpretation of these results. The report will be organized as follows:

- ***Data Evaluation.*** Identifies data sources, evaluates data quality, describes the COPC screening process, and identifies COPCs for each environmental medium.
- ***Exposure Assessment.*** Presents a conceptual site exposure model (CSEM), including contaminant sources, contaminant release mechanisms, receptors, and exposure pathways; describes exposure-point concentrations (EPC); and presents methods for calculating chemical intake and contact rates.
- ***Toxicity Assessment.*** Describes the potential for cancer and/or noncancer human health effects, provides an estimate of the quantitative relationship between the magnitude of dose or contact rate and the probability and/or severity of adverse

effects, identifies the toxicity values that are used in the BHHRA, and describes the development of dermal toxicity values.

- ***Risk Characterization.*** Combines the output of the exposure assessment and toxicity assessment to quantify the risk to each receptor in each area of concern.
- ***Uncertainties Analysis.*** Identifies uncertainties in all phases of the BHHRA and discusses their individual effects on the risk assessment results, emphasizing those items that are most directly relevant to the risk assessment conclusions and most likely to have the greatest effect on risk estimates and/or site management decisions.
- ***Summary/Conclusions.*** Provides a brief summary of the entire BHHRA, including quantitative results, uncertainties, preliminary identification of COCs based on the BHHRA results, and pertinent site information. Summary and discussion is focused on those results and issues that are most likely to directly affect site management decisions.

4.2 Data Evaluation

Data evaluation consists of a description of the appropriate data sources for each environmental medium associated with the BHHRA, a discussion of data quality, a description of the methodology for the identification of COPCs, and a presentation of the COPCs for the Landfill Area 1 and Landfill Area 3 environmental media. A separate COPC evaluation will be performed for each environmental medium and each site area.

4.2.1 Data Sources

Data used in the BHHRA will be the validated analytical results of environmental media samples to be collected as described in the sampling and analysis plan and pertinent validated historical data. This will include all historical surface and subsurface soil, unless there is a specific reason to exclude a particular soil sample. For Landfill Area 1, the historical samples collected in the east part of the site will be excluded because the area has been regraded. New replacement soil samples that are described in Section 3.6.1 of this RI work plan will be used in the BHHRA for this portion of Landfill Area 1.

Because groundwater, surface water, and sediment are dynamic media, subject to movement and considerable change over time, only analytical data collected over the past few years will generally be used in the BHHRA for these media. For Landfill Areas 1 and 3, this will include the analytical results of groundwater, surface water, and/or sediment samples collected during the 2011 and more recent sampling events for these media. With respect to groundwater, only monitoring well data will be evaluated in the BHHRA.

Surface soil samples include all historical soil samples collected from a depth range of either 0 to 1 foot bgs or 0 to 0.5 foot bgs. For purposes of the BHHRA, subsurface soil samples include those from a depth range between 0.5 and 6 feet bgs. Each subsurface soil depth interval will be screened and evaluated separately. Soil samples used in the BHHRA will include only those collected from above the water table.

Generally, only unfiltered groundwater is used in the BHHRA. EPA (2014a) recommends against the inclusion of groundwater samples that exceed a turbidity of 10 nephelometric turbidity units (NTU). Therefore, if any of the groundwater samples exceed 10 NTUs, these samples are subject to exclusion from quantitative evaluation in the BHHRA. In this case the filtered aliquot may be used for that sample if available. If any such groundwater sample is excluded and/or if a filtered aliquot is used, this will be described in the risk characterization and discussed in the uncertainties analysis as appropriate.

4.2.2 Identification of Chemicals of Potential Concern

The purpose of identifying COPCs is to focus the analysis on a set of chemicals that may be pertinent to human health risks. The COPC process includes a screening protocol that considers, in order, status as essential macronutrients, risk-based screening, frequency of detection, and background conditions. A chemical that passes each of the following screening criteria is retained as a COPC.

4.2.2.1 Exclusion of Essential Macronutients

Elements that are identified as essential macronutrients (calcium, chloride, iodine, magnesium, phosphorus, potassium, and sodium) are excluded from further consideration in the BHHRA, unless found to be present at high concentrations (EPA, 2014a).

4.2.2.2 Risk-Based Screening

This step of the human health risk assessment screening consists of comparing the maximum detected concentrations (MDC) of chemicals detected in surface soil, subsurface soil, groundwater, surface water, and sediment with human health risk-based screening levels. The sources of the risk-based screening levels used for detected chemicals are listed by environmental medium in the following bullets. It is noted that depending on the specific chemical and medium, not all of the FDEP values are strictly risk based.

- **Soil –** Screening will be based on the FDEP (2005a) residential SCTLs for direct soil contact, and FDEP SCTLs leachability for protection of groundwater.
- **Groundwater** – Screening will be based on the lesser of the FDEP (2005a) GCTLs.

- **Surface Water** –Screening will be based on the FDEP (2005a) FSWCTLs based on human health effects.
- **Sediment** – Screening will be based on the State of Florida SQAGs.

The SCTLs and GCTLs will be multiplied by 0.1 for screening, except for chemicals whose values should not be apportioned as specified by FDEP (2005a); these include lead and those values that are based on acute toxicity, background, primary drinking water standards, or secondary drinking water standards. Direct exposure to sediment is generally not evaluated quantitatively for human health, unless it is collected from an intermittent stream or drainage, in which case the sediment is regarded as surface soil for the portion of the year that it is uncovered (EPA, 2014a). Sediment at Landfill Area 1 and Landfill Area 3 appears to be perennially covered with water.

Analytes whose MDCs do not exceed their risk-based screening levels are not considered further in the risk assessment because it is very unlikely that they would contribute significantly to risk. If the MDC exceeds the pertinent risk-based screening level, the chemical is selected as a COPC for that medium, unless it is screened out based on other considerations (see Sections 4.2.2.3 and 4.2.2.4). If no chemical within a medium exceeds its risk-based screening level, then that medium and its exposure pathways are eliminated from the quantitative risk assessment process.

4.2.2.3 Frequency of Detection

When confidence is high that a given chemical is present, the data generally are used in the BHHRA. For most chemicals, their detection is presumptive evidence of their presence. As suggested by EPA (1989a), chemicals that are infrequently reported as detected may be artifacts in the data that do not reflect the actual presence of the chemical in question. Consistent with FDEP (2005b), a chemical will be eliminated in the BHHRA from further consideration as a COPC under the following conditions: 1) The chemical is detected in only 1 out of 10 or more samples, or in only 5 percent or less 20 or more samples; 2) the detection(s) are at low concentrations (e.g., less than the default SCTL or GCTL); and 3) there is no reason to believe that the chemical is present due to historical site activities. Chemicals detected infrequently at high concentrations may identify the existence of contaminant plumes or limited “hot spots” and are retained as COPCs.

4.2.2.4 Background Evaluation

The background evaluation that has been used for other LFNAS sites and is described in the LFNAS installation-wide background study report (Shaw, 2004b) will be used for COPC screening of inorganics in the BHHRA. This methodology is composed of a multi-step approach

that relies on both statistics and geochemistry to determine whether detected inorganics are associated with naturally occurring background. It will be used to screen all detected inorganics that are not screened out for the other reasons described in the previous sections.

The first step in the BHHRA screening will be to compare the site-specific MDCs of inorganics with the accepted LFNAS background screening value (BSV). This step is intended primarily to preliminarily identify potential hot areas. The second step employs population testing, using the nonparametric Wilcoxon Rank Sum (WRS) statistical test, coupled with box-and-whisker plots to visually compare distributions. If either the MDC exceed the BSV or the WRS results indicate that the site and background populations for that inorganic analyte are from different populations, then a geochemical evaluation will be performed as described in the LFNAS installation-wide background study report (Shaw, 2004b). The geochemical evaluation provides mechanistic explanations for apparently high, yet naturally occurring inorganic constituents, and also can identify anomalous samples that may represent contamination. The background evaluation will use the results from the hot spot test, WRS test, boxplots, and geochemical evaluation (if performed) to develop a conclusion as to whether a chemical is naturally occurring or if it is site-related.

4.2.3 Data Evaluation Summary

A separate COPC table will be prepared for each exposure medium. Each table will identify the COPCs and the basis for their inclusion/exclusion in that medium. The chemicals identified as COPCs will be carried forward into the exposure assessment.

4.3 Exposure Assessment

Exposure is the contact by a receptor with a chemical or physical agent. An exposure assessment estimates the type and magnitude of potential exposure of a receptor to COPCs found at or migrating from a site (EPA, 1989a). The following steps are included in an exposure assessment:

- Characterize the physical setting.
- Identify the contaminant sources, release mechanisms, and migration pathways.
- Identify the potentially exposed receptors.
- Identify the potential exposure pathways.
- Estimate EPCs.
- Estimate chemical intakes or contact rates.

The BHHRA described in this work plan will characterize exposure to COPCs in environmental media associated with Landfill Area 1 and Landfill Area 3. Estimates of potential exposure will be used in the BHHRA risk characterization to quantify risks.

4.3.1 Conceptual Site Exposure Models

The CSEM provides the basis for identifying and evaluating the potential exposure with respect to human health in the BHHRA for a given site. The CSEMs for Landfill Area 1 and Landfill Area 3 are presented on Figure 4-1. The CSEM includes the receptors appropriate to all site-use scenarios and the potential exposure pathways. This presentation of all possible pathways by which a potential receptor may be exposed, including all sources, release and transport pathways, and exposure routes, facilitates consistent and comprehensive evaluation of risk to human health and helps to ensure that potential pathways are not overlooked. The elements of a CSEM include the following:

- Physical setting
- Source of contamination potentially released at site
- Source media (e.g., soil)
- Contaminant release mechanisms
- Contaminant transport pathways
- Transport (secondary, tertiary) media
- Exposure media (e.g., groundwater)
- Receptors
- Routes of exposure (e.g., ingestion, dermal contact).

Contaminant release mechanisms and transport pathways that result in the transfer of contaminants across media are not relevant for direct receptor contact with a contaminated source medium (e.g., incidental ingestion of soil). The receptors and pathways shown on Figure 4-1 comprise exposure scenarios for the two landfill areas being evaluated separately for exposure. These exposure scenarios were developed from information regarding site background and history, topography, climate, and demographics.

4.3.1.1 Physical Setting

Descriptions of the physical setting specific to Landfill Area 1 and Landfill Area 3 are provided in the following paragraphs. Regional climatological/meteorological information follows. Additional information on Landfill Area 1 and 3 is provided in Section 1.3. This physical characteristics section will be updated in the BHHRA, as appropriate, by information gathered and observations made during the additional RI field activities.

Landfill Area 1. Landfill Area 1 covers approximately 6.2 acres near the southeastern corner of the former LFNAS property and is within the Reynolds Industrial Park. The site is an inactive, heavily vegetated parcel bordered to the north by Wildwood Road and a drainage swale paralleling the road; to the south and southeast by Three Mile Swamp, a cypress wetland area; and to the west by a low, flat, wooded area that usually contains standing water and connects

with Three Mile Swamp (Figure 1-2). East of Landfill Area 1 is the Bayard Wildlife Management Area. An airstrip is north of Landfill Area 1, across Wildwood Road. The elevation of Landfill Area 1 averages approximately 10 feet above mean sea level (amsl), with a high elevation of approximately 20 feet amsl.

The surface of the eastern one-half to two-thirds of the landfill had been generally mounded with abundant debris approximately 8 to 15 feet above the surrounding topography. Various types of debris, such as concrete and brush/timber piles, had been present on the surface or visible through the soil cover. This eastern portion of Landfill Area 1 was regraded during the 2005-2006 timeframe. Three awning-type carport structures were constructed in the 2007 timeframe within the eastern portion of Landfill Area 1, during which time they were used for temporary storage of local law enforcement vehicles and other equipment. These structures and the associated equipment were removed in the 2009-2010 timeframe. Two conex boxes were present in the northeastern portion of Landfill Area 1 based on an aerial photograph dated January 2014, and have been since approximately 2007; any contents of these boxes are unknown. There are currently no permanent structures on site.

The landfill is completely covered with various types of vegetation. The eastern edge of the landfill slopes downward to the east and south toward Three Mile Swamp, where it is dominated by cypress trees and low vegetation. A portion of northeastern part of the site is occasionally mowed. The eastern portion of the landfill contains debris such as concrete culverts, drummed materials, and (reportedly) power poles. Based on recent aerial photographs, additional brush piles appear to have been placed in the eastern portion of the site. The south-central part of the landfill is densely vegetated with cypress trees and vines. The central and west-central portions of the landfill are dominated by thick vegetation such as trees, brush, and scrub and are essentially inaccessible by foot and most equipment. Mounded debris is common here, including concrete, fiberglass materials, rusted drums (some labeled “acetone”), and other miscellaneous debris. The western portion of the landfill is fairly flat and contains a dense canopy of trees, but it is accessible. Surface debris is common here, especially to the south. The northern edge of the landfill slopes downward to the north from the center to Wildwood Road. This northern area has little surface debris visible. Most of the debris observed at the surface is known to be related to post-DoD activities.

A drainage ditch north of Wildwood Road contains water during the rainy season. It flows eastward, and then flows through a culvert under the road, and then flows southward along the eastern extent of the Landfill Area 1 boundary toward Three Mile Swamp. This ditch is of insufficient size to support game fish.

The surface soil is predominantly a poorly sorted fine to medium-grained sand, with a small percentage of coarse and very fine-grained sand. All borings to date have encountered undifferentiated sediments of sand, silty sand, clayey sand, and some clay. The different sediment types formed irregular and discontinuous lenses found at the perimeter of the landfill. Several borings encountered clay layers at depth; however, these units appear to represent discontinuous lenses. Therefore, there is no true confining unit present to a maximum depth of 40 feet.

Groundwater underlying LFNAS is generally toward the north and northeast, but in the southern part of the facility is toward Three Mile Swamp. Likewise, groundwater flow in the southern part of Landfill Area 1 is southward toward Three Mile Swamp. Groundwater flow in the northern part of the Landfill Area 1 may vary seasonally, with flow to the south during wetter periods and flow northward during drier periods. The depth to the water table varies during time of year and area of the site, but it is generally found at 1 to 4 feet bgs. Groundwater in the upper portion of the aquifer is contained under water table conditions in undifferentiated sand, silt, and clayey sand layers. No horizontally continuous confining clay layer was encountered to 40 feet bgs to separate the surficial aquifer from lower water-bearing zones. The upper groundwater unit in the region is not generally used as a potable source because it is so shallow, it is generally high in iron, and it does not typically yield enough water to be used as a potable supply. However, this unit may be used for irrigation. A well at the on-base golf course is likely completed in the upper water unit and is used for irrigation. This well is approximately 0.9 mile north-northeast of Landfill Area 1, which is in the opposite direction of flow in the vicinity of Landfill Area 1. There are two current water supply wells on the base, RS-1 and RS-2. Both of these are installed in the deeper, confined Floridan aquifer and are artesian. These wells are located near the existing Water Treatment Plant No. 2, approximately 1.3 miles north of Landfill Area 1 (Shaw, 2004a).

Landfill Area 3. Landfill Area 3 covers approximately 7.4 acres at the southern edge of the LFNAS property and is within the Reynolds Industrial Park. The landfill is bounded on the north, west, and east by a thick cover of trees (Figure 1-3). Property further west, across County Highway 209S, is also planted in timber. Property to the south is agricultural, and property along the western side of County Highway 209S to the north is industrial.

The base site is generally flat with a high elevation, excluding three mounded areas, of approximately 17 feet amsl in the southwest to a low base elevation about 14 feet amsl in the northeast. The three mounded areas are present in the central portion of the landfill and along the eastern boundary. These are isolated mounds that range in height from 3 to 6 feet above the

surrounding ground surface. Three Mile Swamp lies approximately 400 feet east and extends north of the landfill. The southern edge of Landfill Area 3 is bordered by a dirt access road that connects County Road 209 with Wildwood Road. The remnants of 6-inch-by-6-inch wooden posts from a previous boundary fence are located around the perimeter of the landfill.

Currently, the landfill is heavily wooded with trees and undergrowth. Prior to the end of 2001, the eastern edge of Landfill Area 3 was cleared of larger timber from the bend in the access road to the northeast. The removal of timber in these areas has provided more sunlight, which allowed the growth of grasses and thick scrub vegetation. Portions of the landfill where this has occurred are now nearly impenetrable, as is the northeast corner of the landfill where cutting debris has been piled.

Overall, the landfill area is relatively flat; however, three mounded areas are located within the estimated boundaries of Landfill Area 3. Scattered debris, including bottles, cans, and miscellaneous metal items, is observed at the surface from the south-central portion of the landfill to the east and northeast. Otherwise, there are no other indications that a landfill is present. It is likely that the scattered debris observed at the surface today is the result of random post-DoD disposal.

There are two small ponds on site, and a seasonably wet ditch area with intermittent standing water located approximately 120 feet southeast of the landfill boundary. These two ponds have a combined area of less than 0.1 acre and are thus of insufficient size for gamefishing activities.

The surface soil is predominantly poorly sorted, fine-grained sand, with a small percentage of medium and very fine-grained sand and silt. The soil collected from the shallow saturated zone was found to be moderately sorted fine-grained sand. All borings to date have encountered undifferentiated sediments of sand, silty sand, clayey sand, and minor clay. The different sediment types formed irregular and discontinuous lenses found at the perimeter of the landfill. The predominant sediment type observed was a fine-to-medium-grained sand. Minor lenses of silt and clay were encountered, but they were not continuous across the site. Therefore, there is no true confining unit present to a maximum depth of 40 feet.

Groundwater flow underlying Landfill Area 3 is toward the northwest. The depth to the water table varies during time of year and area of the site, but it is generally found at 1 to 4 feet bgs. Groundwater in the upper portion of the aquifer is contained under water table conditions in undifferentiated sand, silt, and clayey sand layers. No clay confining unit is present in the upper 40 feet to separate the surficial aquifer from lower water-bearing zones.

The upper groundwater unit in the region is not generally used as a potable source because it is so shallow, it is generally high in iron, and it does not typically yield enough water to be used as a potable supply. However, this unit may be used for irrigation. As described in the previous description of groundwater for Landfill Area 1, only the confined underlying Floridan aquifer is used as a potable source in the vicinity of LFNAS.

Regional Climate/Meteorology. Except as noted, the climactic/weather data presented in this section is from the National Oceanic and Atmospheric Administration (NOAA) weather station in Jacksonville (NOAA, 2008), which is approximately 20 miles north of LFNAS. The climate in the area is humid subtropical, with a coastal influence. July is generally the warmest month (average high and low temperatures of 91 and 72 degrees Fahrenheit [°F], respectively), and January is generally the coldest (average high and low temperatures of 64 and 42°F, respectively). The area averages only 15 freezing days (low of 32°F or less) per year, which typically occur only from December through February. The average annual precipitation for Jacksonville is 52 inches per year. The fewest precipitation days (0.01 inch or greater) per month (5) occur during April, and the most (14) occur in July and in August. The mean annual wind speed is 7.8 miles per hour (12.6 kilometers per hour) (NOAA, 2008), with winds predominantly from the west-southwest (NOAA, 1998). This region is relatively sunny with 63 percent sunshine throughout the year, ranging from 54 percent sunshine in December to 73 percent sunshine in April (NOAA, 2008).

4.3.1.2 Contaminant Sources, Release Mechanisms, and Migration Pathways

Contaminant sources, release mechanisms, and migration pathways are summarized on Figure 4-1. Briefly, the contaminant source at Landfill Area 1 and Landfill Area 3 are the landfilled materials which were both placed on the surface and buried at depth. The primary release mechanisms at the two landfill areas are assumed to be infiltration and leaching.

4.3.1.3 Receptors and Exposure Pathways

Neither Landfill Area 1 nor Landfill Area 3 is currently used. However, the eastern portion of Landfill Area 1 is occasionally mowed (approximately 1 per month during the warmer months), and brush is occasionally cut in other areas of this site. The land in the eastern part of Landfill Area 1 was regraded sometime during the 2005-2006 timeframe. Although Landfill Area 3 is not regularly mowed and the ground has not been regraded, a review of aerial photographs indicates that trees have been thinned out and brush appears to have been cut.

Thus, the only current human receptors at Landfill Area 1 are workers who occasionally mow and/or cut brush or trees, and trespassers may possibly frequent the site. Similarly, the only

human receptors currently at Landfill Area 3 are site workers who may occasionally cut brush or clear out trees, and possibly trespassers may visit the Landfill area 3 as well. Trespassers, especially adolescents, may be exposed to surface water associated with the Landfill Area 1 drainage ditches and the Landfill Area 3 ponds and ditches.

Residential development is infeasible because of unstable ground associated with buried debris at the landfills, and the potential for generation of methane. The Army will coordinate with CCP to place a land-use restriction on these closed landfills to prohibit residential development. Additionally, no future site use is planned for either Landfill Area 1 or Landfill Area 3, as both sites are expected to remain as closed landfills into the foreseeable future. Therefore, it is assumed that the occasional worker who mows and/or cuts vegetation will continue to be involved in site activities, and it is assumed that the trespasser will likewise continue to frequent the site. Because of instability issues, neither landfill area could reasonably serve as a construction site for a building. However, it is possible that worker activity at either of the landfill areas may increase in the future, at least temporarily. It is possible that a construction worker may need to perform some type of short-term excavation work outside of the perimeter of the respective landfills and thus be exposed to the associated subsurface soils. However, FDEP (2011) guidance recommends that placing utilities within 200 feet of a landfill should be avoided. All perimeter soil samples have been and will be collected within 50 feet of the landfill perimeter. Therefore, the assumption that a construction worker would be digging an excavation within 50 feet of the landfill perimeter is conservative and likely unrealistic.

Although there is no anticipated land use of either landfill area, each landfill may be used for recreational purposes, such as nature walks. Alternatively, either landfill could be cleared and used as a sports field (e.g., soccer, baseball) in the future. Therefore, the BHHRA will conservatively evaluate the two landfill areas assuming that they are cleared and regraded for use as a sports field by adolescents. Because of the presence of buried waste, it is likely that a substantial amount of additional fill would need to be brought in and emplaced on the respective sites. This would limit the exposure to current landfill area soil, thus rendering as conservative the assumption of exposure to only landfill soil.

Groundwater from the surficial unit will also be evaluated as part of the BHHRA. As described in Section 4.3.1.1, the shallow unit is of low yield and quality and is, thus, used only for irrigation. Therefore, it is assumed that a future off-site landscape worker may be exposed to the groundwater during use of the groundwater for irrigation. Irrigation water may be needed for aesthetic purposes such as watering a lawn, especially during low rain conditions. Irrigation would not be needed for watering either landfill, because vegetation appears to grow well on

both landfill areas without supplemental water. FDEP (2011) Guidance recommends that irrigation wells not be installed within 500 feet of a landfill. All Landfill Area 1 and Landfill Area 3 monitoring well samples and direct-push groundwater samples will be collected from within 150 feet of the respective landfill perimeter. Therefore, the assumption that a landscape worker would be exposed to groundwater within 150 feet of the landfill perimeter is conservative and likely unrealistic.

Receptors selected to represent the upper bound on exposure from all plausibly exposed groups of people associated with Landfill Area 1 and Landfill Area 3 as well as the pathways by which they may be exposed to chemicals are summarized on Figure 4-1. The exposure variable values to be used in the contaminant intake models are compiled in Table 4-1. The receptors to be evaluated in the BHHRA for current and potential future exposure scenarios are listed below with the exposure media to be evaluated in parentheses.

- On-site maintenance worker, current and future land use (surface soil)
- Adolescent trespasser, current and future land use (surface soil and surface water)
- Commercial/industrial worker, future land use (surface soil)
- Construction worker, future land use, (subsurface soil along landfill perimeter)
- Off-site landscaping worker, future (groundwater)

Most BHHRAs are based on a reasonable maximum exposure (RME) assumption. The intent of the RME assumption is to estimate the highest exposure level that could reasonably be expected to occur, but not necessarily the worst possible case (EPA, 1989a; 1991). It is interpreted as reflecting the upper 90 to 95th percentile on exposure. In keeping with EPA (1989a; 1991) guidance, variables chosen for a baseline RME scenario for ingestion rate, exposure frequency, and exposure duration are generally upper bounds. Other variables, such as body weight and exposed skin surface area, are generally central or average values. In the case of contact rates consisting of multiple components, e.g., dermal contact with soil or water, which consists of a dermal absorption factor (ABS) and soil-to-skin adherence factor (AF) for soil, and permeability coefficient (K_p) and exposure time (ET) for water, only one variable, ABS or K_p, needs to be an upper bound. The conservativeness built into the individual variables ensures that the entire estimate for contact rate is sufficiently conservative.

The averaging time for noncancer evaluation is computed as the product of the exposure duration (years) multiplied by 365 days per year. The resultant noncancer averaging time is used to estimate an average daily dose over the entire exposure period (EPA, 1989a). For cancer evaluation, the averaging time is computed as the product of 70 years, the assumed human lifetime, times 365 days/year. This cancer-based averaging time is used to estimate an average

daily dose prorated over a lifetime, regardless of the frequency or duration of exposure. The methodology used in deriving the averaging time for cancer risks assumes that the risk from short-term exposure to a high dose of a given carcinogen is equivalent to long-term exposure to a correspondingly lower dose, provided that the total lifetime doses are equivalent. This approach is generally consistent with the EPA (2005) policy of carcinogen evaluation, although it introduces considerable uncertainty into the BHHRA cancer risk estimates.

Receptors and the associated potential exposure pathways are presented in the following subsections.

4.3.1.3.1 Current/Future On-Site Maintenance Worker

The exposure scenario for the on-site maintenance worker scenario is designed to evaluate the upper bound for site worker exposure to surface soil under current site conditions, conservatively assuming long-term exposure, based on activities that have been performed at Landfill Area 1 and Landfill Area 3. Currently and over the past several years outdoor workers are present only occasionally at the landfill areas to perform work such as cutting trees and brush, infrequent mowing (Landfill Area 1 only) and regrading (which took place in 2005-2006 at Landfill Area 1). The on-site maintenance worker scenario is described in the following paragraphs.

Direct soil exposure pathways include incidental ingestion and dermal contact. Inhalation of dust associated with wind erosion and inhalation of VOCs from the surface soil as gases will be evaluated for the outdoor on-site maintenance worker.

The on-site maintenance worker is assumed to be an 80-kilogram (kg) adult who works for 25 years (EPA, 2014b). It is assumed that the on-site maintenance worker is present at the site an average of 1 full 8-hour day per week throughout the year (52 days/year). Based on the low frequency of workers being present at the site over the past several years, this is likely a high estimate of actual worker exposure frequency under current conditions. The soil incidental ingestion rate is assumed to be 100 milligrams per day (mg/day) (EPA, 2014b). The on-site maintenance worker is assumed to be exposed dermally to soil. An exposed skin surface area of 3,470 square centimeters (cm^2) and a soil AF of 0.12 milligrams per square centimeter (mg/cm^2) are assumed (EPA, 2014b). An inhalation rate of 20 cubic meters per day (m^3/day) is used for on-site maintenance worker, which is based on the FDEP (2005b) value listed for a commercial/industrial worker.

4.3.1.3.2 Current/Future Adolescent Trespasser

The adolescent trespasser is identified as a plausible receptor for both landfill areas under current and/or future conditions. The adolescent is selected for this scenario consistent with the EPA

(2014a) guidance. Access to Landfill Area 1 is currently restricted by fences and gates to the north and east, and the Three Mile Swamp makes access to this site virtually impossible from the east, south, or west. Therefore, trespassing is currently likely to be negligible at Landfill Area 1. Landfill Area 3 is gated and is thus not accessible by vehicle, including bicycle, by the adolescent trespasser. However, access is possible by foot, though it is noted that the nearest residence is more than 1 mile from either landfill.

Potential exposure routes include incidental ingestion of soil, dermal contact with soil, and inhalation of airborne dust and volatiles. The trespasser is assumed to be a nearby adolescent resident who makes regular visits to the landfill areas. However, the nearest resident is more than 1 mile from either landfill area, further limiting the likelihood of regular visits by trespassers. It is assumed that the adolescent trespasser makes, on average, one visit per week throughout the year (52 days per year), and spends 8 hours per day on site on each of these days. This includes 2 hours per day wading in the drainage ditches associated with Landfill Area 1 or the ponds associated with Landfill Area 3. Please note that the largest Landfill Area 3 pond appears to be regularly covered with an algal mat that may make this pond an undesirable water body in which to wade. Given the presence of algae and the limited extent of the Landfill Area 3 ponds and the Landfill Area 1 ditches, an exposure frequency of 52 days per year for wading is likely high.

The adolescent trespasser is assumed to be a 7 to 16-year-old youth with an average body weight of 45 kg exposed for 10 years (EPA, 2014a). This approximates the average body weight for an 11-year-old (EPA, 2011). This receptor is assumed to be exposed to soil via incidental ingestion, dermal contact, and inhalation of windborne dust and VOCs emitted from the soil. An incidental soil ingestion rate of 100 mg/day is assumed for persons over 6 years of age (EPA, 1991; 2014d).

Soil exposure for the trespasser assumes exposure to the following parts of the body: face, hands, forearms, and lower legs. The total surface area for these body parts for an average 13-year-old is approximately 3,600 cm^2. This value is based on these body parts comprising approximately 27.2 percent of the average body surface area for a 13-year-old, which is 13,350 cm^2 (EPA, 2011). Clothing provides protection against dermal contact with soil for the rest of the body. EPA (2014b) recommends a value of 0.2 mg/cm^2 as a soil–to-skin AF value for children. This value will be used in the BHHRA for the youthful trespasser as well. Exposure to surface water while wading may wash off some of the soil, making it less available for dermal absorption. An inhalation rate of 14.0 m^3/day (0.567 cubic meters per hour [m^3/hr]) is used for the adolescent trespasser, which is the aggregate long-term inhalation rate for ages 7 through 16 years of age (EPA, 2011).

As described above, the adolescent trespasser is also assumed to be exposed to surface water. The surface area for exposed skin includes the face, hands, forearms, lower legs, and feet. These comprise approximately 34.0 percent of the total body surface area of a 13 year old (13,350 cm^2 [EPA, 2011]) or about 4,500 cm^2. Per EPA (2014a) guidance, an incidental ingestion rate for surface water of 10 mL per hour is assumed, and as mentioned above, it is assumed that this receptor is exposed to surface water for 2 hours per exposure day. The trespasser's dermal contact with surface water is assumed to be intermittent rather than continuous, thus it is assumed that uptake of organic chemicals across the dermis does not reach steady state.

4.3.1.3.3 Future Commercial/Industrial Worker

The exposure scenario for the on-site maintenance worker scenario is designed to evaluate the upper bound for site worker exposure to surface soil, assuming that worker frequency at the site and consequent exposure to a site worker may increase in the future. As described in Section 4.3.1.3, the presence of buried waste at each landfill area will render both areas unsuitable for building construction. Even so, the BHHRA will conservatively evaluate exposure to a potential future site worker using the FDEP (2005) default commercial/industrial worker scenario, adjusted as noted to accommodate recently updated EPA (2014d) default exposure factor values.

Direct soil exposure pathways include incidental ingestion and dermal contact. Inhalation of dust associated with wind erosion and inhalation of VOCs from the surface soil as gases are also evaluated for the future commercial/industrial worker.

The future commercial/industrial worker is assumed to be an 80-kg adult (EPA, 2014b) who works at the site fulltime, 8 hours per day, 250 days per year for 25 years. The soil incidental ingestion rate is assumed to be 50 mg/day (FDEP, 2005b; EPA, 2014b). An exposed skin surface area of 3,470 cm^2 and a soil AF of 0.12 mg/cm^2 are assumed (EPA, 2014b). An inhalation rate of20 m^3/day is assumed for the default future commercial/industrial worker.

4.3.1.3.4 Future Construction Worker

The construction worker scenario is used to evaluate short-term exposure to subsurface soil in the future land-use scenario, assuming that limited excavation activities may take place immediately outside the perimeters of the respective landfills. As discussed in Section 4.3.1.3, construction activities within the landfill are not plausible because the landfill would not provide suitable stability for a construction project. Nor would an excavation (e.g., for a utility line) be permitted to pass through a landfill. Similarly, construction/excavation work is unlikely to take place immediately outside of the landfill perimeter because FDEP (2011) guidance recommends that placing utilities within 200 feet of a landfill should be avoided. As discussed in Section

4.3.1.3, all perimeter soil samples have been and will be collected from within 50 feet of the landfill perimeter. Therefore, the assumption that a construction worker would dig an excavation within 50 feet of the landfill perimeter is highly conservative.

No projects involving excavation are planned or anticipated in the vicinity of either landfill area. Any such project would be expected to be infrequent and of short duration. As part of the BHHRA, it is assumed that the construction worker participates in one excavation project.

Exposure pathways for the construction worker include incidental ingestion and dermal contact, inhalation of fugitive dust, and inhalation of airborne VOCs released from subsurface soil during excavation and regrading.

The construction worker is assumed to be an 80-kg adult who works 8 hours/day, 225 days per year (EPA, 2014b). The excavation project is assumed to last 6 months. A soil ingestion rate of 330 mg/day is assumed for the construction worker (EPA, 2002a). A dermal soil AF for the construction worker of 0.3 mg/cm^2 (EPA, 2002a) and an exposed body surface area of 3,470 cm^2 are assumed, which represent the head, hands, and forearms (EPA, 2002a; 2014b).

4.3.1.3.5 Future Adolescent Recreational User

As discussed in Section 4.3.1.3, the landfill sites may be used in the future for recreational purposes, such as nature walks. However, if the sites were to be cleared, it is plausible that they could be used for more intense activities such as outdoor sports. Under this scenario it is assumed that each landfill area is cleared, regraded, and used as a sports field. An adolescent recreational user is identified as a plausible receptor for both landfill areas under these future conditions. The adolescent is selected for this scenario because the adolescent is regarded as the most likely individual to participate in sports on a consistent long-term basis. Exposure to the adolescent provides a conservative estimate of exposure to an adult who may participate in sporting events at the site, or who may use the site for other recreational purposes.

Potential exposure routes include incidental ingestion of soil, dermal contact with soil, and inhalation of airborne dust and volatiles. The recreational used is assumed to be a nearby adolescent resident who uses the site for sports activities such as soccer or baseball. It is assumed that the adolescent visits the site and uses it for recreational purposes, on average, twice per week throughout the year (104 days per year), for a duration of 10 years. It is assumed that the youth would participate in sports at the site for 2 hours per visit. This assumption is regarded as conservative based on information contained in the EPA (2011) Exposure Factors Handbook. Although EPA does not provide frequencies or durations for soccer or baseball, Table 16-97 of the Exposure Factors handbook (EPA, 2011) lists the total mean time participating in all sports

as 179 minutes per week (3.0 hours per week) for children ages 6 to 17 years of age. The assumption of two visits per week, 2 hours per visit results in 4 hours per week spent at either site playing sports. This assumption would seem conservative, as it is 34 percent greater than the average value listed by EPA for participation in all sports, including those performed elsewhere, both indoors and outdoors.

The adolescent recreational user is assumed to be a 7 to 16-year-old youth with an average body weight of 45 kg (EPA, 2014a). This approximates the average body weight for an 11-year-old (EPA, 2011). This receptor is assumed to be exposed to soil via incidental ingestion, dermal contact, and the inhalation of windborne dust and volatile emissions from the soil. An incidental soil ingestion rate of 100 mg/day is assumed for persons over 6 years of age (EPA, 1991; 2014b).

Soil exposure for the adolescent recreational user assumes exposure to the following parts of the body: face, hands, forearms, and lower legs. The total surface area for these body parts for an average 11-year old is approximately 3,600 cm^2. This value is based on these body parts comprising approximately 27.2 percent of the average body surface area for an 11-year-old, which is 13,350 cm^2 (EPA, 2011). Clothing provides protection against dermal contact with soil for the rest of the body. EPA (2014b) recommends a value of 0.2 mg/cm^2 as a soil–to-skin AF value for children. This value will be used in the BHHRA for the adolescent recreational user as well. An inhalation rate of 2.8 m^3/hour is used for the adolescent recreational user, which is the aggregate mean inhalation rate for individuals, ages 7 through 16 years, who are involved in a high intensity activity (EPA, 2011) such as soccer.

4.3.1.3.6 Future Off-Site Landscaping Worker

The future off-site landscaping worker scenario is used to evaluate the upper bound for long-term exposure to site groundwater assuming that the water underlying the landfills will be used as a source of irrigation water in the future for off-site landscaping. An off-site worker, rather than on-site worker, is used because vegetation grows well at both Landfill Area 1 and Landfill Area 3 without supplemental water. Irrigation would be used for aesthetic purposes such as watering lawns and gardens. Given that the landfill areas are located within Reynolds Industrial Park and that no residences are present within 1 mile of either landfill area, a landscaping worker scenario is used rather than a residential irrigation scenario. Also, as mentioned in Section 4.3.1.3, FDEP (2011) guidance recommends that irrigation wells not be installed within 500 feet of a landfill. All previous and planned Landfill Area 1 and Landfill Area 3 monitoring wells and direct-push sampling locations are within 150 feet of the respective landfill perimeter. Therefore, the assumption that a landscape worker would be exposed to groundwater within 150 feet of the landfill perimeter is conservative.

This landscaping worker is assumed to perform maintenance of grounds for a commercial/industrial facility located outside of the landfill boundary. A part of this worker's activities involve those being conducted during irrigation of a sprinkling system and/or direct watering of plants. Exposure pathways for the off-site landscaping worker include incidental ingestion and the inhalation of airborne VOCs released as vapors during irrigation (University of Florida, 2009).

The off-site landscaping worker is assumed to be an 80- kg adult who works at his job and uses site groundwater for 25 years, based on the default exposure duration for a worker (EPA, 2014b). The incidental groundwater ingestion rate is assumed to be 0.01 liters per day (L/day) (University of Florida, 2009). An inhalation rate of 2.5 m^3/hr during the workday is used for the irrigation worker, which is based on the FDEP (2005) rate of 20 m^3/day listed for a commercial/industrial worker during an 8-hour workday.

4.3.2 Exposure to Lead

Exposure to lead in environmental media is evaluated separately from other COPCs using the Adult Lead Methodology (ALM) model for adult exposure scenarios (EPA, 2003a; 2009a). The ALM model assumes worker exposure to soil, workplace dust assumed to originate from soil, and drinking water (as well as other sources such as dietary, maternal levels, and ambient air) by a pregnant worker and estimates the resulting blood-lead concentration of the fetus. Exposure and associated risk are characterized based on the resulting modeled blood-lead concentration. If lead is identified as a COPC for any medium at either landfill area, these models will be run as part of the BHHRA for that area.

4.3.3 Quantification of Exposure-Point Concentrations

The EPC is an estimate of the concentration of a COPC in a given medium to which a receptor may be exposed over the duration of the exposure. An EPC may be based on media concentrations that have been directly measured, or it may be derived based on environmental medium-to-medium transport modeling. The EPCs of COPCs in soil, for example, will be statistically derived values, based on measured analytical data. Concentrations of COPCs in air will not be measured (and in some cases cannot reasonably be measured), but will be based on models, which use the EPC of the measured environmental media as input values. The following subsections describe the statistical approaches and the models used to derive EPCs for each environmental medium.

4.3.3.1 Exposure-Point Concentrations in Measured Environmental Media

Generally, the 95th percent upper confidence limit (UCL) on the arithmetic mean or the MDC of the measured concentrations, whichever is lower, will selected as the EPC for soil and surface water in the Landfill Area 1 drainage ditches and Landfill Area 3 ponds. The EPC is understood to represent a conservative estimate of average concentration to which a receptor may be exposed and is used in the exposure assessment for RME evaluation. The MDC value is used as the EPC for groundwater.

Exposure to an environmental medium is generally assumed to be random, and the EPC should be the arithmetic average encountered over the exposure duration (EPA, 1989a). Therefore, the population mean concentration, if known, would be the ideal value selected as the EPC. The sample mean is an obvious estimate of the population mean. However, uncertainties exist as to how well the sample mean represents the population mean. Therefore, EPA (1989a; 2013a) has recommended the inclusion of a UCL of 95 percent on the mean for RME evaluation.

The UCL is estimated by employing statistical calculations on the sample data set. The type of calculation performed is dependent on type of distribution, variability, skewness, and size of the sample data set. For the BHHRA, the ProUCL Version 5.0 software program (EPA, 2013a) will be used to determine distribution type and various calculated estimates of the UCL based on distribution type. ProUCL 5.0 has a built-in UCL selection matrix, which yields one or more recommendations. The ProUCL input and output will be attached to the BHHRA. Analytical results are presented as "nondetects" ("U" qualifier) whenever chemical concentrations in samples do not exceed the reporting limits for the analytical procedures for those samples. The reporting limit will be associated with the “U” qualifier for the purposes of data reporting, EPC, and UCL calculations. Generally, the reporting limit is the lowest concentration of a chemical that can be "seen" above the normal, random noise of an analytical instrument or method. ProUCL Version 5.0 uses Kaplan-Meier statistical methods to evaluate data sets with nondetects (EPA, 2013a). In cases where matrix interference or other phenomena drive the reporting limit unusually high for nondetects, judgment will be reserved to remove these nondetected data from the data set. If any nondetects are eliminated from a data set due to high reporting limits that would otherwise skew the EPC, these samples will be discussed in the uncertainties analysis of the BHHRA.

4.3.3.2 Exposure-Point Concentrations in Ambient Air from Soil

Exposure to COPCs in airborne dust originating from on-site soil and as VOC emissions from soil are potential exposure pathways for each of the on-site receptors described in Section 4.3.1.3.

The air concentration of a COPC resulting from its presence in airborne soil particles as a result of wind erosion is calculated using the following equation:

$$C_a = \frac{C_s}{PEF} \qquad \text{Eq. 1}$$

where:

C_a	=	contaminant concentration in air (milligrams per cubic meter [mg/m^3], calculated)
C_s	=	contaminant concentration in soil (milligrams per kilogram [mg/kg])
PEF	=	particulate emission factor (cubic meters per kilogram [m^3/kg], calculated).

The PEF based on wind erosion is calculated using the following equation (EPA, 2002a):

$$PEF = Q/C \times \frac{3600}{0.036 \times (1 - V) \times (U_m / U_t)^3 \times F(x)} \qquad \text{Eq. 2}$$

where:

PEF	=	particulate emission factor (m^3/kg, calculated)
Q/C	=	inverse of the mean concentration at center of square source (grams per square meter per second per kilograms per cubic meter, value calculated from Exhibit E-3 [assume Miami, Florida] and Equation E-4 in EPA [2002a])
3600	=	seconds/hour
V	=	fraction of surface covered with vegetation or pavement (0.8, unitless, conservatively approximated based on nearly complete vegetation cover)
U_m	=	mean annual wind speed (site-specific 7.8 miles per hour [NOAA, 2008] equals 3.5 meters per second)
U_t	=	equivalent threshold value of wind speed at 7 meters (site-specific or default, 11.32 meters per second)
F(x)	=	function dependent on U_m/U_t (default 0.194).

EPCs of VOC COPCs in ambient air as the result of volatilization from soil are estimated using the following equation (EPA, 2002a):

$$C_a = \frac{C_s}{VF_s} \qquad \text{Eq. 3}$$

where:

C_a	=	COPC concentration in air (mg/m^3, calculated)
C_s	=	COPC EPC in soil (mg/kg) (each soil depth interval is screened and evaluated separately)
VF_s	=	chemical-from-soil volatilization factor (m^3/kg).

The chemical-specific volatilization factor is calculated using the following equations (EPA, 2002a):

$$VF_s = Q/C_{vol} \bullet CF_2 \bullet \left(\frac{[\ 3.14 \bullet D_A \bullet T\ ]^{1/2}}{2 \bullet \rho_b \bullet D_A} \right) \qquad \text{Eq. 4}$$

and

$$D_A = \frac{(\theta_a^{10/3} \bullet D_i \bullet H' + \theta_w^{10/3} \bullet D_W\ ) / n^2}{\rho_b \bullet K_d + \theta_w + \theta_a \bullet H'} \qquad \text{Eq.5}$$

where:

VF_s	=	chemical-from-soil volatilization factor (m^3/kg, chemical-specific, calculated)
Q/C_{vol}	=	inverse of the ratio of the geometric mean air concentration to the volatilization flux at the center of the square source; value calculated from Exhibit D-3 (assume Miami, Florida) in EPA (2002)
CF	=	conversion factor (10^{-4} square meters (m^2) per cm^2)
D_A	=	apparent diffusivity (cm^2 per second, calculated)
T	=	exposure interval (seconds, estimated as ED 4E-7 seconds per year)
ED	=	exposure duration (years, receptor-specific)
ρ_b	=	dry soil bulk density (site-specific or default 1.5 grams per cubic centimeter)
θ_a	=	air-filled soil porosity (site-specific estimated as n - θ_w or default 0.28 unitless)
n	=	total soil porosity (site-specific estimated as 1-[ρ_b/ρ_s] or default 0.43 unitless)
ρ_s	=	true soil or particle density (site-specific or default 2.65 grams per cubic centimeter)
θ_w	=	water-filled soil porosity (site-specific or default 0.15 L_{water}/L_{soil})
D_i	=	diffusivity in air (cm^2 per second, chemical specific)
H'	=	dimensionless Henry's law constant (chemical specific, may be estimated as H x 41)
H	=	Henry's law constant (atmospheres per cubic meter per mole, chemical specific)
D_W	=	diffusivity in water (cm^2 per second, chemical-specific)
K_d	=	soil-water partition coefficient (cubic centimeters per gram, chemical-specific, may be estimated as K_{oc} x f_{oc})

K_{oc}	=	soil organic carbon-water partition coefficient (cubic centimeters per gram, chemical-specific)
f_{oc}	=	organic carbon content of soil (site-specific or default 0.006 g/g).

Site-specific data will be used for as many variables as possible; defaults from various EPA guidance documents will be used where site-specific data are not available.

4.3.4 Quantification of Chemical Intake Rates

This section describes the models used to quantify doses or intakes of the COPCs by the receptors and exposure pathways previously identified. The intake model variables generally reflect 50th or 95th percentile values, which, when applied to the EPCs derived as described previously, ensure that the estimated intake rates represent the RME. Models were taken or modified from EPA (1989a) unless otherwise indicated.

4.3.4.1 Inhalation of COPCs in Air

The inhaled dose of a COPC in air is estimated using Equation 6 (EPA, 1989a). In more recent EPA (2009b) guidance, an exposure concentration is estimated rather than an inhaled dose. However, FDEP (2005) provides calculations that include the estimate of an inhaled dose, consistent with the older EPA approach. Either approach may be regarded as scientifically defensible. Therefore, the following equation will be used in the BHHRA to estimate exposure to COPCs in air, consistent with FDEP (2005):

$$I_a = \frac{(C_a)(IR_a)(ET_a)(EF)(ED)}{(BW)(AT)} \qquad \text{Eq. 6}$$

where:

I_a	=	inhaled dose of COPC (milligrams per kilogram per day [mg/kg-day], calculated)
C_a	=	EPC of COPC in air (mg/m^3)
IR_a	=	inhalation rate, in units of m^3/day if a full day or full workday is assumed; in units of m^3/hr (and used in conjunction with ET_a) if less than a full day or full workday is assumed.
ET_a	=	exposure time (hours/day), used only if exposure is assumed to be less than a full day or full workday
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (hours).

4.3.4.2 Inhalation of COPCs Volatilized from Irrigation Water

COPCs in groundwater may be volatilized to the air during irrigation. Individuals present during irrigation may be exposed to the volatile COPCs. The following equation was excerpted from an equation provided by the University of Florida (2009) to calculate an estimated inhaled dose of a chemical to which an individual would be exposed based on the chemical concentration in groundwater, chemical-specific characteristics, and the irrigation use pattern.

$$I_i = \frac{(C_w)(IR_i)(EF)(ED)(IT)(Vw)(SE/100)}{(BW)(AT)(Va)} \qquad \text{Eq. 7}$$

where:

I_i	=	inhaled dose of COPC volatilized from groundwater used for irrigation (mg/kg-day, calculated)
C_w	=	EPC of COPC in groundwater (mg/kg)
IR_i	=	Inhalation rate (µg/L)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
IT	=	irrigation time (0.483 hour/day) (University of Florida, 2009)
Vw	=	volume of water used for irrigation (1,420 liters) (University of Florida, 2009)
SE	=	water-to-air chemical stripping efficiency (chemical specific; estimated based on Eq. 8)
BW	=	body weight (kg)
AT	=	averaging time (days)
Va	=	volume of air for volatilization (31,320 cubic meters [m^3]) (University of Florida, 2009).

The water-to-air chemical stripping efficiency, or "SE" term described above is estimated using the following equation:

$$SE = [7.95 \times \ln(H)] + 68.17 \qquad \text{Eq. 8}$$

where:

SE	=	water-to-air chemical stripping efficiency (calculated)
H	=	dimensionless Henry's Law constant (chemical specific)

4.3.4.3 Incidental Ingestion of COPCs in Soil

All receptors except the off-site consumer and the farm worker child may be exposed to soil by incidental ingestion. The ingested dose of a COPC in soil is estimated from the following equation:

$$I_s = \frac{(C_s)(IR_s)(FI_s)(EF)(ED)(BFS)(CF)}{(BW)(AT)} \qquad \text{Eq. 9}$$

where:

I_s	=	ingested dose of COPC in soil (mg/kg-day, calculated)
C_s	=	EPC of COPC in soil (mg/kg)
IR_s	=	soil incidental ingestion rate (mg/day)
FI_s	=	fraction of daily soil exposure attributed to site (unitless)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
CF	=	conversion factor (1E-6 kilograms per milligram)
BFS	=	chemical-specific bioavailability factor for soil (default=1; 0.6 is used for arsenic [EPA, 2012], unitless)
BW	=	body weight (kg)
AT	=	averaging time (days).

4.3.4.4 Dermal Contact with COPCs in Soil

Unlike the methodologies for estimating inhaled or ingested dose of COPCs, which quantify the dose presented to the barrier membrane (the pulmonary or gastrointestinal mucosa, respectively), dermal dose is estimated as the dose that crosses the skin and is systemically absorbed. For this reason, dermal toxicity values are also based on absorbed dose. The absorbed dose of a COPC is estimated as follows (EPA, 2004a):

$$DAD = \frac{(DA)(SA)(FI_d)(EF)(ED)}{(BW)(AT)} \qquad \text{Eq. 10}$$

where:

DAD	=	average dermally absorbed dose of COPC (mg/kg-day, calculated)
DA	=	dose absorbed per unit body surface area per day (mg/cm^2)
SA	=	body surface area exposed to soil (cm^2/day)
FI_d	=	fraction of daily soil exposure attributed to site (unitless)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (days).

It is assumed that one exposure event occurs each exposure day to maintain the dimensional integrity of the equation.

Dermal uptake of COPCs from soil assumes that absorption is a function of the fraction of a dermally applied dose that is absorbed. It is calculated from the following equation (EPA, 2004a):

$$DA = (C_s)(CF)(AF)(ABS) \qquad \text{Eq. 11}$$

where:

DA	=	dose absorbed per unit body surface area per day (mg/cm^2, calculated)
C_s	=	EPC of COPC in soil (mg/kg)
CF	=	conversion factor (1E-6 kg/mg)
AF	=	soil-to-skin adherence factor (mg/cm^2)
ABS	=	dermal absorption fraction (unitless, chemical-specific value).
AT	=	averaging time (days).

4.3.4.5 Ingestion of COPCs in Groundwater

The ingested dose of a COPC in groundwater is estimated from the equation:

$$I_w = \frac{(C_w)(IR_w)(EF)(ED)}{(BW)(AT)} \qquad \text{Eq. 12}$$

where:

I_w	=	ingested dose of COPC in groundwater (mg/kg-day, calculated)
C_w	=	EPC of COPC in groundwater (milligrams per liter [mg/L])
IR_w	=	drinking water ingestion rate (L/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (days).

4.3.4.6 Ingestion of COPCs in Surface Water

The ingested dose of a COPC in surface water is estimated from the equation:

$$I_w = \frac{(C_{sw})(IR_{sw})(EF)(ED)(ET)}{(BW)(AT)} \qquad \text{Eq. 13}$$

where:

I_{sw}	=	ingested dose of COPC in surface water (mg/kg-day, calculated)
C_{sw}	=	EPC of COPC in surface water (mg/L)
IR_{sw}	=	surface water ingestion rate (liters per hour)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
ET	=	exposure time (hours/exposure day)
BW	=	body weight (kg)
AT	=	averaging time (days).

4.3.4.7 Dermal Contact with COPCs in Water

Unlike the methodologies for estimating inhaled or ingested doses of a COPC, which quantify the dose presented to the barrier membrane (the pulmonary or gastrointestinal mucosa, respectively), the dermal dose is estimated as the dose that crosses the skin and is systematically absorbed. For this reason, dermal toxicity values are also based on absorbed dose. The absorbed doses of COPCs from water are estimated using the following equation (EPA, 2004a):

$$DAD = \frac{(DA)(SA)(EF)(ED)}{(BW)(AT)} \qquad \text{Eq. 14}$$

where:

DAD	=	average dermally absorbed dose of COPC (mg/kg-day, calculated)
DA	=	dose absorbed per unit body surface area per event (milligrams per square centimeter per event [mg/cm^2-event])
SA	=	surface area of the skin available for contact with water (cm^2)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (days).

Quantification of dermal uptake of constituents from water depends on a K_p, which describes the rate of movement of a constituent from water across the dermal barrier to the systemic circulation (EPA, 2004a). Separate calculation methods are applied to estimate the DA term (defined above) for inorganic and organic chemicals in water. For inorganic chemicals, DA is calculated from the following equation:

$$DA = (C_w)(K_p)(ET_w)(CF) \qquad \text{Eq. 15}$$

where:

DA	=	dose absorbed per unit body surface area per event (mg/cm^2-event, calculated)
C_w	=	EPC of COPC in water (mg/L)
K_p	=	permeability coefficient (centimeters per hour [cm/hour])
ET_w	=	time of exposure (hour/day)
CF	=	conversion factor (0.001 liters per cubic centimeter [L/cm^3]).

K_p values are available for some inorganics (EPA, 2004a). A default K_p value of 0.001 cm/hour (EPA, 2004a) will be used for those inorganics for which no chemical-specific values are available.

K_p values for organic chemicals vary by several orders of magnitude, largely dependent on lipophilicity, expressed as a function of the octanol-water partition coefficient. Because the stratum corneum (the outer skin layer) is rich in lipid content, it may act as a sink, initially reducing the transport of chemical to the systemic circulation. With continued exposure and the attainment of steady state conditions, the rate of transfer to the systemic circulation increases. Therefore, different equations are used to estimate DA, depending on whether the exposure time is less or greater than the estimated time to reach steady state. Non-steady-state exposures occur when either the exposure time is relatively brief (e.g., showering, for most chemicals) or when intermittent exposure occurs throughout the day (e.g., wading exposure to surface water or washing of hands). For exposure scenarios under which steady state is not reached for a given organic chemical (τ> ET, see below), the following equation is used to calculate DA (EPA, 2004a):

Eq. 16

$$DA = 2(FA)(K_p)(C_w)(CF)\sqrt{\left(\frac{6\tau(ET_w)}{\pi}\right)}$$

where:

DA	=	dose absorbed per unit body surface area per day (mg/cm^2-day, calculated)
C_w	=	concentration of COPC in water (mg/L)
FA	=	fraction absorbed from the water (unitless)
K_p	=	permeability coefficient (cm/hour)
CF	=	conversion factor (1E-3 L/cm^3)
τ	=	time for concentration of contaminant in stratum corneum to reach steady state per event (hours)
ET_w	=	time of contact (hour(s)/day).

In cases where steady state is reached (τ<ET), such as where the duration of a bath exceeds the time to reach steady state for a given organic compound, the following equation is used to calculate DA (EPA, 2004a):

Eq. 17

$$DA = (FA)(K_p)(C_w)(CF)\left[\frac{ET_w}{1+B} + 2\tau\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]$$

where:

DA	=	dose absorbed per unit body surface area per day (mg/cm^2-day, calculated)
C_w	=	concentration of COPC in water (mg/L)
FA	=	fraction absorbed from the water (unitless)
K_p	=	permeability coefficient (cm/hour)
CF	=	conversion factor (1E-3 L/cm^3)
τ	=	time for concentration of contaminant in stratum corneum to reach steady state per event (hours)
ET_w	=	time of contact (hour(s)/day)
B	=	Ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis (unitless).

Assuming one exposure event per day allows expressing ET as hour(s) per day, which preserves the dimensional integrity of the equation.

Where values for τ are not available, they will be calculated as follows (EPA, 2004a). Values of K_p and τ to be used in the BHHRA will be appended.

$$\tau = 0.105 \times 10^{(0.0056 \times MW)} \qquad \text{Eq. 18}$$

where:

τ	=	time for concentration of contaminant in stratum corneum to reach steady state (hours, calculated)
MW	=	molecular weight.

4.4 Toxicity Assessment

Toxicity is defined as the ability of a chemical to induce adverse effects in biological systems. The purpose of the toxicity assessment is two-fold:

- Identify the cancer and noncancer effects that may arise from exposure of humans to the COPCs (hazard assessment).

- Provide an estimate of the quantitative relationship between the magnitude and duration of exposure and the probability or severity of adverse effects (dose-response assessment).

The latter is accomplished by the derivation of cancer and noncancer toxicity values, as described in Section 4.4.1.

4.4.1 Evaluation of Carcinogenic Effects

A few chemicals are known, and many more are suspected, to be human carcinogens. The evaluation of the potential carcinogenicity of a chemical includes both a qualitative and a quantitative aspect (EPA, 2005). The qualitative aspect is a weight-of-evidence evaluation of the likelihood that a chemical might induce cancer in humans. EPA (2005) recognizes five weight-of-evidence group classifications for carcinogenicity. Formerly, EPA (1986) used a letter-based system to describe the weight of evidence for carcinogenicity. Reference to this former system is included because many of the carcinogenicity assessments listed on the Integrated Risk Information System (IRIS) use the former letter-based system (EPA, 2014f). The five EPA weight-of-evidence classifications are as follows:

- ***Carcinogenic to Humans*** (corresponds to the former Group A - Human Carcinogen)
- ***Likely to be Carcinogenic to Humans*** (includes both the former Group B1 and Group B2-Probable Human Carcinogens)
- ***Suggestive Evidence of Carcinogenic Potential*** (corresponds to the former Group C - Possible Human Carcinogen)
- ***Inadequate Information to Assess Carcinogenic Potential*** (corresponds to the former Group D - Not Classifiable as to Human Carcinogenicity)
- ***Not Likely to be Carcinogenic to Humans*** (corresponds to the former Group E - Evidence of Noncarcinogenicity to Humans).

The toxicity value for carcinogenicity, called an oral cancer slope factor (SF) or a cancer inhalation unit risk factor (UR), is an estimate of potency. Potency estimates are developed only for chemicals in the first three groups listed above, and only if the data are sufficient. The potency estimates are statistically derived from the dose-response curve from the best human or animal study or studies of the chemical. Although human data are often considered to be more reliable than animal data because there is no need to extrapolate the results obtained in one species to another, most human studies have one or more of the following limitations:

- The duration of exposure is usually considerably less than lifetime.
- The concentration or dose of chemical to which the humans were exposed can be only crudely approximated, usually from historical data.
- Concurrent exposure to other chemicals frequently confounds interpretation.
- Data regarding other factors (tobacco, alcohol, illicit or medicinal drug use, nutritional factors and dietary habits, heredity) are usually insufficient to eliminate confounding or quantify its effect on the results.
- Most epidemiologic studies are occupational investigations of workers, which may not accurately reflect the range of sensitivities of the general population.
- Most epidemiologic studies lack the statistical power (i.e., sample size) to detect a low, but chemical-related increased incidence of tumors.

Most potency estimates are derived from animal data, which present different limitations:

- It is necessary to extrapolate from results in animals to predict results in humans, usually done by estimating an equivalent human dose from the animal dose.
- The range of sensitivities arising from genotypic and phenotypic diversity in the human population is not reflected in the animal models ordinarily used in cancer studies.
- Usually very high doses of chemical are used, which may alter normal biology, creating a physiologically artificial state and introducing substantial uncertainty regarding the extrapolation to the low-dose range expected with environmental exposure.
- Individual studies vary in quality (e.g., duration of exposure, group size, scope of evaluation, adequacy of control groups, appropriateness of dose range, absence of concurrent disease, sufficient long-term survival to detect tumors with long induction or latency periods).

The SF is expressed as risk per mg/kg-day ($[mg/kg\text{-}day]^{-1}$). To be appropriately conservative, the SF is usually the 95 percent upper bound on the slope of the dose-response curve extrapolated from high (experimental) doses to the low-dose range expected in environmental exposure scenarios. EPA (1989b) assumes that there are no thresholds for carcinogenic expression; therefore, any exposure represents some quantifiable risk.

The SF is usually derived directly from the experimental dose data, because oral dose is usually expressed as mg/kg-day. When the test chemical is administered in the diet or drinking water,

oral dose first must be estimated from data for the concentration of the test chemical in the food or water, food or water intake data, and body weight data.

IRIS (EPA, 2014c) expresses inhalation cancer potency as a UR based on concentration, or risk per microgram of chemical/m^3 in ambient air (micrograms per cubic meter $[\mu g/m^3]^{-1}$). Because FDEP uses intake equations to estimate exposure for the inhalation pathway rather than exposure concentrations (Section 4.3.4.2), the UR values will be converted to inhalation SFs in units of risk per dose (i.e., $[mg/kg\text{-}day]^{-1}$). This conversion is performed using the following equation (FDEP, 2005c):

$$SF_i\ (mg/kg\text{-}day)^{-1} = [UR\ ([\mu g/m^3]^{-1}) \times 70\ kg \times 1{,}000\ \mu g/mg] \div 20\ m3/day \qquad \text{Eq. 19}$$

The oral SF, UR, and inhalation SF values and related information will be provided in the toxicity tables that will be included in the BHHRA.

4.4.2 Evaluation of Noncancer Effects

Many chemicals, whether or not associated with carcinogenicity, are associated with noncarcinogenic effects. The evaluation of noncancer effects (EPA, 1989b) involves:

- Qualitative identification of the adverse effect(s) associated with the chemical; these may differ depending on the duration (acute or chronic) or route (oral or inhalation) of exposure.
- Identification of the critical effect for each duration of exposure (i.e., the first adverse effect that occurs as dose is increased).
- Estimation of the threshold dose for the critical effect for each duration of exposure.
- Development of an uncertainty factor; i.e., quantification of the uncertainty associated with interspecies extrapolation, intraspecies variation in sensitivity, severity of the critical effect, slope of the dose-response curve, and deficiencies in the database, in regard to developing a reference dose (RfD) for human exposure.
- Identification of the target organ(s) for the critical effect for each route of exposure.

These information points are used to derive an exposure route- and duration-specific toxicity value called an RfD, expressed as mg/kg-day, which is considered to be the dose for humans, with uncertainty of an order of magnitude or greater, at which adverse effects are not expected to occur. Mathematically, it is estimated as the ratio of the threshold dose to the uncertainty factor. For purposes of risk assessment, chronic exposure is defined as equal to or greater than 7 years, i.e., at least 10 percent of expected life span; subchronic exposure is defined as 2 weeks to 7

years. Although the childhood exposure duration and construction worker scenarios are less than 7 years, chronic toxicity data will be used to evaluate these receptors.

IRIS (EPA, 2014c) expresses the inhalation noncancer reference value as a reference concentration (RfC) in units of mg/m^3. The inhalation RfC is based on continuous exposure of an adult human (assumed to inhale 20 m^3 of air per day and to weigh 70 kg).

Because FDEP uses intake equations to estimate exposure for the inhalation pathway rather than exposure concentrations (Section 4.3.4.2), the RfC values will be converted to inhalation RfD (RfD_i) values in dose unit (i.e., mg/kg-day). This conversion is performed using the following equation (FDEP, 2005c):

$$RfD_i\ (mg/kg\text{-}day) = (RfC\ (mg/m^3) \times 20\ m3/day) \div 70\ kg \qquad \text{Eq. 20}$$

RfD and RfC values are derived for both chronic and subchronic exposure. Under the assumption of monotonicity (incidence, intensity, or severity of effects can increase, but cannot decrease, with increasing magnitude or duration of exposure), a chronic RfD may be considered sufficiently protective for subchronic exposure, but a subchronic RfD may not be protective for chronic exposure. Currently, subchronic RfD values exist for few chemicals. Only chronic RfDs and RfCs will used in the BHHRA. These chronic RfCs will be converted to RfD_i values as described above.

The BHHRA will provide oral and dermal (Section 5.4.3) RfD, RfC, and RfD_i values and related information in table format.

4.4.3 Dermal Toxicity Values

Dermal RfDs and SFs are derived from the corresponding oral values, provided there is no evidence to suggest that dermal exposure induces exposure route-specific effects that are not appropriately modeled by oral exposure data. In the derivation of a dermal RfD, the oral RfD is multiplied by the oral absorption efficiency factor (OAE), expressed as a decimal fraction. The resulting dermal RfD, therefore, is based on absorbed dose. The RfD based on absorbed dose is the appropriate value with which to compare a dermal dose, because dermal doses are expressed as absorbed rather than exposure doses. The dermal SF is derived by dividing the oral SF by the OAE. The oral SF is divided, rather than multiplied, by the OAE because the SF is expressed as a reciprocal dose.

4.4.4 Target Organ Toxicity

As a matter of science policy, EPA assumes dose and effect to be additive for noncarcinogenic effects (EPA, 1989a). This assumption provides the justification for adding the hazard quotient (HQ) or hazard index (HI) values in the risk characterization for noncancer effects resulting from exposure to multiple chemicals, pathways, or media. However, EPA (1989a) acknowledges that adding all HQ or HI values may overestimate hazard, because the assumption of additivity is probably appropriate only for those chemicals that exert their toxicity by the same mechanism.

Mechanisms of toxicity data sufficient for predicting additivity with a high level of confidence are available for very few chemicals. In the absence of such data, EPA (1989a) assumes that chemicals that act on the same target organ may do so by the same mechanism of toxicity; that is, the target organ serves as a surrogate for mechanism of toxicity. When total HI for all media for a receptor exceeds 1 due to the contributions of several chemicals, it is appropriate to segregate the chemicals by route of exposure and mechanism of toxicity (i.e., target organ) and estimate separate HI values for each target organ.

As a practical matter, since human environmental exposures are likely to involve near- or sub-threshold doses, the target organ chosen for a given chemical is the one associated with the critical effect. If more than one organ is affected by a given chemical at the threshold, then the affected target organs are selected for this chemical. The target organ is also selected on the basis of duration of exposure (i.e., the target organ for chronic or subchronic exposure to low or moderate doses is selected rather than the target organ for acute exposure to high doses) and route of exposure. Because dermal RfD values are derived from oral RfD values, the oral target organ is adopted as the dermal target organ. For some chemicals, no target organ is identified. This occurs when no adverse effects are observed or when adverse effects such as reduced longevity or growth rate are not accompanied by recognized organ- or system-specific functional or morphologic alteration. Target organs for the oral and inhalation pathway will be provided in the BHHRA toxicity tables.

4.4.5 Lead Toxicity

The primary toxic effects of lead are neurological and hematological. Subtle neurological changes in children and the effects in the levels of certain blood enzymes appear to occur at levels so low as to be considered nonthreshold effects. Therefore, EPA (2014f) considers the derivation of an RfD inappropriate. Although lead is classified as a B2 carcinogen, EPA declined to derive an SF for carcinogenicity because of high uncertainties associated with a number of factors. The ALM model is used to evaluate lead toxicity and exposure as are described in

Section 4.3.2. This model generates an estimated blood-lead concentration for a human fetus based on a variety of potential lead sources.

4.4.6 Sources of Toxicity Information Used in the Risk Assessment

Toxicity values will be selected for use in the BHHRA based on the EPA Office of Solid Waste and Emergency Response Directive 9285.7-53 (EPA, 2003b), which prescribes the following hierarchy:

- ***Tier 1*** values: IRIS (EPA, 2014c) database.
- ***Tier 2*** values: EPA's provisional peer-reviewed toxicity values (PPRTV). The PPRTVs are developed by the Office of Research and Development, the National Center for Environmental Assessment, and the Superfund Health Risk Technical Support Center on a chemical-specific basis when requested by the Superfund program.
- ***Tier 3*** values: Other toxicity values from additional EPA and non-EPA sources of toxicity information. As stated in the EPA Office of Solid Waste and Emergency Response directive, "priority should be given to those sources of information that are the most current, the basis for which is transparent and publicly available, and which have been peer reviewed." Two common examples of Tier 3 values are the EPA's Health Effects Assessment Summary Tables (EPA, 1997a) and the California Environmental Protection Agency (2014) Office of Environmental Health Hazard Assessment Toxicity Criteria Database.

The Environmental Council of States DoD (2007) has issued a toxicity value hierarchy that basically supports the EPA (2003b) hierarchy presented previously but places higher emphasis on the necessity for external peer review. FDEP also lists a hierarchy of toxicity value sources at 62-780.650. This FDEP hierarchy identifies the PPRTVs as a Tier 1 source, but that the PPRTVs are of lower preference than IRIS. The other Tier 2 and Tier 3 sources listed by FDEP will be considered as appropriate within the EPA direction that priority should be given to the most current, transparent and publicly available sources that have received peer review.

OAEs, used to derive dermal RfD values and SFs from the corresponding oral toxicity values, are obtained from the following sources:

- Oral absorption efficiency data compiled by the National Center for Environmental Assessment for the Superfund Health Risk Technical Support Center of EPA
- Federal agency reviews of the empirical data, such as Agency for Toxic Substances and Disease Registry Toxicological Profiles and various EPA criteria documents

- Other published reviews of the empirical data
- The primary literature.

OAEs obtained from reviews are compared to empirical (especially more recent) data, when possible, and are evaluated for suitability for use for deriving dermal toxicity values from oral toxicity values. The suitability of the OAE increases when the following similarities are present in the oral pharmacokinetic study from which the OAE is derived and in the key toxicity study from which the oral toxicity value is derived:

- The same strain, sex, age, and species of test animal were used
- The same chemical form (e.g., the same salt or complex of an inorganic element or organic compound) was used
- The same mode of administration (e.g., diet, drinking water, or gavage vehicle) was used
- Similar dose rates were used.

The most defensible OAE for each chemical will be used in the BHHRA toxicity tables.

4.5 Risk Characterization

Risk characterization is the process of applying numerical methods and professional judgment to determine the potential for adverse human health effects to result from the presence of site-specific contaminants. This is done by combining the intake rates estimated during the exposure assessment, with the appropriate toxicity information identified during the toxicity assessment. Noncancer hazards and cancer risks are characterized separately.

Quantitative expressions are calculated during risk characterization that describe the probability of developing cancer (ILCRs) or the nonprobabilistic comparison of estimated dose with an RfD for noncancer effects (HQs and HIs). Quantitative estimates are developed for individual chemicals, exposure pathways, and exposure media for each receptor. These quantitative risk characterization expressions, in combination with qualitative information, are used to guide risk management decisions. Risk characterization, as described in this section, is applied only to COPCs.

Generally, the risk characterization follows the methodology prescribed by EPA (1989a), as modified by more recent information and guidance. EPA methods are, appropriately, designed to be health protective and tend to overestimate, rather than underestimate, risk. The risk results, however, may be overly conservative, because risk characterization involves multiplication of

the conservative assumptions built into the estimation of source-term concentrations and EPCs, the exposure (intake) estimates, and the toxicity dose-response assessments. The uncertainties associated with the risk results and other pertinent considerations will be discussed in the uncertainties analysis (Section 4.6) of the BHHRA as appropriate.

4.5.1 Carcinogenic Effects of Chemicals

The risk from exposure to potential chemical carcinogens is estimated as the probability of an individual developing cancer over a lifetime (the ILCR). In the low-dose range, which would be expected for most environmental exposures, cancer risk is estimated from the following linear equation (EPA, 1989a):

$$ILCR = (CDI)(SF) \qquad \text{Eq. 21}$$

where:

ILCR	=	incremental lifetime cancer risk, a unitless expression of the probability of developing cancer, adjusted for background incidence, calculated
CDI	=	chronic daily intake, averaged over 70 years (mg/kg-day)
SF	=	cancer slope factor $(mg/kg\text{-}day)^{-1}$.

The “CDI” term in Equation 21 is equivalent to the "I" or "DAD" terms (intake or dose) in the exposure assessment equations (Section 4.3.4) when these equations are evaluated for cancer intakes/doses.

The use of Equation 21 assumes that chemical carcinogenesis does not exhibit a threshold and that the dose-response relationship is linear in the low-dose range. Because this equation could generate theoretical cancer risks greater than 1 for high dose levels, it is considered to be inaccurate at cancer risks greater than 1E-2. In these cases, cancer risk is estimated by the one-hit model:

$$ILCR = 1 - e^{[-(CDI)(SF)]} \qquad \text{Eq. 22}$$

where:

ILCR	=	incremental lifetime cancer risk, a unitless expression of the probability of developing cancer, adjusted for background incidence, calculated
$e^{(-CDI)(SF)}$	=	the exponential of the negative of the risk calculated using Equation 21.

As a matter of policy, EPA (1986) considers the carcinogenic potency of simultaneous exposure to low doses of carcinogenic chemicals to be additive, regardless of the chemical's mechanisms

of toxicity or sites (organs of the body) of action. Cancer risk arising from simultaneous exposure by a given pathway to multiple chemicals is estimated from the following equation:

$$ILCR_p = ILCR_{(chem\ 1)} + ILCR_{(chem\ 2)} + \cdots ILCR_{(chem\ i)} \qquad \text{Eq. 23}$$

where:

$ILCR_p$ = total pathway incremental lifetime cancer risk, calculated
$ILCR(chem_i)$ = individual chemical cancer risk.

Similarly, the ILCR of a chemical may be summed across pathways. Cumulative cancer risk for a given receptor across pathways and across media is summed in the same manner. The sum of the ILCRs summed across pathways is the total ILCR as shown in the following equation:

$$Total\ \ ILCR = ILCR_{(p\ 1)} + ILCR_{(p\ 2)} + \cdots ILCR_{(p\ i)} \qquad \text{Eq. 24}$$

where:

Total ILCR = total incremental lifetime cancer risk across all pathways
$ILCR_{pi}$ = incremental lifetime cancer risks associate with pathway "I."

The total ILCR represents all additional cancer risks posed to a given receptor by contact with contaminants in site environmental media.

Total ILCRs in the range of 1E-6 to 1E-4 are regarded as acceptable in the National Oil and Hazardous Substances Pollution Contingency Plan Final Rule (NCP) (EPA, 1990); this range is hereinafter referred to as the NCP acceptable range. Risks less than this range are regarded by as *de minimis* or negligible (EPA, 1990). The FDEP has a cumulative cancer risk goal of 1E-6.

4.5.2 Noncancer Effects of Chemicals

The hazards associated with noncancer effects of chemicals are evaluated by comparing an exposure level or intake with an RfD. The HQ, defined as the ratio of intake to RfD, is estimated as follows (EPA, 1989a):

$$HQ = I\ /\ RfD \qquad \text{Eq. 25}$$

where:

HQ = hazard quotient (unitless, calculated)
I = intake of chemical averaged over exposure duration (mg/kg-day)
RfD = reference dose (mg/kg-day).

The “I” term in Equation 25 is equivalent to the "I" or "DAD" terms (intake or dose) in the exposure assessment equations (Section 4.3.4) when these equations are evaluated for noncancer intakes/doses.

As shown in Equation 25, both the “I” and the RfD are in units of mg/kg-day. The RfD has been developed to represent a dose rate unlikely to result in any adverse noncancer health effects, even to the most susceptible members of the population. Therefore, if the “I” is equal to or less than the RfD or the HQ is equal to the RfC (i.e., HQ$\leq$1), adverse noncancer health effects are unlikely. HQ values exceeding 1 do not indicate that noncancer hazard is likely to occur, but rather that the occurrence of an adverse noncancer health effect cannot be termed “unlikely.” The HQ does not define a particular risk level, nor can it be used to infer information regarding a dose-response curve. That is, an HQ of 0.01 does not imply a 1-in-100 chance of an adverse effect, but indicates that the estimated intake or exposure concentration is 100 times lower than the respective RfD or RfC. Similarly, an HQ greater than a value of 1 does not indicate a likelihood of adverse effect, but indicates that adverse human health effects at this HQ are not regarded as unlikely. This approach is different from the probabilistic approach described in Section 4.5.1 to evaluate cancer risks.

In the case of simultaneous exposure of a receptor to several chemicals, an HI is calculated as the sum of the HQs as follows:

$$HI = I_1 / RfD_1 + I_2 / RfD_2 + \ldots I_i / RfD_i \qquad \text{Eq. 26}$$

where:

HI = hazard index (unitless, calculated)
I_i = intake for the ith toxicant
RfD_i = reference dose for the ith toxicant.

If the HI for a given pathway exceeds 1, individual HI values may be calculated for each target organ. A total HI is calculated by summing the HI values, associated by target organ(s), across exposure pathways as follows:

$$Total\ HI_a = HI_{p1-a} + HI_{p2-a} + \ldots HI_{pi-a} \qquad \text{Eq. 27}$$

where:

Total HI_a = total hazard index for target organ “*a*” (unitless, calculated)
HI_{pi-a} = hazard index for target organ “*a*” via pathway “*i*.”

4.5.3 Risk Characterization Results

Risk characterization results for Landfill Area 1 and Landfill Area 3 will be presented in tables and discussed separately in the text. The cancer (Section 4.5.1) and noncancer (Section 4.5.2) risk results will be presented in the BHHRA for each receptor (Section 4.5.2).

4.6 Uncertainties Analysis

The primary objective of the BHHRA is to characterize and quantify potential human health risks. However, these risks are estimated using incomplete and imperfect information that introduces uncertainties at various stages of the risk assessment process. Uncertainties associated with earlier stages of the risk assessment become magnified when they are concatenated with other uncertainties in the latter stages. Reliance on a simplified numerical presentation of dose rate and risk without consideration of uncertainties, limitations, and assumptions inherent in their derivation can be misleading. For example, the calculated ILCR for a given scenario "A" may be 5E-5 (within the NCP acceptable risk range) and that of scenario "B" given as 5E-4 (exceeding the NCP acceptable risk management range). However, if the uncertainties associated with scenario "B" span, for instance, orders of magnitude and the ILCR is regarded as biased high, it is not unlikely that scenario "A" actually presents a higher risk of developing cancer.

The chief goal of this analysis is to evaluate uncertainties and present them in context of their potential impact on the interpretation of the risk assessment results and the types of environmental management decisions that may be based on these results. The uncertainty analysis does not exhaustively describe all potential uncertainties but presents those that have the largest implications for the interpretation of the risk assessment results. This analysis also overviews the types and, as applicable, the magnitude of the uncertainties at each stage of the risk assessment. Although the BHHRA will include generic uncertainties that are common to the state of human health risk assessment practice (e.g., additivity of health effects in the risk characterization), the overall focus of the Uncertainties Analysis will be on the set of uncertainties that is peculiar to each of the site areas being evaluated, especially the site-specific uncertainties that have the greatest impact on the risk characterization results and/or the implication of these results on potential response actions.

4.6.1 Types of Uncertainty

Uncertainties in risk assessment are categorized into two general types: 1) variability inherent in the (true) heterogeneity of the data set, measurement precision, and measurement accuracy; and 2) uncertainty that arises from data gaps. Estimates of the degree of variability tend to decrease as the sample size increases. This is because larger data sets are less impacted by individual samples/measurements and typically allow for greater accuracy. Uncertainty that arises from data

gaps is addressed by applying models and assumptions. Models are applied because they represent a level of understanding to address certain exposure parameters that are impractical or impossible to measure (e.g., COPC concentrations in air that would result from groundwater use that has not yet occurred —or may never occur—at the site) (Table 4-1). Assumptions represent an educated estimate to address information that is not available (e.g., additivity of carcinogens).

4.6.2 Sources of Uncertainty

A discussion will be provided that presents an overview of general sources of uncertainty and focuses on those most likely to affect the interpretation of the BHHRA results. These sources may include, but are not limited to, the following:

- Representativeness of samples
- Laboratory procedures and analytical methods
- Sampling methods
- Adequacy of background data set
- Comparisons to background concentrations
- Land use and groundwater use assumptions
- Routes of exposure
- Exposure assessment values
- Exposure models
- Methods of calculating EPCs
- Toxicity values
- Form or isomer of chemical
- Interactions of multiple contaminants.

The BHHRA will identify and describe the unique set of uncertainties associated with the site. Special attention may be given to those uncertainties that are thought to have the most significant impact on potential risk and/or site management decisions.

4.7 Summary/Conclusions

The BHHRA will include a brief summary/conclusion section that will summarize the results of the risk characterization, with a sufficient level of elucidation addressing the effects that uncertainties may have on these results. This section will also preliminarily identify the COCs, if present, which will be presented in the feasibility study as necessary. The goal is to present the BHHRA in a context that is most appropriate for the support of environmental decision making

5.0 Screening Level Ecological Risk Assessment

SLERAs will be performed for Landfill Areas 1 and 3 at LFNAS. The two landfills will be evaluated independently because they are approximately 2,500 feet apart, and they likely each have different chemical constituents. The SLERAs are designed to evaluate potential unacceptable risks to ecological receptors posed by site-related constituents potentially present at two landfills. The SLERAs will be conducted in accordance with the *Florida Ecological Risk Assessment Guidance Document* (FDEP, 2014) and the EPA *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (EPA, 1997b), known as the "Process Document." Other supplemental guidance (e.g., EPA [2001a]) will also be incorporated and followed, as appropriate.

The SLERA methodology will generally follow the eight-step risk assessment process presented in the Process Document (Figure 5-1). The SLERA will consist of Steps 1 through the first part of Step 3, often referred to as "Step 3a" (U.S. Navy, 1999; 2012), which is approximately equivalent to a Tier I evaluation under the FDEP (2014) guidance. Thus, the SLERA includes the following steps:

- Step 1: Problem formulation
- Step 2: Preliminary exposure estimate and risk calculation
- Step 3a: COPEC refinement.

The first two steps include an initial screen to identify COPECs. Because of the highly conservative assumptions used in this initial screen, some of the COPECs are likely to pose an acceptable risk. The SLERA will incorporate multiple lines of evidence to refine the list of COPEC in Step 3a. At the conclusion of the SLERA, a recommendation will be made as to whether further investigation or action is necessary to address COPECs (e.g., continuing to a baseline ecological risk assessment [BERA], or performing remediation), or if sufficient evidence is available to justify a recommendation for no further action. The methods and approaches that will be used to perform the SLERAs for Landfill Areas 1 and 3 are described in the following sections.

5.1 Facility Description

Section 1.3 of this Work Plan presents a description of the LFNAS property, as well as Landfill Area 1 and Landfill Area 3. Landfill Areas 1 and 3 are approximately 6.2 and 7.4 acres in size, respectively, inactive, and heavily vegetated by a mixture of grasses, shrubs, and trees. Three

Mile Swamp is adjacent to Landfill Area 1 to the south and east, and is approximately 400 feet east and northeast of Landfill Area 3.

5.1.1 Ecological Description

The SLERA will present a detailed ecological description of the site, including a listing of the habitat types, water bodies, flora and fauna assemblages (if known), and wetlands present at or near each landfill area. The Florida National Areas Inventory and Florida Fish and Wildlife Conservation Commission will be contacted to determine if potential habitat for rare (including threatened or endangered) species is present at or near each site, and whether there are any known records of state or federal threatened or endangered species in the vicinity of each landfill area.

5.1.2 Results of Previous Investigations

As described in Sections 1.4 and 1.5, many previous investigations have been performed at Landfill Areas 1 and 3. The most recent ecological risk investigation was a SLERA performed as part of the 2004 Landfill Area 1 and Landfill Area 3 RI (Shaw, 2004a). The Landfill Area 1 SLERA identified 10 organic chemicals in soil as COPECs requiring additional evaluation, including four PAHs (benzo[a]pyrene, fluoranthene, phenanthrene, and pyrene), four pesticides (4,4'-dichlorodiphenyldichloroethane, 4,4'-DDE, 4,4'-dichlorodiphenyltrichloroethane, and dieldrin), and two PCBs (Aroclor 1254 and Aroclor 1260). One pesticide (4,4'-DDE) and two PCBs (Aroclor 1254 and Aroclor 1260) in sediment were also recommended for further evaluation. Ecological risk associated with chemicals detected in surface water was considered acceptable, and no chemicals in that medium were recommended for additional consideration. For Landfill Area 3, two chemicals in sediment (iron and Aroclor 1260) were recommended for further evaluation. Ecological risk associated with chemicals detected in surface water and soil was considered acceptable, and no chemicals in those media were recommended for additional consideration. The sampling events performed at the sites since 2004 were conducted using information gained from the previous RI results. The current SLERA will provide a re-evaluation of all media (soil, surface water, and sediment) at both landfill areas using updated screening values and risk assessment practices to generate a comprehensive analysis of the potential for ecological risk at Landfill Areas 1 and 3.

5.2 Scope and Objectives

The SLERA will provide an updated estimate of the potential for adverse ecological effects associated with suspected releases at Landfill Areas 1 and 3 using all appropriate and representative data from the sites. Current screening levels and ecological risk assessment guidance will be followed, and additional methods useful for determining possible risk to

specific representative wildlife species (i.e., using food chain modeling) will be included. Although the term "SLERA" is often used in the singular in this work plan, two SLERAs will be performed independently for the two landfill areas.

The results of the SLERA will contribute to the overall characterization of the sites and may be used to determine the need for additional investigations or to develop, evaluate, and select appropriate remedial alternatives. The SLERA will be performed following guidelines outlined in ecological risk assessment guidance documents, including the following:

- *Florida Ecological Risk Assessment Guidance* (FDEP, 2014)
- *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (EPA, 1997b)
- *Tri-Service Procedural Guidelines for Ecological Risk Assessments* (Wentsel et al., 1996)
- *The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments* (EPA, 2001a).

The primary objective of the SLERA is to evaluate the potential for adverse ecological effects to ecological receptors from suspected releases. This objective will be met by characterizing the ecological communities in the vicinity of the landfill areas, determining the contaminants present, identifying pathways for receptor exposure, and estimating the magnitude and the likelihood of potential adverse effects to identified receptors. The SLERA will address the potential for adverse effects to the vegetation, terrestrial invertebrates, wildlife, aquatic life (e.g., sediment- and surface water-dwelling organisms), threatened and endangered species, and wetlands or other sensitive habitats associated with the landfill areas. As recommended by FDEP (2014) guidance, both chemical and non-chemical stressors will be considered; however, non-chemical stressors are expected to be of minor concern at these two sites and will be evaluated qualitatively, and chemical stressors are expected to be the focus of the SLERA.

Concentrations of chemicals measured in relevant environmental media will be used to perform a SLERA. A problem formulation (described in Section 5.3) will be performed that will describe the ecological condition at the site, determine if ecological receptors or habitat is present at the site that could result in exposure to chemical contamination, and present a site ecological conceptual model describing contamination sources and potential exposure pathways for ecological receptors. A preliminary risk calculation (Section 5.4) will provide an initial determination of whether chemicals are present at concentrations that could result in toxicity. Initial COPECs will be selected in each medium using the results of the preliminary risk

calculation as well as other criteria that will assist in identifying the list of site-related chemicals that have the potential to result in adverse effects to ecological receptors (Section 5.5). The problem formulation and preliminary risk calculation represent Steps 1 and 2 of the 8-Step ecological risk assessment process. If no COPECs are identified, the SLERA process will conclude. If COPECs are present, the process will continue to Step 3a, COPEC refinement (Section 5.6). The COPEC refinement will include a second comparison to benchmarks using a more realistic EPC as a refined approach for evaluating organisms at the base of the food chain and will also present a food chain model to determine if chemicals present in site media are a potential risk to bird and mammal species representative of the various foraging guilds likely to be present at the site. The food chain model consists of exposure characterization, ecological effects characterization, and risk characterization. Additional lines of evidence may be used in the COPEC refinement as well, including consideration of the spatial distribution of COPECs, their relative magnitude of exceedance of chemical benchmarks, and other factors that may more fully inform risk managers and project stakeholders. Uncertainties inherent in the risk assessment process will be described for consideration by risk managers (Section 5.7). The final sections of the SLERA will provide a risk description, and summary and conclusions of the risk assessment (Sections 5.8 and 5.9).

This will conclude the FDEP Tier I ecological risk assessment process. A scientific/management decision point will then occur, wherein it will be determined if additional action or investigation is needed to address identified hazards or uncertainties associated with COPECs in one or more media. If adequate information exists to conclude that the potential for adverse ecological effects is sufficiently low, the recommendation would be made to terminate the ecological risk assessment process following the completion of the SLERA.

5.3 Screening-Level Problem Formulation

The goal of the screening-level problem formulation is to develop an ecological site conceptual model for the site that addresses the following:

- The environmental setting
- The contaminants known or suspected of being present at the site
- The presence or absence of contaminant fate or transport mechanisms
- The presence or absence of viable exposure pathways and receptors.

The screening-level problem formulation will provide a detailed description of the site, including historical uses, current habitat information, the potential for the presence or absence for various types of receptors to be present, and a list of chemicals that may be potentially linked to previous site activities. This information will be incorporated in an initial conceptual site model that will

describe the ecological properties of the site and their potential interactions with contaminants. A general description of these chemicals' fate and transport and toxicological properties will be provided. Some of the elements of the problem formulation are described in the following sections and will be expanded upon in the SLERA based on any additional site-specific information available at that time.

5.3.1 Site Description

A description of each landfill area will be compiled from existing site reports, maps (e.g., jurisdictional wetlands determination, defined under criteria administered by USACE, Department of the Army, DoD), available aerial photographs, communication with appropriate agencies (e.g., U.S. Fish and Wildlife Service, National Heritage Program), and a site visit. For each landfill, the site history will include information about the events that have led to the current investigation. The site setting of each landfill will include geographical location, accessibility, and its surroundings. Land use (e.g., industrial, business, residential, military, agricultural, and undeveloped) upgradient and downgradient of the sites will be described, with special note to natural areas such as parks, wildlife refuges, and wetlands. A general description of topography, including a description of whether the site is open or wooded, flat or hilly, and marshy or dry, will be presented. The setting will describe surface water associated with each site. A description of the ecological features present at the site (e.g., wetlands, woodlands, grasslands, open fields, ponds, streams) will also be provided. Information regarding flora and fauna known or likely to be present at the site will be provided, including migratory species of animals and species that use the area during only part of their life cycle. Species of special interest, such as game species, federal- or state-listed endangered or threatened species, and species protected under other statutes, will be described. A brief overview of the two landfill areas is provided in the following paragraphs based on readily available information.

Landfill Area 1 is approximately 6.2 acres in size, is currently inactive, and is heavily vegetated. The site is bordered to the north by Wildwood Road and a drainage swale paralleling the road; to the south and east by a cypress wetland area (Three Mile Swamp); and to the west by a low, flat, wooded area that contains standing water during the rainy season and connects with Three Mile Swamp (Figure 1-2). The eastern portion of Landfill Area 1 was regraded by the property owner (CCP). Prior to this regarding, the eastern one-half to two-thirds of the landfill was generally mounded with abundant debris approximately 8 to 15 feet above the surrounding topography. Land cover in this portion of the landfill consists of a thin layer of soil, which supports mostly grasses, scrub vegetation, and few trees. There is a leveled and clear-cut open area of approximately one-quarter acre in the northeastern portion of the site that has been used for temporary storage of local law enforcement equipment. The eastern edge of the landfill slopes

downward toward the wetland area, which is dominated by cypress trees and low vegetation common to wetlands in the southeastern United States. The southwestern portion of the landfill is low and relatively flat as the ground surface slopes downward from the high central portion of the landfill. The southeastern and southwestern edges of the landfill are covered mostly with grasses and low vegetation common near wetland areas. The south-central part of the landfill is densely vegetated with cypress trees and vines. The central and west-central portions of the landfill are dominated by thick vegetation such as trees, brush, and scrub. Mounded debris is common here. The western portion of the landfill is relatively flat and contains a dense canopy of trees. Surface debris is common here, especially to the south. The northern edge of the landfill slopes downward from the center to Wildwood Road.

Landfill Area 3 is approximately 7.4 acres in size and is bounded on the north, west, and east by a thick cover of trees (Figure 1-3). Three Mile Swamp lies approximately 400 feet east and northeast of the landfill. The southern edge of Landfill Area 3 is bordered by a dirt access road. Landfill Area 3 is heavily wooded with trees and undergrowth. The eastern edge of Landfill Area 3 is covered by grasses and thick scrub vegetation that resulted from timber activities that occurred prior to the end of 2001. The landfill area is relatively flat; however, three mounded areas are located within the estimated boundaries of Landfill Area 3. The mounds are approximately 3 to 5 feet high, and their origin is unknown. Aside from scattered debris on the landfill area surface, there are no other visible indications that a landfill is present.

5.3.2 Screening-Level Ecological Conceptual Site Model

A screening-level ecological conceptual site model (ECSM) will be developed for each landfill area that describes the relationships between contaminated media and ecological receptors by identifying sources, transport, partitioning, contaminated media, and possible exposure routes. These routes will either be confirmed or discounted as insignificant or improbable in the SLERA. Pictorial representations of these ECSMs will visually depict how contaminants are moving among aquatic and terrestrial organisms and through trophic levels at the site. Incomplete pathways, or media that are not relevant and/or evaluated in the SLERA, will also be noted.

5.3.3 Management Goals

Management goals, which are similar to screening-level assessment endpoints (FDEP, 2014; EPA, 1997b), define the ecological values that are to be protected at the site. The management goal for the two landfill areas will be the protection of terrestrial and aquatic ecological receptor populations from unacceptable hazard associated with the release of chemicals originating from the waste burial activities that historically occurred at Landfill Area 1 and Landfill Area 3. If

threatened or endangered species are documented on site, the management goal would be protection at the individual level (not the population level).

5.4 Preliminary Exposure Estimate and Risk Calculation

The preliminary exposure estimate and risk calculation will provide an indication as to whether chemicals detected in site media have the potential to result in adverse ecological effects. This will be accomplished by screening the MDC against a conservative ecological screening value (ESV). If the MDC for a given chemical exceeds the ESV, there is the potential for environmental impacts, and the chemical will be initially retained as a COPEC.

5.4.1 Selection of Data for Use in the SLERA

For these SLERAs, results of soil (0 to 6 feet), surface water, and sediment samples will be used. Sections 3.5 and 3.6 present details of environmental samples to be collected at each landfill area. Although most ecological exposure occurs in the top 1 to 2 feet of soil, including soil down to 6 feet in the SLERA evaluation is protective of burrowing organisms and deep-rooted plants that may be exposed to deeper soil depths.

The analytical data to be used will be derived from the following sources:

- Samples used in the previous Landfill Area 1 and Landfill Area 3 RI report (Shaw, 2004a)
- Samples from additional studies performed at the two landfill areas since the RI report has been finalized
- Samples collected by CB&I for the current RI sampling effort.

The available data will be reviewed prior to their use in the SLERA. Data from sample locations that are no longer valid or appropriate for use (e.g., soil samples from the portion of Landfill Area 1 that was regraded, data from sample locations that have been subsequently resampled, etc.) will not be used as part of the SLERA data set.

5.4.2 Review, Evaluation, and Presentation of Analytical Data

Chemical analytical data, as well as all previous and ongoing investigations, will be reviewed and evaluated for quality, usefulness, and uncertainty. Data identified as being of acceptable quality for use in the SLERA will be summarized in a manner that presents the pertinent information to be applied in the SLERA.

The analytical data may have qualifiers from the analytical laboratory quality control or from the data validation process that reflect the level of confidence in the data. Some of the more common qualifiers and their meanings are as follows (EPA, 1989a):

- U - Chemical was analyzed for but not detected; the associated value is the sample quantitation limit.
- J - Value is estimated, probably below the contract-required quantitation limit.
- R - QC indicates that the data are unusable (chemical may or may not be present).
- B - Concentration of chemical in sample is not sufficiently higher than concentration in the blank (using the 5-times/10-times rule).

Validated data with "J" qualifiers are used in the risk assessment; data assigned "R" and "B" qualifiers following data validation are not. The handling of "U"-qualified data (nondetects) is described in the following sections of this work plan.

Analytical data from field duplicates and parent sample results will be combined to yield one result for use in the generation of mean (and UCLs; see Section 5.6.2) concentrations, as follows:

- Use the average of the field duplicate and parent sample if both are positive detections or if both are nondetects.
- Use the detected value if one sample is a positive detection and the other is a nondetect.

Nondetect results will be estimated to be equal to the reporting limit, as currently recommended in EPA ProUCL guidance (EPA, 2013b).

5.4.3 Selection of Ecological Screening Values and Risk Calculation

As an initial indication of potential ecological risk, the MDCs for each positively identified chemical in each medium will be compared individually to appropriate ecological screening values (ESVs). The following ESV hierarchy, following the order of preference specified in FDEP (2014) guidance, will be used for the ecological evaluation.

- ***Soil.*** Soil screening values will be selected using the following hierarchy: (1) EPA ecological soil screening levels (Eco-SSL) (EPA, 2008a), (2) *Supplemental Guidance to RAGS: Region 4 Bulletins, Ecological Risk Assessment* (EPA, 2001b), (3) EPA Region 5 ecological screening levels (EPA, 2003c), (4) *Preliminary Remediation Goals for Ecological Endpoints* (Efroymson, et. al. 1997a), (5) *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process* (Efroymson et al., 1997b),

(6) *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants* (Efroymson et al., 1997c), (7) Los Alamos National Laboratory (LANL) EcoRisk screening levels (LANL, 2014), and (8) *Ecological Data Quality Levels* (EPA, 1999). Please note that effects on heterotrophic processes is not an ecological endpoint that will be evaluated in the SLERA, and ESVs based on their protection will not be selected.

- ***Groundwater.*** If there is reason to believe that groundwater associated with the Landfill Area 1 or Landfill Area 3 is currently impacting surface water, surface water ESVs (presented below) will be used to evaluate groundwater.

- ***Surface Water.*** Surface water screening values will be selected using the following hierarchy: (1) FDEP Surface Water Quality Standards, Chapter 62-302, F.A.C. (FDEP, 2010), (2) FDEP *Contaminant Cleanup Target Levels* (Chapter 62-777, F.A.C. (FDEP, 2005b), (3) EPA National Recommended Water Quality Criteria (current), (4) *Supplemental Guidance to RAGS: Region 4 Bulletins, Ecological Risk Assessment* (EPA, 2001b), (5) EPA *Region 3 Screening Benchmarks* (EPA, 2006), (6) *Preliminary Remediation Goals for Ecological Endpoints* (Efroymson et al., 1997a), (7) LANL EcoRisk screening levels (LANL, 2014), and (8) *Ecological Data Quality Levels* (EPA, 1999).

- ***Sediment.*** Sediment screening values will be selected using the following hierarchy: (1) Sediment Quality Assessment Guidelines for Florida Inland Waters – TECs (FDEP, 2003), (2) Sediment Quality Assessment Guidelines for Florida Coastal Waters – TELs (FDEP, 1994), (3) *Supplemental Guidance to RAGS: Region 4 Bulletins, Ecological Risk Assessment* (EPA, 2001b), (4) EPA *Region 3 Screening Benchmarks* (EPA, 2006), (5) consensus-based threshold effect concentration values (MacDonald et al., 2000), (6) EPA Region 5 ecological screening levels (EPA, 2003c), (7) (LANL EcoRisk screening levels (LANL, 2014), (8) *Ecological Data Quality Levels* (EPA, 1999), (9) *Preliminary Remediation Goals for Ecological Endpoints* (Efroymson, et al., 1997a), and (10) *Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario* (Ontario Ministry of the Environment and Energy, 1993).

The preliminary risk calculation will be presented as a ratio described by the following formula:

$$HQ = MDC / ESV \qquad \text{Eq. 28}$$

where:

HQ	=	hazard quotient
MDC	=	maximum detected concentration
ESV	=	ecological screening value.

The results of the initial risk calculation will be used in the selection of COPECs, as described in Section 5.5.

5.5 Selection of COPECs

The selection of COPECs will identify a subset of site-related chemicals to be carried forward in the risk assessment. The initial screening criterion will be the comparison to the ESV, as described in the previous section. COPECs will be selected for further consideration in the SLERA if the MDC exceeds the available ESV. If no ESV is available, and the chemical is not eliminated as a COPEC due to other screening criteria, the constituent will be carried forward for further consideration in the SLERA. Following the comparison to the ESV, additional criteria will be used to determine whether each chemical is a COPEC. Screening criteria include the frequency the chemical was detected, whether inorganic constituents represent naturally occurring background concentrations, and whether the chemical is an ecologically essential nutrient. These COPEC refinement criteria are described in more detail in the following bullets:

- ***Frequency of Detection.*** Chemicals that are detected infrequently may be artifacts in the data that may not reflect site-related activity or disposal practices. These chemicals may be eliminated from the SLERA, assuming that the sampling strategy adequately characterizes the site. Generally, chemicals that are detected only at low concentrations in only 1 out of 10 or more samples, or 5 percent or fewer out of 20 or more samples may be dropped from further consideration in a given medium, unless their presence is expected based on historical information about the site (EPA, 2001a; FDEP, 2005c). Chemicals detected infrequently at high concentrations may identify the existence of "hot spots" and will be retained in the evaluation, unless other information exists to suggest that their presence is unlikely to be related to site activities.

- ***Background Evaluation.*** The RI report will present a comprehensive evaluation of whether or not chemicals that would otherwise be selected as COPECs are naturally occurring using the approaches and methods described in the LFNAS installation-wide background study report (Shaw, 2004b). This integrated statistical and geochemical approach provides a rigorous analysis to differentiate site-related contamination from background concentrations. This approach has been used for previous LFNAS reports (e.g., Shaw [2004a]), and has been successfully demonstrated at other facilities to identify and explain suspect inorganic concentrations detected in site media. Briefly, the background evaluation will perform a "hot measurement" test that compares the MDC of the contaminant to the accepted LFNAS background screening value to compare site concentrations to the upper limit of the background range. For data sets that meet the statistical test requirements, a WRS test will be performed in parallel with the hot measurement test, and will test the null hypothesis that the samples were drawn from populations with distributions having the same medians. Also, box plots will be created to visually compare the site and background distributions and qualitatively determine whether the data sets are similar or distinct. If either the hot measurement test or the WRS test fail, a geochemical evaluation will be performed on the chemical. The geochemical evaluation provides mechanistic explanations for apparently high, yet naturally

occurring constituents, and also can identify anomalous samples that may represent contamination.

The background evaluation will use the results from the hot measurement test, WRS test, boxplots, and geochemical evaluation (if performed) to develop a conclusion as to whether a chemical is naturally occurring or if it is site-related. This comparison is generally valid for inorganic chemicals but not for organic chemicals, because inorganic chemicals are naturally occurring and most organic chemicals are not. However, consideration of ubiquitous anthropogenic concentrations may be performed for the purposes of delineation (FDEP, 2014). Background data are available for soil, surface water, and sediment at LFNAS.

- ***Essential Nutrients.*** Evaluating essential nutrients is a special form of risk-based screening applied to certain ubiquitous elements that are generally considered to be required nutrients. Essential nutrients such as calcium, iron, magnesium, potassium, and sodium are usually eliminated as COPECs because they are generally considered to be innocuous in environmental media. Other essential nutrients, including chloride, iodine, and phosphorus, may be eliminated as COPECs, provided that their presence in a particular medium is shown to be unlikely to cause adverse ecological effects.

A COPEC table will be prepared for each medium for each site with the following information:

- Chemical name
- Frequency of detection
- Range of detected concentrations
- Range of detection limits
- Arithmetic mean (average) of site concentrations
- Distribution type
- UCL of the mean of the concentration (only for chemicals selected as COPECs)
- Appropriate ESV
- Results of the background determination (only for chemicals that fail the ESV comparison)
- COPEC selection conclusion: NO (with rationale for exclusion), or YES (selected).

Footnotes in the table(s) will provide the rationale for selecting or rejecting a chemical as a COPEC.

An evaluation of all of the eliminated constituents will be performed to determine whether any should be reinstated as COPECs due to special considerations. Examples of chemicals that may warrant additional consideration even if they are initially screened out as COPECs include potential breakdown products of known site contaminants, chemicals with detection limits greater than the ESV, chemicals known to have been used on site historically, and chemicals with high bioconcentration factors and/or bioaccumulation factors (BAF) (particularly if the ESVs used during the preliminary risk calculation were not protective of food chain effects). Chemicals not eliminated using the screening procedures previously presented will be considered COPECs.

If no COPECs are identified in any media, no additional investigation is necessary. Otherwise, the assessment will proceed on to COPEC refinement (Step 3a). Because ecological benchmark screening values are highly conservative, it is anticipated that several chemicals will produce HQs greater than 1, thus requiring additional examination in the COPEC refinement step (Step 3a).

5.6 COPEC Refinement (Step 3a)

Because of the conservative nature of the initial risk calculation and COPEC selection step, an additional COPEC refinement step will be used prior to deciding whether further ecological investigation at the site in the form of a BERA is necessary. During the COPEC refinement, COPECs identified during Steps 1 and 2 will undergo a secondary evaluation to determine if additional evaluation in a BERA is recommended, and if so, will ensure that subsequent efforts focus only on those site-related contaminants that are realistically capable of posing unacceptable ecological risk.

5.6.1 Ecological Endpoint (Assessment and Measurement) Identification

The selection of appropriate assessment endpoints (explicit expressions of the actual environmental values that are to be protected) and measurement endpoints (measurable biological responses to a stressor that can be related to the value characteristic chosen as the assessment endpoint) help to ensure that all identified ecological resources of concern are adequately evaluated. Unlike the human health risk assessment process, which focuses on the protection of individual receptors, the SLERA will focus on populations or groups of interbreeding nonhuman, nondomesticated receptors. In the SLERA process, the risks to individual receptors will be assessed only if they are protected under the Endangered Species Act or are species that are candidates for protection.

Given the diversity of the biological world and the multiple values placed on it by society, there is no universally applicable list of assessment endpoints. Suggested criteria that may be considered in selecting assessment endpoints suitable for a specific ecological risk assessment are (1) ecological relevance, (2) susceptibility to the contaminant(s), (3) accessibility to prediction and/or measurement, and (4) definability in clear, operational terms (Suter, 1993). Selected assessment endpoints will reflect environmental values that are protected by law, are critical resources, or have relevance to ecological functions that may be impaired. Both the entity and attribute will be identified for each assessment endpoint.

Assessment endpoints are inferred from effects to one or more measurement endpoints. The measurement endpoint is a measurable response to a stressor that is related to the valued attribute of the chosen assessment endpoint. It serves as a surrogate attribute of the ecological entity of interest (or of a closely related ecological entity) that can be used to draw a predictive conclusion about the potential for effects to the assessment endpoint. Measurement endpoints for the SLERA will be based on toxicity values from the available literature and not statistical or arithmetic summaries of actual field or laboratory observations or measurements.

Assessment endpoints developed during Step 3a will be selected based on the ecosystems, communities, and/or species potentially present at the site (EPA, 1997b). Thus, the ecological assessment and measurement endpoints will be formally identified after the site reconnaissance and a thorough review of existing reports and site-related documents is performed. Table 3-1 presents a preliminary summary of the assessment and measurement endpoints that may be appropriate for both Landfill Area 1 and Landfill Area 3.

The primary method that will be used for refining the list of COPECs for terrestrial and aquatic invertebrate and plant communities will be a second screen against the ESVs, using the 95 percent UCL rather than the MDC as the exposure concentration. This will provide a more realistic (yet still conservative) estimate of the concentrations that organisms at the base of the food chain may be exposed to on a regular basis at the site.

The primary method that will be used for refining the list of COPECs for the evaluation of upper trophic level organisms will be the implementation of a food chain model to estimate the potential risk to ecological assessment receptors representative of the various wildlife foraging guilds present at each landfill area. The food chain model will calculate HQs based on a comparison of the average daily dose for a given receptor to a toxicity reference value (TRV). The average daily dose is the estimated dose incurred from exposure pathways unique to these receptors, as described in a refined ECSM. The results of the food chain model, in conjunction

with the consideration of other lines of evidence and uncertainties associated with the SLERA process, will provide supplemental information that will be used to determine whether any final COPECs may require additional evaluation. The various components of the food chain model are presented in the following sections.

5.6.2 Development of Exposure Point Concentrations

Because of the uncertainty associated with characterizing contamination in environmental media, the 95 percent UCL of the COPEC mean will be used as the EPC for determining the average daily dose for the assessment receptors. The EPA ProUCL software (Version 5.0 [EPA, 2013b]) will be used to estimate UCLs for the data sets of all environmental media represented by at least five samples. If the data set consists of fewer than 10 data points, the MDC will be selected as the EPC. As recommended by ProUCL technical guidance (EPA, 2013c) the reporting limit will be used as the ProUCL input concentration for nondetects.

ProUCL generates a variety of UCL estimates for each data set. Generally, the results of one or two (sometimes more) of the UCL estimates are recommended. This recommendation is based on a variety of factors, including the distribution (i.e., normal, lognormal, gamma, or unknown) that provides the best fit, number of nondetects, size of the data set, and skewness. Occasionally, ProUCL will recommend the 97.5 or 99 percent UCL on the arithmetic mean estimated by the Chebyshev method. In these cases, the 95 percent UCL estimated by the Chebyshev method will be selected as the EPC because this is more consistent with the intent of the RME paradigm as defined by EPA (1989a; 2002b).

The UCL generated by the ProUCL protocol described in the preceding paragraphs or the MDC, whichever is lower, will be selected as the EPC in the food chain model, and is understood to represent a conservative estimate of the average exposure concentration experienced by receptors utilizing the site.

5.6.3 Selection of Assessment Receptors

Assessment receptors will be selected separately for the two landfill areas for evaluation in the SLERA. The assessment receptors will be used to evaluate the wildlife assessment endpoints. The goal of the exposure characterization portion of the SLERA (Section 5.6.5) is to focus on species or components that represent the range of functional foraging guilds present at the site, and that are also sensitive or susceptible to possible site-related contamination. Whereas the initial screening-level risk calculation (Section 5.4) was protective of generic terrestrial and aquatic endpoints, the assessment receptors will be used as representative species from multiple trophic levels and functional groups present at the site to quantitatively evaluate these critical

ecological components in a food chain model. For terrestrial communities, the major functional groups are herbivorous, omnivorous, and carnivorous mammalian and avian vertebrates. For aquatic and/or wetland communities, the major functional groups are herbivorous, omnivorous, and carnivorous/piscivorous mammalian and avian vertebrates.

Primary criteria for selecting appropriate assessment receptors will include, but will not be limited to, the following:

- The assessment receptor will have a relatively high likelihood of contacting chemicals via direct or indirect exposure.
- The assessment receptor will exhibit marked sensitivity to chemicals.
- The assessment receptor will be a key component of ecosystem structure or function (e.g., importance in the food web, ecological relevance).
- The assessment receptor may be listed as rare, threatened, or endangered by a governmental organization.

Additional criteria for selection of assessment receptors will be used to identify species that offer the most favorable combination of characteristics for determining the implications of on-site contaminants. These criteria may include (1) limited home range, (2) role in local ecological food chains, (3) potential high abundance and wide distribution at the site, (4) sufficient toxicological information available in the literature for comparative and interpretive purposes, (5) sensitivity to COPECs, (6) relatively high likelihood of occurrence on site following remediation, (7) suitability for long-term monitoring, (8) importance to the stability of the ecological food chain or biotic community of concern, and (9) relatively high likelihood that the species will be present at the site or that habitats present at the site could support the species.

The following list of candidate assessment receptors that may be appropriate for evaluation at Landfill Areas 1 and 3 was developed based on both the current knowledge of the site and the preliminary management goals established in this Work Plan (Section 5.3.3):

- Deer mouse (*Peromyscus maniculatus*) (small omnivorous mammal) (terrestrial)
- Short-tailed shrew (*Blarina brevicauda*) (small insectivorous mammal) (terrestrial)
- Eastern cottontail rabbit (*Sylvilagus floridanus*) (medium-sized herbivorous mammal) (terrestrial)
- Marsh wren (*Cistothorus palustris*) (small insectivorous bird) (terrestrial)
- Red fox (*Vulpes vulpes*) (medium-sized carnivorous mammal) (terrestrial)

- Red-tailed hawk (*Buteo jamaicensis*) (large carnivorous bird) (terrestrial)
- Raccoon (*Procyon lotor*) (medium-sized omnivorous mammal) (semiaquatic)
- Muskrat (*Ondatra zibethicus*) (medium-sized herbivorous mammal (aquatic)
- Mallard (*Anas platychyncos*) (medium-sized herbivorous bird (aquatic)
- Bank Swallow (*Riparia riparia*) (small insectivorous bird (aquatic)
- River Otter (*Lutra canadensis*) (medium-sized piscivorous mammal) (aquatic)
- Belted Kingfisher (*Ceryle alcyon*) (small piscivorous bird) (aquatic).

The list of assessment receptors selected to evaluate Landfill Areas 1 and 3 will be modified, if necessary, following the site reconnaissance visit and a review of the local habitat types and available species lists. It is important that sufficient toxicological information be available in the literature on the receptor species. Because most candidate assessment receptor species have likely not been used extensively for toxicological testing, toxicity data on species that are as closely related as possible to the assessment receptor species will be used.

5.6.4 Refined Ecological Site Conceptual Model

Depictions of the exposure characterization (such as a flow chart) will be prepared for the Landfill Areas 1 and 3 in the SLERA. These pictorial representations and any text necessary to clarify the representations will represent the refined ESCM. As opposed to the more simplified screening-level ESCM described in Section 5.3.2, the refined ESCM will trace the contaminant pathways through both abiotic components and biotic food web components of the environment. Exposure pathways consist of four primary components: source and mechanism of contaminant release, transport medium, potential receptors, and exposure route. A chemical may also be transferred between several intermediate media before reaching the potential receptor. All of these components will be addressed within the SLERA. If any of these components is not complete, then contaminants in those media do not constitute an environmental risk at that specific site.

The refined ESCM will be used as a tool for judging the appropriateness and usefulness of the selected measurement endpoints in evaluating the assessment endpoints and for identifying sources of uncertainty in the exposure characterization.

Media-Specific Exposure Pathways. Exposure to environmental media may be either indirect or direct and include the following routes or mechanisms:

- Direct (passive) uptake (e.g., root or foliar absorption)
- Ingestion of contaminated food items
- Ingestion of water
- Incidental ingestion of soil and/or sediment
- Dermal contact
- Inhalation of vapors or dust.

Although dermal contact and inhalation of COPECs are possible, these exposure routes are generally not evaluated quantitatively in ecological risk assessments because they are considered minor relative to ingestion and because there is a tremendous amount of uncertainty related to dermal and inhalation exposures in animals. VOCs, which are typically the class of compounds of greatest concern for inhalation exposure, have not been identified as COPCs based on previous investigations (Section 5.1.2). Toxicity data associated with dermal exposure is generally lacking, and dermal absorption is only considered likely for organic compounds; direct contact from most inorganic compounds is expected to result in minimal risk due to the low dermal permeability of these compounds. In addition, birds and mammals are less susceptible to dermal exposures because their feathers or fur prevent skin from coming into direct contact with the soil (EPA, 1993). Therefore, potential risk from these pathways will not be estimated in the SLERA. Medium-specific exposure pathways are discussed below.

Soil Exposure Pathways. Soil exposure pathways are potentially important for terrestrial plants and animals at the landfill areas. Environmental conditions such as soil moisture, soil pH, and cation exchange capacities significantly influence whether potential soil contaminants remain chemically bound in the soil matrix or can be chemically mobilized (in a bioavailable form) and released for plant absorption. Generally, neutral to alkaline soils (soil pH of 6.5 or greater) restrict the absorption of toxic metals, resulting in incomplete plant exposure pathways. The release mechanisms include disposal/burial practices, overland runoff, and airborne deposition. Potential receptors exposed to contaminated soil include terrestrial flora and fauna. Direct exposure routes for contaminated soil include contact by terrestrial invertebrates, uptake by flora, and ingestion by terrestrial fauna. Indirect exposure pathways from soil include consumption of bioaccumulated contaminants by consumers in the food chain. As previously discussed, potential risk from dermal and/or inhalation pathways will not be estimated. In addition, these pathways are generally considered to be incidental for most species, with the possible exceptions of burrowing animals and dust-bathing birds.

For non-burrowing animal exposure, the EPC will be developed using soil samples obtained from a depth of 0 to 1 foot bgs, as this would be the typical depth range of exposure for these organisms. For burrowing animals, the EPC will be based on soil samples obtained from a depth

of 0 to 6 feet. For plant exposure, soil samples taken from 0 to 6 feet bgs (or the water table surface) will be considered, because most feeder roots are located within this depth.

Sediment Exposure Pathways. Sediment generally consists of soil or other material settled out of suspension in surface water or native soils underlying flowing or standing surface water bodies. Potential contaminant sources for sediment include buried or stored waste and contaminated surface water, groundwater, and soil. The release mechanisms include surface water runoff, groundwater discharge, and airborne deposition. Chemical bioavailability of many nonpolar organic compounds (e.g., PCBs and pesticides) decreases with increasing concentrations of total organic carbon in the sediment; however, these compounds can still bioaccumulate up the food chain (Landrum and Robbins, 1990). Potential receptors exposed to chemicals in contaminated sediment include aquatic flora and fauna and semiaquatic fauna. Direct exposure routes for contaminated sediment include contact by benthic-dwelling organisms such as catfish, uptake by aquatic flora, and ingestion by aquatic and/or semiaquatic fauna. Indirect exposure pathways from sediment include consumption of bioaccumulated contaminants by consumers in the food chain.

Surface Water Exposure Pathways. Surface water represents a potential transport medium for COPECs. Potential sources for contaminated surface water include buried or stored waste, stored or spilled fuel, contaminated soil and groundwater, and deposition of airborne contaminants. The release mechanisms include surface runoff, leaching, and groundwater seepage. Chemical bioavailability of some metals and other chemicals is controlled by water hardness, pH, and total suspended solids. Potential receptors exposed to contaminated surface water include terrestrial, aquatic and semiaquatic fauna, and aquatic flora. Exposure routes for contaminated surface water include ingestion by terrestrial fauna and uptake and absorption by aquatic flora and fauna. Consumption of bioaccumulated contaminants constitutes a potential indirect exposure pathway for faunal receptors.

Groundwater Exposure Pathway. Groundwater represents a potential transport medium for COPECs. Potential contaminant sources for groundwater include contaminated soil and buried or stored waste. The release mechanism for contaminants into groundwater is direct transfer of contaminants from waste materials to water as water passes through the materials.

Groundwater itself is not an exposure medium in ecological risk assessments, although contaminant transport along the shallow groundwater pathway may be considered an exposure route to aquatic life, wetlands, and some wildlife where the groundwater discharges to surface water. This pathway is of importance to aquatic, semiaquatic, and wetland receptors if

groundwater is found to be discharging to surface water. It should be noted that groundwater will not be evaluated as a medium of concern in the SLERA when surface water data are available or when groundwater is not discharging to the surface.

5.6.5 Exposure Characterization

An estimate of the nature, extent, and magnitude of potential exposure of assessment receptors to COPECs that are present at or migrating from the landfill areas, considering both current and reasonably plausible future uses of the site, will be presented in the SLERA exposure characterization. Exposure and chemical uptake will be modeled to produce upper-bound exposure estimates. Exposure characterization is critical in further evaluating the risks of compounds identified as COPECs during the screening process (Section 5.5). The exposure assessment will be conducted by characterizing the magnitude (concentration) and distribution (locations) of the contaminants detected in the media sampled during the investigation, evaluating pathways by which chemicals may be transported through the environment, and determining the points at which organisms found in the study area may contact contaminants.

For the selected assessment receptors, calculation of exposure rates relies upon determination of an organism's exposure to COPECs found in soil, surface water, and sediment. Exposure rates for wildlife receptors will be based on the complete exposure routes described in the refined ECSM (Section 5.6.4). Thus, the food chain model will focus on the direct exposure of contaminants in these media via ingestion, as well as indirect exposure via consumption of plants or prey items that are modeled to have accumulated contaminants in their tissues.

Daily doses of COPECs for vertebrate receptors will be calculated using standard exposure algorithms. These algorithms incorporate species-specific natural history parameters (e.g., feeding rates, water ingestion rates, dietary composition, etc.) and also include site-specific area use factors, as follows:

$$Total\ Daily\ Dose = \left(\frac{\left(\left[Soil_j * IR_{soil} \right] + \left[Water_j * IR_{water} \right] + \left[\sum_{i=1}^{N} B_{ji} * P_i * IR_{food} \right] \right)}{Body\ Weight} \right) * AUF \qquad \text{Eq. 3-2}$$

where:

$Soil_j$	=	Concentration of COPEC “j” in soil
$Water_j$	=	Concentration of COPEC “j” in surface water
B_{ji}	=	Concentration of COPEC “j” in food type “i”
IR_{soil}	=	Soil ingestion rate
IR_{water}	=	Surface water ingestion rate

IR_{food}	=	Food ingestion rate
P_i	=	Proportion of food $type_i$ in receptor diet
AUF	=	Area use factor (equal to area of exposure unit/home range of receptor)
Body Weight	=	Body weight of receptor.

Sediment may replace soil in the above equation for aquatic or semiaquatic receptors.

The first step in estimating exposure rates for wildlife involves the calculation of feeding and drinking rates for site receptors. Species-specific information regarding feeding and drinking rates and dietary composition based on empirical data are available for many species and will be used if identified in the literature. If species-specific data are not available, allometric equations are available that can be used to calculate food and water ingestion rates for birds and mammals based on an organism's body weight (EPA, 1993; Sample and Suter, 1994).

Data will be gathered on incidental ingestion of soil and incorporated for the receptor species. This information will be summarized and documented in the SLERA. Literature values for animal-specific sediment ingestion will also be used, if available. However, such values generally are not available in the literature. Where sediment ingestion rates cannot be found, the species-specific incidental soil ingestion rate will be used for sediment ingestion as well, if the receptor's life history profile suggests a significant aquatic component (e.g., raccoons' use of surface water in foraging activities).

In addition to direct ingestion of the media present at the site, food web exposure can occur when terrestrial or aquatic/semiaquatic fauna consume contaminated biota. Examples of food web exposure include animals at higher trophic levels consuming plants or animals that bioaccumulate contaminants. Bioavailability is an important contaminant characteristic that influences the degree of chemical-receptor interaction. Bioavailable compounds are those that a receptor can take in from the environment (i.e., chemicals that would be expected to partition from site media to the organism or be absorbed from the gastrointestinal tract). Bioavailability of a chemical is a function of several physical and chemical factors. Contamination of biota could result from exposure to one or more COPECs. Algorithms will be developed to estimate concentrations in dietary items based on literature-based BAFs. In general, BAFs developed using empirical data will be preferred over BAFs that model uptake based on chemical-specific properties (e.g., from a chemical's log octanol-water partition coefficient). BAFs recommended in EPA (2008a) will be given the highest preference. To supplement these values, BAFs will be estimated for organic constituents using other sources or calculations identified in the literature,

such as the regression equation for uptake of nonionic chemicals into unrinsed plants as presented in the Eco-SSL guidance (EPA, 2008a).

Proposed life history parameters from the literature—including body weight, diet, home range, and other species-specific variables that will be used to calculate daily dose for the assessment receptors listed in Section 5.6.3—are presented in Table 5-1. If assessment receptors other than those listed in Table 5-1 are ultimately selected for use in the SLERA, their exposure parameters will be determined in a consistent manner as those provided in this Work Plan. Specific details on how some of the parameters were calculated or selected are presented in the following bullets:

- Body Weight: The minimum, maximum, and average mean body weights from the Exposure Factors Handbook (EPA, 1993) were the primary sources for the minimum, maximum, and mean body weights listed in Table 5-1. A mean body weight will be used to calculate exposure doses.

- Food Consumption Rate: Food consumption rates were obtained from the literature. If available, empirical data based on feeding rate studies were used for the assessment receptor. Empirical data obtained from studies in the literature are often reported in grams of food per gram body weight of the organism. Therefore, the lowest, highest, and average foraging rates were multiplied by the mean body weight of the receptor to obtain the minimum, maximum, and mean food consumption rates. If empirical data were not available, food consumption rates were obtained from the allometric ingestion equations presented in the *Exposure Factors Handbook* (EPA, 1993). Allometric ingestion equations are available for several different categories of mammalian and avian receptors, and the most appropriate equation for the assessment receptor in question was selected (e.g., the equation to calculate food consumption for "passerine birds" was used for the Marsh Wren). The minimum, maximum, and mean body weights were used in the allometric equation to obtain the minimum, maximum, and mean food ingestion rates. A mean food consumption weight (based on the mean body weight) will be used to calculate exposure doses.

  It should be noted that the allometric equations in EPA (1993) present food consumption rates on a dry-weight basis, but most other sources of dietary intake information do not. Therefore, to maintain internal integrity of units within the food chain model algorithms (which calculate a dry weight average daily dose), any ingestion rates based on wet weight food consumption data were converted to dry weight by using percent water content of the receptor's dietary items information provided in Sample and Suter (1994) and the diet composition information documented in Table 5-1.

- Diet Composition: Diet composition was estimated using various literature sources. Certain categories of food items identified in the literature for a particular receptor were consolidated for simplicity (e.g., "beetles," "earthworms," "butterfly larvae," etc., were collectively included under "terrestrial invertebrates"). Percentages were

adjusted slightly based on professional judgment and to ensure that the total summed dietary components equaled 100 percent.

- Soil and/or Sediment Ingestion Rate: These values are usually provided in the literature as a percentage of the food consumption rate. To obtain the value in kg (dry weight) per day as presented in Table 5-1, the soil or sediment ingestion rate percentage identified in the literature was multiplied by the mean (dry weight) food consumption rate.

- Water Ingestion Rate: Similar to the Food Consumption Rate, empirical data on water ingestion rates were used, if available. Otherwise, the bird and mammal allometric equations in the *Wildlife Factors Handbook* (EPA, 1993) were used, and were calculated using the mean assessment receptor body weight.

- Home Range: Minimum, maximum, and mean home ranges are provided based on the range of home range or territory size information provided in the literature. Home ranges are often reported as mean values; for example, EPA (1993) may present data from several studies on home ranges for a given receptor, and provide a mean for each individual study (sometimes with accompanying statistics, such as the minimum, maximum, and standard deviation). The lowest and highest means of the individual studies were selected as the minimum and maximum home ranges presented in Table 5-1, respectively (rather than the highest and lowest values from the individual studies), and the mean home range in Table 5-1 represents an average of the study means. Per FDEP (2014) guidance, the minimum home range will be used to calculate exposure doses, as a smaller home range (e.g., home ranges associated with nesting individuals, or fledglings) is more protective of receptor populations. However, the smallest published home range may be rejected (or may be discounted in the SLERA uncertainty section) if it represents a study area or geographic area inappropriate for the landfill sites.

5.6.6 Ecological Effects Characterization

The ecological effects characterization will include the selection of literature benchmark values and the development of TRVs. TRVs provide a reference point for the comparison of toxicological effects upon exposure to a contaminant. Appropriate sources for literature benchmark values will be consulted for toxicological information, such as (1) EPA Eco SSL guidance (EPA, 2008a), (2) EPA EcoTox Database Release 4.0 (last updated March 2014), (3) U.S. Army Wildlife Toxicity Reference Values (2001-2009), (4) *Toxicological Benchmarks for Wildlife* (Sample et al., 1996), and (5) LANL EcoRisk Database (LANL, 2014).

The review of TRVs to be used in the SLERA will focus on TRVs that are protective of the growth, survival, and reproduction of a given species, which reflect endpoints most critical to the protection of receptor populations. Empirical data may be available for the specific assessment receptor-endpoint combinations in some instances. However, for some COPECs, data on surrogate species and/or on endpoints other than the no-observed-adverse-effects level (NOAEL)

and lowest-observed-adverse-effects level (LOAEL) may have to be used. Chronic data (as opposed to subchronic or acute data) are also preferred for TRVs. Uncertainty factors such as those presented on Figure 5-2 will be used to convert TRVs to chronic NOAELs and LOAELs. Also, in instances where data for a COPEC are unavailable, toxicological information for surrogate chemicals may be used. The NOAEL is the highest dose of a chemical at which the response is not statistically different from controls (i.e., the highest dose that produces no adverse effects in the test species). The NOAEL is judged to be an appropriate toxicological endpoint because it provides the greatest degree of protection to the receptor species. The LOAEL will be used as a point of comparison for decision making for risk management purposes. LOAEL-based TRVs represent the lowest dose at which a statistically significant difference from controls is observed.

Toxicity information pertinent to identified receptors will be gathered for those analytes identified as COPECs. Because the measurement endpoint will range from the NOAEL to the LOAEL, preference will be given to chronic studies that note concentrations at which no adverse effects were observed and ones for which the lowest concentrations associated with adverse effects were observed. As previously noted, where data are unavailable for the exposure of a receptor to a COPEC, data for a surrogate chemical (e.g., endrin for endrin aldehyde) may be used in the SLERA.

5.6.7 Risk Characterization

The risk characterization phase integrates information on exposure, exposure-effects relationships, and defined or presumed target populations. The result is a determination of the likelihood, severity, and characteristics of adverse effects of environmental stressors present at a site. A semi-quantitative approach will be taken to estimating the likelihood of adverse effects occurring as a result of exposure of the selected site receptors to COPECs. For plant and invertebrate receptors, risk characterization will essentially refer to the comparison of the EPC (i.e., the 95 percent UCL or MDC, whichever is lower) to the benchmark values protective of aquatic and terrestrial flora and fauna, as described in Section 5.6.1. This comparison represents the measurement endpoint for soil and aquatic plants and invertebrates for the COPEC refinement step (Table 3-1). For other wildlife evaluated using the food chain model, TRVs and exposure rates will be calculated for the assessment receptors and used to generate HQs (Wentsel et al., 1996) by dividing the receptor exposure rate for each contaminant by the TRV. These HQs represent the measurement endpoint for higher trophic level species (Table 5-2). HQs are a means of estimating the potential for adverse effects to organisms of a contaminated site and for assessing the potential that toxicological effects will occur among site receptors. For COPECs with a similar mode of toxicity (e.g., PAHs, phthalates, structurally similar organochlorine pesticides, etc.), the HQs

may be summed for a given receptor to provide an HI that reflects the potential cumulative risk of the group chemicals.

Because of the conservative assumptions used to determine receptors' daily doses of COPECs and in generating TRVs, HQs greater than 1.0 are not unexpected, and will not be interpreted to mean that an adverse effect is occurring, has occurred, or may occur in the future. Although all HQs greater than 1.0 are potentially significant, an HQ above 1.0, even exceedingly so, does not necessarily mean that there is even one individual expressing the toxicological effect associated with a given chemical to which it was exposed (Tannenbaum, 2003; Bartell, 1996). Therefore, guidelines from the *Tri-Service Procedural Guidelines for Ecological Risk Assessments* (Wentsel et al., 1996) will be used to assist in the interpretation of potential risk posed from contaminants: HQs less than or equal to 1.0 present no probable risk; HQs greater than 1.0 but less than 10 present a low potential for environmental effects; HQs from 10 up to, but less than 100, present a significant potential that effects could result from greater exposure; and HQs greater than 100 present the highest potential for expected effects.

5.7 Uncertainty Analysis

The results of the SLERA will be influenced to some degree by variability and uncertainty. In theory, investigators might reduce variability by increasing sample size of the medium or species sampled. Alternatively, uncertainty within the risk analysis can be reduced by using species-specific and site-specific data (i.e., to better quantify contamination of media, vegetation, and prey through direct field measurements, toxicity testing of site-specific media, field studies using site-specific receptor species). Detailed media, prey, and receptor field studies are costly; thus, the preliminary scoping and predictive analyses of risk are conducted to limit the potential use of these resource-intensive techniques to only those COPECs that continue to show a relatively high potential for ecological risk. Because assessment criteria were developed based on conservative assumptions, the results of the screening and predictive assessments will err on the side of conservatism. This has the effect of maximizing the likelihood of accepting a false positive (Type I error: the rejection of a true null hypothesis that no risk is present) and simultaneously minimizing the likelihood of accepting a false negative (Type II error: the acceptance of a false null hypothesis that no risk is present). The use of soil data from 0 to 6 feet bgs may overestimate ecological effects, because many ecological receptors are only exposed to shallower soils. The uncertainty analysis will thus assess the soil depth of elevated concentrations of COPECs identified as risk drivers and will evaluate the significance of these findings on the results of the SLERA (e.g., if COPEC hot spots only occur at deeper soil depths, realistic ecological exposure could be expected to be minimal).

A number of factors contribute to the overall variability and uncertainty inherent in ecological risk assessments. Variability is due primarily to measurement error; laboratory media analyses and receptor study design are the major sources of this kind of error. Uncertainty, on the other hand, is associated primarily with deficiency or irrelevancy of effects, exposure, or habitat data to actual ecological conditions at the site. Species physiology, feeding patterns, and nesting behavior are poorly predictable; therefore, all toxicity information derived from toxicity testing, field studies, or observation will have uncertainties associated with them. Laboratory studies conducted to obtain site-specific information often suffer from poor relevance to the actual exposure and uptake conditions on site. For example, bioavailability, exposure, assimilation, etc., are generally greater under laboratory conditions as compared to field conditions. Calculating an estimated value based on a large number of assumptions is often the only alternative to the accurate (but costly) method of direct field or laboratory observation, measurement, or testing.

The calculation of HQs also introduces uncertainty. The following limitations associated with HQs are noted and will be briefly addressed in the final SLERA report:

- HQs are not measures of risk.
- HQs are not population based.
- HQs are not linearly scaled.
- HQs are often produced that are unrealistically high and toxicologically impossible.
- Trace soil concentrations of inorganic chemicals (including concentrations well below background levels) can lead to HQ threshold exceedances.

The uncertainty analysis will include a discussion of the assumptions made for the SLERA, including the direction of bias caused by each assumption (i.e., if the uncertainty results in an overestimate or underestimate of risk), the likely magnitude of impact and, if possible, a description of recommendations for minimizing the identified uncertainties if the SLERA progresses to higher level assessment phases (EPA, 1997b).

5.8 Risk Description

As part of the risk description, the following will be completed for the Landfill Area 1 and Landfill Area 3 SLERAs: (1) summary of the ecological risks associated with the landfill areas, and; (2) interpretation of the ecological significance, which describes the magnitude of the identified risks and the accompanying uncertainty. The likely outcome on the use of additional data or analyses to reduce uncertainty will also be discussed. A weight-of-evidence approach will be used to interpret the ecological significance of the SLERA findings.

5.9 Risk Summary and Conclusions

The potential adverse ecological effects associated with releases from each landfill area will be summarized. This summary will be supported by the steps performed as described in the previous sections. Additionally, recommendations for further investigations will be made if appropriate. The information presented in the SLERA, including calculated HQs and their associated uncertainties, may be used in a feasibility study to develop cost-effective site-specific remedial action objectives, if remedial action for the protection of ecological receptors is warranted.

Should the risk managers decide that there are significant ecological threats at either of the landfill areas, a BERA may be conducted for the site(s). General BERA details are provided in the Process Document (EPA, 1997b) and include the remaining portions of Steps 3 through 8 as presented on Figure 5-1. The BERA comprises Tier II and potentially Tier III of the FDEP ecological risk assessment process (FDEP, 2014). Details on how the BERA would be conducted are not provided at this time. Should a BERA be considered necessary, a separate work plan will be developed providing details on how the BERA will be performed. A separate report on the data, results, professional judgment, and conclusions concerning the potential for ecological impacts at the site would then be prepared.

6.0 Feasibility Study

Following completion of the RI, a FS will be prepared for Landfill Area's 1 and 3.. The FS will identify appropriate remedial alternatives that meet CERCLA requirements, analyze the remedial alternatives, and provide decision makers with the technical and cost information necessary to select a remedial alternative. Following EPA guidance (EPA, 1988), OSWER Directive 9355.3-01, EM CX Interim Guidance 06-04, USACE ER 200-3-1, FUDS Program Policy, and FDEP guidance, the FS will involve three primary phases: development of alternatives, screening of alternatives, and detailed analysis of alternatives. The initial phase of the FS (i.e., development of alternatives) will be based on the existing and supplemental data sets. However, the FS will also include an assessment of data gaps potentially necessary to demonstrating the feasibility of the remedial alternatives. Should data gap exists, the investigations will be conducted and the results incorporated into the remedy development process.

In the feasibility study, remedial strategies will be developed based on the nature and extent of contamination, impacted media, contaminant migration pathways, and potential risks to human and ecological receptors, as identified in the BHHRA and SLERA. Chemical, location, and action specific Applicable or Relevant and Appropriate Requirements (ARARs) will be developed. Alternatives will be evaluated against the nine evaluation criteria developed by the EPA to address CERCLA criteria for remedial actions. These criteria, which are listed below, fall into three categories –threshold, primary, and other – and form the framework for conducting the detailed analyses during the FS and for the final selection of an appropriate remedy.

Threshold Criteria (must be achieved for each alternative)

- Overall protection of human health and the environment
- Compliance with ARARs

Primary Criteria (upon which analysis is based)

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume
- Short-term effectiveness
- Implementability
- Cost

Other Criteria (evaluated in the ROD following comment on the RI/FS)

- State acceptance
- Community acceptance

The evaluation of individual alternatives will be presented in the FS report. The report will describe the technology components, quantities of hazardous materials to be handled, timeframe and requirements for implementation, significant ARARs, key assumptions, and other information.

The feasibility study report will also include a comparative analysis to evaluate the relative performance of each alternative in relation to each specific evaluation criteria. The purpose of the comparative analysis is to identify relative advantages, disadvantages, and key tradeoffs for each alternative. The presentation of differences among alternatives may be measured either qualitatively or quantitatively and will identify substantive differences (e.g., greater long-term effectiveness, lower costs).

7.0 Quality Control Plan

This chapter identifies the approach and operational procedures that will be employed to perform QC during activities associated with the project. The objectives of this quality control plan (QCP) are to address the specific operating needs of the project and to establish the necessary levels of management and control. This will ensure all work performed meets the technical requirements of the applicable project plans and conforms in all respects to the requirements of the contract and applicable regulations. This chapter addresses the following:

- Daily Quality Control Reports (DQCR)
- Quality Control Inspection Process
- QC Audits and Surveillance
- Corrective/Preventive Action
- Nonconformance Documentation
- Continual Improvement
- Lessons Learned
- Submittal Review
- Document Change Management
- Document Control and Records Management
- Qualifications and Training
- Chemical Data Quality Management
- Qualifications and Training.

Contractor forms are located in Appendix D. The project specific laboratory SOPs are found in Attachment 2 of the UFP-QAPP (Appendix F).

7.1 Daily Quality Control Reports

For all field work days, the Contractor Quality Control Site Manager (CQCSM) is responsible for preparing and submitting the DQCR to the USACE COR, or designee and to the project file. The DQCR is provides an overview of QC activities performed each day, including those performed for subcontractor and supplier activities. The DQCRs are intended to provide an accurate and complete picture of QC activities performed during the day. The reports will describe both conforming and deficient conditions. They should be precise, factual, legible, and objective. Copies of supporting documentation, such as inspection checklists, surveillance reports, sample collection logs, COC Records and field photo-documentation are to be submitted as attachments to the DQCR.

Each DQCR is assigned a unique tracking number comprised of the Delivery Order number followed by the date expressed as DDMMYY. Copies of DQCRs with attachments are maintained on-site as a project record.

7.2 Quality Control Inspection Process

The project QC Manager is responsible for assisting project management in maintaining compliance with this QCP through implementing a three-phase inspection process. This section specifies the minimum requirements that must be met and to what extent QC monitoring must be conducted by the QC Manager. The inspection system is based on the three-phase system of control to cover the activities. The three-phase of control system consists of preparatory, initial, and follow-up inspections for each applicable Definable Feature of Work (DFW). The following sections present the DFWs and describe the Three Phases of Control that will be implemented for Landfill Areas 1 and 3.

7.2.1 Definable Features of Work

A DFW is a major work element that must be performed to execute and complete the project. It consists of an activity or task that is separate and distinct from other activities and requires separate control. The DFWs that have been identified for this project include the following:

- Mobilization (Including the project Kick-off Meeting; site set-up; locate and stake sample locations, etc.)
- Surface Water and Sediment Sampling
- Soil Sampling (Including soil borings)
- Monitoring Well Installation
- Groundwater Sampling (Including DPT groundwater sampling)
- Sample Handling, Preparation and Shipment
- Site Restoration
- Demobilization.

Inspection criteria for these DFWs will depend on the work tasks being performed. Procedures for conducting these DFWs are provided in this work plan, which may include specific QC procedures and tests that are integral to the work, such as equipment calibration and testing. This QCP does not attempt to reiterate these procedures. The QC staff will refer to the applicable portion of this work plan for specific QC requirements to be checked during QC inspections.

7.2.2 Three Phases of Control

The following sections present an overview of the Three Phases of Control inspection process.

7.2.2.1 Preparatory Phase Inspection

A preparatory phase inspection will be performed prior to beginning each DFW. The purpose is to review applicable work plans, processes, and specifications and verify that the necessary resources, conditions, and controls are in place and compliant before the start of work activities. The QC staff shall verify that lessons learned during similar previous work have been incorporated as appropriate into the project procedures to prevent recurrence of past problems. The quality surveillance inspection form provided in Appendix D (CMS-720-01-FM-00230) may be customized to address the specific DFW, work scope, and site conditions. Work plans and operating procedures are to be reviewed by the QC staff to ensure that prequalifying requirements or conditions, equipment and materials, appropriate work sequences, methodology, hold/witness points, and QC provisions are adequately described. The QC staff shall verify, as applicable, the following:

- The required plans and procedures have been prepared and approved and are available to the field staff
- Field equipment and materials meet required specifications
- Field equipment is appropriate for intended use, available, functional, and calibrated
- Work responsibilities have been assigned and communicated
- Field staff possess the necessary qualifications, knowledge, expertise, and information to perform their jobs
- Arrangements for support services (such as on-site testing and off-site test laboratories) have been made
- Prerequisite site work has been completed.

Discrepancies between existing conditions and approved plans/procedures are to be resolved. Corrective actions for unsatisfactory and nonconforming conditions identified during a preparatory inspection are to be verified by the QC staff prior to granting approval to begin work.

Client notification should be performed at least 48 hours prior to conducting preparatory phase inspections. Results are to be documented in the Preparatory Phase Inspection Checklist and summarized in the DQCR.

7.2.2.2 Initial Phase Inspection

An initial phase inspection will be performed, as applicable, during the start each DFW is performed. The purpose of this inspection is to check preliminary work for compliance with procedures and specifications, to establish the acceptable level of workmanship, check for omissions and resolve differences of interpretation. The QC staff shall generate and use an initial inspection checklist. The Initial Phase Inspection Checklist form provided in Appendix D may be customized to address the specific work scope and site conditions. The QC staff will be responsible to ensure that discrepancies between site practices and approved specifications are identified and resolved. The QC staff will oversee, observe, and inspect all applicable DFWs at the project site and ensure that off-site activities, such as analytical testing, are properly controlled. Discrepancies between site practices and approved plans/procedures are to be resolved and corrective actions for unsatisfactory and nonconforming conditions or practices are to be verified by the CQCSM or designee before granting approval to proceed. Client notification for initial inspections will be required at least 48 hours in advance. Results of initial inspections are to be documented in the Initial Phase Inspection Checklist and summarized in the DQCR.

7.2.2.3 Follow-Up Phase Inspection

Follow-up phase inspections will be performed periodically while the DFW is performed in order to ensure continuous compliance and level of workmanship. The QC staff will be responsible to monitor on-site practices and operations taking place, and to verify continued compliance of the specifications and requirements within the contract, site work scope, and applicable approved project plans and procedures. Discrepancies between site practices and approved plans/procedures will be resolved, and corrective actions for unsatisfactory and nonconforming conditions or practices must be verified by the QC staff prior to granting approval to continue work. Follow-up inspection results will be summarized in the DQCR.

Periodic checks of procedures and/or documentation will be made for completeness, accuracy, and consistency. Follow-up inspections of field activity will typically include a review of field data and any calibration logs for all instruments in use.

7.2.2.4 Additional Inspections

Additional inspections may be performed on the same DFW at the discretion of the client or the QC staff. Completion and acceptance inspections will also be performed to verify that project requirements relevant to the DFW are satisfied. Materials, equipment and/or supplies arriving on site should be inspected to ensure they meet the procurement requirements, are stored in accordance with specifications and are in acceptable conditions. Any materials, equipment, or

supplies that arrive damaged or do not meet procurement specifications will be retained in an area where they will not be inadvertently used and labeled as nonconforming. At the first available opportunity, they will be returned to the vendor for prompt replacement.

7.3 Quality Audits and Surveillance

Because of the importance of quality in this project, it is anticipated that at least one on-site audit will be conducted by a qualified CB&I auditor or designee. Quality audits may be conducted at the discretion of project management in consultation with the CQCSM. Audits are a formal assessment tool to determine the degree of conformance with project and external requirements. Surveillance is a method for monitoring and/or verifying methods, procedures, and or processes for further assurance of effective implementation and suitability. Audits and/or surveillance of various project functions will be performed by the CQCSM, the QC staff, and may also be performed by USACE. These functions include, but are not limited to, explosive inventory, site documentation, scheduled reports, MEC/MD accountability, site reconnaissance, MC sampling, and administrative support activities. Audit reports are typically a rich source of feedback information. Audits and surveillance will be conducted using CB&I procedures CMS-720-01-PR-00220 and CMS-720-01-PR-00230 respectively.

7.4 Corrective/Preventive Action Procedures

Regular inspections should prevent deviations from the work plans and methods being used to perform quality work. When unplanned deviations are detected that may affect the quality of the work performed, a nonconformance will be reported. If corrective actions are required because of nonconforming work process or of defective materials, it will be done in accordance with standard operating procedure CMS-720-01-PR-00170, Corrective Action. If a change is discovered prior to beginning work, it will be documented as a variance.

7.5 Nonconformance Documentation

Complex field investigation, sampling, and analysis tasks, such as those performed routinely as part of the RI, are sometimes subject to nonconformances. A nonconformance is defined as an unplanned deviation that occurs during the implementation of a task that cannot usually be corrected until after it has occurred. Nonconformances may include using unapproved methods, not following procedures, or substituting unapproved materials or equipment to perform an activity. All nonconformances must go through a cycle of being identified, documented, assessed, corrected, and reported. Each of these steps is critical in handling nonconformances as they are encountered. Nonconforming activities or products will be done IAW standard operating procedure CMS-720-01-PR-00150, Identification, Control, and Disposition of Nonconforming Products.

The identification of a nonconformance is the responsibility of every person assigned to support the project. This responsibility is incorporated into each person's understanding of the tasks assigned by the supervisor or task leader and the individual's function on the project. As personnel perform their duties on the project, they must constantly be aware of the scope of the activity and recognize when a deviation from the planned activity has occurred or is occurring. After recognizing deviations, they must take action by informing their supervisors or site leaders and documenting in writing the specifics of what occurred using a nonconformance report. When completed, the nonconformance report will be reviewed by a peer or supervisor and presented to the PM. The PM will assign a lead individual who will work with the person who identified the nonconformance (and other team members as needed) to assess its impact on the project and develop a corrective action plan.

As warranted by the nonconformance, the USACE PM and/or appropriate technical support person will be contacted by the CBI PM and asked to provide input into the assessment and corrective action process. In all cases, the CBI PM will be consulted and the corrective action will be decided upon and recorded on the nonconformance report. Once the corrective action is implemented, the CBI PM will assign a person to verify that the corrective action is successful in preventing future occurrences of the nonconformance. When this has been verified, the nonconformance report will be completed, and copies will be distributed to all individuals who participated in the identification, assessment, and resolution of the nonconformance. The completed report will be included as a permanent part of the project file. In addition, full documentation will be provided to USACE detailing what failed the QA process, why it failed, and how the problem was corrected.

Before the next periodic revision of the QCP, documented nonconformances will be reviewed and appropriate resolutions incorporated into the revised document. Nonconformances will also be used by project auditors to help focus audits on the historical project deviations. The auditors will review the corrective action procedures established from the resolution of the nonconformances and determine whether the original nonconformance issues have been permanently resolved. Modified corrective actions may be indicated by the findings of the audit.

7.6 Continual Improvement

Project staff at all levels are encouraged to provide recommendations for improvements in established work processes and techniques. The intent is to identify activities that are compliant but can be performed in a more efficient or cost-effective manner.

Typical quality improvement recommendations include the identification of an existing practice that should be improved (e.g., a bottleneck in production) and/or recommendations for an alternative practice that provides a benefit without compromising prescribed standards of quality. Project staff members are to bring their recommendations to the attention of project management or QC staff through verbal or written means.

Deviations from established protocols are not to be implemented without prior written approval of the PM and concurrence of the CQCSM. Staff-initiated recommendations resulting in tangible benefits to the project should be formally acknowledged by project management personnel.

7.7 Lesson Learned

Lessons learned on the project will be captured and reported on QC documentation forms described in this work plan. Significant lessons learned will be highlighted, as applicable, in the monthly status reports.

7.8 Submittal Management

The PM will be responsible for overall management and control of project submittals, including submittal scheduling and tracking. The CQCSM will be responsible for ensuring, through detailed review, that submittals, as well as the materials and work these represent, are in full compliance with applicable contract specifications. The CQCSM will also be responsible for ensuring that a project file is established and maintained and that accurate project documents are retained and controlled as prescribed herein.

7.8.1 Submittal Reviews

Project submittals shall be reviewed and approved through a CBI internal process prior to client delivery or use. Knowledgeable members of the project staff and the PM or designated representative will conduct technical reviews for the project planning documents and report(s). Multiple reviewers will be used to evaluate different components of the documents (i.e., technical, editorial, and QC reviews). The reviewers will ensure that the planning documents and report(s) meet the following requirements:

- The documents satisfy the requirements of the Scope of Work, requirements and data quality objectives (DQOs) identified, client requirements (including applicable DIDs), and applicable regulatory requirements
- Report assumptions are clearly stated, justified, and documented
- The reports clearly and accurately present the site investigation results

- The basis for the recommendations and conclusions presented in the reports are clearly documented
- The tables and figures are prepared and checked according to CB&I requirements
- The documents have been proofread (i.e., punctuation, grammar, and spelling are correct).

Submitted documents may also contain signature locations for CQCSM and PM approval. Original document review routing sheets, external reviewer comments, and comment resolution records will be retained in the project file, traceable to the deliverable, for recordkeeping purposes and future reference.

7.9 Document Change Management

The distribution of this work plan will be controlled by the CQCSM in order to ensure that the most recent, accepted version is available at all locations where investigative activities covered by this work plan addendum and subsequent work plan addenda are performed. Revisions to this work plan will require the same level of approval, control, and distribution as the original. Revisions will be documented in a revision log, on the cover pages and the footer of each page. All affected personnel will be informed of changes.

7.10 Document Control and Records Management

The project record files will be stored electronically on the project SharePoint Site and will be organized by various project file categories and corresponding activity dates. Records will be maintained at CB&I office in Knoxville, TN with copies of pertinent critical records also stored at the project site. Records will be readily retrieved for review and audit purposes by CB&I, the USACE, or regulatory agencies. The records will be controlled so that the possibility of their loss or damage is avoided.

To facilitate communications and submittal of technical documents with USACE and stakeholders, an internet portal has been created. This portal will serve as a collaborative workspace between CB&I, USACE, and the project regulators. Electronic files of deliverables, data, presentations, etc. in portable document format (PDF) will be placed on the portal. Access rights are provided by request only.

7.11 Qualifications and Training

Key project staff will be qualified to perform their assigned tasks in accordance with the terms outlined by the contract. The qualifications are presented in UPF-QAPP Worksheet 4, 7, and 8 *Personnel Qualifications and Sign-off Sheet*.

7.12 Chemical Data Quality Management Plan

The UFP-QAPP is provided as Appendix F, and presents a detailed discussion of chemical data quality.

7.13 Data Quality Objectives

Landfill Area 1 Remedial Investigation. Previous investigations have described numerous spot exceedances of applicable environmental threshold values in fill material, soil, and groundwater within and around Landfill Area 1.

The DQOs of the Landfill Area 1 RI are as follows:

- Utilize supplemental data set in combination with existing data to accurately delineate chemical footprint of the landfill and update human health and ecological risk. Additionally, obtain sufficient data within the landfill to define the nature and extent of isolated COC exceedances and their potential for off-site migration.
- Utilize the existing and supplemental data sets to develop a verifiable conceptual site model to support the FS.

The Landfill Area 1 RI activities are as follows:

- Collect surface water and sediment samples from three locations to investigate extent of contaminant migration. Analyze surface water and sediment samples for VOCs, SVOCs with PAHs, TRPH, pesticides, and TAL metals (total and dissolved) with low-level thallium. Surface water samples will also be analyzed for geochemical parameters. Employ detection limits that are below applicable regulatory screening values.
- Drill six vertical profile soil borings to characterize previously identified contamination in existing monitoring wells LF1MW02 and LFDW01. Collect screening-level DPT groundwater samples from the six vertical profile borings to define the horizontal and vertical extent of previously identified GCTL exceedances. Analyze screening-level DPT groundwater samples for VOCs, SVOCs with PAHs, TRPH, pesticides, and TAL metals (total and dissolved) with low-level thallium. Employ detection limits that are below applicable regulatory screening values.
- Collect surface and subsurface soil samples from 10 locations to redefine the contact exposure risks associated with the potential presence of nearsurface contaminants in the regraded area. Analyze soil samples for VOCs, SVOCs with PAHs, TRPH, pesticides, and TAL metals (total and dissolved) with low-level thallium. Employ detection limits that are below applicable regulatory screening values.
- Install one deep monitoring well adjacent to existing shallow well LF1MW02 to define the vertical extent of previous GCTL exceedances.

- Collect groundwater samples from the new deep well and 13 existing monitoring wells in support of the FS. Analyze groundwater for VOCs, SVOCs with PAHs, TRPH, TAL metals (total and dissolved) with low-level thallium, and geochemical parameters (used for a geochemical evaluation to discern site-related from naturally occurring metals concentrations at the site). Employ detection limits that are below applicable regulatory screening values.

Landfill Area 3 Remedial Investigation. Previous sampling efforts have identified limited impacts to soil, surface water, sediment, and groundwater within most of the footprint of the landfill as currently configured/mapped. However, high levels of VOCs at the eastern/southeastern limits of the landfill have been detected and have not been completely delineated. Groundwater flow is to the north-northeast, indicating that these elevated VOC levels are not derived from releases within the current boundaries of the landfill. These data suggest that the footprint of the landfill could be larger than currently configured.

The DQOs of the Landfill Area 3 RI are as follows:

- Utilize supplemental data set in combination with existing data to accurately delineate chemical footprint of the landfill and update human health and ecological risk. Additionally, obtain sufficient data within the landfill to define the nature and extent of isolated COC exceedances and their potential for off-site migration.

- Utilize the existing and supplemental data sets to develop a verifiable conceptual site model to support the FS.

Field sampling at Landfill Area 3 will consist of:

- Collect surface water and sediment samples from one location to investigate surficial extent of VOC impacts outside the southeastern landfill boundary. Analyze surface water and sediment samples for VOCs only. Employ detection limits that are below applicable regulatory screening values.

- Drill ten vertical profile soil borings to delineate the extent of previously identified GCTL exceedances in groundwater along the southeastern portion of the landfill area. Collect screening-level DPT groundwater samples from the ten vertical profile borings to define the horizontal and vertical extent of previous dichloroethene and vinyl chloride exceedances. Analyze screening-level DPT groundwater samples for VOCs only. Employ detection limits that are below applicable regulatory screening values.

- Collect surface and subsurface soil samples from three locations to define the extent of previous SCTL exceedances within the landfill footprint. Analyze soil samples for VOCs, SVOCs with PAHs, TRPH, pesticides, PCBs, and TAL metals (total and dissolved). Employ detection limits that are below applicable regulatory screening values.

- Install four shallow and four deep monitoring wells to define the horizontal and vertical extent of previous dichloroethene and vinyl chloride GCTL exceedances
- Collect groundwater samples from the eight new and twelve existing monitoring wells. Analyze groundwater for VOCs, SVOCs with PAHs, TRPH, pesticides, PCBs, TAL metals (total and dissolved), and geochemical parameters (used for a geochemical evaluation to discern site-related from naturally occurring metals concentrations at the site). Employ detection limits that are below applicable regulatory screening values.

7.14 Data Uses Quality Control Sampling

To ensure that the data meet the designated DQOs, QC samples will be collected during the field activities. To evaluate sampling and analysis method precision, field duplicate samples equal to approximately 10 percent of the number of field samples (or a minimum of one sample) will be sent for QC analysis. To evaluate laboratory analysis precision, one field split sediment sample and one field split surface water sample will be collected and sent for QA analysis. QA/QC samples will not be collected and analyzed for samples collected for disposal purposes. Additionally, at least one matrix spike/matrix spike duplicate pair will be included for every 20 soil samples collected.

All samples collected during the Landfill Area 1 and Landfill Area 3 RI will be sent for off-site analysis to a fixed-base laboratory and will be analyzed on a normal 30-day turnaround time. The fixed-base analytical laboratory will be responsible for analyzing the QC samples and conforming to the approved laboratory procedures.

All data collected will be stored in an electronic database for management and reporting.

Table 3-2 presents the list and number of samples to be collected and the analyses to be performed for all samples collected during the field activities. The rationales for selection of sample analyses and sampling approach, which will be used during the Landfill Area 1 and Landfill Area 3 RI, are discussed in the following sections.

7.15 Rationale for Selection of Sample Analyses

Landfill Area 1. Based on the results of previous investigations, surface/subsurface soil samples will be analyzed for VOCs, SVOCs with PAHs, TRPH, pesticides, and TAL metals with low-level thallium. Surface water and sediment samples will be analyzed for VOCs, SVOCs with PAHs, TRPH, pesticides, PCBs, and TAL metals (total and dissolved for surface water only) with low-level thallium. Surface water will also be analyzed for geochemical parameters. DPT groundwater samples will be analyzed for VOCs, SVOCs with PAHs, TRPH, pesticides, TAL

metals (total and dissolved) with low-level thallium, and geochemical parameters. Groundwater samples will be analyzed for VOCs, SVOCs with PAHs, TRPH, TAL metals (total and dissolved) with low-level thallium, and geochemical parameters. Analytical results will be compared to EPA Region 9 residential and industrial RSLs and the FDEP SCTLs (residential and industrial) and GCTLs. Sediment will be compared to the State of Florida SQAGs.

Landfill Area 3. Based on the results of previous investigations, surface/subsurface soil samples will be analyzed for VOCs, SVOCs with PAHs, TRPH, pesticides, PCBs, and TAL metals. Surface water and sediment samples will be analyzed for VOCs. DPT groundwater samples will be analyzed for VOCs. Groundwater samples will be analyzed for VOCs, SVOCs with PAHs, TRPH, pesticides, PCBs, TAL metals (total and dissolved), and geochemical parameters. Analytical results will be compared to EPA Region 9 residential and industrial RSLs and the FDEP SCTLs (residential and industrial) and GCTLs. Sediment will be compared to the State of Florida SQAGs.

7.16 Sampling and Analysis Requirements

The purpose of the sampling program is to collect representative soil and groundwater samples. The samples will be utilized to assess remedial alternatives for contaminants in site media. A summary of RI sampling, including the number of field samples to be collected and analyses to be performed, is presented in Table 3-1.

7.17 Quality Control Sampling

To ensure the reliability of field sampling procedures and materials, field QC samples will be collected or prepared as appropriate for each medium sampled, each sample shipment, and/or each sampling event. The field activities will be considered one event unless field personnel leave the site for more than 72 hours during the course of the investigation.

7.18 Sample Custody and Tracking Procedures

Sample custody is a vital aspect of the environmental investigation. Samples must be traceable from the time of sample collection. All sample custody and tracking procedures, including laboratory notification, field custody procedures, identification, and shipping, will be performed as specified in the following sections.

7.18.1 Notification to Laboratory of Sample Shipment

Prior to any sampling activity, the project chemist will contact the laboratory Project Manager to:

- Review sample quantities, types, identification procedures, and analytical methods
- Review task-specific analysis requirements, reporting limits, or target analytes
- Review schedule

- Set up lines of communication under nonconformance conditions
- Review deliverable requirements.

During project implementation, the project chemist notifies the laboratory of anticipated samples and any changes in sampling schedule or scope. Gulf Coast Analytical Laboratories accepts samples Monday through Saturday.

Before QA split samples are collected for shipment to the USACE South Atlantic Division-designated laboratory, the data coordinator or project chemist must contact the USACE laboratory point of contact to verify sample shipment schedule.

7.18.2 Field Custody Procedures

Adequate field custody procedure activity includes:

- The sampling team and field sampling coordinator have overall responsibility for the care and custody of the samples collected until they are transferred or properly dispatched to the laboratory.
- Samples must be secured in a locked on-site refrigerator or ice chest sealed with custody seals.
- Shipment information is recorded for shipment of samples at the end of the shift, day, or collection period on the field activity daily log (FADL) and on the site logbook.

7.18.3 Identification and Shipping

Samples may be stored on site longer than 24 hours provided they are stored in a secure location such as a locked refrigerator or sealed ice chest and temperature blanks are monitored at least twice per day. Storage temperatures will be logged and recorded on a log form and in the logbook.

Procedures for transfer of custody and shipping include the following:

- All coolers must be secured at the site with custody seals prior to transport. Seals should be signed and dated by person relinquishing samples.
- An AR)/chain-of-custody record will be initiated in the field for each sample shipment. The original of this record will accompany each sample. The copies will be retained at the site and will be placed in the project files at the conclusion of field activities.
- If the laboratory sample custodian judges sample custody to be compromised (e.g., samples arrive damaged or seals were applied but broken), the data manager and/or

project chemist will be notified and the situation reviewed. A consensus decision will be made as to the fate of the samples in question.

- Each time responsibility for custody of the sample changes, the new custodian will sign the chain-of-custody portion of the AR/ chain-of-custody record and note the date and time of acceptance. Courier personnel who handle the enclosed sealed coolers will not be required to sign for custody transfer. Instead, the air bill or shipping paper will signify transfer.

- The custody of individual sample containers will be documented by recording each container's identification on the AR/ chain-of-custody form.

- Upon sample destruction or disposal, the laboratory custodian responsible for the disposal will complete the chain-of-custody record, file a copy, and send a copy to the CB&I Project Manager for project files.

7.19 Documentation

All field activities shall be documented in an official logbook or FADL to maintain a record of the progress of the fieldwork and allow the reconstruction of events that occur during the Landfill Area 1 and Landfill Area 3 RI activities. Field documentation forms to be used, in addition to the official logbook, include FADL, sample collection log, and AR/ chain-of-custody record.

7.20 Sample Analysis

Summaries of the samples to be submitted for laboratory analysis and their analyses are presented in Tables 3-1 and 3-2. Off-site analyses will be performed by a fixed-base laboratory using approved methods.

7.21 Data Management

The data management process includes all aspects of data review and data validation. All data associated with the Landfill Area 1 and Landfill Area 3 RI will undergo several evaluations in the laboratory and by CB&I personnel prior to release to an end data user.

- ***Data Packages.*** Laboratory data packages will undergo internal review by the analyst and a peer or supervisor review prior to submittal to CB&I. The project chemist will review the data and compare it to the planned objectives in the work plan and to QC sample data to evaluate the validity of the results.

- ***Data Validation.*** A thorough evaluation of the data will be conducted to determine whether the project objectives have been met. Specific issues to be addressed include precision, accuracy, and representativeness, such as duplicate results, matrix spike/matrix spike duplicate, and blank sample results. An evaluation of completeness will be performed and data deficiencies will be identified and rectified or documented

for the report. An overall assessment will be made with respect to the decision statements identified by the data quality objective process to determine that the data meet the objectives.

Data validation will take place for 100 percent of the collected samples. Data validation will be based on the DoD QSM Version 5.0and will follow the QC guidance outlined in *Test Methods for Evaluation of Solid Waste* (EPA, 1986). Data qualifiers will be applied following the logic of the EPA *Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (EPA, 2004b) and the EPA *Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review* (EPA, 2008b).

Data completeness represents the percentage of valid data collected compared to the amount expected to be obtained under optimal or normal conditions. The completeness goal for critical samples (i.e., soil samples and groundwater samples) is defined as 95 percent.

Following completion of the data validation, the validator will compile the data review notes and assemble them into a standardized data validation report format. The project chemist or a designee will review all data and assess the usability of the data based on the validation effort findings.

8.0 Environmental Protection Plan

8.1 On-Site Materials

The suspect constituents that potentially could be encountered are VOCs, SVOCs, PAHs, pesticides, PCBs (Landfill Area 3), and TRPH. On-site materials consist of (but are not limited to) contaminated soil and groundwater.

8.1.1 Fuel and Flammable Liquid Storage

It is not anticipated that any fuel and/or flammable liquids will be stored. CB&I may store on-site fuels and oils for vehicles during implementation of the project. The types of materials that may be stored at the site include the following:

- Gasoline
- Motor transmission oils
- Greases
- Used oil
- Hydraulic fluid.

8.1.2 Material Compatibility

The materials potentially stored on site are not anticipated to be mixed or combined during site operations and will be stored in a manner to prevent accidental mixing in the event of a spill/release.

8.2 Organic Vapor Releases

Organic vapor releases could occur during sampling activities. Organic vapor concentrations in the air during soil boring collection will be monitored using air-monitoring equipment such as a PID. Air monitoring requirements are described in the accident prevention plan (APP)-site safety and health plan (SSHP) (CB&I, 2014).

8.3 Emergency and Decontamination Equipment

This section presents the types of emergency equipment that will be used in the event of a spill or other emergency situation.

8.3.1 Small-Scale Emergency Equipment

Small-scale emergency equipment will include the following:

- Dry chemical, ABC-rated fire extinguishers
- Spill control equipment
- Absorbent materials

- Decontamination equipment
- Air-purifying respirators
- Radio and telephone equipment
- Windsock
- Various hand tools.

This equipment will be made accessible to all on-site workers.

8.3.2 Large-Scale Emergency Equipment

Large scale emergency equipment may be obtained from the local fire department or other emergency response agencies, if required.

8.3.3 Decontamination Equipment

Equipment necessary for decontamination of sampling equipment will be provided and verified in working order prior to any site operations. Equipment for equipment decontamination includes the following items:

- Clean water supply
- Detergent solution
- Containers for used decontamination solution and decontamination residues/solids
- Brushes
- Waste containers.

8.4 Spill Prevention and Response

This section discusses the techniques that will be utilized to minimize the potential for spills and will describe the measures that will be implemented in response to a spill. The following sections include the detailed CB&I procedures for activities that include containment, collection, and material disposal or reuse.

8.4.1 Small Spillage

Small spills (less than 10 gallons) may include solid materials or liquid materials being mishandled, dumped, leaked, knocked over, etc. Any material spillage will be immediately contained and collected and placed on the drying pad for later disposal. Work will be performed such that exposed source materials remain within the limits of the construction or below the limits of temporarily constructed soil berms. All spilled liquids will be contained and collected by absorbent materials and the materials taken to the decontamination pad area. CB&I will notify the USACE in the event of a spill greater than 10 gallons. The spill will be cleaned up in accordance with FDEP requirements outlined in Chapter 62-620 F.A.C.

8.4.2 On-Site Material Transportation

All materials will be transported on and around the site via site roads. Practices for preventing material spills will include not overfilling trucks, driving at posted speeds, and maintaining haul roads in good condition. Additional information is provided in the APP-SSHP (CB&I, 2014).

8.5 Severe Weather

Short-duration, high-intensity rain showers could create unexpected delays and sample location access problems. After such events, all access routes will be closely inspected for structural and practical integrity.

8.6 Protection of Natural Resources

Although CB&I will take all reasonable measures to assure no residual damage beyond the limits of the planned disturbance, it is inevitable that some damage will occur. In the event that damage is done to the landscape beyond the limits of disturbance, the affected area or feature will be restored to the satisfaction of the client's representative, as soon as the restoration is deemed practical. Plant life or trees damaged beyond repair will be cleared and replaced as directed. Vegetation removed as part of the planned clearing will be replaced in accordance with design specifications.

8.6.1 Dust Control

Dust control measures are not anticipated to be required for the Landfill Area 1 and Landfill Area 3 RI.

8.6.2 Erosion Protection

Erosion protection measures are not anticipated to be required for the Landfill Area 1 and Landfill Area 3 RI.

8.7 Inspection

Inspections of the site will be performed by the CBI Site Manager and Site Safety Officer (SSO) to verify that procedures for proper storage, handling, and transport of materials are being followed. Inspection and monitoring methods will be through visual observation.

Other areas and items that will be monitored and noted in the site logbook include the following:

- Evidence of spilled materials along drainage ditches
- Effectiveness of housekeeping practices
- Various shipping and storage containers used throughout the site
- Staging area.

Inspections of hazardous material containers will be documented in the SSO's FADL.

8.7.1 Equipment Maintenance

All sampling equipment will be properly maintained and inspected to facilitate safe operation. Equipment (especially trucks) will be properly maintained to minimize spillage or leakage that may occur during sampling activities. Spill kits will be ready and available during all maintenance activities.

8.7.2 Calibration of Monitoring Equipment

It is important that all environmental monitoring equipment be calibrated so that accurate readings of potential spilled or leaked materials may be detected upon inspection. Calibration frequency and procedures will be followed as per FDEP and manufacturer's specifications. CB&I will retain calibration records on site.

8.8 Housekeeping Program

CB&I's housekeeping program includes neat and orderly storage of materials and equipment, proper truck and tank placards, prompt removal of spillage, regular refuse pickup and disposal, and maintenance of roads and surfaces.

8.9 Worker Training

All employees with the potential of exposure to hazardous substances will be required to attend and complete the Occupational Health and Safety Administration 40-hour Health and Safety course (Hazardous Waste Operations and Emergency Response) as per 29 Code of Federal Regulations 1910-120. All site employees requiring 40-hour health and safety training will be current with respect to 8-hour annual refresher training.

A site-specific training program will involve at least one hour of instruction per employee. At a minimum, the training program will ensure that personnel are able to respond effectively to emergencies by familiarizing them with emergency procedures and emergency equipment systems, including, where applicable:

- Procedures for using, inspecting, repairing, and replacing emergency and monitoring equipment
- Communication and alarm procedures
- Response to fires and explosions
- Site evacuation procedures
- Shutdown operation.

In addition, the employee training program will address other aspects of the environmental protection section, such as preventive maintenance, inspection and monitoring, housekeeping practices, etc.

Job-specific environmental protection and health and safety instructions will be reviewed before beginning each new phase of work. If conditions require, the SSO or Site Superintendent will conduct follow-up training related to a change in operations or any other training deemed necessary by the SSO. CB&I will hold daily safety meetings (tailgate safety meetings) at the beginning of each shift to discuss current considerations.

9.0 Site Safety and Health Plan

All Landfill Area 1 and Landfill Area 3 RI work at the site performed by CBI or its subcontractors will be performed in accordance with the Programmatic APP-SSHP (CB&I, 2014). The Programmatic APP-SSHP complies with applicable Occupational Safety and Health Administration, EPA, and USACE regulations. The plan follows the guidelines established in the following:

- Standard Operating Safety Guidelines
- Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities (National Institute of Occupational Safety and Health 86-116)
- 29 Code of Federal Regulations 1910.120, U.S. Department of Labor/Occupational Safety and Health Administration
- 29 Code of Federal Regulations 1926.65, U.S. Department of Labor/Occupational Safety and Health Administration
- Safety and Health Elements for Hazardous, Toxic, and Radioactive Waste and OWE Documents (USACE CER 385-1-92, Appendix B [March 18, 1994]).

The contents of the Programmatic APP-SSHP are also consistent with all CB&I corporate health and safety policies and procedures.

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