FINAL
SITE SPECIFIC FINAL REPORT
TIME CRITICAL REMOVAL ACTION (TCRA)
SPECIFIC AREAS WITHIN THE NORTHWEST PENINSULA
CULEBRA ISLAND, PUERTO RICO

Contract No. W912DY-10-D-0023
Task Order No. 0022
DERP-FUDS Project No. I02PR006816

Prepared for

U.S. Army Corps of Engineers
U.S. Army Engineering and Support Center, Huntsville
and
Geographical District: US Army Corps of Engineers - Jacksonville District

Prepared by:

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Suite 400
Reston, VA 20190

November 2019

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Signed: _____
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Quality Management Representative

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TABLE OF CONTENTS

Section **Page**

TABLE OF CONTENTS (continued)

Section **Page**

TABLE OF CONTENTS (continued)

Section **Page**

LIST OF TABLES

Page

LIST OF FIGURES

Page

LIST OF CHARTS

LIST OF APPENDICES

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%	percent
%R	percent recovery
µg/kg	micrograms per kilogram
m3/d	cubic meters per day
mg/L	milligrams per liter
AC	advanced classification
AGC	advanced geophysical classification
ACDEC	Authority of Conservation and Development of Culebra
AHA	activity hazard analysis
AP	armor piercing
APP	Accident Prevention Plan
BDU	Bomb Dummy Unit
bgs	below ground surface
CAL	caliber
CEHNC	Huntsville Engineering and Support Center
CESAJ	U.S. Army Corps of Engineers, Jacksonville District
cm	centimeter
CSM	Conceptual Site Model
DDESB	Department of Defense Explosives Safety Board
DERP-FUDS	Defense Environmental Restoration Program – Formerly Used Defense Site
DGM	digital geophysical mapping
DID	Data Item Description
DL	detection limit
DoD	Department of Defense
DQCR	Daily Quality Control Reports
DQE	data quality evaluation
DQI	data quality indicators
DQO	data quality objectives
DUA	data usability assessment
Ellis	Ellis Environmental Group
EM	Engineer Manual
EM61	EM61-MK2A
EMI	electromagnetic induction
EPA	U.S. Environmental Protection Agency
ESS	Explosives Safety Submission
Eurofins	Eurofins Lancaster Laboratories Environmental, LLC
EZ	exclusion zone
FCR	field change request
ft	feet/foot

GDB	geophysical database
GIS	geographic information system
GP	general purpose
GPS	global positioning system
GSV	geophysical system verification
HE	high explosive
HGL	HydroGeoLogic, Inc.
HMX	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
Hz	hertz
IAW	in accordance with
IMU	inertial measurement unit
ISO	industry standard object
IVS	Instrument Verification Strip
LANL ESV	Los Alamos National Laboratory EcoRisk Database v.3.3, 2015
LB	pound
LCS	laboratory control sample
LOD	limit of detection
lsf	line/station/fiducial
m	meter
MC	munitions constituent
MD	munitions debris
MDAS	material documented as safe
MEC	munitions and explosives of concern
mm	millimeter
MM2x2	MetalMapper 2x2
MMRP	Military Munitions Response Program
MPC	measured performance criteria
MPPEH	material potentially presenting an explosive hazard
MQO	measurement quality objective
MRS	munitions response site
MS	matrix spike
MSD	matrix spike duplicate
MTA	MTA, Inc.
mV	millivolt
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NWP	Northwest Peninsula
OSHA	Occupational Safety and Health Administration

PAL	project action level
PETN	Pentaerythritol Tetranitrate
PLS	professional land surveyor
PM	Project Manager
PR DNER	Puerto Rico Department of Natural and Environmental Resources
PREQB	Puerto Rico Environmental Quality Board
PWS	performance work statement
PVC	polyvinyl chloride
QA	quality assurance
QASP	Quality Assurance Surveillance Plan
QC	quality control
RCA	root cause analysis
RCA-CA	root cause analysis – corrective action
RDX	Hexahydro-1,3,5-trinitro-1,3,5-triazine
RPD	relative percent difference
RRD	range related debris
RTK	real time kinetic
RSL	Regional Screening Level
RTS	robotic total station
SDG	sample delivery group
SOP	standard operating procedure
SSFR	Site Specific Final Report
SSHP	Site Safety and Health Plan
SU	survey unit
SUXOS	Senior UXO Supervisor
TCRA	Time Critical Removal Action
	2,4,6-Trinitrotoluene
TOI	target of interest
UFP-QAPP	Uniform Federal Policy Quality Assurance Project Plan
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UXO	unexploded ordnance
UXOSO	UXO Safety Officer
UXOQCS	UXO Quality Control Specialist
WERS	Worldwide Environmental Remediation Services

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EXECUTIVE SUMMARY

ES.1 The U.S. Army Corps of Engineers (USACE) conducted a Time Critical Removal Action (TCRA) at specific Congressionally-authorized locations within the Northwest Peninsula (NWP) of Culebra Island (Defense Environmental Restoration Program-Formerly Used Defense Site [DERP-FUDS] Project No. I02PR006816), Puerto Rico, specifically within portions of Carlos Rosario Beach, Flamenco Beach, Tamarindo Beach, the Flamenco Campground, and the Carlos Rosario Trail. This work was conducted for the USACE by HydroGeoLogic, Inc. (HGL) under Contract No. W912DY-10-D-0023, Task Order No. 0022.

ES.2 The May 2016 TCRA Action Memorandum for Specific Congressionally Authorized Areas within the NWP detailed the specific areas to be covered and selected response actions to be performed under the TCRA including surface and subsurface removal of Munitions and Explosives of Concern (MEC), and disposal of recovered munitions. The primary objective of the TCRA was to mitigate and minimize the threat posed by the potential proximity of munitions to recreational users of the beaches and campground, whose activities may present exposure to and potentially trigger an unintentional detonation of an item. The evaluation included numerous public encounters with MEC and emergency responses by local authorities and Explosive Ordnance Disposal personnel. Based on the established exposure pathway at the authorized areas within the NWP, the Action Memorandum determined that a TCRA would significantly reduce the risk at these sites.

ES.3 Project objectives were detailed in the performance work statement (PWS) dated 23 February 2016 (Revision: 1 dated 22 March 2016). The general scope of work included activities necessary to remove Material Potentially Presenting an Explosive Hazard (MPPEH) from the areas within the NWP. Specific project objectives included the following:

- Develop a Uniform Federal Policy Quality Assurance Project Plan (UFP-QAPP) and an Accident Prevention Plan (APP)/Site Safety and Health Plan (SSHP);
- Prepare an Explosives Safety Submission (ESS);
- Conduct TCRA field activities;
- Conduct beach monitoring; and
- Prepare this Site Specific Final Report (SSFR).

ES.4 MEC is a safety hazard and may constitute imminent and substantial danger to site personnel. All MEC were destroyed on site. Applicable provisions of Chapter 29 of the Code of Federal Regulations 1910.120 and Section C, Paragraph 2.4 of the Basic Contract (Applicable Laws and Regulations) applied to work on this task order. All activities involving work in areas potentially containing MEC and MPPEH hazards were conducted in full compliance with USACE, Huntsville Engineering and Support Center (CEHNC), Department of the Army, and state and local requirements regarding personnel, equipment, and procedures; and with U.S. Department of Defense standard operating procedures (SOPs) and safety regulations.

ES.5 The site is located on Culebra Island, Commonwealth of Puerto Rico, approximately 17 miles east of the main island of Puerto Rico (Figure 2.1). The southern portion of the NWP is located in the northwestern point of the main island of Culebra; also known as Lot 91. This portion of the peninsula is approximately 408 acres in size and is bounded by the Caribbean Sea to the northeast and southwest, to the northwest by a portion of the U.S. Fish and Wildlife Service (USFWS) Culebra Island National Wildlife Refuge, and to the southeast by the remainder of the island. NWP TCRA areas are located within Munitions Response Site (MRS) 16. The site is accessible via existing roads and from watercraft. Local workers are regularly present within the site to manage recreational areas. The Flamenco Beach Campground consists of commercial vendor structures and an expansive tent-camping area. Additionally, Flamenco Beach, Carlos Rosario Trail and Beach, and Tamarindo Beach receive thousands of visitors yearly. Access to the site is unrestricted to the public.

ES.6 The TCRA encompassed 29.04 acres. The final TCRA boundary differs from the original TCRA boundary of 31.83 acres due to inaccessible areas. Inaccessible areas include steep slopes along Carlos Rosario Beach and Trail, fencing along Carlos Rosario Trail and Flamenco Campground, and the actual low water line of all beaches. The beaches are dynamic in nature and the low water line fluctuates due to seasonal influences, tidal action, and storm surges. Figure 2.5 details the original and final TCRA boundaries. During the TCRA, over 49,200 exposure hours were expended, 31 unexploded ordnance (UXO) were destroyed on site, and over 72,800 pounds of material documented as safe (MDAS) were processed, certified, and recycled. No lost workday accidents occurred during the execution of this project. MEC discoveries at the site included the following:

- 20mm high explosive (HE) projectile
- 3-inch HE projectiles
- 5-inch HE rockets
- 100-pound General Purpose (GP) Bombs
- 2.75-inch HE rockets
- 5-inch HE projectiles
- 5-inch white phosphorous rocket
- 500-pound GP Bomb

ES.7 USACE conducted the TCRA from October 4, 2016, through March 22, 2018, with two intermediate demobilizations/remobilization efforts during this period.

- October 4, 2016 to April 10, 2017 – Mobilization to initiate TCRA field activities.
- August 1, 2017 to September 5, 2017 – Remobilization to resume TCRA field activities. Emergency demobilization due to hurricanes Irma and Mar a.
- November 14, 2017 to March 22, 2018 – Remobilization post hurricanes Irma and Mar a. Completion of TCRA field activities.

ES.8 All TCRA objectives were met, and no unresolved or outstanding issues or concerns remain regarding this project.

SITE SPECIFIC FINAL REPORT
TIME CRITICAL REMOVAL ACTION
SPECIFIC AREAS WITHIN THE NORTHWEST PENINSULA
CULEBRA ISLAND, PUERTO RICO

1.0 PROJECT ACTIVITIES AND ACTIONS

1.0.1 The U.S. Army Corps of Engineers (USACE) conducted a Time Critical Removal Action (TCRA) at specific Congressionally-authorized locations within the Northwest Peninsula (NWP) of Culebra Island (Defense Environmental Restoration Program-Formerly Used Defense Site [DERP-FUDS] Project No. I02PR006816), Puerto Rico, specifically within portions of Carlos Rosario Beach, Flamenco Beach, Tamarindo Beach, the Flamenco Campground, and the Carlos Rosario Trail. This work was conducted by HydroGeoLogic, Inc. (HGL) for the USACE under Contract No. W912DY-10-D-0023, Task Order No. 0022.

1.0.2 The primary objective of the TCRA was to mitigate and minimize the threat posed by the potential proximity of munitions to recreational users of the beaches and campground. Recreational users could encounter and potentially trigger an unintentional detonation of an item. The May 2016 TCRA Action Memorandum for Specific Congressionally Authorized Areas within the NWP (USACE, 2016) detailed the specific areas to be covered and selected response actions to be performed under the TCRA including surface and subsurface removal of Munitions and Explosives of Concern (MEC), and disposal of recovered munitions. Project objectives were detailed in the performance work statement (PWS) dated 23 February 2016 (Revision: 1 dated 22 March 2016). The general scope of work included activities necessary to remove Material Potentially Presenting an Explosive Hazard (MPPEH) from the specific areas within the NWP. PWS objectives included the following:

- Develop a Uniform Federal Policy Quality Assurance Project Plan (UFP-QAPP) and an Accident Prevention Plan (APP)/Site Safety and Health Plan (SSHP);
- Prepare an Explosives Safety Submission (ESS);
- Conduct TCRA field activities;
- Conduct beach monitoring; and
- Prepare this Site Specific Final Report (SSFR).

1.0.3 The work was conducted in close coordination with the Huntsville Engineering and Support Center (CEHNC), U.S. Army Corps of Engineers, Jacksonville District (CESAJ), and other stakeholders while developing the UFP-QAPP and in executing the TCRA. HGL completed the work in accordance with (IAW) the PWS and the approved project UFP-QAPP titled *Final Uniform Federal Policy Quality Assurance Plan (UFP-QAPP), Time Critical Removal Action (TCRA), Specific Areas Within the Northwest Peninsula, Culebra Island, Puerto Rico* (HGL, 2016). Field Change Requests (FCRs) associated with the UFP-QAPP are included

in Appendix G. HGL conducted the TCRA from October 4, 2016, through March 22, 2018, with two intermediate demobilizations/remobilization efforts during this period.

- October 4, 2016 to April 10, 2017 – Mobilization to initiate TCRA field activities.
- August 1, 2017 to September 5, 2017 – Remobilization to resume TCRA field activities. Emergency demobilization due to hurricanes Irma and Mar a.
- November 14, 2017 to March 22, 2018 – Remobilization post hurricanes Irma and Mar a. Completion of TCRA field activities.

1.1 PROJECT TEAM ORGANIZATION

1.1.1 As the prime contractor, HGL had overall responsibility for completing the TCRA IAW the PWS and meeting project objectives and schedule goals. This task included coordinating the activities of the technical staff and integrating the project delivery team, managing data, including geographic information system (GIS) data, managing program safety and quality control (QC), and procuring and managing subcontractors. HGL coordinated all activities and provided an analysis of the schedule and project status on a weekly basis while fieldwork was underway, with CEHNC and CESAJ.

1.1.2 The roles of project team members are described below. Table 1.1 is a matrix identifying the roles and responsibilities of the project team during specific phases of the project. On-site HGL management personnel and unexploded ordnance (UXO) technicians were approved as qualified personnel by the CEHNC contracting officer.

1.1.1 Huntsville Engineering and Support Center

1.1.1.1 CEHNC was the implementing agency and had approval authority on the project. CEHNC provided expertise for MEC-related activities, and its responsibilities included providing direction to HGL and conducting document reviews.

1.1.2 U.S. Army Corps of Engineers Jacksonville District

1.1.2.1 CESAJ was the Project Management District for the TCRA project at Culebra and had the ultimate authority role for management of this project. In addition, CESAJ coordinated materials and information about the project with the regulators and local community.

1.1.3 HydroGeoLogic, Inc.

1.1.3.1 HGL was the prime contractor to CEHNC and provided all services for the TCRA. HGL was responsible for performing the activities detailed in the PWS. Project tasks included developing the UFP-QAPP, monitoring the beach, performing TCRA field activities, and monitoring the project objectives and schedule. Parsons, HGL's subcontractor, was responsible for conducting the digital geophysical mapping (DGM) and the advanced classification (AC) fieldwork. In support of the AC effort, Parsons provided the AC Project Manager (PM), AC Senior Geophysicist, and AC Field Geophysicist.

1.2 OVERALL PROJECT APPROACH

1.2.1 The goal of the TCRA was to identify and dispose of MEC within specific areas of the NWP. The following subsections provide a discussion of the overall technical approach.

Table 1.1
Roles and Responsibilities Matrix

TASK	CEHNC	CESAJ	HGL (Contractor)
UFP-QAPP	Reviewed, quality assurance (QA), and approval	Reviewed, coordinated regulator review: Authority of Conservation and Development of Culebra (ACDEC), Puerto Rico Environmental Quality Board (PREQB), Puerto Rico Department of Natural and Environmental Resources (PR DNER), U.S. Fish and Wildlife Service (USFWS), National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), and U.S. Environmental Protection Agency (EPA)	Primary author. Prepared the UFP-QAPP to support a munitions response at a Munitions Response Site (MRS). Delineated tasks to be completed for this project and provided the rationale for the technical approach, staffing, and project schedule.
TCRA Field Activities	QA inspections IAW the QA Surveillance Plan (QASP)	Communicated with regulators (ACDEC, PREQB, PR DNER, USFWS, NOAA, and EPA)	Conducted TCRA field activities IAW the PWS, UFP-QAPP, and applicable standards.
SSFR	Reviewed, QA, and approval	Reviewed, coordinated regulator review (ACDEC, PREQB, PR DNER, USFWS, NOAA, and EPA)	Primary author. Prepared the SSFR IAW the general format presented in Data Item Description (DID) Worldwide Environmental Remediation Services (WERS)-013.01 to include the results for all field activities conducted.

1.2.1 Data Quality Objectives

1.2.1.1 MEC clearance was conducted to reduce the risk of the public encountering MEC at the site. The data quality objectives (DQOs) detailed in the UFP-QAPP involved the following measures to ensure that results obtained were repeatable and verifiable:

- Use of fully functional and reliable tools, sensors, and equipment;
- Use of site personnel fully qualified to perform the tasks in a safe and efficient manner;
- Collection of information in a manner that yielded high-quality, accurate datasets; and
- Development of a complete, fully detailed listing of items encountered and removed during the clearance.

1.2.1.1 Munitions and Explosives of Concern Clearance Areas

1.2.1.1.1 HGL removed MEC from the specific areas of the NWP shown on Figure 2.2 using the survey methods indicated in Table 1.2. Work was performed IAW the PWS, UFP-QAPP, and all applicable standards. Munitions with an explosive hazard were destroyed on site.

Table 1.2
Survey Methods for Northwest Peninsula Time Critical Removal Action

Location	Survey Method	Advanced Classification
Flamenco Beach	DGM	Yes
Flamenco Campground Open Areas	DGM	Yes
Flamenco Campground Vegetated	Analog	No
Carlos Rosario Trail	Analog	No
Carlos Rosario Beach	DGM	No
Carlos Rosario Vegetated Area	Analog	No
Tamarindo Beach	DGM	No
Tamarindo Vegetated Area	Analog	No

- Flamenco Beach: From the mean low water line to the vegetation line.
- Flamenco Campground: From the vegetation line to the campground fence line.
- Carlos Rosario Trail: 20 feet (ft) from either side of the trail centerline, excluding areas that cannot be reached due to physical constraints such as steep slopes or existing fences.
- Carlos Rosario Beach: From the mean low water line to the vegetation line and extended 50 ft into the vegetation line (tree line).
- Tamarindo Beach: From the mean low water line to the vegetation line and extended 50 ft into the vegetation line (tree line).
- Anomalies were investigated within the paved Flamenco parking lot and road leading into the campground. All parking lot and road excavations were repaired.

1.2.1.1.2 MEC clearance activities were not conducted within the TCRA footprint (approximately 1-acre) at the following locations: ACDEC Flamenco Campground Office, ACDEC Flamenco Campground structures (sheds, bathrooms, showers, walkways, and water systems), Flamenco Campground kiosks and associated decking, Flamenco Campground basketball courts, Flamenco Campground pond, and other permanent structures (Figure 2.5). Permanent buildings and structures were not to be removed as part of this TCRA. Additionally, underwater clearance in the Flamenco Campground pond was not included as part of this TCRA.

1.2.1.2 Geospatial Information

1.2.1.2.1 G Pedro J. Davila Colon, Inc., a professional land surveyor (PLS) licensed in Puerto Rico, conducted and signed all survey plats completed at the site. The survey crew met personnel/work standards as described in DID WERS-007.01. All grid corners and clearance

boundaries were marked with wooden stakes using high-visibility paint or flagging. HGL provided UXO technicians for MEC avoidance escort operations in support of surveying inside the expected UXO operations area.

1.2.1.2.2 Figure 2.4 accurately conveys the clearance areas and data and is signed by the PLS. An electronic submittal of all control points, grid corners, and any boundaries or closures will be provided to CEHNC with the SSFR.

1.2.1.2.3 Project-specific GIS was used to store and manage all relevant geospatial-related data and information. The geospatial-related data includes physical features, MEC found during the investigation, and sampling locations. Post-project response action geospatial data will be provided to CEHNC with the SSFR.

1.2.1.3 Munitions and Explosives of Concern Clearance Performance Criteria

1.2.1.3.1 HGL's performance was measured by the criteria established in the PWS:

1. The U.S. Government finding no MEC or MPPEH, excluding small arms ammunition (.50 cal and smaller), and no munitions debris (MD) or range related debris (RRD) equivalent to, or greater than 37 millimeter-(mm) in diameter or width on the surface of the MRS;
2. The U.S. Government finding no subsurface MEC or MPPEH shallower than 8X the item's diameter; and,
3. The U.S. Government finding no signal equivalent to, or greater than, anomaly selection criteria as documented in the Instrument Verification Strip (IVS) Letter Report without an acceptable explanation.

1.2.1.4 General Site Activities

1.2.1.4.1 All intrusive activities were conducted under the direction, supervision, and observation of the Senior UXO Supervisor (SUXOS) or a UXO Technician III. All personnel strictly adhered to approved plans and established procedures. Safety precautions and procedures were detailed in the project APP/SSHP.

1.2.1.4.1 Work Hours

1.2.1.4.1.1 Field operations were conducted during daylight hours only. UXO personnel were limited to a 60-hour workweek consisting of a maximum of 50 hours of MEC field operations. No single workday exceeded 10 hours, and 24 hours separated each MEC field operation workweek. These work restrictions applied only to MEC personnel performing intrusive or explosive demolition work activities.

1.2.1.4.2 Site Access

1.2.1.4.2.1 HGL controlled access to intrusive work areas and limited access to only those personnel necessary to accomplish the specific operations or who had a specific purpose and

authorization to be on the site. Prior to commencing intrusive activities, HGL placed security personnel to ensure the public did not access the worksite during intrusive activities due to the site having open public access.

1.2.1.4.3 Safety Training/Briefing

1.2.1.4.3.1 All personnel reviewed and signed the UFP-QAPP and the APP/SSHP. The SUXOS and UXO Safety Officer (UXOSO) provided site-specific training on emergency response procedures, site orientation, equipment, and field operations. The UXOSO conducted daily safety meetings with all site personnel before beginning work. The briefings covered general hazards for the project and any new safety issues or hazards identified since the last briefing. The UXO team leaders conducted a tailgate briefing in the field that covered team assignments and zone-specific hazards. The Project Biologist also trained site personnel regarding the potential presence of endangered species, in particular the status of sea turtles at this location.

1.2.1.4.4 Personnel Qualifications/Records

1.2.1.4.4.1 The UXOSO maintained personnel files on each employee. All UXO personnel met the requirements of U.S. Department of Defense Explosives Safety Board (DDESB) Technical Paper 18. Before beginning work on site, all employees completed a training program that complied with Occupational Safety and Health Administration (OSHA) requirements, as specified in 29 Code of Federal Regulations 1910.120(e)(9). All employees who worked on hazardous sites received training that included an equivalent of 40 hours of training off site and 3 days of actual field experience under the direct supervision of a trained, experienced supervisor. Management and supervisors received an additional 8 hours of training on program supervision. UXO personnel receive 8 hours of OSHA refresher training annually. Before assigning staff members to a duty position or changing them to a different duty position, the UXOSO checked their training and experience levels in their personnel records to ensure that they were qualified to fill the position.

1.2.1.4.5 Handling of Munitions and Explosives of Concern

1.2.1.4.5.1 Only UXO-qualified personnel (UXO Technician II or higher) performed identification of MEC and ascertained their condition. Similarly, MPPEH was not handled or touched unless first inspected by UXO-qualified personnel. The SUXOS and UXOSO had to be in agreement on the nature and condition of suspect live MEC before any action could be taken.

1.2.1.4.6 Site Preparation

1.2.1.4.6.1 A portable office and equipment storage container were placed at the project site. An explosives magazine was sited IAW the project ESS and Puerto Rico regulations. HGL staff communicated via cell phones, satellite phones, and portable radios. Drinking water and ice were provided by local retailers, and an adequate supply of each was maintained on site. First aid equipment and fire extinguishers were maintained in each team vehicle.

1.2.1.5 Deviations from Uniform Federal Policy Quality Assurance Project Plan

1.2.1.5.1 Deviations from the UFP-QAPP were documented with FCRs and submitted for the items described in the following paragraphs. CESAJ coordinated FCRs with the regulators. Project FCRs are located in Appendix G.

1.2.1.5.2 FCR 01 addressed DGM coverage and point-to-point spacing measurement quality objective (MQO). FCR 01 reduced acceptance criteria for "In-line measurement spacing (EM61-MK2 [EM61])" MQO from 100 percent (%) ≤ 0.25-meter (m) between successive measurements to 98% ≤ 0.25-m and revised "Coverage (EM61)" MQO frequency to apply to survey units (SUs) rather than 100-ft by 100-ft grid blocks. The 100% success for this MQO was shown to be nearly unachievable due to rapid global positioning system (GPS) swings or single missed points due to sensor/GPS electronics or data streaming effectiveness. The recommended revision has been used on most previous DGM- and AC-based removal actions. The DGM data collection strategy could not be effectively executed as grid-based because significant portions of the 100-ft by 100-ft grids contained significant areas of vegetation or water. Evaluating coverage for grids in which data cannot be collected in more than 25% of the grid was not a useful measure of coverage. SUs were defined as DGM data were collected. The SUs included significantly larger areas of data than 100-ft by 100-ft and were used for final data processing and target selection. As an example, two SUs defined both Flamenco North and Flamenco South. These two SUs cover the entirety of the DGM data that can be collected on Flamenco Beach. All datasets had greater than 99.5% of points pass the revised MQO and DGM data gaps were filled, as necessary.

1.2.1.5.3 FCR 02 addressed TEMTADS initial system function and seed offset MQOs. FCR 02 changed "Initial system functionality test" MQO from the MetalMapper 2x2 (MM2x2)-specific test originally described in Worksheet 22A.2 of the UFP-QAPP to the TEMTADS /MM2x2 -specific test in the Advanced Geophysical Classification (AGC) QAPP Template (v1.0, March 2016). It also changed "Confirm inversion model supports classification (3 of 3)" MQO to increase acceptable horizontal offset between known and predicted seed locations from 0.15-m to 0.25-m. The data collection software for the TEMTADS and MM2x2 is able to perform a real-time comparison between measured responses for a standard test item (a small industry standard object [ISO]) and the expected responses for that item to determine if the sensor is functioning correctly. The use of this test is specified as the initial system functionality test for the TEMTADS and MM2x2 in the AGC QAPP Template. The test originally specified in the UFP-QAPP was a standard MM2x2-specific test because the MM2x2 data collection software cannot perform real-time comparison of measured versus expected response. The AGC QAPP Template specifies 0.25-m as an acceptable horizontal offset between the predicted and known locations of seed items. It is speculated that the 0.15-m specified in the UFP-QAPP was a typo that went unnoticed during development. Acceptable vertical offset will remain at the currently specified 0.15-m, which agrees with the QAPP Template.

1.2.1.5.4 FCR 03 addressed the EM61 Target Selection Threshold. FCR 03 revised Worksheet 17, Paragraph 17A.8.2, to agree with Worksheet 12A, which specified that the EM61 target selection threshold will be the higher of the expected response for a horizontal 37-mm projectile at 12 inches depth, or 5X the local average background noise. The worksheet was also edited to

specify that the selection threshold was based on the sum of channels 1-3. The text originally specified that the target selection threshold would be the minimum expected response for a 37mm projectile (12.1 millivolt [mV]) minus 2X the standard deviation of the average site-specific noise (2.455 mV x 2 = 4.91 mV). The resulting target selection threshold would be 7.19 mV, which is less than 3X the standard deviation of response measured on the IVS noise line. The use of a target selection threshold this low would result in a significant number of target selections on geophysical noise (i.e. false positives). The 5X noise specified in Worksheet 12 is generally considered the signal-to-noise ratio at which false positives are limited to acceptable levels.

1.2.1.5.5 FCR 04 addressed the AC Sensor Function Test MQO. The acceptance criteria for the ongoing function test MQO was revised to "Response above 60% of baseline response (1)". The associated footnote was revised to indicate that the baseline response will be the average of the first five tests performed. Multiple MQO failures were noted during ongoing data collection. A review of the process determined that the MQO specified in the UFP-QAPP was generally unachievable. The HGL team and the USACE discussed the issue with regard to the MM2x2 AC sensor on a previous project and agreed that the existing MQO was more conservative than necessary given the goal of the test (i.e. identifying a clearly failing transmitter or receiver). The MQO was revised to a value considered achievable that was still expected to be indicative of a problem with the sensor. All data collected passed the revised MQO.

1.2.1.5.6 FCR 05A addressed the PDM8 and EM61 5% QC check of analog clearance areas. FCR 05A detailed the proposed QC methodologies for analog clearance areas on Carlos Rosario Trail and Tamarindo and Carlos Rosario beaches, and analog clearance areas at Flamenco Beach and Campground that are not accessible for 100% DGM survey. FCR 05B addressed analog clearance areas with 100% DGM follow-up surveys. FCR 05B detailed the analog clearance in Flamenco Beach and Campground, where DGM clearance will be used as a secondary tool to validate the results for the analog removal areas.

1.2.1.5.7 FCR 06 addressed the analog test plot. FCR 06 revised the acceptance criteria to reflect the test plot as it was actually constructed. The acceptance criteria specified the use of small ISOs buried at 12 inches in best and worst-case orientation and a medium ISO at 24 inches in worst case in the analog instrument test plot.

1.2.1.5.8 FCR 07 addressed the AC sensor function test MQO. The acceptance criteria for the ongoing function test (advanced sensors) MQO was revised to "Response within 20% of predicted response for all monostatic Tx/Rx pairs (1)". The associated footnote was revised to indicate that the predicted response will be the average of the first five tests performed. While the original version of the MQO was repeatedly passable with all Tx/Rx pairs in the TEMTADS sensor, the responses for some pairs in the MM2x2 sensor used on the project were low enough that repeated failure of the MQO was unavoidable. Transmitter and receiver placement in the MM2x2 was nearly identical to that of the TEMTADS. The TEMTADS developer indicated that the function test was never meant to be a non-monostatic test. However, it has been viewed as such because the language in the AGC QAPP Template used to develop the MQOs for this project was ambiguous. The acceptance criteria for the predicted response was reduced to 20% from 25% to match the acceptance criteria of the ongoing instrument function test for the EM61.

The MQO was revised to require the results considered applicable for this test by the TEMTADS manufacturer.

1.2.1.5.9 FCR 08 was rescinded.

1.2.1.5.10 FCR 09 added an activity hazard analysis (AHA) for transportation of explosives via water vessel. The AHA was added to the UFP-QAPP, Appendix D.

1.2.1.5.11 FCR 10 addressed the pond located within Flamenco Campground. This FCR clarifies the investigative approach for the pond located within the Flamenco Campground. No underwater investigation within the pond was completed during the TCRA. The intrusive investigation at the pond occurred along the bank of the pond to the water line using analog geophysical detection instruments with limited vegetation clearance to gain access. No MEC was found in the vicinity of the pond. The objective of the TCRA was to identify and dispose of MEC within specific areas of the NWP where receptors may come into contact with explosive hazards. The pond is surrounded by vegetation (including mangroves) and inhabited by wildlife. Potential receptors do not enter the pond, so there is no risk of human receptors contacting explosive hazards. The technical approach required to investigate underwater anomalies within the pond could negatively impact the environment without reducing the likelihood of receptors of contacting explosives hazards. The revised approach achieved TCRA objectives without impacting the local environment and maintained the project schedule.

1.2.1.5.12 FCR 11 addressed the analog test plot revised according to FCR 06. Upon remobilization to the site, the previous test plot could not be relocated with confidence. Field staff detected multiple anomalies where the test plot items were thought to be located but could not excavate the anomalies because the public had access to the site during this period and the required exclusion zone could not be enforced. The previous test plot was in a location commonly visited by the public and beach staff, which increased the chance for disturbance and/or the addition of discarded debris. The new test plot, as described in FCR 11, meets the general design requirements specified in the UFP-QAPP. The new plot design added an item at a shallower depth and moved the vertical 37mm simulant to a greater depth. This was done to train operators on a greater variety of item attitudes and depths. Table 1.3 provides a summary of sea turtles and sea turtle nests encountered during the TCRA.

Table 1.3
Sea Turtle and Nest Summary

Date Discovered	Sea Turtle Activity Observed	Status
10/21/16	Hawksbill nest, Flamenco Beach	Hatch occurred 12/23/16
11/04/16	Hawksbill nest, Carlos Rosario Beach	Hatch occurred 1/11/17
12/20/16	Hawksbill false nest, Carlos Rosario Beach	N/A
12/21/16	Hawksbill nest, Tamarindo Grande	Hatch occurred 2/22/17
01/26/17	Hawksbill nest, Carlos Rosario Beach	Hatch occurred during field break
01/29/17	Hawksbill false nest, Carlos Rosario Beach	N/A
02/22/17	Hawksbill possible nest, Carlos Rosario	Hatch occurred during field break

1.3 TIME CRITICAL REMOVAL ACTION FIELD ACTIVITIES

1.3.1 Beach Monitoring

1.3.1.1 A qualified Project Biologist provided daily beach monitoring before intrusive activities occurred. The Project Biologist trained site personnel regarding the importance of endangered species, in particular the status of sea turtles at this location, potential penalties associated with violations, measures for crawl and nest identification, and sea turtle biology. The Project Biologist inspected the beach and surrounding areas prior to detonations for the presence of protected species to include sea turtles, sea turtle nests, signs of recent sea turtle activity, seabird species, signs of bird nesting, and nearshore waters for marine mammals. The biologist conducted daily beach surveys to determine whether sea turtles were using beaches within the MRS and to identify other protected fauna and flora. Daily Biologist Beach Monitoring Reports are provided in Appendix D3.

1.3.2 Vegetation Trimming

1.3.2.1 Vegetation trimming involved the use of tools and equipment appropriate to site conditions including handheld brush cutters/trimmers, saws, and machinery. Personnel assigned to vegetation trimming were trained in proper equipment operation/safety and were required to attend daily safety briefings and wear appropriate personal protective equipment. The Project Biologist conducted beach monitoring surveys before and during vegetation removal. A site visit was conducted with resource agencies prior to initiating vegetation trimming activities to ensure the Project Biologist was aware of Culebra specific requirements and was following to the proper procedures. The Project Biologist trained clearance crews before beginning vegetation removal regarding the importance of endangered, threatened, and protected species and what species to avoid, such as sea grapes. Photographs detailing the level of vegetation removal are provided in Appendix F.

1.3.3 Munitions and Explosives of Concern Surface Clearance

1.3.3.1 HGL conducted a MEC surface clearance in areas accessible to DGM. All clearance operations were performed under the general supervision of the SUXOS. Surface clearance teams conducted an instrument-assisted surface clearance by forming a sweep line, marking lanes with pin flags within the grid network, and sweeping the area using analog instrumentation. Individual sweep lanes were established at a maximum of 5-ft intervals to ensure 100% coverage of the footprint. Photographs detailing the MEC surface clearance are provided in Appendix F. The Surface Clearance Memorandum is provided in Appendix I and summarizes the results of the surface clearance performed for the TCRA.

1.3.4 Geophysical Investigation

1.3.4.1 To the maximum extent possible, areas designated for DGM or AC subsurface investigation (Table 1.2) were performed using DGM for anomaly detection, followed by cued AC data collection and anomaly reacquisition/investigation. However, the EM61 data in some portions of the MRS were so saturated with response that individual targets could not be identified for follow-on cued survey or DGM investigation. In the saturated response areas,

clearance was initially performed using analog investigation techniques. The areas were then resurveyed with the EM61 to confirm that removal was complete. Any detected anomalies were cleared via anomaly reacquisition/investigation without additional AC data collection.

1.3.4.2 DGM data for approximately eight acres were initially collected by two teams between December 2016 and March 2017 using EM61 detectors deployed on person-portable wheeled platforms. Another 8.7 acres of person-portable EM61 data were collected between January 3 and February 7 of 2018 following analog clearance of the saturated-response areas on Flamenco Campground. Positioning of the EM61 data for the initial eight acres of data collection (i.e., those areas where a follow-on cued survey was expected to be possible) was achieved using a real time kinetic (RTK) GPS where a GPS signal was available or by using a robotic total station (RTS) where a signal was not available. Positioning was achieved using line/station/fiducial (lsf) methods for the QC data collected over the analog-cleared areas.

1.3.4.3 AC cued data were collected using either a TEMTADS or an MM2x2 advanced electromagnetic induction (EMI) sensor over 2,078 targets that were identified in the EM61 data collected on Flamenco Beach/Flamenco Campground. The cued data were processed, and each target was classified as a target of interest (TOI), non-TOI, or inconclusive. Targets classified as TOI or inconclusive were excavated, along with a subset of targets classified as non-TOI for QC purposes. As with the initial EM61 data, AC data were positioned using a GPS where a signal was available and an RTS where a signal was not available.

1.3.4.4 Carlos Rosario Trail and vegetated areas of Carlos Rosario and Tamarindo Beaches were cleared using analog techniques, with follow-on DGM QC using an EM61 in accessible areas. Follow-on DGM QC data were collected over approximately 5% of these analog-cleared areas. EM61 data positioning was performed using GPS on Carlos Rosario Trail and using lsf on the Carlos Rosario and Tamarindo Beaches.

1.3.4.5 The DGM/AC QC program consisted of the geophysical system verification (GSV) approach, which included an IVS and blind seeding of the DGM-accessible areas. Additional elements of the QC program included a battery of instrument functional tests performed in the morning before production DGM and at the end of each day, and implementation of the geophysical feedback process and acceptance sampling (hole checks). One hundred sixty-three (163) blind seed items were emplaced in the DGM grids to assess MQOs for dynamic positioning and signal repeatability. Four seeds were placed on Carlos Rosario and Tamarindo Beaches where no AC was performed after DGM.

1.3.4.6 The DGM data deliverable provided under separate cover with this SSFR includes the EM61 IVS Memorandum (Appendix K), EM61 Target Selection Technical Memorandum (Appendix J), Microsoft Access database (DB), and digital versions of the geophysical data (Oasis Montaj, geophysical database [GDB], MAP, and .XYZ files). Specific tables within the Microsoft Access DB document the results of the DGM program performed during production activities and during the DGM-only anomaly reacquire and intrusive phases of the project.

1.3.4.1 Digital Geophysical Mapping Data Collection

1.3.4.1.1 DGM data were collected using a single sensor EM61 on a person-portable wheeled platform. RTK GPS, RTS, or lsf methods were used to provide positioning data depending on the availability/non-availability of a GPS signal or the type of survey being performed, as described above. EM61 data were acquired at a minimum rate of 10 hertz (Hz). As applicable, positioning string data from the GPS/RTS was updated at 1 Hz and integrated with the EM61 measurements in real time using Geomar's NAV61MK2 data acquisition program. For lsf-located data, fiducial lines were laid every 25 ft for positioning purposes.

1.3.4.2 Review of Daily Instrument Function Tests

1.3.4.2.1 Daily QC tests were analyzed using the UX-Process suite of applications in Oasis Montaj and the results were documented in appropriate tables in the Microsoft Access DB. For the static background and spike test, the data processor used the static test tool in the UX-Process module to assess the background level, instrument drift, and the response to the standard test item. Evaluation of the IVS geodetic accuracy repeatability test included using the data profiles to manually identify target locations of each IVS item. The daily location for each IVS item was compared to a running average of the location of that item as specified in the UFP-QAPP.

1.3.4.3 Digital Geophysical Mapping Data Processing

1.3.4.3.1 The UX-Process module of Oasis Montaj was used to perform the final data processing. The general processing sequence consisted of correcting for latency and drift for all four EM61 time gates or channels. Channels 1 through 3 were added together to produce a sum channel (Sum 1-3) after each individual channel was leveled. As part of the final data processing, spatial sampling statistics that included coverage and in-line measurement spacing were calculated using UX-Process tools and documented in appropriate tables in the Microsoft Access DB.

1.3.4.3.2 Individual Oasis Montaj GDBs for the DGM data collection files were merged into master survey unit GDBs to facilitate evaluation of the survey progress, data assessment, and target list review prior to the AC cued surveys. SUs were generally created as data collection was completed in contiguous areas of the site so targets could be picked, reviewed by the QC and Corps Geophysicists, and finalized prior to the cued surveys. Six SUs were created: Flamenco South and Flamenco North (both on Flamenco Beach), Southeast and Southwest Campgrounds (south end of the campground area west of Flamenco Beach, mainly surrounding and including the parking lot), South Road (sand road north and adjacent accessible area north of the Flamenco Campground parking lot), and DGM-accessible portions of Carlos Rosario and Tamarindo Beaches. The final processed data for each SU and Microsoft Access DB are provided under separate cover with the SSFR.

1.3.4.3.3 Once DGM collection in each survey unit was complete, the DGM sum channel data were gridded to generate color-coded images of the EM61 data using the minimum curvature gridding routine at a 10-centimeter (cm) cell size and 50-cm blanking distance. The Blakely routine in the UX-Process module was used in the approach documented in the EM61 Target

Selection Technical Memorandum (Appendix J) to select targets. A representative color scale was selected to exhibit responses from small, isolated anomalies and responses from more significant features such as target areas.

1.3.4.3.4 The final processed grid data and Microsoft Access QC DB were transferred to USACE Geophysicist on a weekly basis during project execution.

1.3.4.4 Digital Geophysical Mapping Target Selection

1.3.4.4.1 A total of 2,254 targets were selected in the EM61 data collected on Flamenco Beach/Flamenco Campground, and nearly all were cued using the MM2x2 or TEMTADS. An additional 502 EM61 targets were selected in Carlos Rosario and Tamarindo Beaches survey unit data (415) and trail/western beach QC data (102). A total of 171 targets were identified in the 100% coverage QC data collected in the analog-only areas of Flamenco Beach/Flamenco Campground. These were also excavated rather than cued. Finally, 73 polygons were identified in the initial 8 acres of 100% DGM coverage within Flamenco, Carlos Rosario, and Tamarindo Beaches. These consisted of smaller saturated areas where individual EM61 targets could otherwise be selected and areas inaccessible to DGM (trees, vegetation, slopes, etcetera). During the DGM coverage of analog areas, 56 polygons were identified in the Flamenco Beach/Flamenco Campground area.

1.3.4.4.2 The DGM target selection threshold was set at 12.1 mV using the sum of channels 1-3. This was the minimum expected response for a 37mm projectile at 1 ft below ground surface (bgs) and 0.35-m lateral offset, as determined using Naval Research Laboratory's EM61 Response program. The criteria and approach used during anomaly reacquire and resolution was later amended to 16.4 mV based on a 37mm projectile at 1-ft bgs with no lateral offset. The determination of the target selection threshold and the reacquire and resolution threshold is documented in the EM61 IVS Technical Memorandum (Appendix K) and the EM61 Target Selection Technical Memorandum (Appendix J).

1.3.4.5 Digital Geophysical Mapping Reacquisition and Resolution

1.3.4.5.1 Dig sheets and color-coded images of each grid with the target selections superimposed were sent to the SUXOS at the site from the geophysical processing center. Polygons were also included to intrusively investigate inaccessible areas (trees, vegetation, slopes, etcetera) within the DGM boundary and areas of saturated response using mag and dig techniques.

1.3.4.5.2 Before beginning intrusive activities, field teams navigated to the location of each target with an RTK GPS/RTS, and then used an EM61 to locate the anomaly peak and record the sum channel (channels 1-3) response. The reacquire peak's location was then recorded using the RTK GPS rover and a flag and paint mark was used to identify the location for the dig team. The dig team intrusively investigated each target by starting at the location of the highest mV reading and extending to within a 1-m search radius for excavation. Excavation teams dug at the location of the highest mV reading within the search radius until the target was resolved.

1.3.5 Advanced Geophysical Classification

1.3.5.1 Geophysical System Verification

1.3.5.1.1 The same IVS and QC seeds described in Section 3 were used for AC GSV. The AC data deliverable, included under separate cover with this SSFR, includes the TEMTADS and MM2x2 IVS Memorandum (Appendix K), Background Location Report, Classification Technical Memorandum, Recovered Object Verification and Validation Reports, checklists for instrument set-up and background location verification/validation, Microsoft Access QC DB, and digital versions of the geophysical data (raw [.TEM or .H5], Oasis Montaj geophysical data [GDB, MAP, PNG], and AC decisions in Microsoft Access). Specific tables within the Microsoft Access DBs document the results of the AC program performed during production activities; a separate Microsoft Access DB documents the results of the AC-related intrusive investigation.

1.3.5.2 Advanced Classification Data Collection

1.3.5.2.1 Cued data collection was performed as described in standard operating procedures (SOPs) AC-05 (background data collection) and AC-06 (cued target data collection) in the UFP-QAPP. Generally, the data were collected by navigating the sensor to each DGM-based target location and collecting a point. Because the TEMTADS does not have an integrated map showing target locations, targets were pre-flagged using RTK GPS or RTS during TEMTADS data collection. The MM2x2 does include an integrated map that shows target locations as well as the location of the sensor relative to the targets. No pre-flagging was necessary for points collected with the MM2x2. Background data were collected at a pre-determined, validated location at least once every two hours unless adverse weather conditions prevented collection.

1.3.5.2.2 Cued data collection in each survey unit began with validation of the background locations selected for possible use in cued data correction. Background validation results are described in the Background Location Report. Cued target lists were submitted to the cued data collection field team by survey unit once the DGM data and target list had been approved by the QC and USACE Geophysicists.

1.3.5.3 Review of Daily Instrument Function Tests

1.3.5.3.1 Daily QC tests were analyzed using the UX-Analyze suite of applications in Oasis Montaj (IVS data) or purpose-built Microsoft Excel spreadsheets (function tests), and the results were documented in appropriate tables in the Microsoft Access DB. Evaluation of the IVS data included confirmation that the polarizabilities measured over each IVS seed matched the expected polarizabilities for that item. For the expected results, the initial measurement over each seed item was compared to the same item in the standard ordnance library. Upon confirmation that it matched with the required confidence, the field measurement from Culebra was added to the library to serve as the comparison for ongoing testing.

1.3.5.3.2 The modeled position for each IVS item was compared to a running average of the location of that item as specified in the UFP-QAPP. Each sensor was supposed to have its own

internal function test that would indicate pass/fail immediately following collection. The TEMTADS' internal function test was functional, but the MM2x2's test was not. Therefore, the monostatic results for each sensor was compared to a baseline expected response developed by averaging the response measured for the first five function tests performed with each sensor. Results for each transmitter/receiver pair were tracked in Excel spreadsheets, while the maximum difference for all pairs was recorded in Microsoft Access.

1.3.5.4 Advanced Classification Data Processing and Classification

1.3.5.4.1 Data processing and classification, including data import, background correction, source modeling, data QC, library matching, and final classification, were generally performed according to SOP AC-07 in the UFP-QAPP. Nearly all processing and classification, aside from data leveling, were accomplished using the Classify and Rank tool in UX-Analyze. Default settings in the Classify and Rank menus were unchanged with the exceptions of the decay and size thresholds. The low and high thresholds for these metrics were purposely set outside of the dataset limits so targets with high decision statistics, but with outlying sizes/decays, would not be automatically classified as non-TOI.

1.3.5.4.2 The one aspect of processing/classification not covered by either the SOP or the Classification Technical Memorandum was conversion of the raw data to a format importable/usable in Geosoft. TEMTADS raw data are recorded as .TEM files, and MM2x2 raw data are recorded as .H5 files. Neither was importable into the version of UX-Analyze available during the project. TEMTADS data can be converted to .CSV files that can be imported into Geosoft using a purpose-built program; however, this program does not perform any inertial measurement unit (IMU)-based corrections for pitch, roll, or heading on the data, and neither did UX-Analyze on import. There was no conversion program for the .H5 files. Therefore, all raw data were converted to .CSV using programs developed by Parsons for this purpose. During conversion, pitch, roll, and heading were used to correct the sensor location measured by the GPS during collection. Once in Geosoft, all MM2x2 transients were scaled by a factor of 4 to match the TEMTADS response over similar items and, more importantly, the polarizability curves in the site-specific library.

1.3.5.4.3 The site-specific classification library that served as the basis for most of the classification decisions was compiled from a master Department of Defense (DoD) library using measured polarizabilities for munitions known or suspected to be present at the site. The specific munitions examples in the library were confirmed to be representative of the munitions expected on site by a UXO Technician, as required by Parsons' SOP AC-07 and the classification survey completeness/comparability measured performance criteria (MPC) in the UFP-QAPP. Table 1.4 lists the types of munitions included in the final site-specific library and provides brief comments on why each was included.

Table 1.4
Munitions in Site-Specific Library

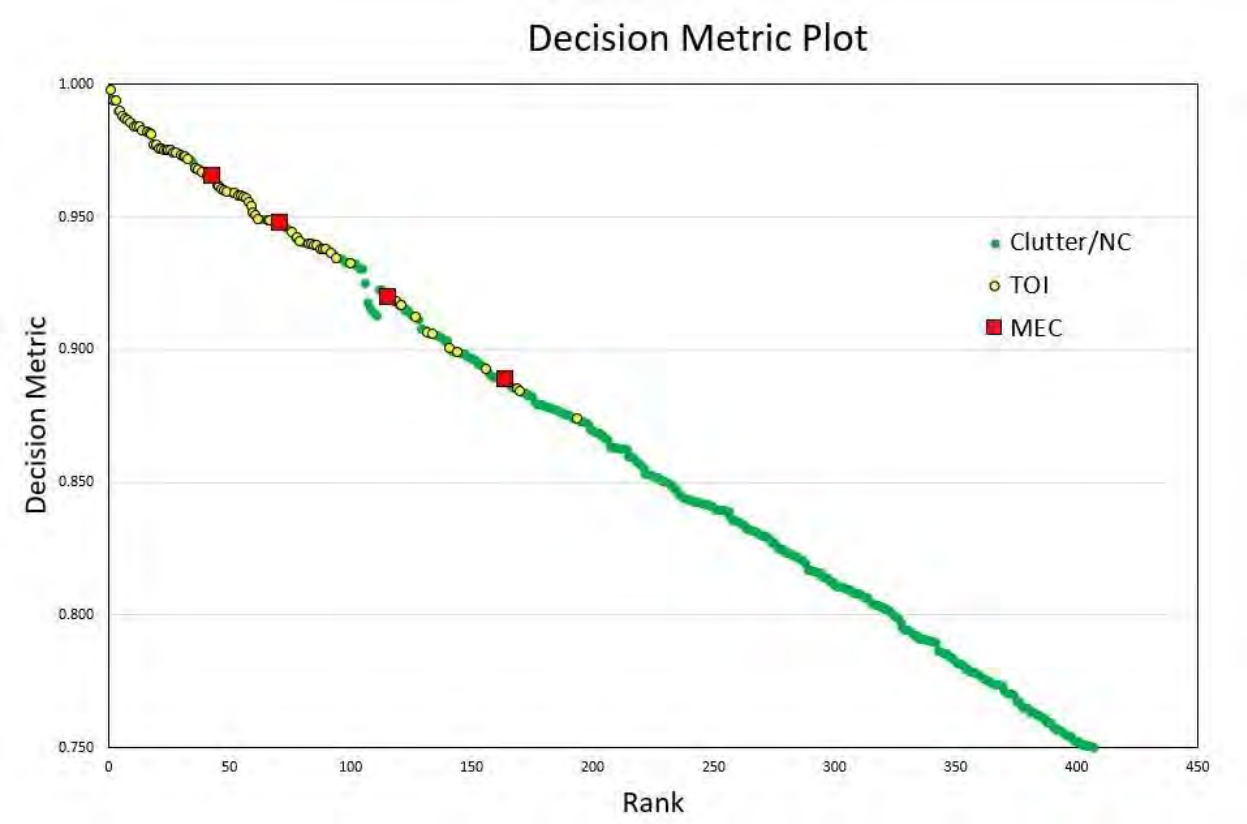
Munition Type	Reason for Inclusion
20mm projectiles	Included in the Conceptual Site Model (CSM) in UFP-QAPP
37mm projectiles	Included in the CSM in UFP-QAPP
75mm projectiles	Included in the CSM in UFP-QAPP
76mm projectiles	Included in the CSM in UFP-QAPP
2.75-inch rockets	Included in the CSM in UFP-QAPP
3.5-inch rockets	Included in the CSM in UFP-QAPP; native version recovered during the project
5-inch rockets/projectiles	Included in the CSM in UFP-QAPP
25-pound practice bombs (BDU Mk33)	Included in the CSM in UFP-QAPP
Parachute flares	Included in the CSM in UFP-QAPP
Small ISOs (schedule 40)	Similar to schedule 80 small ISOs used as QC seeds
Small ISOs (schedule 80)	Used as QC seeds
Medium ISOs	Used as QC seeds
Large ISOs	Used as QC seeds

1.3.5.5 Ranked Dig List

1.3.5.5.1 A total of 2,078 EM61 targets were cued as part of the project. The 176-target difference between the cued targets and the number of targets selected in the EM61 survey was due to 1) EM61 targets on Flamenco Beach that could not be accessed with the MM2x2 following a storm in January 2017 (i.e. they were underwater after beach erosion), or 2) targets that were determined to be within the analog investigation area when the DGM/analog boundary was revised in late 2017 to simplify/streamline work flow. Modeling of the 2,078 targets resulted in 2,213 unique sources that were placed on a ranked dig list, generally ordered from most likely to be TOI at the top to least likely to be TOI at the bottom. Minor exceptions were for 38 training digs and 23 "inconclusive" targets placed at the top of the list despite being considered unlikely to be TOI. An additional 411 targets were classified as potential TOI, with the remainder (1,741) classified as non-TOI.

1.3.5.5.2 Of the 2,213 unique sources on the ranked dig list, the lowest ranked TOI was number 194 with a decision metric of 0.87 (Chart 1.1). The boundary between TOI and non-TOI for the dig list was set at a decision metric of 0.75, which corresponded to a rank of 407. Four additional sources with lower decision statistics were manually added by the data analyst to the dig category and an additional 38 training digs and 23 inconclusive results were also investigated, bringing the total to 411 ranked digs and 472 digs overall (79% reduction). A more aggressive stop dig point using a decision metric of 0.85 (rank = 231) would have resulted in an 87% reduction in the dig list and correct classification of all non-TOI. However, the presence of 20mm high explosive (HE) projectiles recovered during the TCRA prevented implementation of the more aggressive approach.

Chart 1.1
Decision Metric versus Rank Plot Depicting TOI and MEC Recovery



1.3.5.6 Advanced Classification Source Reacquisition and Resolution

1.3.5.6.1 Reacquisition of all classification-based digs was conducted using RTK GPS or RTS. Target locations were identified with a plastic pin flag marked with the target identification number. They were not moved based on EM61 response, although the maximum response in the immediate vicinity of the flag was recorded on the dig sheet as the pre-dig response.

1.3.5.6.2 It was intended that all excavation be performed using a search radius of 35 cm. However, numerous sources seemed to be missing or significantly offset during the intrusive investigation. Root cause analysis (RCA) 15 covers the offsets in detail. The main causes were determined to be movement due to Hurricanes Irma and Mar a and associated cleanup, normal beach/campground activities, mag and dig teams accidentally encroaching on AC areas, Geosoft source selection methods (most TOI-like source selected to represent each target location regardless of whether it was the most likely source to exist or not), and the length of some of the recovered sources. As a result, the search radius was expanded significantly, with the intrusive team generally searching within at least one meter of the reacquisition location to find an appropriate source, as necessary. Sources more than 35 cm from the flagged location were also regularly investigated to clear a hole (i.e., reduce EM61 response) even if they did not appear to be associated with another nearby target classified as a dig.

1.3.5.6.3 As each source item was uncovered, location data were collected using GPS/RTS to document the center of mass, and the depth of each item below ground surface was measured with a ruler. A photograph was taken of the item(s) recovered, and the dig result data was written on a whiteboard. Finally, an EM61 was used to survey the target location to confirm the absence of all metallic items from that target location or that the post dig mV reading had been reduced below the threshold. Remaining EM61 response was typically caused by nearby cultural sources such as fences, signs, or other beach-related items. In addition to the photos of the recovered objects, intrusive results were also recorded on dig sheets later transcribed into the Microsoft Access DB.

1.3.6 Analog Clearance

1.3.6.1 In areas designated for analog clearance (Table 1.2), UXO teams used analog (mag and dig) procedures to remove MEC and MPPEH. The UXO team conducted analog clearance by sweeping analog detectors and establishing 5-foot-wide search lanes. During this operation, UXO technicians swung analog instruments back and forth across the search lanes as close to the ground as practical to identify the location of any subsurface metallic anomaly encountered. Subsurface anomalies were intrusively investigated and removed.

1.3.7 Munitions and Explosives of Concern Disposal

1.3.7.1 MEC were destroyed by detonation using standard demolition procedures as outlined in the project UFP-QAPP, SOPs, and ESS. Minimum separation distances for demolition operations were calculated IAW DDESB Technical Paper 16. Standard nonelectric and electric demolition equipment was used. Explosives Accountability Records are provided in Appendix B.

1.3.8 Material Potentially Presenting Explosive Hazard Processing

1.3.8.1 All MPPEH were processed, certified, and recycled IAW DODI 4140.62 (DoD, 2017). The SUXOS certified and the UXO QC Specialist (UXOQCS) verified that all debris was free of explosive hazards. DD Form 1348-1A was used as certification/verification documentation. All material documented as safe (MDAS) was released to Gema Recycling, Inc., for subsequent disposal. Disposal documentation receipts that identified the day of off-site removal, approximate scrap weight, and signature of the recipient were generated. Documentation for Final Disposition of MPPEH is provided in Appendix A.

1.4 PUBLIC INVOLVEMENT ACTIVITIES

1.4.1 HGL did not conduct public involvement activities under this task order. Public involvement and notifications were coordinated by CESAJ.

1.5 FURTHER ACTIVITIES REQUIRED TO ATTAIN CONTRACT CLOSEOUT

1.5.1 No further activities are required to attain the TCRA project closeout. HGL completed all tasks associated with Contract No. W912DY-10-D-0023, Task Order No. 0022. HGL provided

Military Munitions Response Program (MMRP) services necessary to remove MEC and MPPEH from specific areas of the NWP (DERP-FUDS Project No. I02PR006816).

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2.0 MUNITIONS AND EXPLOSIVES OF CONCERN REMOVAL ACTION RESULTS

2.0.1 The activities conducted during the MEC TCRA included vegetation trimming, surveying, surface and subsurface clearance, and MEC/MPPEH disposal. Additional details on reportable materials are included in the sections below. No corrective actions were required because of damage to trees or vegetation on site, and no re-seeding was necessary.

2.1 REPORTABLE MATERIALS

2.1.1 Tables 2.1 and 2.2 identify MEC and list reportable material discovered by grid. Over 200,000 subsurface excavations were completed and over 72,800 pounds of MDAS were processed, certified, and recycled. A total of 31 MEC were safely destroyed during the TCRA. Daily SUXOS reports documenting site activities are provided in Appendix D1. MEC and munitions fragmentation encountered during TCRA tasks were of the type expected at the specific areas of the NWP.

Table 2.1
Munitions and Explosives of Concern Listing

Grid/ Location	Date Found	MEC Type	MEC Classification	Demo Date
F26	01/03/17	Projectile, 3 inch 50 CAL AP, MK29 Mod 2	UXO	02/16/17
F28	01/04/17	Projectile, 3 inch 50 CAL AP, MK29 Mod 2	UXO	02/16/17
G29	01/09/17	Projectile, 3 inch 50 CAL, MK33	UXO	02/16/17
I35	01/19/17	Projectile, 5 inch, MK28	UXO	02/16/17
H37	01/26/17	Projectile, 5 inch, MK28	UXO	02/16/17
AF3	02/14/17	Projectile, 3 inch 50 CAL AA, MK27	UXO	02/16/17
AF3	02/15/17	Projectile, 3 inch 50 CAL AA, MK27	UXO	02/16/17
AE3	08/28/17	Projectile, 5 inch 38 CAL, MK34	UXO	12/21/17
AI10	08/30/17	Projectile, 20MM HE	UXO	12/21/17
AE4	08/31/17	Projectile, 3 inch 50 CAL AP, MK29	UXO	12/21/17
AG5	08/31/17	Bomb, GP, 100 LB, MK4 MOD 4	UXO	09/3/17
AG5	08/31/17	Projectile, 3 inch 50 CAL AP, MK29	UXO	12/21/17
AE4	09/01/17	Bomb, GP, 100 LB, MK4 MOD 4	UXO	09/3/17
AF6	12/13/17	Projectile, 3 inch 50 CAL AP, MK29	UXO	12/21/17
AO25	12/15/17	Rocket, 2.75 inch, MK 1	UXO	12/21/17
AP24	12/15/17	Projectile, 75 MM, MK 1	UXO	12/21/17
AM23	12/18/17	Projectile, 3 inch 50 CAL AP, MK29	UXO	12/21/17
AN22	12/18/17	Projectile, 3 inch 50 CAL AP, MK29	UXO	12/21/17
AN22	12/18/17	Projectile, 3 inch 50 CAL AA, MK27	UXO	12/21/17
AJ12	12/28/17	Projectile, 3 inch 50 CAL AP, MK29	UXO	01/12/18
AJ13	12/28/17	Projectile, 5 inch 38 CAL, MK34	UXO	01/12/18
AG4	12/29/17	Rocket, 2.75 IN, MK 1	UXO	01/12/18

Table 2.1 (Continued)
Munitions and Explosives of Concern Listing

Grid/ Location	Date Found	MEC Type	MEC Classification	Demo Date
H32	01/02/18	Projectile, 3 inch 50 CAL AA, MK27	UXO	01/12/18
AO19	01/04/18	Mortar, 3 inch, MK1, STOKES	UXO	01/12/18
AI9	01/04/18	Rocket, 2.75 inch, MK 1	UXO	01/12/18
AF3	01/22/18	Rocket, 5 inch, MK24	UXO	01/27/18
AI9	01/24/18	Projectile, 3 inch 50 CAL AP, MK29	UXO	01/27/18
AF4	01/26/18	Projectile, 4.5 inch, N1A2, U.K.	UXO	01/27/18
AE4	02/02/18	Projectile, 5 inch 38 CAL, MK35	UXO	02/7/18
AH10	02/19/18	Bomb, GP, 500 LB, MK12 MOD 2	UXO	02/22/18
AF5	03/01/18	Rocket, 5 inch, MK4 Mod 1, white phosphorous	UXO	03/7/18

AP = armor piercing
CAL = caliber
GP = general purpose
HE = high explosive
LB = pound

Table 2.2
Reportable Material Listing

Grid	Date Started	Date Completed	MEC Found (count)	MD[1] Estimate (pounds)	Non-munitions Related Debris[1,2] Estimate (pounds)
A16	11/22/16	12/27/16	0	55	
A17	11/22/16	12/28/16	0	21	
AA33	12/01/16	12/01/16	0	40	
AB32	11/30/16	11/30/16	0	5	
AB33	11/30/16	11/30/16	0	15	
AC31	11/30/16	11/30/16	0	60	
AC32	11/30/16	11/30/16	0	35	
AD1	01/03/18	01/03/18	0	20	90
AD2	01/03/18	03/09/18	0	1	1
AD3	12/11/17	02/23/18	0	40	29
AD30	11/29/16	11/29/16	0	25	
AD31	11/29/16	11/29/16	0	20	
AD4	09/01/17	02/01/18	0	140	14
AD5	12/28/17	12/28/17	0	0	1
AE1	01/08/18	01/08/18	0	12	
AE2	12/20/17	12/21/17	0	170	77
AE3	08/23/17	01/12/18	1	910	212
AE30	11/29/16	11/29/16	0	45	
AE4	08/29/17	02/06/18	3	760	32
AE5	12/28/17	02/27/18	0	976	209
AE6	12/14/17	02/26/18	0	77	5
AF2	11/21/16	12/21/17	0	398	1
AF3	11/21/16	03/12/18	3	1801	334
AF30	11/28/16	11/28/16	0	115	
AF4	12/16/17	01/29/18	1	1224	77
AF5	08/23/17	03/02/18	1	1445	70
AF6	12/12/17	03/05/18	1	861	123
AF7	08/31/17	02/23/18	0	62	93
AG29	11/25/16	11/25/16	0	15	
AG3	12/21/17	12/21/17	0	35	10
AG30	11/25/16	11/28/16	0	90	
AG4	12/28/17	01/30/18	1	525	100
AG5	08/30/17	02/27/18	2	889	5
AG6	12/29/17	02/21/18	0	1819	253
AG7	08/23/17	02/15/18	0	1247	49
AH10	12/14/17	02/20/18	1	123	40
AH11	08/28/17	03/02/18	0	391	5116
AH12	08/31/17	02/16/18	0	532	66
AH13	12/14/17	02/15/18	0	322.5	39
AH14	12/19/17	02/07/18	0	134	5
AH15	01/18/18	01/18/18	0	0	
AH28	11/23/16	11/23/16	0	3	

Table 2.2 (Continued)
Reportable Material Listing

Grid	Date Started	Date Completed	MEC Found (count)	MD[1] Estimate (pounds)	Non-munitions Related Debris[1,2] Estimate (pounds)
AH29	11/25/16	12/12/16	0	25	700
AH30	11/25/16	12/12/16	0	0	
AH4	01/03/18	01/03/18	0	1	
AH5	01/03/18	01/03/18	0	2	8
AH6	01/01/18	02/15/18	0	91.55	25
AH7	08/29/17	02/13/18	0	107.6	185
AH8	09/01/17	02/23/18	0	6	46
AH9	08/29/17	01/24/18	0	81	19
AI10	08/30/17	02/23/18	1	408	6
AI11	08/30/17	03/02/18	0	442	99
AI12	12/12/17	02/20/18	0	228	111
AI13	12/16/17	02/14/18	0	321	115
AI14	12/15/17	02/06/18	0	173	80
AI15	12/06/17	01/16/18	0	126	31
AI16	12/14/17	02/02/18	0	117	57
AI17	12/14/17	12/14/17	0	1	
AI28	11/23/16	11/23/16	0	35	
AI29	11/23/16	11/23/16	0	50	
AI6	01/03/18	01/03/18	0	2	1
AI7	09/01/17	09/01/17	0	41	7
AI8	12/21/17	02/26/18	0	122	7
AI9	08/24/17	01/26/18	2	363	177
AJ10	12/29/17	02/21/18	0	144	45
AJ11	08/28/17	02/27/18	0	255	42
AJ12	12/20/17	02/22/18	1	259	50
AJ13	12/21/17	02/09/18	1	141	306
AJ14	12/28/17	02/02/18	0	186	184
AJ15	12/07/17	01/12/18	0	34	84
AJ16	12/11/17	01/20/18	0	222	37
AJ17	12/13/17	01/22/18	0	181	474
AJ18	12/04/17	02/08/18	0	37.28	6
AJ19	12/04/17	12/04/17	0	0	2
AJ28	11/23/16	11/23/16	0	10	
AJ29	11/23/16	11/23/16	0	0	
AJ8	01/03/18	01/03/18	0	5	1
AJ9	01/02/18	01/03/18	0	5	11
AK10	01/18/18	01/18/18	0	0	1
AK11	01/04/18	01/04/18	0	1	1
AK12	01/02/18	01/04/18	0	1	3
AK13	01/02/18	01/04/18	0	1	11
AK14	12/30/17	02/02/18	0	129	78
AK15	12/08/17	01/27/18	0	115	84
AK16	12/09/17	01/27/18	0	90	89

Table 2.2 (Continued)
Reportable Material Listing

Grid	Date Started	Date Completed	MEC Found (count)	MD[1] Estimate (pounds)	Non-munitions Related Debris[1,2] Estimate (pounds)
AK17	12/12/17	01/22/18	0	114	38
AK18	12/04/17	01/25/18	0	93	851
AK19	12/08/17	01/23/18	0	46	6648
AK20	12/11/17	02/08/18	0	95.5	305
AK21	12/12/17	02/07/18	0	15	36
AK27	01/04/18	01/04/18	0	7	6
AK28	11/23/16	11/23/16	0	25	
AL13	01/18/18	01/18/18	0	0	1
AL14	01/05/18	01/05/18	0	0	
AL15	01/03/18	01/26/18	0	0	5
AL16	12/15/17	02/01/18	0	32	45
AL17	12/07/17	01/27/18	0	88	85
AL18	12/28/17	01/24/18	0	66	698
AL19	12/14/17	01/23/18	0	99	1722
AL20	12/13/17	01/20/18	0	39	39
AL21	12/21/17	02/07/18	0	5	3587
AL22	12/14/17	02/05/18	0	87	5182
AL23	12/16/17	02/02/18	0	10	10
AL24	12/11/17	02/09/18	0	0	78
AL25	12/06/17	01/29/18	0	0	
AL26	01/04/18	01/04/18	0	0	1
AL27	01/04/18	03/06/18	0	1	2
AL28	01/04/18	01/04/18	0	2	
AM15	01/04/18	01/04/18	0	0	
AM16	01/03/18	01/26/18	0	0	10
AM17	12/15/17	02/07/18	0	113	62
AM18	12/30/18	02/07/18	0	115	62
AM19	12/18/17	01/27/18	0	199	110
AM20	12/04/17	01/20/18	0	120	113
AM21	12/08/17	02/07/18	0	60	1022
AM22	12/09/17	02/06/18	0	31	1027
AM23	12/16/17	02/02/18	1	31	162
AM24	12/11/17	02/09/18	0	0	85
AM25	12/06/17	01/29/18	0	0	
AM26	11/21/16	02/12/18	0	55.6	1065
AM27	01/18/17	01/18/17	0	0	
AN16	01/04/18	01/04/18	0	0	
AN17	01/03/18	01/26/18	0	0	8
AN18	01/04/18	02/15/18	0	19.4	78
AN19	12/28/17	01/27/18	0	13	34
AN20	12/28/17	01/29/18	0	39	20
AN21	12/19/17	02/06/18	0	5	7
AN22	12/12/17	02/14/18	2	7.5	29

Table 2.2 (Continued)
Reportable Material Listing

Grid	Date Started	Date Completed	MEC Found (count)	MD[1] Estimate (pounds)	Non-munitions Related Debris[1,2] Estimate (pounds)
AN23	12/13/17	02/08/18	0	7	45
AN24	01/05/18	01/30/18	0	0	
AN25	12/21/17	02/08/18	0	0	516
AN26	12/16/17	02/13/18	0	74.1	381
AN27	01/18/18	01/18/18	0	0	12
AO17	01/03/18	01/03/18	0	0	
AO18	01/04/18	01/04/18	0	0	12
AO19	01/04/18	01/26/18	1	0	4
AO20	01/03/18	01/26/18	0	5	70
AO21	01/04/18	01/29/18	0	25	20
AO22	01/03/18	01/29/18	0	0	5
AO23	12/16/17	01/29/18	0	0	
AO24	12/05/17	01/31/18	0	0	
AO25	12/20/17	02/13/18	1	19.5	179
AO26	12/20/17	02/26/18	0	4.75	117
AP18	01/04/18	01/04/18	0	0	
AP19	01/04/18	01/04/18	0	0	
AP20	01/04/18	01/04/18	0	0	1
AP21	01/04/18	01/26/18	0	0	5
AP22	01/03/18	01/26/18	0	0	15
AP23	01/03/18	01/30/18	0	1	1
AP24	12/20/17	01/30/18	1	0	
AP25	12/19/17	03/14/18	0	10.25	301
AQ20	01/04/18	01/04/18	0	0	
AQ21	01/05/18	01/05/18	0	0	
AQ22	01/03/18	01/03/18	0	0	4
AQ23	01/02/18	02/08/18	0	0	10
AQ24	12/16/17	02/08/18	0	0	
AQ25	12/19/17	02/08/18	0	0	26
AR21	01/03/18	01/03/18	0	0	
AR22	01/04/18	01/04/18	0	0	
AR23	01/02/18	01/02/18	0	0	11
AR24	01/02/18	01/26/18	0	0	10
AS22	01/04/18	01/04/18	0	0	
AS23	01/04/18	01/04/18	0	0	
AS24	01/02/18	01/02/18	0	0	1
AT23	01/04/18	01/04/18	0	0	
B17	11/22/16	12/28/16	0	19	
B18	11/22/16	12/28/16	0	32	
B19	11/22/16	12/28/16	0	37	
B20	11/22/16	12/29/16	0	41	
C19	11/22/16	12/29/16	0	19	

Table 2.2 (Continued)
Reportable Material Listing

Grid	Date Started	Date Completed	MEC Found (count)	MD[1] Estimate (pounds)	Non-munitions Related Debris[1,2] Estimate (pounds)
C20	11/22/16	12/29/16	0	75	
C21	11/22/16	01/02/17	0	87	
C22	11/22/16	12/30/16	0	88	
C23	11/22/16	01/02/17	0	0	
D22	11/22/16	12/30/16	0	20	
D23	11/22/16	01/02/17	0	29	
D24	11/22/16	01/02/17	0	39	
E24	11/22/16	01/02/17	0	11	
E25	11/22/16	02/10/17	0	57	
F25	11/22/16	02/09/17	0	9	
F26	11/22/16	02/10/17	1	193	
F27	11/22/16	02/09/17	0	192	
F28	11/22/16	02/09/17	1	42	
F29	11/22/16	02/09/17	0	0	
F42	11/22/16	01/25/17	0	25	
F43	11/22/16	01/25/17	0	25	35
G27	11/22/16	01/04/17	0	68	
G28	11/22/16	02/09/17	0	148	16
G29	11/22/16	02/09/17	1	176	
G30	11/22/16	02/10/17	0	79	17
G31	11/22/16	02/10/17	0	0	
G37	11/22/16	01/26/17	0	0	
G38	11/22/16	02/03/17	0	10	
G39	11/22/16	02/08/17	0	21	150
G40	11/22/16	02/08/17	0	48	100
G41	11/22/16	02/02/17	0	335	
G42	11/22/16	02/01/17	0	45	75
G43	11/22/16	01/25/17	0	30	75
H30	11/22/16	01/09/17	0	85	22
H31	11/22/16	02/10/17	0	160	74
H32	11/22/16	02/10/17	1	403	
H33	11/22/16	02/10/17	0	111	15
H34	11/22/16	02/09/17	0	104	
H35	11/22/16	02/09/17	0	25	
H36	11/22/16	02/02/17	0	140	18
H37	11/22/16	02/03/17	1	95	
H38	01/11/17	01/12/17	0	19	12
H39	11/22/16	12/20/16	0	20	100
H40	11/22/16	12/21/16	0	110	250
H41	11/22/16	12/27/16	0	5	
H42	11/22/16	02/03/17	0	40	
H43	11/22/16	01/26/17	0	40	100

Table 2.2 (Continued)
Reportable Material Listing

Grid	Date Started	Date Completed	MEC Found (count)	MD[1] Estimate (pounds)	Non-munitions Related Debris[1,2] Estimate (pounds)
I32	11/22/16	01/13/17	0	20	15
I33	11/22/16	01/12/17	0	146	233
I34	11/22/16	01/19/17	0	39	60
I35	11/22/16	01/19/17	1	61	87
I36	11/22/16	01/20/17	0	10	2
I37	11/22/16	01/12/17	0	0	
I40	12/09/16	12/09/16	0	2	
I41	11/22/16	01/24/17	0	15	
I42	11/22/16	02/03/17	0	157	103
J40	11/22/16	12/09/16	0	5	
J41	11/22/16	01/24/17	0	85	
J42	11/22/16	01/24/17	0	0	
K40	11/22/16	12/08/16	0	1	
K41	11/22/16	01/24/17	0	85	
K42	02/08/16	01/24/17	0	0	
L36	12/07/16	12/07/16	0	10	
L37	12/07/16	12/07/16	0	52	
L38	12/07/16	12/07/16	0	5	
L40	11/22/16	12/08/16	0	5	
L41	11/22/16	01/24/17	0	155	220
M36	12/07/16	12/07/16	0	25	
M37	12/07/16	12/07/16	0	18	
M38	12/08/16	12/08/16	0	30	
M39	12/08/16	12/08/16	0	15	
M40	12/08/16	12/08/16	0	15	
M41	11/22/16	01/24/17	0	35	
N36	12/07/16	12/07/16	0	20	
N41	11/22/16	01/24/17	0	50	
O36	12/06/16	12/06/16	0	14	
O41	11/22/16	01/23/17	0	40	150
O42	02/08/16	01/23/17	0	0	
P35	12/06/16	12/06/16	0	10	
P36	12/06/16	12/06/16	0	40	
P41	12/12/16	01/25/17	0	50	340
Q35	12/06/16	12/06/16	0	26	
R35	12/06/16	12/06/16	0	30	
S35	12/05/16	12/05/16	0	65	
T35	12/05/16	12/05/16	0	75	
U35	12/05/16	12/05/16	0	65	
V35	12/02/16	12/02/16	0	23	
W35	12/02/16	12/02/16	0	45	
X34	12/02/16	12/02/16	0	2	
X35	12/02/16	12/02/16	0	55	

Table 2.2 (Continued)
Reportable Material Listing

Grid	Date Started	Date Completed	MEC Found (count)	MD[1] Estimate (pounds)	Non-munitions Related Debris[1,2] Estimate (pounds)
Y34	12/01/16	12/01/16	0	23	
Y35	12/02/16	12/02/16	0	15	
Z33	12/01/16	12/01/16	0	15	
Z34	12/01/16	12/01/16	0	10	
Totals			31	26,818	37,482

1. MD and Non-munitions Related Debris totals are estimated field weights.
2. Non-munitions related debris includes metal scrap not associated with munitions or range debris (car parts, trash, construction debris, etcetera).

2.2 MAPS

2.2.1 The TCRA clearance area was surveyed and overlaid with a 100- by 100-ft grid network. No cultural features or archeological sites were encountered during the TCRA tasks. The SSFR figures are summarized below.

- Figure 2.1, Site Location Map. The site is located on Culebra Island, Commonwealth of Puerto Rico, approximately 17 miles east of the main island of Puerto Rico. The southern portion of the NWP, also known as Lot 91, is located in the northwestern point of Culebra. This portion of the peninsula is approximately 408 acres in size and is bounded by the Caribbean Sea to the northeast and southwest, and to the northwest by a portion of the USFWS Culebra Island National Wildlife Refuge and to the southeast by the remainder of the island. The TCRA clearance area is 29.04 acres.
- Figure 2.2, TCRA Clearance Areas. This figure details the specific Congressionally-authorized locations within the NWP: portions of Carlos Rosario Beach, Flamenco Beach, and Tamarindo Beach; Flamenco Campground; and Carlos Rosario Trail.
- Figure 2.3, Status Map. This figure details MEC locations encountered during the TCRA and the post-detonation soil sample locations.
- Figure 2.4, Surveyor Map. This figure accurately conveys the clearance areas and it is signed by the PLS.
- Figure 2.5, TCRA Boundary Map. This map details where MEC clearance activities were not conducted within the TCRA footprint. Figure 2.5 also details the original TCRA clearance boundary of 31.83 acres and the final TCRA clearance boundary of 29.04 acres.
- Figure 2.6, Culebra DGM Data. This figure details the original DGM survey conducted to support the TCRA.
- Figure 2.7, Culebra DGM Anomaly Density. This figure details anomaly densities based on the DGM survey.
- Figure 2.8, CSM. This figure visual representation of the CSM.

2.3 PROPERTY DAMAGE

2.3.1 No unplanned damage to trees or facilities occurred during the performance of this task order. Planned excavations of anomalies were conducted in the Flamenco Campground parking lot. AC was used at the parking lot, reducing the amount of excavations required and limiting the damage to property resulting from digging operations. All parking lot excavations were repaired and accepted during a final site walk with representatives from the municipality of Culebra. Photographs detailing parking lot excavations and repairs are provided in Appendix F.

2.3.2 Flamenco Campground contains polyvinyl chloride (PVC) water lines that feed various showers and bathroom facilities. The locations of the PVC piping were unknown to ACDEC, the entity responsible for managing Flamenco Campground. As such, certain PVC piping locations were not identified during a dig permit process. During intrusive investigation of anomalies, several unidentified PVC water lines were damaged. All damaged PVC pipes were repaired and accepted during a final site walk with representatives from the municipality of Culebra.

2.4 REVEGETATION

2.4.1 Revegetation seeding was not required during the performance of this task order.

2.5 CONCEPTUAL SITE MODEL

2.5.1 The CSM is a description of a site and its environment, both natural and man-made, based on existing knowledge. It describes sources of MEC and/or hazardous, toxic, and radioactive waste known or suspected to be present at a site. The CSM also describes complete, potentially complete, or incomplete exposure pathways; current, determined, or reasonably anticipated future use of property; and potential receptors.

2.5.1 Site Description and Background

2.5.1.1 Site Location

2.5.1.1.1 The site is located on Culebra Island, Commonwealth of Puerto Rico, approximately 17 miles east of the main island of Puerto Rico. The southern portion of the NWP is located in the northwestern point of the main island of Culebra, also known as Lot 91. This portion of the peninsula is approximately 408 acres in size and is bounded by the Caribbean Sea to the northeast and southwest, bounded to the northwest by a portion of the USFWS Culebra Island National Wildlife Refuge, and bounded to the southeast by the remainder of the island. NWP TCRA areas are under MRS 16.

2.5.1.2 Topography

2.5.1.2.1 Culebra Island is comprised of sandy beaches, irregular rugged coastlines, lagoons, coastal wetlands, steep mountains, and narrow valleys. Ninety percent of the island is mountainous; the island has volcanic origins. The southern portion of the NWP has irregular, rugged coastlines with sandy beaches, lagoons, coastal wetlands, and mountainous terrain.

2.5.1.3 Vegetation

2.5.1.3.1 Vegetation is moderately to extremely dense within the NWP. Hazardous vegetation includes the Mesquite acacia or thorny brush, which may be present on NWP. Also, the poisonous Manchineel tree (also called Manzanillo Tree on Culebra) is known to be present on NWP and near Flamenco Lagoon.

2.5.1.4 Geology

2.5.1.4.1 Culebra is underlain primarily by volcanic and plutonic rocks of Late Cretaceous age. Andesite lava, lava breccia, and tuffs are the dominant volcanic rocks with intrusions by diorite and diorite porphyry; these rocks are characterized by fractures formed in a joint pattern. Some faulting is also present, with major faults aligned in a northwest-southeast direction. Alluvium, predominately composed of silt and clay with minor quantities of sand and gravel, is deposited in the few existing river valleys near the coast. Alluvium interfingers with coral, beach, and mangrove habitat deposits along the coast (USGS, 1996).

2.5.1.5 Soils

2.5.1.5.1 The soil cover is homogeneous with only one soil association, the Descalabrado-Guayama. This association is described as composed of shallow, well drained, strongly sloping to very steeply sloping soils derived from the underlying volcanic rocks. Permeability is moderate and ranges from 0.6 to 2.0 inches per hour (USGS, 1996). Loamy organic-rich soils are found in areas of dense vegetation and grasses, while sandy soils are found on tidal flats or areas near the beach. Many of the beaches on Culebra, including Flamenco Beach and Carlos Rosario Beach, have clean white to tan sand, while other beaches are rocky with a mix of cobbles and pieces of dead coral reef.

2.5.1.6 Hydrology

2.5.1.6.1 There are no permanently flowing surface water streams on Culebra. Potable water is obtained from a utility pipeline from the main island by way of Vieques Island (Parsons, 2007). Three large ephemeral streams drain the hills north of Great Harbor to the south, and one large ephemeral stream has developed along an old, washed-out jeep road on the north side of the island toward Brava Beach. These ephemeral streams generally only carry water after heavy precipitation. There are many small ephemeral gullies and ditches throughout the island.

2.5.1.7 Hydrogeology

2.5.1.7.1 Groundwater in Culebra occurs in alluvial deposits and in the volcanic and plutonic rocks. Alluvial deposits are located along major stream valleys that reach the coast. The alluvium is mostly composed of silt and clay with limited quantities of sand and gravel (USGS, 1996). The total estimated thickness of the unconsolidated deposits in the embayments (alluvium and weathered rock) is less than 18 m (Gomez-Gomez, et al, 2014). Fractures and joints within the volcanic and plutonic rock formations store water in small quantities. Most of these fractures and joints diminish in number and size with depth and pinch out at about 300 ft below land surface. Water-table conditions prevail in the bedrock aquifer. The specific yield for the bedrock

aquifer was estimated at less than 1% by comparing changes in water levels with records of pumpage and estimates of recharge (USGS, 1996).

2.5.1.7.2 A 1995 study listed 77 wells on the island of Culebra, of which only 16 were being used for any purpose. The report stated that well water from 10 wells was being used to flush toilets, water and clean horses, water livestock, and water plants. The remaining six wells were listed as owned by the Puerto Rico Aqueduct and Sewer Authority; however, only two were listed as being pumped, and no information was provided about the use of this water (Parsons, 2007).

2.5.1.7.3 Direct rainfall is the only source of recharge for the Culebra aquifer system. However, recharge from rainfall only occurs during storms that last two to four days. Such storms take place only two to three times a year. About 1% of the rainfall infiltrates to the aquifer during these events. Annual recharge ranges from 0 to 6.8% of annual rainfall (USGS, 1996).

2.5.1.7.4 The depth to the water table beneath the ridges may be 100 ft or more and may be less than 10 ft in the lower part of the valleys. The water flows toward the sea; however, evaporation prevents much of the water from being discharged. In coastal embayments, the water table usually is 1-2 ft above mean sea level. Salt water encroachment is common due to low heads and proximity to the sea (USGS, 1996). Most wells on the island of Culebra are shallow, dug wells that supply water to livestock. To augment the water supply of the island, several wells were drilled within an upland depression; however, the sustained yield of these wells was less than 20 cubic meters per day (m3/d) (Gomez-Gomez, et al, 2014).

2.5.1.7.5 Groundwater is characterized by naturally high mineral concentrations, with dissolved-solids concentrations ranging from 500 to 1,000 milligrams per liter (mg/L). This condition is a result of airborne particulates that fall on the land surface and infiltrate the aquifer during periods of recharge. High mineral concentrations on Culebra exceed EPA standards for drinking water in most cases; therefore, the public water supply on Culebra is provided by a utility pipeline from the main island of Puerto Rico by way of Vieques Island. In some households, municipal water is supplemented with rooftop cisterns or groundwater for non-drinking water uses.

2.5.1.8 Endangered Species, Sensitive Habitats, and Historical or Cultural Resources

2.5.1.8.1 The main island of Puerto Rico and its associated islands support many federally listed threatened and endangered species. Among this diverse group of fauna and flora are multiple species, such as migratory birds, that are known to exist, potentially exist, or temporarily use areas within the Culebra Island. According to the National Wildlife Refuge System, portions of Culebra Island are considered National Wildlife Refuge area. According to the PR DNER, the conservation priority areas within the southern portion of NWP are as follows:

- All lagoons
- All beaches
- Designated critical habitat area for the Virgin Islands Boa
- Flamenco Peninsula

2.5.1.8.2 There are no known cultural or archeological resources within this project site (Parsons, 2007).

2.5.1.9 Site Access

2.5.1.9.1 The site is accessible via boat or existing roads. Local workers are regularly present within the site to manage recreational areas. The Flamenco Beach Campground consists of commercial vendor structures and an expansive tent-camping area. Additionally, Flamenco Beach, Carlos Rosario Trail and Beach, and Tamarindo Beach receive thousands of visitors yearly. Access to the site is unrestricted to the public.

2.5.1.9.2 DGM data collection were not performed in heavily vegetated areas because of limitations of vegetation removal. Analog geophysical instruments were used in heavily vegetated areas. Otherwise, no other impediments to geophysical data collection (such as electromagnetic interference) were present.

2.5.2 Historical DoD Use

2.5.2.1 The public lands in the Culebra Island Archipelago were placed under the control of the U.S. Department of Navy in 1901. The Culebra Island Archipelago was used for training purposes by the U.S. Navy and U.S. Marines, and the North Atlantic Treaty Organization. The U.S. Marines used portions of Culebra Island as a training facility from 1902 through 1941. The NWP was used as a bombing and gunnery range from 1935 through 1975. Aircraft bombing and strafing of the NWP ended around 1970, while the use of live-fire naval gunfire support training ended in 1971. Subsequent naval support training was conducted using practice rounds until ordnance use was terminated on September 30, 1975. Between 1975 and 1982, the facilities were turned over to the General Services Administration. In 1982, the Quit Claim Deed was executed that transferred the NWP lands from the U.S. Department of the Interior to the Commonwealth of Puerto Rico.

2.5.3 Current and Projected Land Use

2.5.3.1 Currently, the southern portion of NWP of Culebra Island includes wildlife conservation and recreational areas. The Culebra Conservation and Development Authority manages the land comprising the southern portion of NWP. Receptor access is limited on the northern portion of Flamenco Beach. Fencing and natural barriers such as dense vegetation and rocky cliffs make access to many areas difficult beyond the Flamenco Beach and Campground areas. Receptors also have access to the western beach area, Carlos Rosario Beach, by the Carlos Rosario Trail that runs along the southern side of the southern portion of NWP from the Flamenco Beach area. Site use for wildlife conservation and for recreation is expected to continue in the future.

2.5.3.2 Prior to the 2018 TCRA, potential presence of large, HE munitions in, or near, heavily used public beaches (e.g., Flamenco, Carlos Rosario and Tamarindo beaches), trails, and nearby businesses posed a significant imminent risk to public health, safety, and the environment.

2.5.4 Previous Investigations

2.5.4.1 1991 Inventory Project Report

2.5.4.1.1 An Inventory Project Report was signed on December 24, 1991, establishing the Culebra Island site as a FUDS, defining a site boundary, and assigning FUDS Project No. I02PR006800 (USACE, 1991). The Findings and Determination of Eligibility concluded that "the site, except for 87.5 acres still under control of the Navy, has been determined to be formerly used by the DoD. It is therefore eligible for the DERP."

2.5.4.2 1995 Archives Search Report

2.5.4.2.1 The Archives Search Report was completed by the USACE Rock Island District in February 1995 (USACE, 1995) after reviewing available records, photographs, and reports that documented the history of the site. As part of the Archives Search Report, a site visit was conducted in October 1994, during which the team identified MD on Flamenco Beach, Flamenco Peninsula.

2.5.4.3 1995 Interim Remedial Action

2.5.4.3.1 In 1995, MTA, Inc. (MTA) completed an interim remedial action on 3.66 acres of the Flamenco Beach Campground near Flamenco Beach to dispose of MEC within 2 feet of the ground surface at the campground (MTA, 1995). Work was conducted on the site between 12 May and 26 May 1995. MTA found 11 MEC including 5-inch HE naval projectiles, 40mm tracer rounds, Bomb Dummy Unit (BDU)-33s, and various flares.

2.5.4.4 1997 Final Engineering Evaluation/Cost Analysis

2.5.4.4.1 The 1997 Engineering Evaluation/Cost Analysis investigation included surface and subsurface sample grids on NWP, Isla Culebrita, Cayo Botella, Cayo del Agua, Cayo Lobo, and Cerro Balcon (Environmental Science and Engineering, 1997). MEC were found in all areas except Cayo Lobo and Cerro Balcon, where only ordnance-related scrap was identified. Items found included 20mm HE incendiary devices, Mk76 practice bombs, Mk50 5-inch projectiles, 37mm projectiles, 5-inch rockets, 76mm projectiles, 3- and 6-inch naval projectiles, 81mm mortars, and a grenade. The MEC found in grids located specifically in the southern portion of NWP are listed in Table 2.3.

2.5.4.5 2004 UXO Construction Support

2.5.4.5.1 The 2004 UXO Construction Support Report, Culebra Island Wildlife Refuge (Ellis Environmental Group [Ellis], 2004) documented clearance efforts conducted by Ellis on NWP. Ellis performed four phases of clearance from January 2001 to February 2004. Phase I consisted of construction support by clearing roadways, a wind generator foundation, a desalination plant foundation, and re-grading the site. Phase II of the construction support was not exercised because of a stop in funding for the construction project. Phase III included surface clearance of 70 acres of bird nesting area and 4-foot-depth subsurface clearance of roadways, firebreaks, and

an observation post. Phase IV consisted of demilitarization of scrap, construction of a fence and information kiosk, and development of public awareness information.

2.5.4.5.2 During the UXO Construction Support project, Ellis excavated 6,121 holes and recovered 15,479 pounds of scrap metal and 249 MEC. Fifteen (15) of the 249 MEC were found within the boundary of the southern portion of NWP. Table 2.3 includes a list of the MEC found during the UXO Construction Support project.

2.5.4.6 2004 UXO Archives Search Report Supplement

2.5.4.6.1 The Archives Search Report Supplement was completed by the USACE Rock Island District as an addition to the 1995 Archives Search Report (USACE, 2004). No site visit was conducted in support of the Supplement. This report provides detail of aerial training conducted by the Navy between 1935 and 1975 and identifies 20 range/sub-range areas. The boundaries of the following sub-ranges encompass areas within the southern portion of NWP:

- Naval Gunfire Target Area: This range was a naval gunfire and air-to-ground range with its target located on NWP. Munitions used included general small arms, .50-cal small arms, Mk80s series GP bombs, M1 105mm HE, Mk21 8-inch armor piercing (AP), Mk5 16-inch AP, 2.75-inch rockets, and the 11.75-inch Tiny Tim rocket.
- Agua Cay: This area, also known as Water Key, was used as a target for bombing and rocket fire. Munitions used include Mk80s series GP bombs and 2.75-inch rockets.
- Air-to-Ground North: This target was located at the northern tip of NWP. Munitions used include general small arms, .50-cal small arms, Mk82 500-pound GP bombs, 2.75-inch rockets, and 11.75-inch Tiny Tim rockets.
- Air-to-Ground South: This target was located at the southern portion of NWP. Munitions used include general small arms, .50-cal small arms, Mk82 500-pound GP bombs, 2.75-inch rockets, and 11.75-inch Tiny Tim rockets.

2.5.4.7 2005 Revised Inventory Project Report

2.5.4.7.1 A Revised Inventor Project Report was completed in June 2005 (USACE, 2005a). The revised report further clarified the military use of the Island of Culebra and divided the original site, Property No I02PR0068, into 14 separate MRSs. One hazardous and toxic waste project was identified and assigned the number 00, and 13 MMRP project areas were identified and assigned Risk Assessment Code scores. The southern portion of NWP and the portion of Flamenco Beach are contained within the boundaries of MRS 02 (Culebra Island and Cays), which was given a Risk Assessment Code score of 1.

2.5.4.8 2005 Supplemental Archives Search Report

2.5.4.8.1 The Supplemental Archives Search Report was completed by the USACE St. Louis District in 2005 as an addition to the 1995 and 2004 Archives Search Reports (USACE, 2005b). The Supplemental report provided historical information pertaining to site operations and identified the key areas of focus for a Site Investigation. This document provided a detailed summary of military activities conducted on Culebra Island and the surrounding cays. The

document summarized planned and/or executed maneuvers and training conducted at the site, including specific time periods, locations, and munitions used.

2.5.4.9 2007 Site Inspection

2.5.4.9.1 A Site Inspection of Culebra Island and the surrounding cays was completed in 2007 (Parsons, 2007). The objective was to determine whether the MRSs delineated in the 2005 Revised Inventor Project Report warranted further investigation under the MMRP. The southern portion of NWP and a portion of Flamenco Beach are contained within the boundaries of MRS 02. IAW Public Law 93-166, Site Investigation data were not collected from the NWP portion of MRS 02. However, because MD and MEC was previously found within the southern portion of NWP, the recommendation was to proceed to Remedial Investigation/Feasibility Study status for MRS 02.

2.5.4.10 2009 Non-Time Critical Removal Action, Flamenco Beach

2.5.4.10.1 In 2008-2009, a Non-TCRA was completed on Flamenco Beach (USACE, 2009). The project included DGM of 12.3 acres and reacquiring target anomalies. Findings included 6 MD and one MEC (5-inch projectile) on Flamenco Beach.

2.5.4.11 2012 Congressional Study Report

2.5.4.11.1 The study was conducted between June 2011 and December 2011, pursuant to PL 111-383, SEC. 2815, "Former Naval Bombardment Area, Culebra Island, Puerto Rico" that requires the Secretary of Defense to conduct a study at the request of the Commonwealth of Puerto Rico. The study included a geophysical/intrusive investigation (transects/grids) of the Study Area, or the southern portion of the NWP, as well as a munitions constituent (MC) investigation. During the geophysical investigation, the field team recovered 36 UXO. UXO encountered included 5-inch HE naval projectiles, 2.75-inch rockets, 3-inch naval projectiles, 40mm projectiles, 75mm projectiles, 81mm mortars, 100-pound GP bombs, a 500-pound GP bomb, and BDU-33 practice bombs. A list of UXO recovered during the field work is included in Table 2.3. The study confirmed that there was potentially hazardous MEC presence within the southern portion of the NWP and recommended further evaluation (DoD, 2012).

2.5.4.11.2 In addition to the geophysical investigation, over 100 soil, surface water, and sediment samples were collected within the Study Area. All samples were analyzed for MC, including explosives and metals, and analytical results were compared to preliminary screening values to determine if there was evidence of an MC release. MC detected in soil and evaluated in the risk assessment included metals (antimony, chromium, copper, lead and zinc) and explosives (2-amino-4,6-dinitrotolune, 4-amino-2,6-dinitrotoluene, 2,4,6-trinitrotoluene, and methyl-2,4,6-trinitrophenyl-nitramine). Copper in sediment, and copper, lead, and zinc in surface water were also evaluated in the risk assessment (DoD, 2012).

2.5.4.11.3 Copper and 2,4,6-trinitrotoluene were detected in soil above their human health preliminary screening values, and results indicated that they may pose an unacceptable human health risk in soil at the Study Area. However, the study determined that an unacceptable human

health risk from MC would not be expected through exposure to surface water or sediment within the Study Area (DoD, 2012).

2.5.4.11.4 Five metals (antimony, chromium, copper, lead, zinc) and four explosives (2-amino-4,6-dinitrotolune, 4-amino-2,6-dinitrotoluene, 2,4,6-trinitrotoluene, and methyl-2,4,6-trinitrophenylnitramine [tetryl]) were present in soil above their preliminary ecological screening values. Additionally, one metal (copper) was detected in sediment and three metals (copper, lead, and zinc) were detected in surface water above their preliminary ecological screening values. The study indicated that exposure to these compounds in soil, sediment, and surface water may pose an unacceptable risk to ecological receptors within the Study Area (DoD, 2012).

Table 2.3
MEC Found During Previous Investigations

Item[1]	Quantity	Reference	Location/ID
.50-cal cartridge cases	1	Archive Search Report	Flamenco Peninsula
5-inch rocket	1	Archive Search Report	Flamenco Peninsula
11.75-inch Tiny Tim aerial rocket	1	Archive Search Report	Flamenco Beach
Candle, illumination, from 5"/ 38 naval projectile	1	1995 MTA TCRA	NWP Grid No. 1
Bomb, practice, 25-pound, MK 76/BDU-33	1	1995 MTA TCRA	NWP Grid No. 2
Projectile, 40mm, M81A1 TP-T	1	1995 MTA TCRA	NWP Grid No. 2
Projectile, 40mm, M81A1 TP-T	1	1995 MTA TCRA	NWP Grid No. 2
BLP, 3-inch, with tracer	1	1995 MTA TCRA	NWP Grid No. 2
Projectile, 3-inch/ 50 HE	1	1995 MTA TCRA	NWP Grid No. 2
Projectile, 40mm, M81A1 TP-T	1	1995 MTA TCRA	NWP Grid No. 2
Fuze, BD, from 5-inch/ 38 projectile	1	1995 MTA TCRA	NWP Grid No. 3
Fuze, BD, from 5-inch / 38 projectile	1	1995 MTA TCRA	NWP Grid No. 4
Fuze, BD, from 5-inch / 38 projectile	1	1995 MTA TCRA	NWP Grid No. 4
Projectile, 40mm, Bofors	1	1995 MTA TCRA	NWP Grid No. 4
Candle, illumination, from 5-inch / 38 naval projectile	1	1995 MTA TCRA	NWP Grid No. 4
Naval gun fire, 3-inch	2	1997 Engineering Evaluation/Cost Analysis	NWP NP-3
Candle, illumination, 3-inch	3	1997 Engineering Evaluation/Cost Analysis	NWP NP-4
Naval gun fire, 5-inch	9	1997 Engineering Evaluation/Cost Analysis	Flamenco Beach FB-6, NWP NP-16, NP-17, NP-18, NP-20
Naval gun fire, 6-inch	1	1997 Engineering Evaluation/Cost Analysis	NWP NP-21
Projectile, 37mm HE	1	1997 Engineering Evaluation/Cost Analysis	Flamenco Beach FB-6
Warhead, rocket, 5-inch	1	1997 Engineering Evaluation/Cost Analysis	Flamenco Beach FB-6
Candle, illumination, 5-inch	11	1997 Engineering Evaluation/Cost Analysis	Flamenco Beach FB-6, NWP NP-4, NP-15, NP-19, NP-22

Table 2.3 (Continued)
MEC Found During Previous Investigations

Item[1]	Quantity	Reference	Location/ID
Grenade, w/o fuze	1	1997 Engineering Evaluation/Cost Analysis	NWP NP-17
Fuze, projectile base	1	1997 Engineering Evaluation/Cost Analysis	NWP NP-21
Various UXO	15	2001-2002 UXO Construction Support, Ellis	NWP
Candle, illumination, 5-inch	1	2002 Ellis Grid Log	2029724.479N 2529724.682E
Bomb, 100 pound	1	2002 Ellis Grid Log	2029921.471N 25279.397E
Bomb, 1,000 pound	1	2002 Ellis Grid Log	2029922.685N 252796.915E
Candle, illumination, 5-inch	1	2002 Ellis Grid Log	2029922.685N 252796.915E
Mortar, 81mm	1	2002 Ellis Grid Log	2029924.127N 252920.989E
MK 80 series bomb body	1	2007 SI Report - Recon	NWP
MK 76 practice bomb body	25+	2007 SI Report - Recon	NWP
Aircraft flare tray	2	2007 SI Report - Recon	NWP
MK 80 series bomb body	1	2007 SI Report - Recon	NWP
5-inch Projectile	1	2008-2009 USACE NTCRA	Flamenco Beach
5-inch HE Projectile	1	Congressional Study Fieldwork	ID No. 2
BDU-13	1	Congressional Study Fieldwork	3
2.75-inch Rocket WH	1	Congressional Study Fieldwork	5
20mm HE Projectile	1	Congressional Study Fieldwork	6
BDU-13	1	Congressional Study Fieldwork	7
5"-inch HE Projectile	1	Congressional Study Fieldwork	8
2.75-inch Rocket WH	1	Congressional Study Fieldwork	9
5-inch MK41Projectile	1	Congressional Study Fieldwork	10
5-inch AP HE Projectile	1	Congressional Study Fieldwork	11
75mm Projectile	1	Congressional Study Fieldwork	12
75mm Projectile	1	Congressional Study Fieldwork	13
5-inch HE Projectile	1	Congressional Study Fieldwork	14
Signal Flare	1	Congressional Study Fieldwork	16
100 pound GP Bomb	1	Congressional Study Fieldwork	17
5-inch MK39 Projectile	1	Congressional Study Fieldwork	19
Candle, illumination	1	Congressional Study Fieldwork	21

Table 2.3 (Continued)
MEC Found During Previous Investigations

Item[1]	Quantity	Reference	Location/ID
Candle, illumination	1	Congressional Study Fieldwork	22
3-inch AP HE Projectile	1	Congressional Study Fieldwork	23
Candle, illumination	1	Congressional Study Fieldwork	24
5-inch AP HE Projectile	1	Congressional Study Fieldwork	26
5-inch HE Projectile	1	Congressional Study Fieldwork	27
5-inch HE Projectile	1	Congressional Study Fieldwork	28
5-inch HE Projectile	1	Congressional Study Fieldwork	29
5-inch HE Projectile	1	Congressional Study Fieldwork	30
100 pound GP Bomb	1	Congressional Study Fieldwork	31
Candle, illumination	1	Congressional Study Fieldwork	32
5-inch HE Projectile	1	Congressional Study Fieldwork	33
5-inch HE Projectile	1	Congressional Study Fieldwork	34
Flare	1	Congressional Study Fieldwork	35
3-inch HE Projectile	1	Congressional Study Fieldwork	36
81mm White Phosphorous Mortar	1	Congressional Study Fieldwork	37
Partial 81mm White Phosphorous Mortar	1	Congressional Study Fieldwork	38
Partial 3-inch HE Projectile	1	Congressional Study Fieldwork	39
500-pound Bomb MPPEH	1	Congressional Study Fieldwork	40
Signal Flare	1	Congressional Study Fieldwork	41
Signal Flare	1	Congressional Study Fieldwork	42
Unknown - Young girl was reportedly burned from small 5- to 6-inch long cylindrical item.	4	2013 - Reported by Local Authorities	NWP
Unknown - Tentatively Identified as High Velocity Aircraft Rocket Warhead	1	2014 - Reported by Local Authorities	NWP
(1) Projectile 3" and (3) unknown items	4	2015 - Reported by Local Authorities	NWP (Playa Blanca)

2.5.4.12 2016 TCRA Action Memorandum and 2018 TCRA

2.5.4.12.1 In May 2016, CESAJ completed a TCRA Action Memorandum for Specific Congressionally-Authorized Areas within the NWP. The specific areas covered within the Action Memorandum were portions of Carlos Rosario Beach, Flamenco Beach, Tamarindo Beach, the Flamenco Campground, and Carlos Rosario Trail. The Action Memorandum selected response actions to be performed under the TCRA including surface and subsurface removal of MEC by conducting identification (visual and geophysics), confirmation, surface and subsurface removal, and disposal of recovered munitions. The primary objective of the TCRA was to mitigate and minimize the threat posed by the potential proximity of munitions to recreational users of the beach and campground, whose activities may present exposure to and potentially trigger an unintentional detonation of an item.

2.5.4.12.2 The TCRA detailed in this SSFR was executed from October 4, 2016, through March 22, 2018. A list of UXO recovered during the field work is included in Table 2.1. The updated CSM table is presented in Table 2.4. Munitions depth of detection in comparison to their depths of recovery are presented in Table 2.5. A visual graphic depicting the CSM is presented in Figure 2.8.

Table 2.4
Updated Conceptual Site Model, NWP Culebra

Site Details	Known or Suspected Contamination Source(s)	Potential/Suspected Location and Distribution[1]	Source or Exposure Medium	Current and Future Receptors	Potentially Complete Exposure Pathway
NAME: Specific Areas, NWP, Culebra Island **Acreage**: 29.04-acre-acre clearance area within 408-acre area of interest **Suspected Past DoD Activities (*release mechanisms*)**: Aerial bombing, maneuvers, naval gun and artillery firing, and amphibious training **Current and Future Land Use**: Wildlife conservation and recreation	MEC and MD from the following munitions types have been recovered on site: General small arms .50-cal small arms Mk80 general purpose bombs MK12 500-pound general purpose bomb MK4 100-pound general purpose bombs M1 105mm HE Mk21 8-inch AP Mk5 16-inch AP 2.75-inch rockets 5-inch rockets 11.75-inch Tiny Tim Rocket Mk82 500-pound bombs M43 81mm mortar 3-inch to 16-inch projectiles 20mm projectiles 75mm projectiles 76mm projectiles Pyrotechnic Rounds 81mm White Phosphorous Mortar Various HE, incendiary, and practice bombs MC from MEC and MD on site.	Flamenco Beach (4.3 acres): Post TCRA low probability of MEC and MPPEH.	Surface or subsurface soil.	Current and Future: Site workers, recreational users, trespassers, and ecological receptors.	Exposure of human receptors to surface and/or subsurface MEC at areas outside TCRA boundaries.
		Flamenco Campground (17.06 acres): Post TCRA low probability of MEC and MPPEH.	Surface or subsurface soil, sediment, and surface water.		Exposure of human and ecological receptors to MC within soil, sediment, and surface water at concentrations above relevant screening criteria at areas outside TCRA boundaries.
		Carlos Rosario Trail (3.67 acres): Post TCRA low probability of MEC and MPPEH.			
		Carlos Rosario Beach (5 acres): Post TCRA low probability of MEC and MPPEH.			
		Tamarindo Beach (1.8 acres): Post TCRA low probability of MEC and MPPEH.			

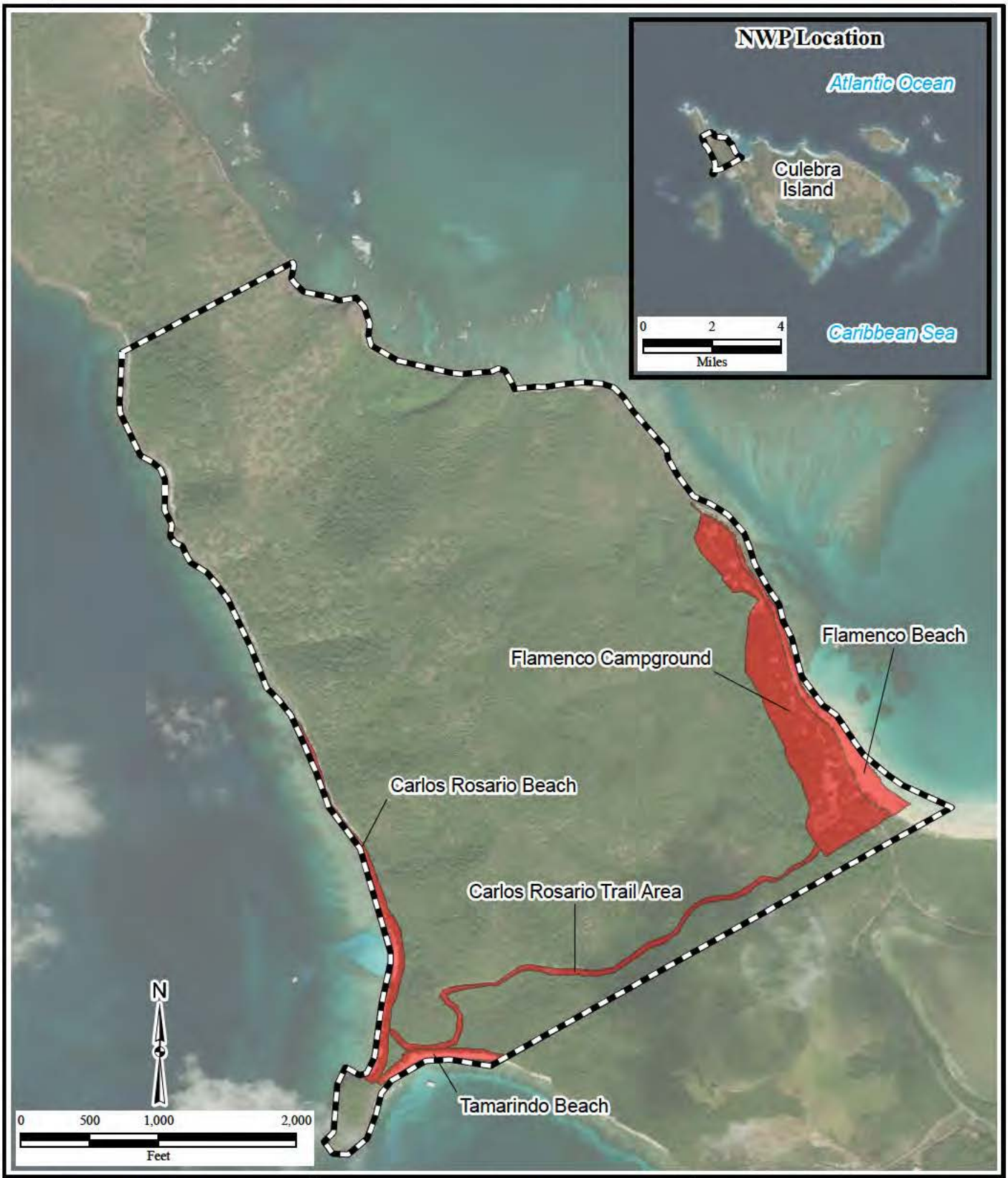
Table 2.5
Munitions Depth of Detection Versus Depth of Recovery

Item Recovered	Detection Depth	MD Recovery Depth Maximum	MEC Recovery Depth Maximum
20mm Projectile[1]	---	30-inches	7-inches
81mm Mortar	26.4-inches[2]	48-inches	---
2.75-inch Rocket	26.8-inches[2]	---	22-inches
75mm Projectile	33.9-inches[2]	---	6-inches
3-inch Projectile	33.9-inches[2]	30-inches	42-inches
3-inch Stokes Mortar	35.4-inches[2]	36-inches	10-inches
4.5-inch Projectile	44.3-inches[2,3]	---	36-inches
5-inch Projectile	53.5-inches[2,3]	24-inches	54-inches
5-inch Rocket	53.5-inches[2,3]	25-inches	60-inches
100-pound Bomb	79.2-inches[3]	---	43-inches
500-pound Bomb	133.3-inches[3]	---	30-inches
	Orange Shaded - MEC and/or MD recovered deeper than the item's calculated depth of detection.		
	Green Shaded - MEC and/or MD recovered shallower than the item's calculated depth of detection.		

1-Detection Depth not within National Research Laboratory calculator, and extrapolation does not provide realistic values.

2-Detection Depth Based on National Research Laboratory's EM61 Response Program, using 3.6 mV on Channel 2, consistent with the project target selection memorandum which used a 37mm at 1-foot bgs, with a coil offset of 0.35 meters. These are the same parameters used to determine the 12.1 mV threshold using the sum of channels 1-3.

3-Detection Depth Interpolated or Extrapolated Using 75mm, 105mm, and/or 155mm Projectile Depths.



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6/21/2019 CNL
Source: HGL, Parsons, USACE
ArcGIS Online Imagery

Legend

Clearance Area and Project Boundaries or Limits (29.04 acres)

Southern Portion of Northwest Peninsula

Figure 2.1
Site Location
Northwest
Peninsula (NWP)
Culebra, Puerto Rico

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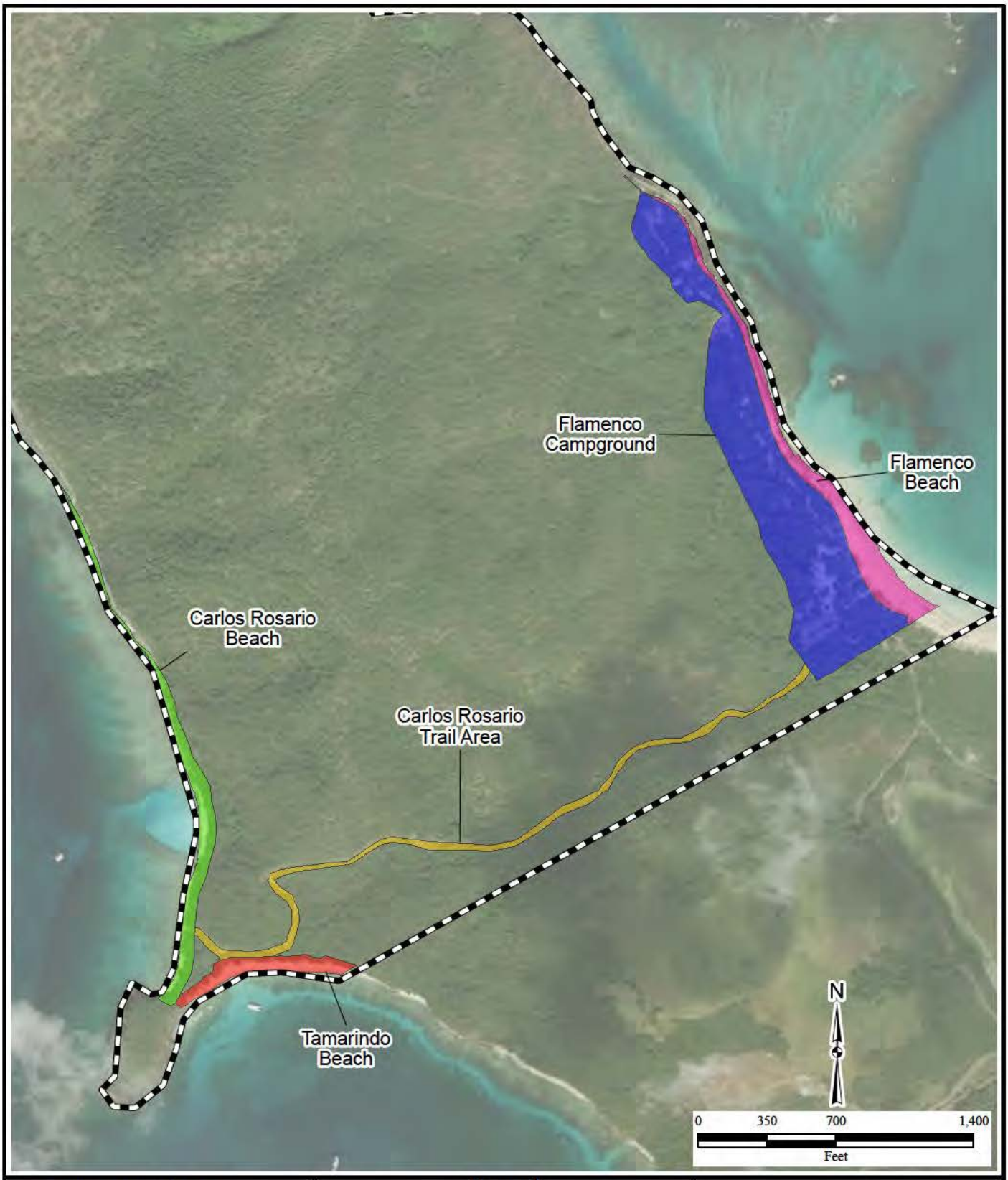

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6/21/2019 CNL
Source: HGL, Parsons, USACE ArcGIS Online Imagery

Legend
- Flamenco Beach
- Carlos Rosario Beach
- Carlos Rosario Trail Area
- Flamenco Campground
- Tamarindo Beach
- Southern Portion of Northwest Peninsula

Figure 2.2
Clearance Areas

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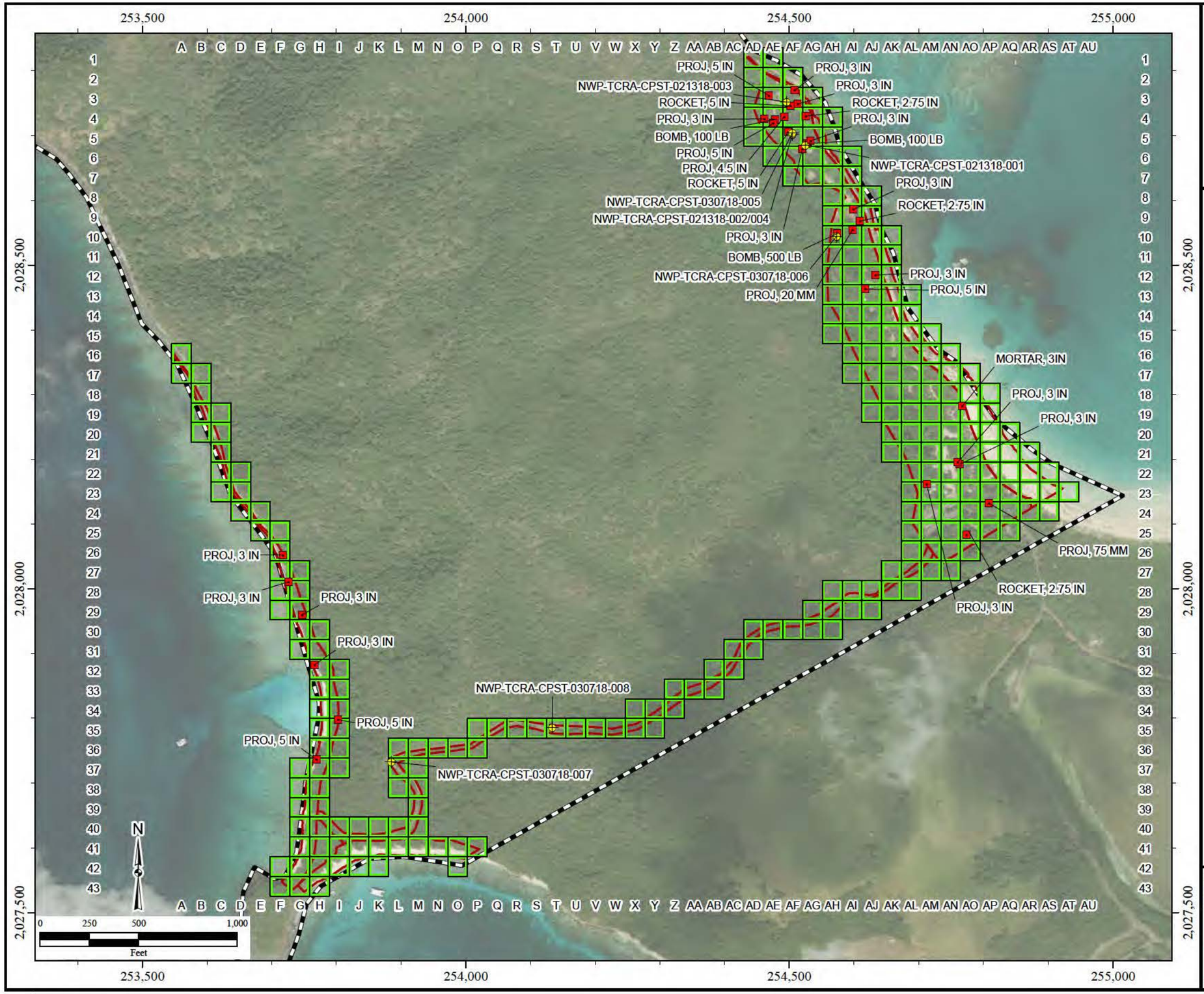

Figure 2.3
Final Status Map
Culebra Island, Puerto Rico

Legend

- Post-Detonation Soil Sample Location
- MEC
- Intrusive Complete
- 100 ft x 100 ft grid
- Surveyor Boundary: 29.04 Acres
- Southern Portion of Northwest Peninsula

Notes:
Coordinates shown in NAD 1983 UTM, Zone 20, Meters.

ft=feet
MEC=munitions and explosives of concern

\\gst-srv-01\hgigis\Culebra_MSIW\SSFR\(2-03)Status_Map_Final.mxd
3/28/2019 CNL
Source: HGL, USACE
ArcGIS Online Imagery

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Figure 2.4 - Surveyor Map

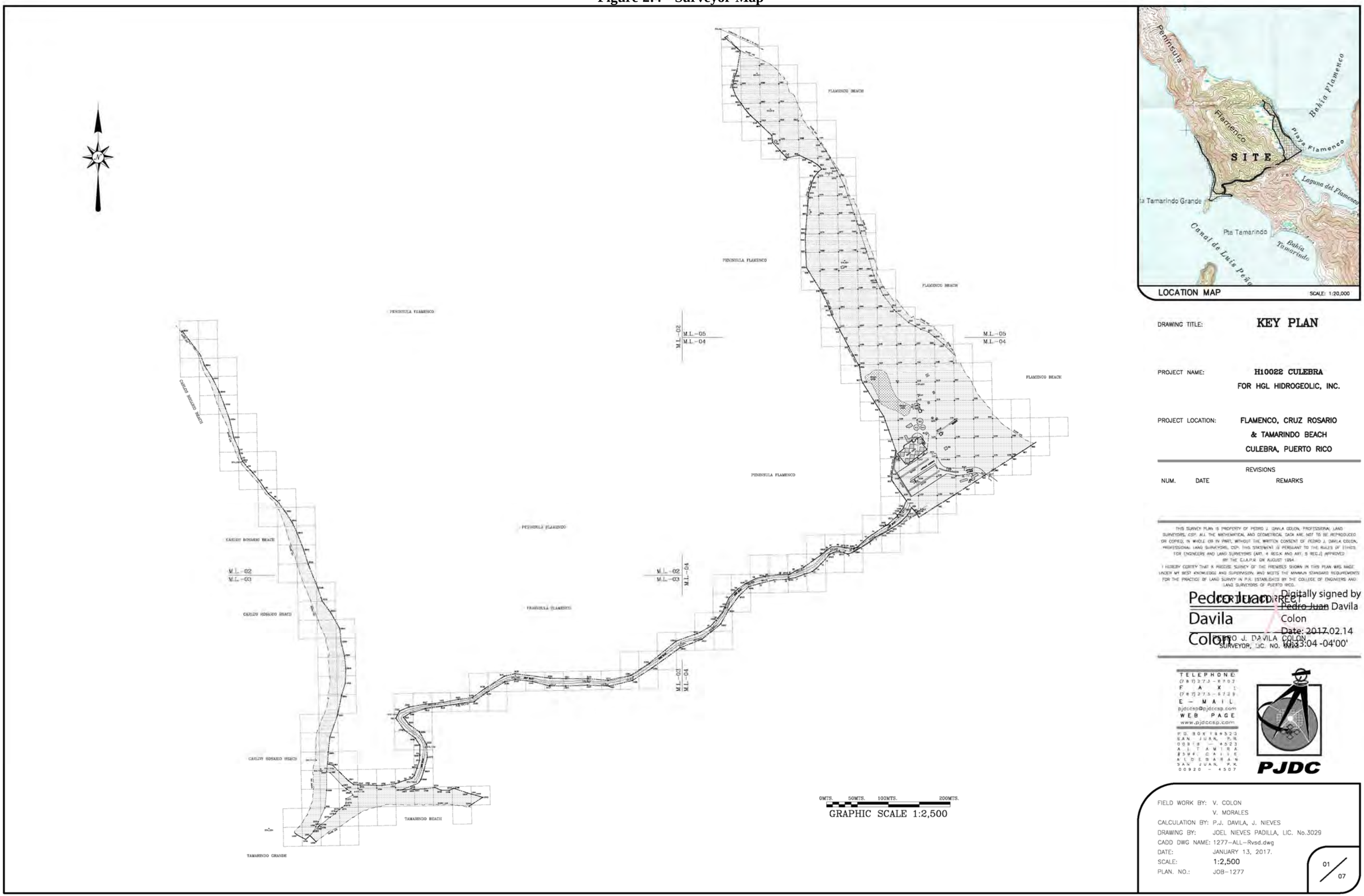

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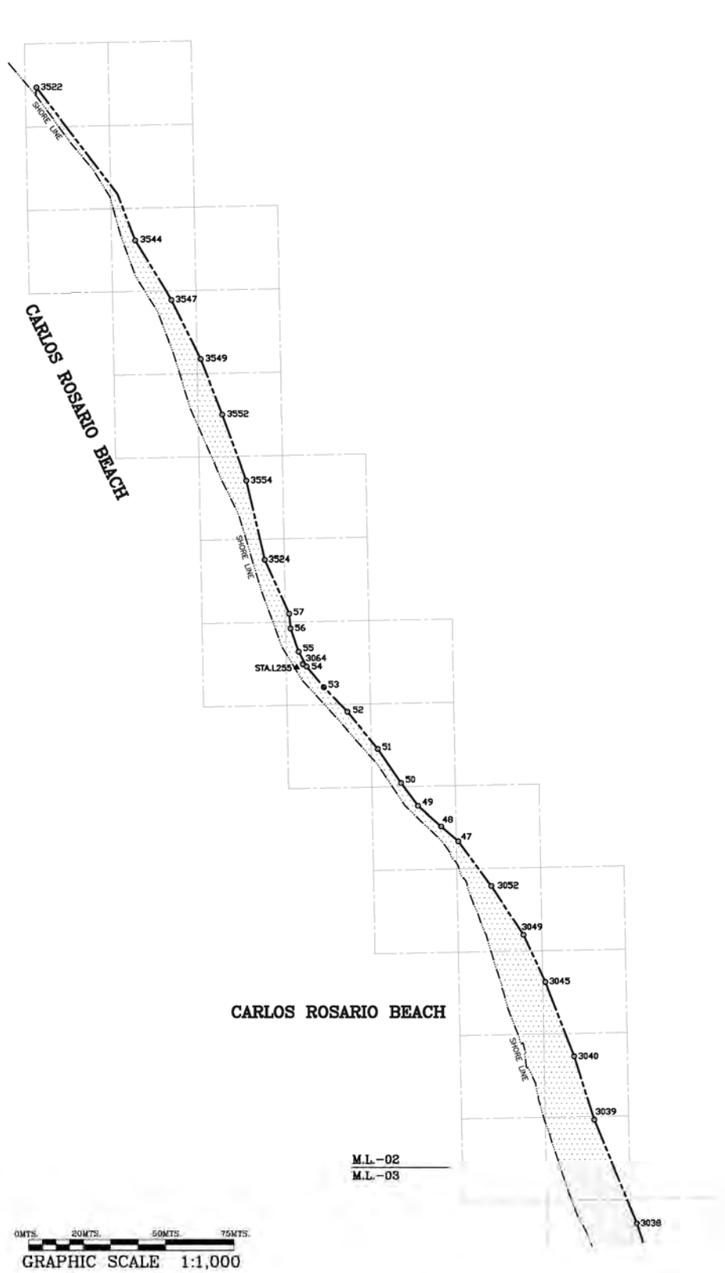
Figure 2.4 - Surveyor Map (continued)



SURVEY & AS-BUILT PLAN

H10022 CULEBRA, FOR HGL HIDROGEOLIC, INC.

FLAMENCO, CRUZ ROSARIO & TAMARINDO BEACH, CULEBRA, PUERTO RICO

DATE	REVISION

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CADD DWG NAME: 1277-02-Rvsd.dwg
DATE: JANUARY 13, 2017.

SCALE: 1:1,000
PLAN. NO.: JOB-1277
SHEET NO.: 02
OF: 02

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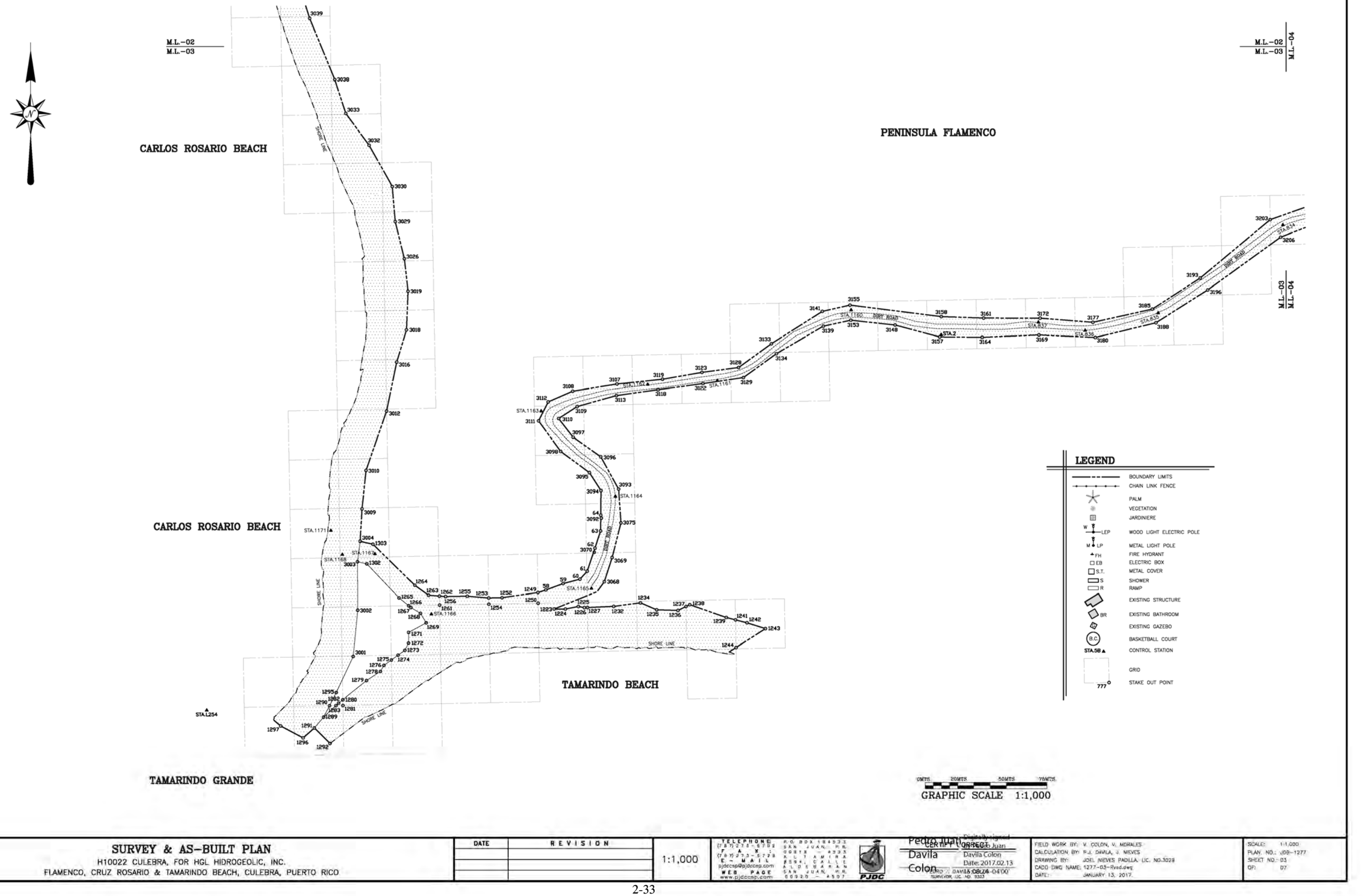
Figure 2.4 - Surveyor Map (continued)



SURVEY & AS–BUILT PLAN
H10022 CULEBRA, FOR HGL HIDROGEOLIC, INC.
FLAMENCO, CRUZ ROSARIO & TAMARINDO BEACH, CULEBRA, PUERTO RICO

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SCALE: 1:1,000
PLAN NO.: JOB-1277
SHEET NO.: 03
OF: 07

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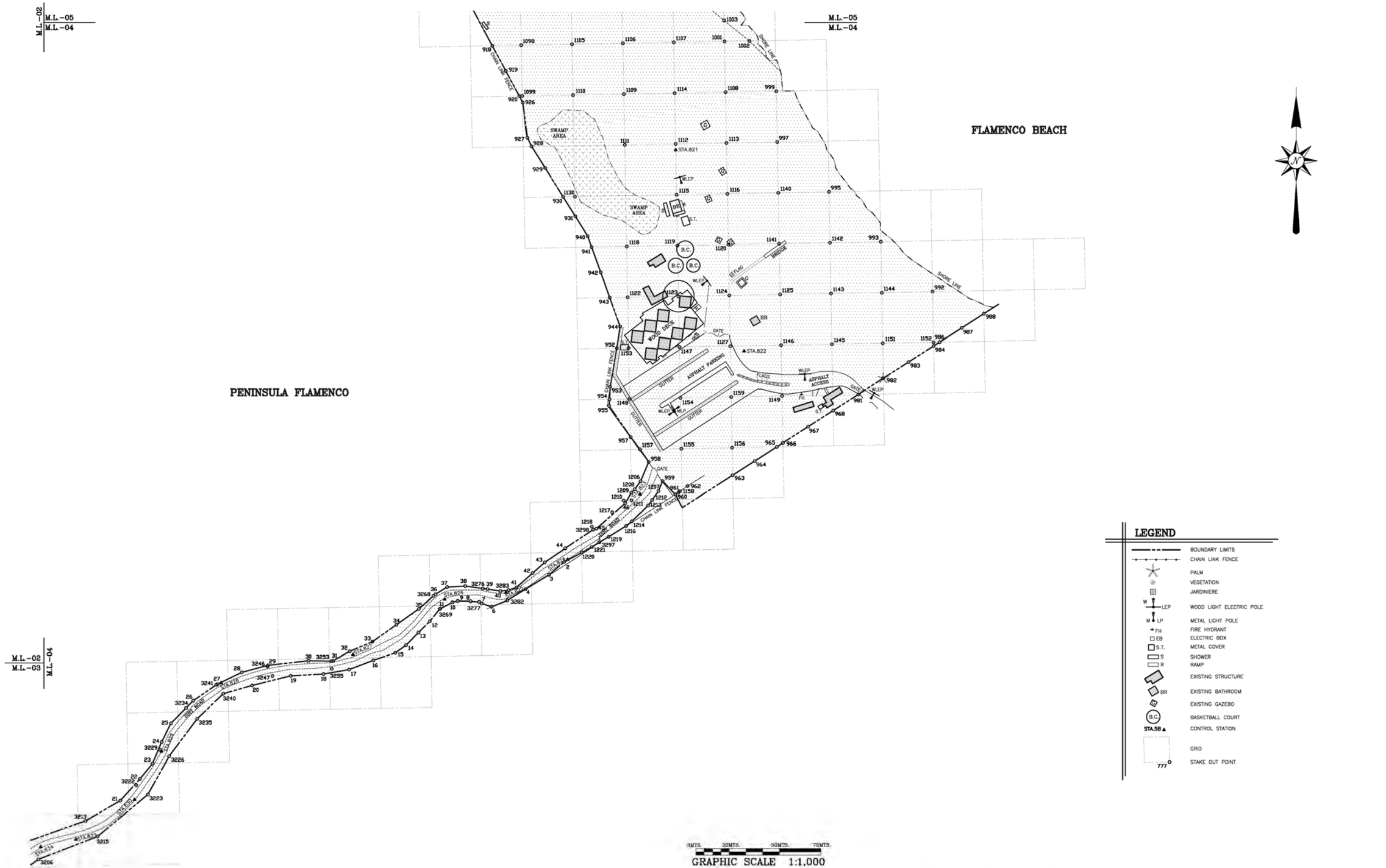
Figure 2.4 - Surveyor Map (continued)



SURVEY & AS-BUILT PLAN

H10022 CULEBRA, FOR HGL HIDROGEOLIC, INC.

FLAMENCO, CRUZ ROSARIO & TAMARINDO BEACH, CULEBRA, PUERTO RICO

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CADD DWG NAME: 1277-04-Rvsd.dwg
DATE: JANUARY 13, 2017.

SCALE: 1:1,000
PLAN. NO.: JOB-1277
SHEET NO.: 04
OF: 07

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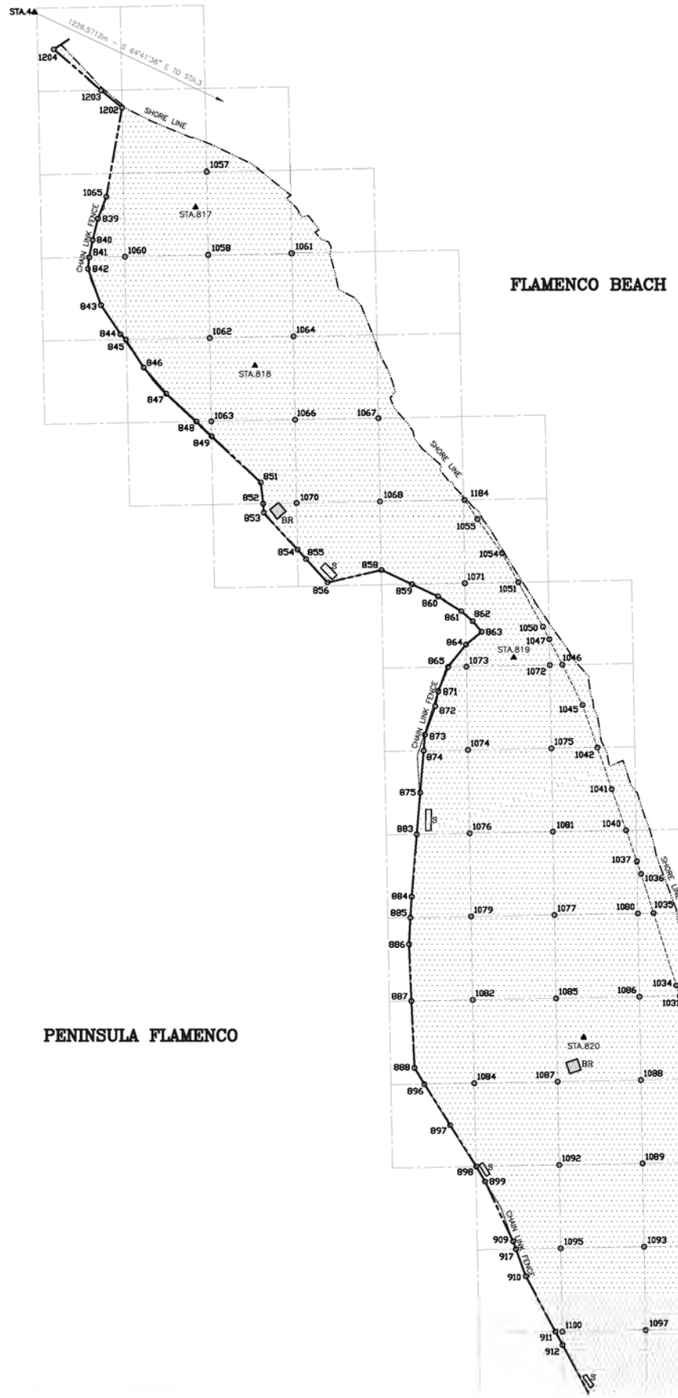
Figure 2.4 - Surveyor Map (continued)



FLAMENCO BEACH

PENINSULA FLAMENCO

FLAMENCO BEACH

M.L.-02

M.L.-05

M.L.-04

M.L.-05

M.L.-04

LEGEND

- BOUNDARY LIMITS
- CHAIN LINK FENCE
- PALM
- VEGETATION
- JARDINIERE
- W LEP — WOOD LIGHT ELECTRIC POLE
- M LP — METAL LIGHT POLE
- FH — FIRE HYDRANT
- EB — ELECTRIC BOX
- S.T. — METAL COVER
- S — SHOWER
- R — RAMP
- EXISTING STRUCTURE
- BR — EXISTING BATHROOM
- EXISTING GAZEBO
- B.C. — BASKETBALL COURT
- STA.58 ▲ — CONTROL STATION
- GRID
- 777 — STAKE OUT POINT

0MTS. 20MTS. 50MTS. 75MTS.

GRAPHIC SCALE 1:1,000

SURVEY & AS-BUILT PLAN

H10022 CULEBRA, FOR HGL HIDROGEOLIC, INC.

FLAMENCO, CRUZ ROSARIO & TAMARINDO BEACH, CULEBRA, PUERTO RICO

DATE	REVISION

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CERTIFY CORRECT

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DRAWING BY: JOEL NIEVES PADILLA, LIC. NO.:3029
CADD DWG NAME: 1277-05-Rvsd.dwg
DATE: JANUARY 13, 2017.

SCALE: 1:1,000
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OF: 07

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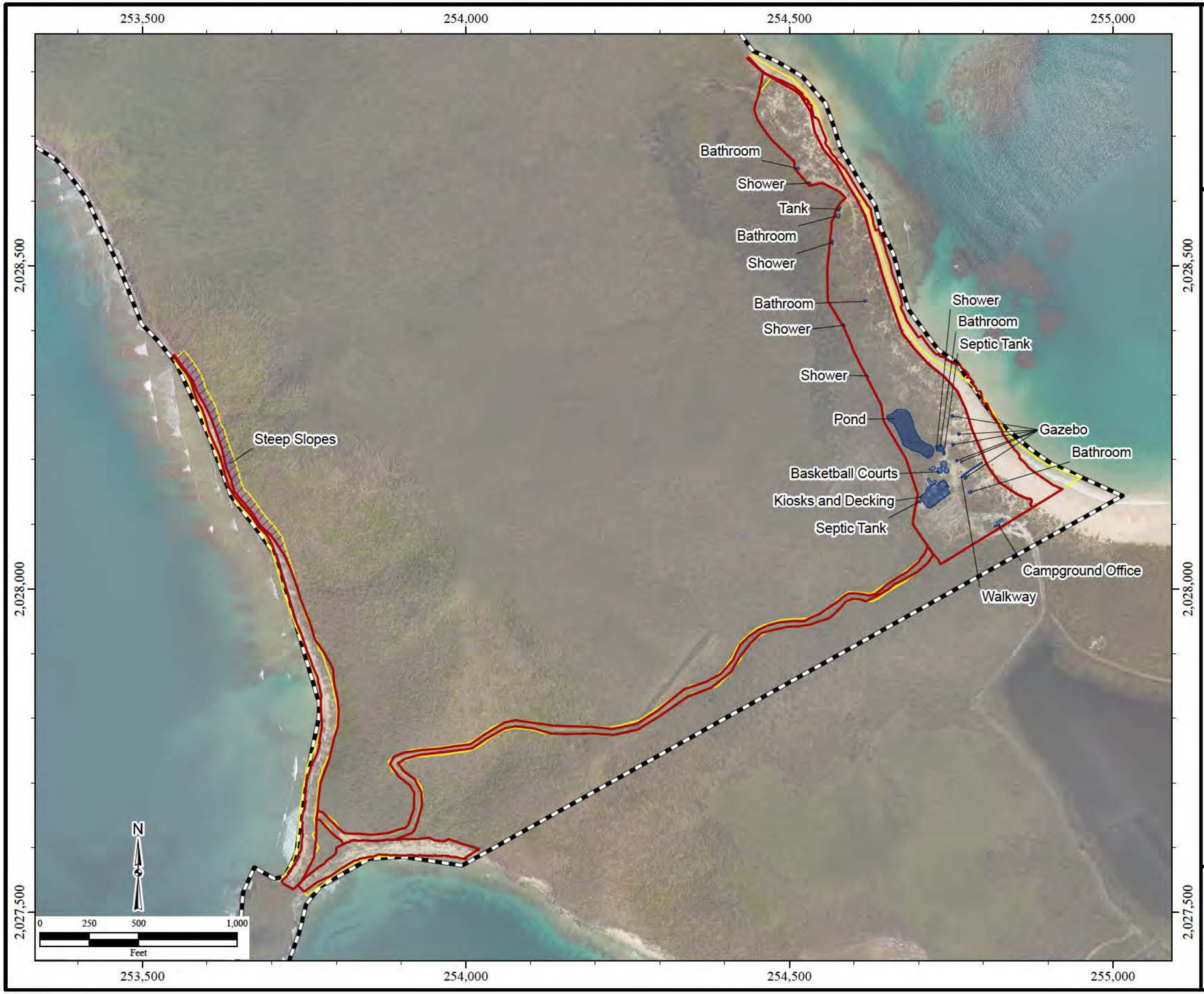

Figure 2.5
Final TCRA Clearance Area

Legend

- Final TCRA Clearance Footprint: 29.04 Acres
- Proposal TCRA Clearance: 31.83 Acres
- Steep Slopes Northern Carlos Rosario Beach
- Area Not Cleared within Footprint:1.00 Acres
- Southern Portion of Northwest Peninsula

Notes:
Coordinates shown in NAD 1983 UTM, Zone 20, Meters.
Final TCRA Clearance boundary excludes buildings, structures, basketball courts, tanks, and pond.

Exterior acreage for areas not cleared:
- Carolos Rosario Beach Slopes = 1.25 acres
- Actual Low Water Line = 1.09 acres net
- Additional Slopes and Fences = 0.46 acres net

\\gst-srv-01\HGLGIS\Culebra_MSIW\SSFR\(2-05)Final_Clearance_11x17.mxd
7/24/2018 CNL
Source: HGL, USACE
NOAA Imagery dated September 2017

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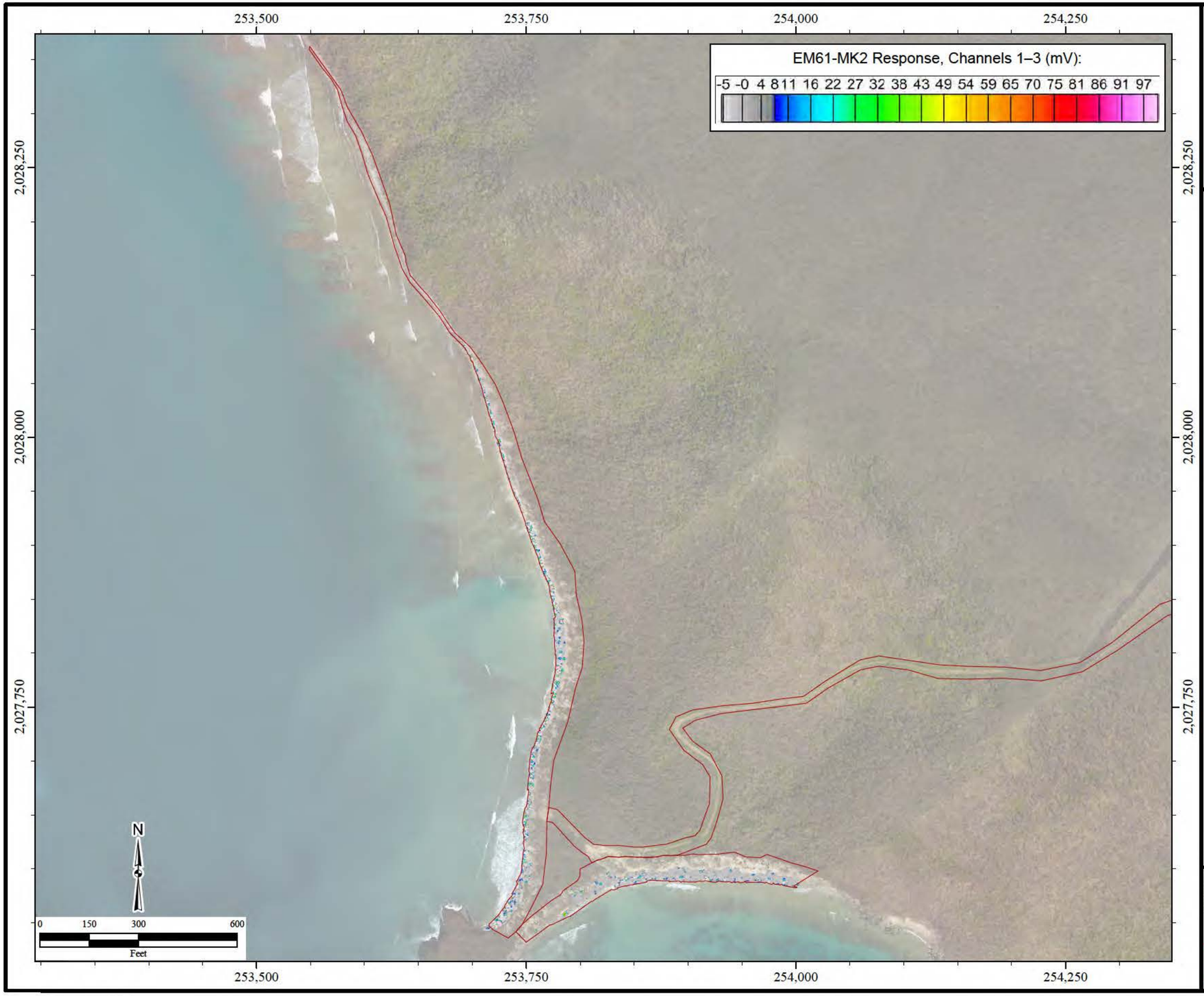

Figure 2.6a
DGM Survey Results
Tamarindo Beach and
Carlos Rosario Beach

Legend

Final TCRA Clearance Footprint

Notes:
Coordinates shown in NAD 1983 UTM, Zone 20, Meters.

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(2-06a)DGM_Results_West.mxd
1/2/2019 CNL
Source: HGL, USACE
NOAA Imagery dated September 2017

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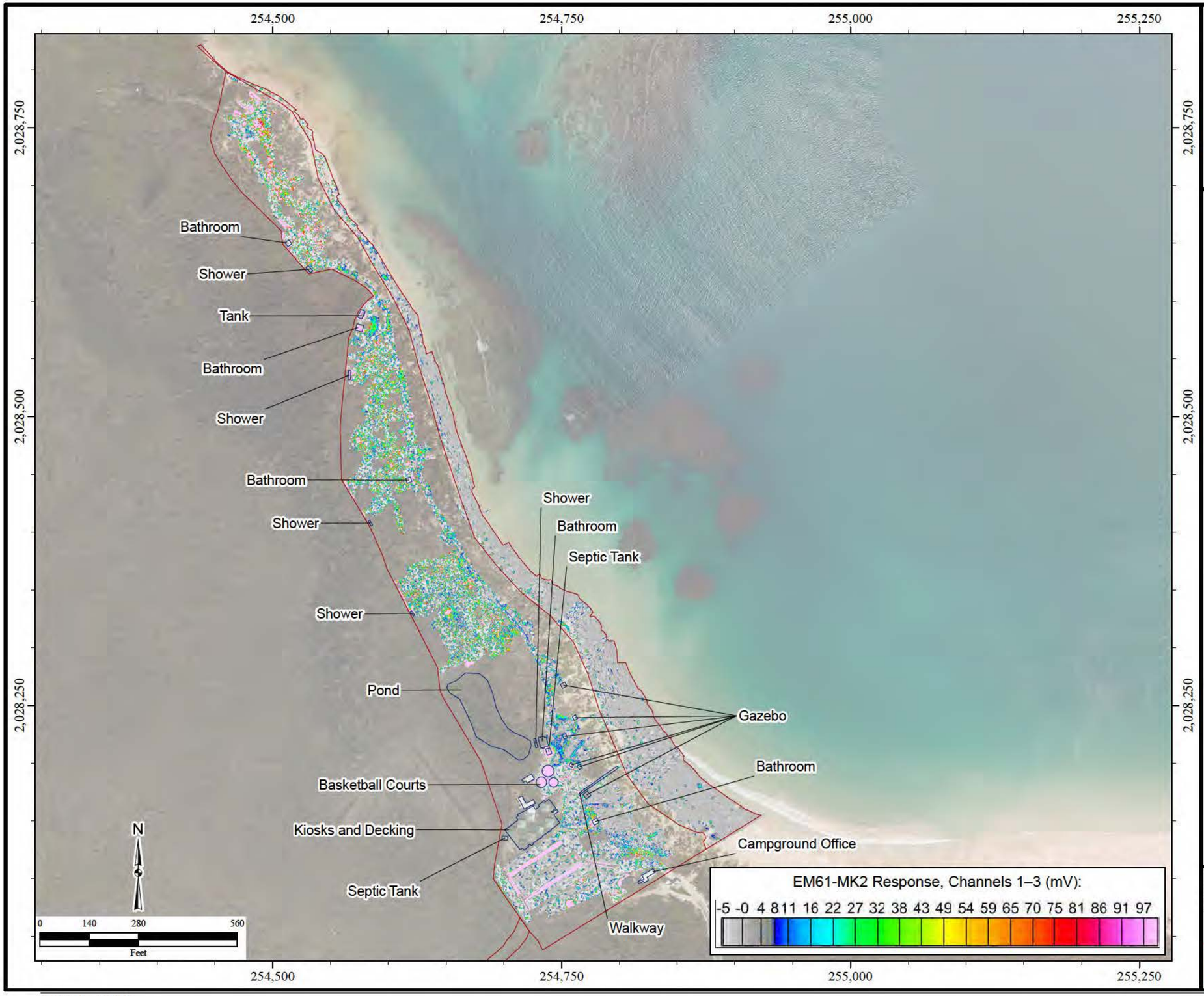

Figure 2.6b
DGM Survey Results
Flamenco Beach and Campground

Legend

Final TCRA Clearance Footprint

Area Not Cleared within Footprint

Notes:
Coordinates shown in NAD 1983 UTM, Zone 20, Meters.
Final TCRA Clearance boundary excludes buildings, structures, basketball courts, tanks, and pond.

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1/2/2019 CNL
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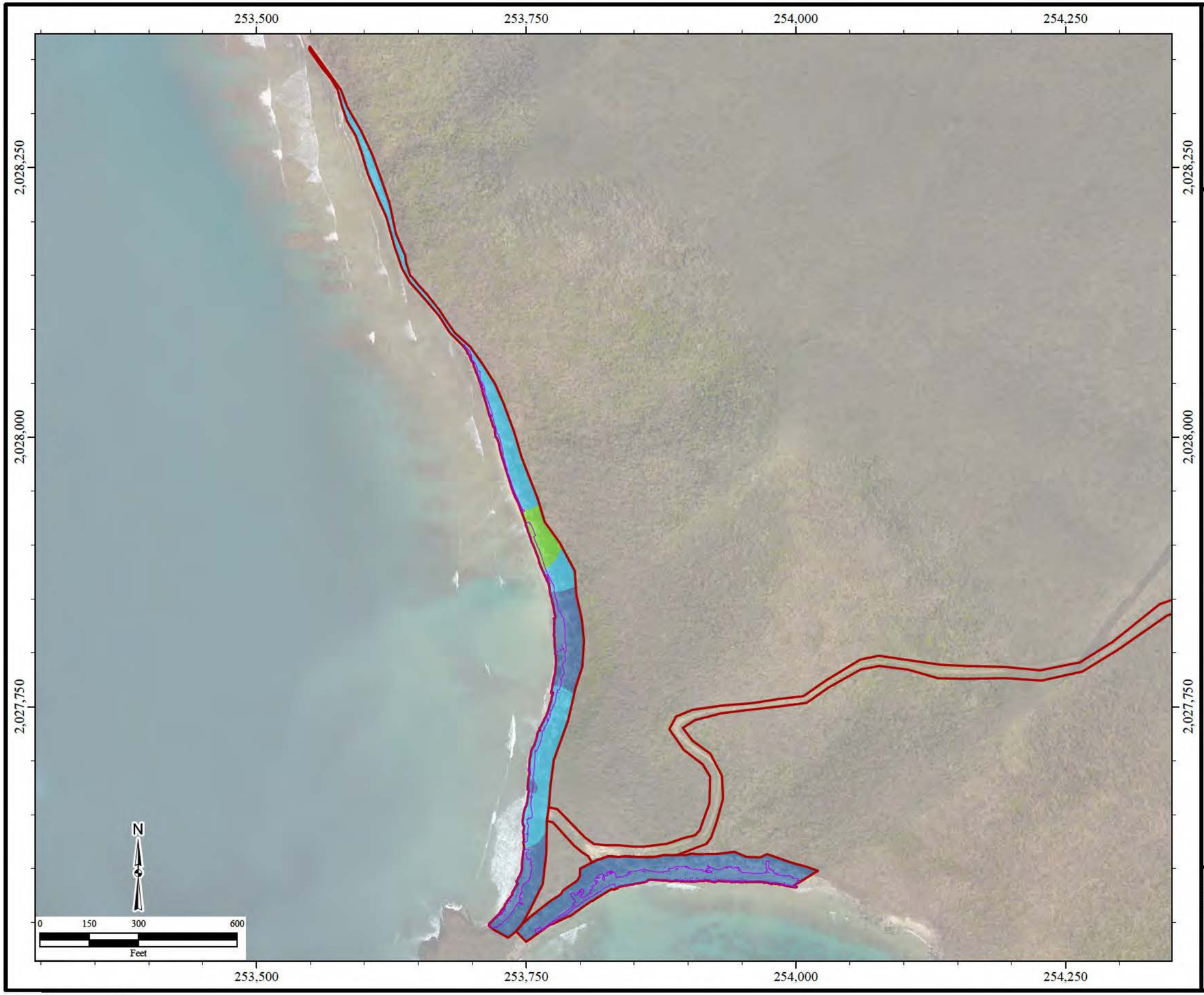

Figure 2.7a
DGM Anomaly Density
Tamarindo Beach and
Carlos Rosario Beach

Legend

Final TCRA Clearance Footprint

DGM Coverage Area

Estimated DGM Anomalies per Acre:

85 – 500
501 – 1,000
1,001–1,308

Notes:
Coordinates shown in NAD 1983 UTM, Zone 20, Meters.

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(2-07a)DGM_Density_West.mxd
1/4/2019 CNL
Source: HGL, USACE
NOAA Imagery dated September 2017

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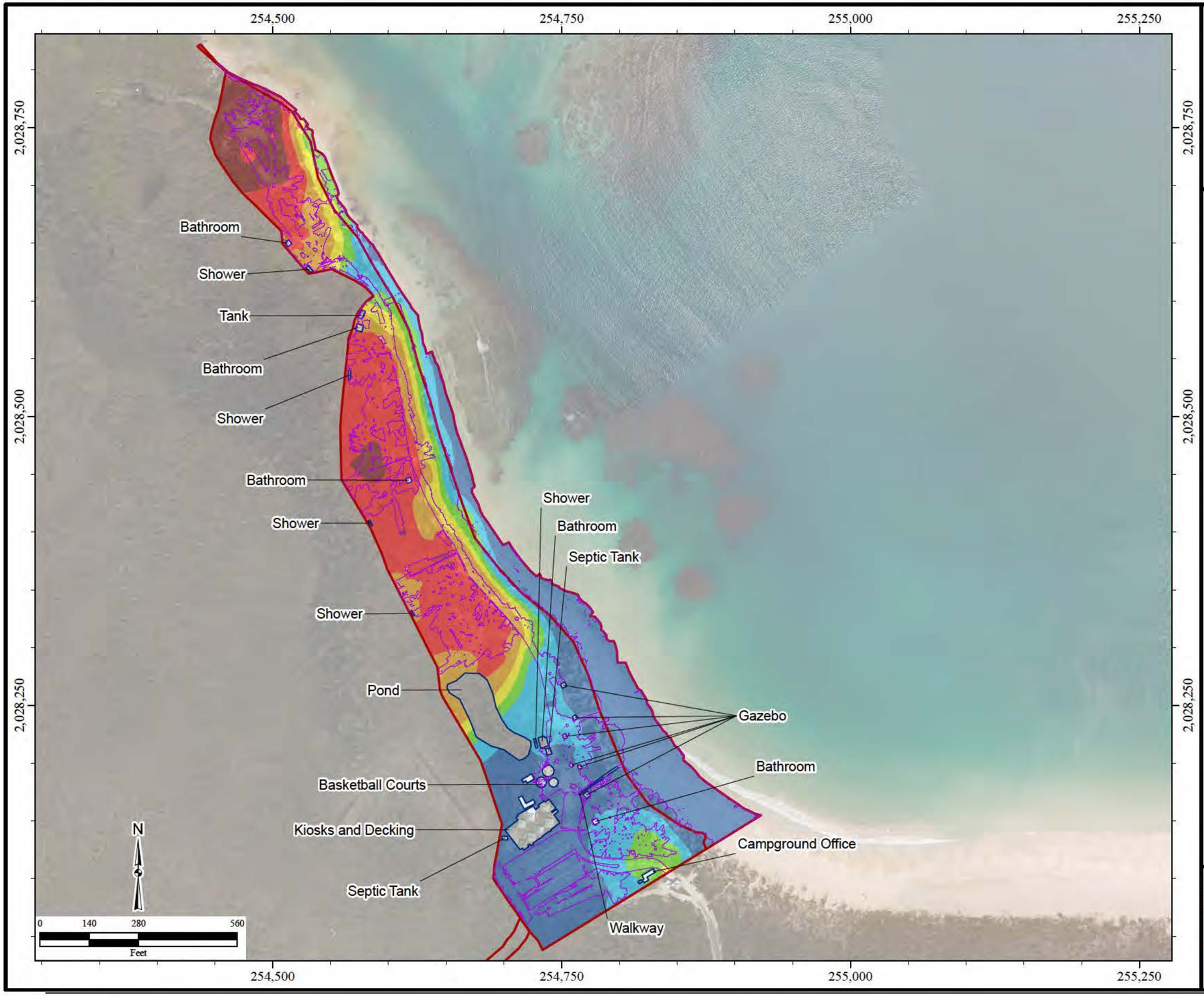

Figure 2.7b
DGM Anomaly Density
Flamenco Beach and Campground

Legend

- Final TCRA Clearance Footprint
- Area Not Cleared within Footprint
- DGM Coverage Area

Estimated DGM Anomalies per Acre:

- 85 – 500
- 501 – 1,000
- 1,001–1,500
- 1,501–2,000
- 2,001–2,500
- 2,501–3,000
- 3,001–3,815

Notes:
Coordinates shown in NAD 1983 UTM, Zone 20, Meters.
Final TCRA Clearance boundary excludes buildings, structures, basketball courts, tanks, and pond.

\\gst-srv-01\HGLGIS\Culebra_MSIW\SSFR\(2-07b)DGM_Density_East.mxd
1/4/2019 CNL
Source: HGL, USACE
NOAA Imagery dated September 2017

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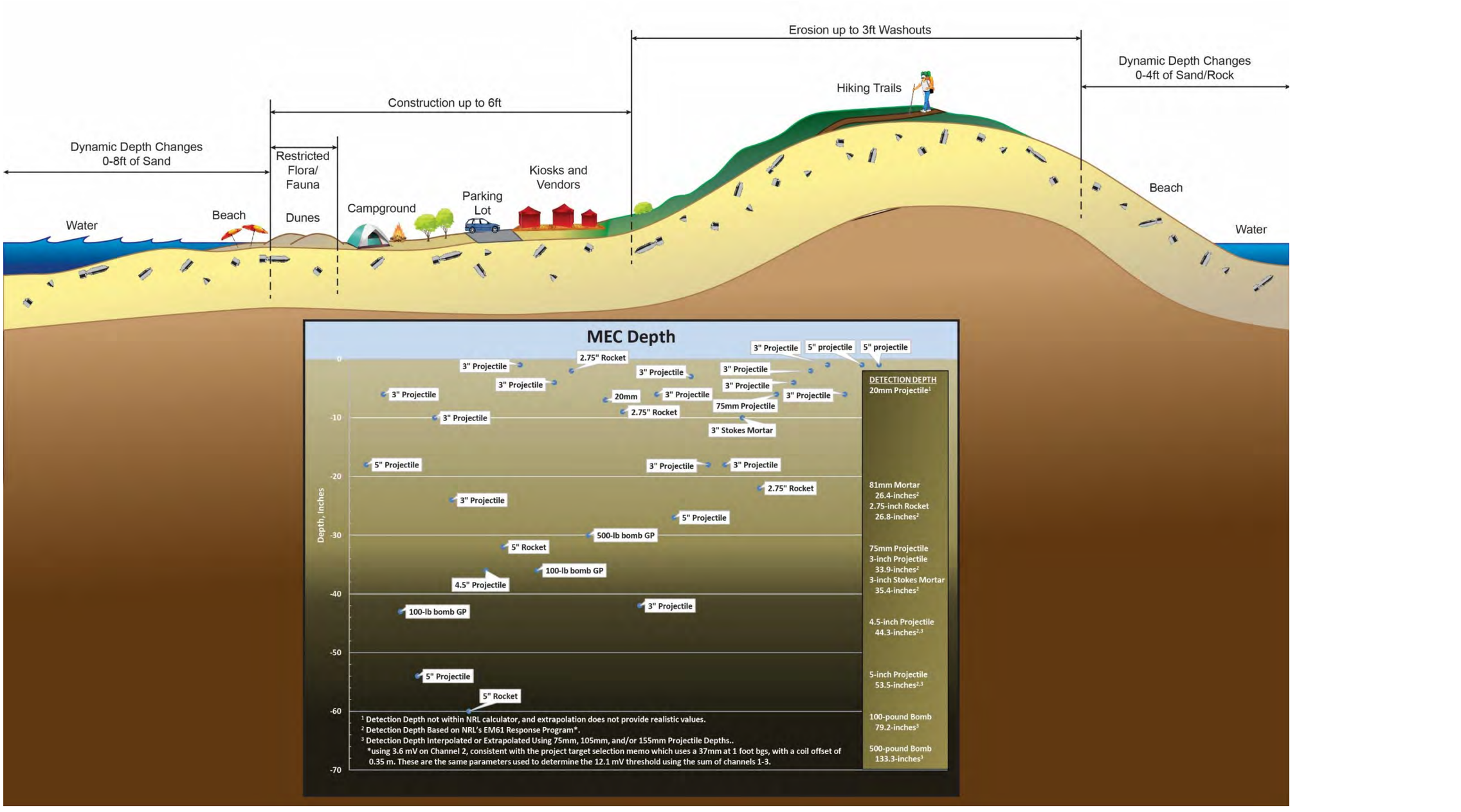
Figure 2.8 – Conceptual Site Model



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3.0 QUALITY CONTROL ACTIVITIES AND RESULTS

3.1 QUALITY CONTROL PLAN

3.1.1 The UFP-QAPP documented the approach and procedures used to ensure appropriate quality throughout the execution of the TCRA at the NWP. The plan included all aspects involving quality as required by the PWS. Implementation of these polices ensured that QC procedures were followed and consistently met the quality and performance requirements of the task order.

3.2 PERSONNEL RESPONSIBILITIES

3.2.1 Quality Control Manager

3.2.1.1 The QC Manager developed and maintained QC policies and procedures, oversaw internal QC organization to implement policies and procedures, and oversaw and monitored QC practices and policy compliance.

3.2.2 Unexploded Ordnance Quality Control Specialist

3.2.2.1 UXOQCS qualified personnel contributed to the development of the UFP-QAPP, implemented the UFP-QAPP in the field, and conducted QC audits.

3.2.3 Quality Control Geophysicist and Field QC Geophysicist

3.2.3.1 The QC Geophysicists contributed to the UFP-QAPP, designed and implemented the Blind Seed Plan, generated the data usability assessments (DUAs) for the dynamic and cued surveys, developed FCR and root cause analysis – corrective action (RCA-CA) documents and performed weekly (or more often) checks of the following project elements:

- Analog and DGM/AC daily QC tests;
- Blind seed results (DGM/AC);
- Coverage and blind seed results (analog); and
- Intrusive results.

3.2.3.2 The results are documented in the Microsoft Access DB that is provided under separate cover with the SSFR.

3.2.4 Project Manager

3.2.4.1 The PM was responsible for all aspects of the project including the quality of products and services provided as part of this PWS. He ensured that all deliverables satisfied project requirements and were conducted IAW applicable DIDs and QC policies. The PM performed the following:

- Maintained the nonconformance, corrective, and preventive action systems;
- Responded to QC audits;

- Coordinated improvements to the UFP-QAPP based on suitability reviews;
- Obtained and communicated client requirements to the appropriate personnel;
- Ensured that qualified, skilled, and trained personnel and other resources were available to implement the UFP-QAPP;
- Ensured that products and services satisfied client requirements including quality, safety, cost, schedule, performance, reliability, and accuracy; and
- Ensured that personnel complied with applicable standards, regulations, specifications, and documentation procedures.

3.2.5 Senior Unexploded Ordnance Supervisor

3.2.5.1 The SUXOS was responsible for the day-to-day on-site management of UXO services. His responsibilities included direction of all UXO site operations and coordination with the HGL UXOQCS.

3.2.6 Site Personnel and Staff

3.2.6.1 During the TCRA, HGL personnel and subcontractors assigned to this task order performed the following QC roles and responsibilities.

- Ensured appropriate quality of work products; and
- Operated in conformance with the requirements of the PWS and UFP-QAPP.

3.2.7 Project Biologist

3.2.7.1 The Qualified and independent Project Biologist was responsible for conducting an initial environmental survey prior to fieldwork and daily inspections until ordnance or vegetation removal actions were completed. The Project Biologist also trained site personnel before beginning vegetation removal and MEC clearance activities regarding the importance of endangered species, in particular the status of sea turtles at this location.

3.3 THREE-PHASE QC PROCESS

3.3.1 The UXOQCS ensured that the three-phase QC system was implemented. This process consists of preparatory, initial, and follow-up phases. Each QC phase is important for obtaining a high-quality product; the preparatory and initial phases are particularly valuable in preventing QC problems. The QC Geophysicist also conducted inspections for AC and DGM work. The QC Geophysicist ensured the quality and completeness of the geophysical deliverables, produced DUAs and the Validation Report, and reviewed the Verification Report. Three-phase QC Forms are included in Appendix D5. Follow-up phase inspections were captured on the Daily Quality Control Reports (DQCR), provided in Appendix D2.

3.3.1 Preparatory Phase

3.3.1.1 The preparatory phase was completed before the initiation of on-site work and included the following:

- Reviewing specifications, references, and plans;
- Checking field equipment and ensuring that it is appropriate for its intended use and has been tested, submitted, and approved;
- Assigning responsibilities and ensuring that field staff have the necessary knowledge, expertise, and information to perform their jobs;
- Verifying arrangements for support services;
- Inspecting work areas to verify that required preliminary work has been completed;
- Reviewing appropriate AHAs and the UFP-QAPP; and
- Ensuring the applicable process and procedures have been approved by the contracting officer.

3.3.1.2 The UFP-QAPP and SOPs were reviewed by the UXOQCS during this phase to ensure that they described the prequalifying requirements or conditions, equipment, materials, methodology, and QC provisions. The UXOQCS reviewed the APP and applicable AHAs to ensure that safety requirements were achieved.

3.3.2 Initial Phase

3.3.2.1 This phase was performed at the beginning of work. The purpose of the phase was to accomplish the following:

- Check preliminary work;
- Verify that QC controls will ensure full contract compliance;
- Establish an acceptable level of workmanship;
- Check safety to include compliance with the APP and AHAs; and
- Resolve differences of interpretation.

3.3.3 Follow-Up Phase

3.3.3.1 Periodic checks were performed to ensure compliance with contract requirements. The purpose of the follow-up phase was to accomplish the following:

- Ensure that work was in compliance with contract requirements;
- Maintain the quality of workmanship required; and
- Perform safety inspections.

3.3.3.2 The UXOQCS was responsible for on-site monitoring of the practices and operations taking place and verifying continued compliance with the specifications and requirements of the contract, approved project plans, and procedures.

3.3.3.3 The UXOQCS was also responsible for verifying that a daily safety and health briefing was performed and documented as prescribed in the SSHP. The UXOQCS observed activities as specified in the initial inspection and verified that corrective actions for nonconforming conditions were taken before granting approval to continue work.

3.4 QUALITY CONTROL AUDIT PROCEDURES

3.4.1 Inspections for Munitions and Explosives of Concern-Related Activities

3.4.1.1 The UFP-QAPP, Worksheet 22A, details the key elements of the performance metrics include maintaining alignment with stated project objectives, maintaining product quality, ensuring timely delivery of products, maintaining customer satisfaction, and meeting CEHNC requirements (DIDs).

3.4.2 Quality Control Process

3.4.2.1 Listed below are QC processes and procedures associated with personnel, instruments/sensors and other equipment, and data deliverables used for measuring the effectiveness of MEC clearance. The MQOs in UFP-QAPP Worksheet 22 and Measurement Performance Criteria in UFP-QAPP Worksheet 12 were evaluated during project execution to ensure that data acquisition, processing, and interpretation were sufficient to meet the overall program objectives. HGL's QC processes provide for the following:

- Testing equipment used to perform work:
  - Functional instrument tests for the system were recorded.
  - All instruments and equipment used in the field were checked before the start of each workday.
  - Batteries were replaced as needed, and the instruments were checked against a known source item.
- Monitoring/measuring the effectiveness of work performed:
  - The UXOQCS was responsible for ensuring that personnel accomplished all QC checks and that the appropriate log entries were made. The UXOQCS performed random, unscheduled checks to ensure that personnel accomplished all work specified in the UFP-QAPP.
  - The PM prepared project deliverables, such as the UFP-QAPP and SSFR. Deliverables were reviewed by a QC representative before submittal.
  - The UXOQCS completed daily QC inspections and submitted reports to the PM and SUXOS. Reports included descriptions of the areas checked and the results of the QC checks. DQCRs are included in Appendix D2.
- Inspecting the maintenance and accuracy of site records
- Determining compliance with site safety, environmental, and operational plans
- Ensuring the accuracy, timeliness, and completeness of data deliverables

3.5 DATA MANAGEMENT

3.5.1 HGL stored data generated during the project in hard copy and electronic form. Data deemed critically important was backed up with multiple electronic versions. IAW the UFP-QAPP, required data was provided to CEHNC with the SSFR.

3.6 ANALOG GEOPHYSICS

3.6.1 Analog geophysics were performed IAW Chapter 9 of Engineer Manual (EM) 200-1-15 (USACE, 2015); the methods are detailed in the project UFP-QAPP. The UXOQCS conducted a 25% instrument-assisted re-sweep of each analog-only lot (approximately 0.25 acres) in a random pattern. In analog-only areas, where practicable and accessible, a 5% DGM coverage survey using an EM61 was completed. In areas where reliable positioning could not be achieved (either RTK/RTS or line and fiducial) or where terrain and vegetation preclude the use of the sensor, the 5% DGM re-sweeps were not required. Additionally, seed items were distributed such that each team on average encountered between one and three detection seeds per team per day and coverage seeds such that each operator encountered between one and three total seeds per day. Additional QC steps were included to ensure that data and results were of high quality and that field data collection personnel implemented QC steps in a consistent manner. QC checks of the following were conducted:

- Analog geophysical instruments
- Operators
- Site preparation procedures
- Subsurface clearance procedures

3.6.2 QC checks were designed to test these procedures and systems to ensure high-quality output and results. In addition to the checks described above, the SUXOS reviewed data for completeness and coverage and audited operator activities to ensure conformance to site-specific protocols. RCAs (Appendix H) were performed when nonconformances were identified to ensure the measurement performance criteria in UFP-QAPP Worksheet 12 were ultimately achieved.

3.6.3 FCR 6 and 11 (Appendix G) were completed to address the UFP-QAPP Worksheet 22 MQO for instrument functionality. RCAs (Appendix H) addressed the detection and recovery of coverage and blind seeds as required by UFP-QAPP Worksheet 12.

3.6.4 The results for the coverage and blind seeds and daily QC tests are documented in the Microsoft Access DB provided under separate cover with the SSFR. No significant limitations on data use were identified for the analog surveys.

3.6.5 Relevant Access DB tables for analog include the following:

- Analog instrument function test results
- Analog seed and test item
- Analog seed recovery
- Analog Daily Summary
- Grids
- Geodetic Functionality

3.7 DIGITAL GEOPHYSICAL MAPPING

3.7.1 The IVS area was used for daily QC tests for the DGM system. Daily tests at the IVS included the following:

- Static spike
- IVS center line
- IVS noise line
- Known position check (RTK GPS and RTS only)

3.7.2 In addition to the daily QC tests, the following elements of the DGM program were also tracked during project execution:

- In-line measurement spacing
- Coverage
- Dynamic detection performance
- Valid position data (RTK GPS)

3.7.3 The results of the daily QC tests, spatial sampling, QC and validation seed detection, and positioning checks are documented in the Microsoft Access DB provided under separate cover with the SSFR.

3.7.4 The MQOs applicable to the DGM dynamic survey in UFP-QAPP Worksheet 22 (Table 3.1) were evaluated for each final data submittal. FCR 1 (Appendix G) addresses the modification for the in-line measurement spacing. RCAs (Appendix H) were performed when nonconformances were identified to ensure the measurement performance criteria in UFP-QAPP Worksheet 12 (Table 3.2) were ultimately achieved. RCA 1 and 3 address the ongoing dynamic positioning precision MQO. RCA 6 and 23 address the dynamic detection performance for the production EM61 data. In general, data were recollected or not used when QC tests and/or MQOs were not achieved. If the data were deemed acceptable for use, justification was provided in the respective Microsoft Access DB tables. All QC and validation seeds were placed on the cued target list. No significant limitations on data use were identified for the dynamic data acquired with the EM61.

3.7.5 A Dynamic DUA documented whether each MEC-related data element has been verified and validated according to UFP-QAPP, whether the DQOs have been attained, and whether the data can be used as intended. The project DUAs are included electronically with the SSFR. The Final DUA is included in Appendix L.

Table 3.1
Dynamic Survey (Instrument: EM61-MK2 and Analog Sensor)

Measurement Quality Objective	Frequency	Acceptance Criteria	Failure Response	Performance Results	Associated FCRs and RCAs
Instrument Functionality (Analog System)	Daily	Each operator demonstrates, in a test plot separate from the IVS, positive detection on a daily basis to the presence of 37mm projectile buried at a depth of 12 inches in best- and worst-case orientation and 5-inch HE projectiles buried at a depth of 40 inches (or equivalent ISOs).	Repair or replace instrument, then repeat test	All tests passed. FCRs 6 and 11 allowed changes to the test items used and test strip design.	FCR 6 and FCR 11
Coverage, Detection, and Recovery (Analog)	Evaluated for each 100-ft by 100-ft grid.	QC seed items will be distributed such that each team will encounter between one and three detection seeds per team per day and coverage seeds such that each operator encounters between one and three total seeds per day	RCA/CA CA assumption: grid fails; re-clear	Grids were seeded at a frequency based on estimated production rates. Overall for the project, each team averaged 2.1 detection seeds per day and operators recovered 1.6 coverage seeds per day. Team-Days where this requirement was not met is documented in RCA 25.	RCA 25

Table 3.1 (Continued)
Dynamic Survey (Instrument: EM61-MK2 and Analog Sensor)

Measurement Quality Objective	Frequency	Acceptance Criteria	Failure Response	Performance Results	Associated FCRs and RCAs
Anomaly Resolution	Evaluated for 100-ft by 100-ft grid.	UXOQCS will conduct a 25% instrument-assisted resweeps of each grid in random patterns. For 5% of the analog clearance area, digital surveys will be conducted by establishing QC grids or transects where practicable and accessible. A dig team will investigate DGM targets that exceed established thresholds. Finding no MEC or MPPEH excluding small arms ammunition (.50 cal and smaller), and no MD or RRD equivalent to, or greater than 37mm in diameter or width on the surface of the MRS. Finding no subsurface MEC or MPPEH shallower than 8X the item's diameter.	RCA/CA CA assumption: excavation fails; re-clear	All 25% re-sweeps performed by the UXOQCS passed. All 5% DGM QC lots passed except for those associated with Grids AN18 and AQ23 where seeds were detected in the DGM data following analog clearance (RCA 15).	FCR 05A RCA 15
Geodetic Equipment Functionality	Daily	Measured position of control point within 10 cm of ground truth	CA assumption: redo affected work	A failure occurred on 1/13/2017 using the RTS and is documented in RCA 03. Production data collected on this date were discarded.	RCA 03
Initial dynamic positioning accuracy (IVS, EM61-MK2)	Once prior to start of dynamic data acquisition	Derived positions of IVS target(s) are within 25 cm of the ground truth locations	CA: Make necessary adjustments, and re-verify		

Table 3.1 (Continued)
Dynamic Survey (Instrument: EM61-MK2 and Analog Sensor)

Measurement Quality Objective	Frequency	Acceptance Criteria	Failure Response	Performance Results	Associated FCRs and RCAs
Ongoing Instrument Function Test (EM61-MK2)	Beginning and end of each day and each time instrument is turned on	Response within 20% of initial response (comparison with the mean static spike minus mean static background)	CA: make necessary repairs and re-verify	All tests passed except for tests performed on 1/26 and 1/27/2017 by the anomaly resolution team. The instrument had been inadvertently switched to differential mode and Ch4 failed the response requirement. Ch1-3 passed, Sum of Ch1-3 was used for anomaly resolution, therefore no work was adversely affected.	None
Ongoing dynamic positioning precision (EM61-MK2)	Beginning and end of each day	Derived positions of IVS target(s) within 25 cm of the average locations	RCA/CA	Failures occurred on 12/7/2016 (RCA 01) using RTK-GPS and again on 1/9/2017 (RCA 03) using RTS. Both failures did not affect production data.	RCA 01, RCA 03
Reacquisition and anomaly resolution precision (EM61-MK2)	Beginning and end of each day	Derived positions of IVS target(s) within 25 cm of the average locations	RCA/CA	Anomaly reacquisition and resolution was not performed using DGM methods (integrated positioning with EM61 response data). Geodetic instruments used for target reacquisition were tested in accordance with the Geodetic Equipment Functionality MQO listed above.	None
In-line measurement spacing (EM61-MK2)	Verified for each data collection day using existing UX Detect tools based upon sensor center position	98% $\leq$ 0.25 m between successive measurements	RCA/CA CA assumption: data set fails, (recollect portions that fail)	All data are acceptable	FCR 01

Table 3.1 (Continued)
Dynamic Survey (Instrument: EM61-MK2 and Analog Sensor)

Measurement Quality Objective	Frequency	Acceptance Criteria	Failure Response	Performance Results	Associated FCRs and RCAs
Coverage (EM61-MK2)	Verified for each SU using existing UX Detect tools based upon sensor center position	100% at ≤0.7 m cross-track measurement spacing (excluding site-specific access limitations, e.g., obstacles, unsafe terrain)	CA. CA assumption: Gaps require fill-in lines to achieve required coverage unless no indication of subsurface metal in gap (1)	All are acceptable	FCR 01

Table 3.1 (Continued)
Dynamic Survey (Instrument: EM61-MK2 and Analog Sensor)

Measurement Quality Objective	Frequency	Acceptance Criteria	Failure Response	Performance Results	Associated FCRs and RCAs
Dynamic detection performance (EM61-MK2)	Evaluated by 100-ft by 100-ft grid	All GSV seeds detected with at least 75% of minimum expected response at maximum horizontal offset Positional accuracy of GSV seed ≤ 0.35m + ½ line spacing for data collected with RTK GPS positioning, ≤ 0.50m + ½ line spacing for data collected with fiducial positioning.	RCA/CA	Five seeds did not initially meet the offset requirements. Three seeds were in the SE Campground Survey Unit where target selection procedures were modified to capture the associated anomaly peaks (RCA 06). Another seed offset was likely due to an isolated error in the line and fiducial positioning in Grid AE03 (RCA 23). The other seed's target pick location in Grid AM20 was manually adjusted by the data analyst and/or merged with another adjacent target (RCA 23). All seeds were successfully recovered by the dig team using a 1-meter search radius, except for one that was within a mag and dig area. Another seed was not detected at or above the target selection threshold of 12.1 mV on the sum channel and therefore was not picked as a target. The seed item was a small bolt (20mm projectile surrogate) and the expected response for this item was below the project target selection threshold. This seed was discarded (RCA 09). Several other seeds did not achieve this metric because they were removed by wave action on the beach (RCA 10).	RCA 06, RCA 09, RCA 10 and RCA 23

Table 3.1 (Continued)
Dynamic Survey (Instrument: EM61-MK2 and Analog Sensor)

Measurement Quality Objective	Frequency	Acceptance Criteria	Failure Response	Performance Results	Associated FCRs and RCAs
Valid position data (EM61-MK2)	Per measurement	GPS status flag indicates fix and confirmation that fix should be indicative of DOP <4.0[(2)]	CA: Interpolate positions for minor (<3 m) GPS fluctuations along straight lines (path before and after gap indicates line was straight). Longer out-of-spec data was rejected. Interpolations across larger distances along straight lines may be made for the 5% DGM QC re-sweeps.	All data are acceptable	FCR 05A

(1) Analyst will review data surrounding identified gaps to determine the possibility that subsurface metal is present in the gap. If the analyst and USACE Geophysicist agree that the data surrounding the gap indicates there is no potential for subsurface metal in the gap, it will not be recollected.

Table 3.2
Method Measurement Performance for MEC-Related Tasks

Measurement Performance Activity (or DFW)	Specification	Activity Used to Assess Performance	Results
QC Seeding (Analog)	UXOQCS or designee places small and ISOs as blind seeds and coverage seeds in analog removal area(s) IAW Table 22A.1.	Review of Production Area QC Seeding Report	Achieved. Documented in the Analog Seed and Test Item Table of the project Access DB
QC Seeding (DGM)	Blind QC seeds will be placed at the site by the contractor. Blind QC seeds must be detectable as defined by the DQOs (11A.4) and located throughout the horizontal and vertical survey boundaries defined in the DQOs (11A.4). Seed items will consist of small schedule 80 ISOs; medium schedule 40 ISOs; and inert 37mm projectiles and 2.75-in Rocket warheads, as available. Blind QC seeds will be distributed such that the field team can be expected to encounter between one and three per team(s) per day.	Review of Production Area QC Seeding Report	Small schedule 80 ISOs, medium schedule 40 ISOs and bolts (20mm surrogates) were used. The expected response for the bolts ended up below the target selection threshold and were not used for QC purposes. Documented in the Seed and Test Item Table of the project Access DB.
Site Preparation	Staking grid corners and removal area boundaries. Performing surface clearance for MEC/MPPEH: Remove surface metal as necessary to reduce the interference with the geophysical survey. Performing vegetation removal.	Review of QC reports.	Achieved. Documented in the Surface Clearance Memorandum and the Surveyor Map .
Analog Removal	Ability to detect a horizontal 37mm projectile at a depth of 12 inches bgs.	Function tests at an instrument test strip will be used to validate the proper operation of handheld detectors by personnel on a daily basis	Achieved. Documented in the Analog Instrument Function Test Results Table of the project Access DB.
Analog Removal	100% of blind seeds must be recovered.	Review of seed recovery results	Seeds not recovered resulted in rework in the analog portions of five grids. For details, see RCAs 15-19 and 24.
Detection Survey (DGM)	100% of the site is surveyed.	Verification of conformance to MQOs for in-line spacing and cross-line spacing (see Worksheet #22A)	Achieved. The dynamic nature of the beach continually changed the eastern boundary, adding or removing sediment thereby changing the water line. Documented in the Coverage Table of the project Access DB.

Table 3.2 (Continued)
Method Measurement Performance for MEC-Related Tasks

Measurement Performance Activity (or DFW)	Specification	Activity Used to Assess Performance	Results
Detection survey (DGM)	The EM61-MK2 detection threshold will be set to detect a horizontal 37mm projectile at a depth of 12 inches bgs or 5X the local average background noise, whichever is higher.	Initial and ongoing function tests and IVS surveys. Validation/QC seed detection Analysis of background variability across the site	The EM61-Mk2 Response software was used to calculate the response to a 37mm projectile at 12 inches bgs and at a 0.35m lateral offset, resulting in a 12.1 mV threshold on the sum of channels 1-3, which is documented in the EM61 Target Selection Technical Memorandum. On 1/22/2018, the memorandum was updated to include a 16.4 mV (Sum Ch1-3) reacquire and resolution threshold based on a 0.0 m lateral offset of a 37mm projectile at 12 inches bgs.
Detection survey (DGM)	100% of validation seeds must be detected	Review of validation seed detection results per 100-ft by 100-ft grid	Validation seeds emplaced by USACE were detected. Several validation seeds were washed away along the beach and several others were excluded from AC collection on account of high anomaly density. Seed detection is documented in the Seed and Test Item table of the Access DB.

Table 3.2 (Continued)
Method Measurement Performance for MEC-Related Tasks

Measurement Performance Activity (or DFW)	Specification	Activity Used to Assess Performance	Results
Detection survey (DGM)	Complete project-specific DBs and target lists delivered.	Data verification/data validation	Achieved. Documented in geophysical data deliverables and in the Anomaly Table in the project Access DB
Reacquisition	If the reacquired anomaly cannot be located within a 1-meter radius of the location provided on dig sheets, the locations will be rechecked by the QC Geophysicist and a CA may be determined.	The reacquisition team will use RTK GPS to flag the location of the reacquired anomaly within a 1-meter radius of the location provided on dig sheets.	Achieved. Documented in the Reacquisition and Intrusive Results Tables of the project Access DB.
Classification survey	Library must include signatures for all munitions known or suspected to be present at the site, as listed in the CSM.	Verification of site-specific library	Achieved. Documented in the site-specific library in the AC deliverables.
Classification survey	Background data will be collected at least once every two hours of cued survey data collection. Background locations will be selected such that background data will be representative of the various subsurface conditions expected to be encountered within each grid at the site.	Data verification/data validation	Achieved
Classification survey	All detected anomalies classified as: 1. TOI 2. Non-TOI 3. Inconclusive	Data verification	Achieved. Documented in the AC deliverables and the 01b-Single Results table in the project Access DB.
Classification survey	Cued survey must correctly classify 100% of validation Seeds.	Review of validation seed classification results	Achieved. Documented in the Seed and Test Item and 01b-Single Results Tables of the project Access DB.
Classification survey	Background data, cued target data, munitions libraries, modeling results and any other supporting documentation used to make classification decisions are delivered.	Data verification Data validation	Achieved. Documented in the AC deliverables.
Classification survey	100% of predicted non-TOI that are intrusively investigated are confirmed to be non-TOI.	Visual Inspection of recovered items	Achieved. Documented in the 03 Intrusive Results Table and in the Verification Report.
Intrusive Investigation (AC)	100% of recovered object sizes qualitatively match predicted size.	Visual inspection of recovered items for items classified as TOI	Partially achieved, see RCA 23 for details. Documented in the 03 Intrusive Results Table of the project Access DB.

Table 3.2 (Continued)
Method Measurement Performance for MEC-Related Tasks

Measurement Performance Activity (or DFW)	Specification	Activity Used to Assess Performance	Results
Classification analysis / Intrusive Investigation	Inversion results correctly predict one or more physical properties (e.g. size, symmetry, or wall thickness) of the recovered non-TOI items.	Visual inspection and qualitative evaluation of recovered items from the validation digs (see Worksheet #22)	Partially achieved, see RCA 23 for details. Documented in the 03 Intrusive Results Table of the project Access DB.
Intrusive Investigation	Complete Microsoft Access intrusive results DB delivered including records reconciling inversion results to the physical properties of the recovered items.	Data verification/ Data validation	Achieved. Documented in the 03 Intrusive Results Table.
MEC/MPPEH Handling	Should MPPEH be encountered, only UXO-qualified personnel (UXO Technician II or higher) will perform identification of the item and ascertain its condition. The SUXOS and UXOSO must be in agreement on the nature and condition of a MEC before any action is taken.	Joint SUXOS and UXOSO determination that a MEC is acceptable to move. After determining an item is acceptable to move, the SUXOS and UXOSO will determine the most expeditious route for safe movement of the MEC to the disposal point. UXOQCS verifies that MDAS is properly documented in a DoD Form 1348-1A.	Achieved. Documented in Daily Reports and Form 1348-1A.

3.7.6 Relevant Microsoft Access DB tables for DGM include the following:

- Along line spacing
- Anomaly resolution
- Anomaly resolution revisits
- Anomaly
- Coverage
- Data processing
- Dataset
- Geodetic Accuracy Repeatability
- Geodetic Functionality
- Geodetic Functionality
- Grids
- Intrusive results DGM
- Minimum seed response
- QC QA tracking
- Reacquisition
- Revisit intrusive results
- Seed and Test Item
- Speed
- Static repeatability test
- Static repeatability test

3.8 ADVANCED GEOPHYSICAL CLASSIFICATION

3.8.1 The IVS area was used for daily QC tests for the AC sensors. Daily tests at the IVS included the following:

- Initial and ongoing background measurements
- Initial and ongoing polarizabilities
- Initial and ongoing derived target position accuracy
- Initial and ongoing sensor function tests
- GPS precision (RTK GPS and RTS)

3.8.2 Prior to using the TEMTADS or MM2x2, the correct assembly was verified and an initial sensor function test was performed. The background cell at the IVS area for cued data measurements was validated at the start of the project with the TEMTADS. In addition to the daily QC tests, the following elements of the AC program were also tracked during project execution:

- Transmit current levels
- Orientation data
- Valid response (not saturated and within 40-cm of flag)

- Inversion models support AC
  - Model response
  - Fit location
  - Seed items
- AC performance
  - Seed items
  - Predicted sizes
- GPS precision

3.8.3 The results for the daily QC tests, data collection, and processing and analysis are documented in the Microsoft Access DB that is provided under separate cover with the SSFR. SOP checklists for AC and the Weekly QC Reports were archived on a SharePoint site during project execution and are also provided as part of the geophysical deliverable under separate cover with the SSFR.

3.8.4 The MQOs applicable to the AC survey in UFP-QAPP Worksheet 22 (Table 3.3) were evaluated for each final data submittal.

- FCR 2 (Appendix G) addresses one of the three classification MQOs (3 of 3).
- FCR 4 and 7 (Appendix G) address the ongoing instrument function test.
- RCA 9 (Appendix H) addresses the MQO for classification performance.
- RCA 11 and 13 (Appendix H) address the ongoing derived polarizabilities precision MQO for the IVS.

3.8.5 In general, data were recollected or not used when QC tests and/or MQOs were not achieved. If the data were deemed acceptable for use, justification was provided in the respective Microsoft Access DB tables. All QC and validation seeds that were not disturbed by the hurricane storm surges achieved relevant UFP-QAPP Worksheet 22 MQOs. No significant limitations on data use were identified for the cued data acquired with the TEMTADS and MM2x2. A cued survey DUA documented whether each MEC-related data element has been verified and validated according to UFP-QAPP, whether the DQOs have been attained, and whether the data can be used as intended. The project DUAs are included electronically with the SSFR, the Final DUA is included in Appendix L.

Table 3.3
Advance Classification Measurement Quality Objectives

Measurement Quality Objective	Frequency	Acceptance Criteria	Failure Response	Performance Results	Associated FCRs and RCAs
Verify correct assembly	Once following assembly	As specified in **SOP AC-01**, Assembly checklist.	CA: Make necessary adjustments, and re-verify	TEMTADS 2x2 and MM2x2 correctly assembled and documented in the appropriate SOP checklists	None
Initial system functionality test	Once following assembly	Response (mean static spike minus mean static background) within 20% of predicted response for all Tx/Rx combinations.	CA: Make necessary repairs or adjustments and re-verify.	Achieved	FCR 02
Initial IVS background measurement (five background measurements, one centered at the flag and one offset at least 35 cm in each cardinal direction)	Once during initial system IVS test	All decay amplitudes lower than project threshold (threshold dependent upon soil response).	CA: Clear and resurvey or reject/replace background location.	Achieved	None
Initial derived polarizabilities accuracy (IVS)	Once during initial system IVS test	Library Match metric ≥ 0.9 for each set of inverted polarizabilities.	RCA/CA	Achieved	None
Derived target position accuracy (IVS)	Once during initial system IVS test	All IVS item fit locations within 0.25 m of ground truth locations.	RCA/CA	Achieved	None
Ongoing IVS background measurements	Beginning and end of each day as part of IVS testing	All decay amplitudes lower than project threshold.	RCA/CA CA assumption: rejection of background measurement (unless RCA indicates system failure).	Two of the background collections failed the threshold requirement. This occurred on 3/30/2017. It was later discovered a nail had contaminated the background location (RCA 13).	RCA 13

Table 3.3 (Continued)
Advance Classification Measurement Quality Objectives

Measurement Quality Objective	Frequency	Acceptance Criteria	Failure Response	Performance Results	Associated FCRs and RCAs
Ongoing derived polarizabilities precision (IVS)	Beginning and end of each day as part of IVS testing	Library Match to initial polarizabilities metric ≥ 0.95 for each set of three inverted polarizabilities.	RCA/CA	Two IVS items failed to achieve a 0.95 metric during the project. A failure occurred on 3/20/2017 that was due to noise in the data (RCA 11). The other failure occurred on 3/30/2017 and was due to a contaminated background location (RCA 13).	RCA 11 and RCA 13
Ongoing derived target position precision (IVS)	Beginning and end of each day as part of IVS testing	All IVS items fit locations within 0.25 m of average of derived fit locations.	RCA/CA	Three IVS items were not modeled within 0.25 m during the execution of the project. Two failed on 2/9/2017 (RCA 07) and another IVS item failed on 1/13/2017 (RCA 04), which were caused by the RTS losing fix on the prism. No production data were affected on 2/9/2017 and all data on 1/13/2017 were rejected for other reasons (RCA 03).	RCA 04 and RCA 07
Initial measurement of production area background locations (five background measurements: one centered at the flag and one offset at least 35 cm in each cardinal direction)	Once per background location	All decay amplitudes lower than project threshold.	CA: Reject background location and find alternate or review project threshold if measured responses seem correct based on varying site conditions.	Fourteen background locations were successfully validated. Four other locations failed the requirements and were discarded, which is documented in the Background Location Report.	None

Table 3.3 (Continued)
Advance Classification Measurement Quality Objectives

Measurement Quality Objective	Frequency	Acceptance Criteria	Failure Response	Performance Results	Associated FCRs and RCAs
Ongoing production area background measurements	Once per background measurement. Background data collected a minimum of every two hours during production	All decay amplitudes lower than project threshold.	CA: Background measurement rejected. Earlier/later background point used if background measurements are consistent throughout the day; re-collect affected data if varying background results indicate loss of point is significant.	Five production area backgrounds (including the two described in RCA 13) failed the threshold requirements. All cued production data were either recollected or another acceptable background was used.	RCA 13
Ongoing production area background measurements	Evaluated for each background measurement	Background point collected within 0.4 m of initial collection location for that point.	CA: Background measurement rejected; re-collect affected targets.	One production area background was not documented as collected within 0.40 m due to the RTS losing fix on the prism on 2/13/2017. Background 2131702_001 was below the threshold and was used to level production data.	None
Ongoing instrument function test	Beginning and end of each day as part of IVS testing	Response (mean static spike minus mean static background) within 20% of predicted response for all monostatic Tx/Rx pairs. Predicted response will be the average of the first five tests.	CA: Make necessary repairs and re-verify.	The initial acceptance criterion was not appropriate for the sensors and did not agree with the requirements in the AGC-QAPP. FCRs 04 and 07 changed the criteria after failures were noted in RCA 02 and 08 according to the criterion in place at the time. The change in criterion described in FCR 07 is described in the Acceptance Criteria column of this table and agrees with the AGC-QAPP. All sensor function tests collected during project execution pass the criterion.	FCR 04 and FCR 07 RCA 02 and RCA 08

Table 3.3 (Continued)
Advance Classification Measurement Quality Objectives

Measurement Quality Objective	Frequency	Acceptance Criteria	Failure Response	Performance Results	Associated FCRs and RCAs
Transmit current levels	Evaluated for each sensor measurement	Peak transmit current must be ≥ 5 amps for lithium ion batteries; ≥ 80% of initial currents measured for lead acid batteries when fully charged.	CA: Stop data acquisition activities until condition corrected.	All TEMTADS 2x2 data used for the project met this requirement. No FCR was submitted, but this criterion should have been revised to include the MM2x2 mininum transmit current of 8A. All MM2x2 data used for this project met the 8A requirement.	None
Orientation Data	Evaluated for each sensor measurement	Ensure orientation data are valid: orientation data reviewed for out of range data.	CA: Stop data acquisition activities until condition corrected or project team decides on acceptable work around.	All orientation data collected for the project was determined to be valid. An error was discovered that corrected for declination twice when MM2x2 data were converted to a CSV file and then upon import to Oasis Montaj (RCA 12). Affected data were reprocessed.	RCA 12
Ongoing production area measurements	Evaluated for each dynamic target	Cued measurement collected within 0.4 m of all dynamic targets.	CA: Collect cued measurement directly over dynamic target.	At least one cued measurement was collected within 0.4 m of all dynamic targets. On 1/13/2018 the RTS was set up incorrectly leading to large offsets (RCA 03). All production data from 1/13/2018 were discarded and recollected.	RCA 03
Confirm adequate spacing between units	Evaluated at start of each day (or grid)	Minimum separation of 25 m.	CA: Recollect all coincident measurements.	Sensor spacing was maintained throughout the duration of the project.	None

Table 3.3 (Continued)
Advance Classification Measurement Quality Objectives

Measurement Quality Objective	Frequency	Acceptance Criteria	Failure Response	Performance Results	Associated FCRs and RCAs
Confirm response is not saturated	Evaluated for each cued measurement	Monitor for response clipping (identifiable as consecutive measurements of similar response [flat-line] for individual Tx/Rx pair data, typically above 800 milliVolts/Amps).	CA: Cued measurements exhibiting saturation will be classified as either "TOI," if the data indicates such despite saturation, or "inconclusive" if the data indicates non-TOI.	Achieved	
Confirm inversion model supports classification (1 of 3)	Evaluated for all models derived from a measurement (i.e. single item and multi- item models)	Derived model response must fit the observed data with a fit coherence $\geq$ 0.8.	CA: Target classified as inconclusive or recollected unless analyst can justify poor coherence (dynamic target looks like noise, pick on edge of anomaly, etc.).	Achieved	None

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3.8.5 Relevant Microsoft Access DB tables for AC include the following:

- 01a validation digs
- 01b single results
- 01b verification digs
- 01b single results Geosoft Oasis Montaj UX Analyze 9pt additions
- 02 reacquisition
- 03 intrusive results
- 04 intrusive GPS results
- AC training digs
- Anomaly table AC
- Background QC
- Background validation
- Cued IVS results
- Culebra MM2x2 Cluster results
- Culebra TEMTADS Cluster results
- Current Orientation GPS checklist
- Dataset
- Geodetic accuracy repeatability
- Grids
- Parsons Geosoft Oasis Montaj UX Analyze Version 9.2 additions
- QC QA tracking
- Sensor function test
- Training dig summary
- Validation target list

3.9 MUNITIONS AND EXPLOSIVES OF CONCERN IDENTIFICATION

3.9.1 Before fieldwork commenced, archival data regarding the individual types of expected MEC were made available to UXO technicians. This data included nomenclature, dimensions, general appearance, fillers, and any unique features useful in identifying items. When MEC were located, they were documented on the Team Leader Grid Sheet and photographed with a digital camera. Photographs of MEC are included in Appendix F.

3.10 GENERAL EQUIPMENT CALIBRATION/INSPECTION

3.10.1 Analog Geophysical Instruments

3.10.1.1 Analog geophysical instruments arrived on site in a ready state. The White's all-metals detectors and Schonstedt magnetometers were the primary instruments used during the investigation for anomaly avoidance, surface clearance, and mag and dig operations. The analog detectors were operationally tested daily to ensure the systems achieved the applicable MQOs in UFP-QAPP Worksheet 22.

3.10.2 Communication Equipment

3.10.2.1 On- and off-site communications equipment was checked daily to ensure that communications could be established with off-site responders. When on- or off-site communications could not be established, no intrusive work was performed until communications were re-established.

3.10.3 Vehicles and Machinery

3.10.3.1 Vehicles and machinery were used correctly per manufacturers' instructions and IAW AHAs.

3.10.4 Personal Protective Equipment

3.10.4.1 The UXOSO and UXOQCS were responsible for ensuring that each employee had appropriate personal protective equipment, as described in the APP/SSHP.

3.11 QUALITY CONTROL DOCUMENTATION

3.11.1 UXOQCS three-phase documentation has been appropriately filed and preserved. RCA-CA forms are included in Appendix H. The project DB, provided under separate cover with the SSFR, contains the results for all QC tests performed for the analog and digital geophysical systems during the intrusive investigation. Checklists for AC survey are also included in the project DB. RCA 15, 16, 17, and 19 (Appendix H) address recovery of coverage and blind detection seeds placed for the analog program. The Classification, Verification, and Validation reports submitted with the geophysical deliverable provide a summary of the relevant UFP-QAPP Worksheet 22 MQOs that were achieved for the intrusive investigation.

3.11.1 Materials Documented as Safe Inspection Forms

3.11.1.1 The SUXOS certified and the UXOQCS verified that MPPEH was free of explosive hazards. A DD Form 1348-1A was used as certification/verification documentation. To account for the transfer and release of MDAS, a chain of custody form accompanied shipments until disposition. All MDAS was managed, certified, and recycled according to procedures in the PWS. Copies of these forms are included in Appendix A.

3.11.2 Daily Quality Control Reports

3.11.2.1 DQCRs were maintained during field activities and documented field measurements, calibration and maintenance of field instruments, and QC management procedures. DQCRs are located in Appendix D2.

3.12 LESSONS LEARNED

3.12.1 Project lessons learned were captured during fieldwork. Lessons learned were developed with feedback from the staff and field crews who contributed to the execution of the project. The following summary highlights the lessons learned to improve future operations.

- **Public access and exclusion zone (EZ) control** - Public activity on Culebra beaches and tourist attractions requires competent security to maintain safe EZs. Security should be bilingual, professional, and easily identifiable for the public. Security personnel should also be instructed on how to interact with public to ensure safety is enforced and a positive public perception of the project is maintained. Depending on operations, 24-hour guards may be required.
- **DGM in dynamic environment** – Because of a lag between DGM survey and anomaly reacquire, anomalies could be covered by additional overburden or relocated because of surf action and storm surges. Additionally, public usage (foot traffic/metal detectors) could impact anomaly relocation. The duration between DGM survey and reacquisition/intrusive investigation should be reduced to the maximum extent practicable. DGM in dynamic environments may require secondary analog clearances to ensure project objectives are achieved.
- **Blind seeding in a dynamic environment** – In dynamic environments such as Culebra, there is a potential for seeds to be covered. Additionally, public usage (foot traffic/metal detectors) could impact blind seeding efforts. The duration between QC blind seeding and intrusive investigation should be reduced to the maximum extent practicable.
- **MEC and MPPEH Clearance in dynamic environment** – Hurricanes and storm surges significantly changed site conditions during the project. Due to the dynamic beach environment, the potential remains for the public to interact with relocated or exposed anomalies in the future. Beach erosion may expose deep anomalies that were not detectable during the TCRA. Resupply from storm surges may add new anomalies that were not present during the TCRA.
- **Root cause analysis/corrective action forms** – Appendix H contains RCA-CA forms for several issues encountered during the TCRA.

3.13 QUALITY CONTROL SUMMARY

3.13.1 In total, 242 grids passed a final UXOQCS inspection, and all blind seeded items that were not displaced by hurricane activities or storm surges were recovered by the UXO teams. A total of 19 grids were completed with AC and were monitored by the UXOQCS, but the UXOQCS was not the final inspection process for AC. Acceptance of the AC process was accomplished by the verification and validation process documented in the Verification Report and Validation Report (Appendix D6), respectively. Five grids failed UXOQCS inspection and are summarized below.

- Grid AN18, Seed 9681768 (RCA 15 Appendix H), a small ISO located in an analog-only area of the vegetated dunes in grid AN18 was recovered by the UXOQCS. The UXOQCS stated that the seed was located about 1.5 meters from a grounding rod that was left in place and was not detectable using a Schonstedt. A review of 5% QC DGM data submitted after the seed was recovered showed that the seed was detected as a separate anomaly from the adjacent grounding rod, though the grounding rod anomaly did have a wide influence and large response and nearly masked the seed. The dig teams used both Schonstedt and Whites all-metal detectors while clearing the grid, but failed to use the Whites to clear around the grounding rod.

- Grid AQ23, Seed 9681771 (RCA 15 Appendix H), a small ISO located in an analog-only area in the vegetated dunes in grid AQ23, was detected by the 5% QC DGM grid survey and intrusively recovered at the depth and orientation it was initially buried (0.20-m and horizontal).
- Grid AQ24, Seed 9681570 (RCA 15 Appendix H), a small ISO buried at 0.15-m in worst-case orientation and was not recovered by the analog dig teams.
- Grid AN22, Seed 9681552 (RCA 16 Appendix H), a small ISO located in an AC mag and dig polygon in grid AN22, was not recovered by the analog dig team. The UXOQCS successfully recovered the seed at the known location and verified the original depth and orientation. Although the seed item was located adjacent to relatively large anomalies, the UXOQCS was able to identify a response at the known location of the seed with an all-metals detector and Schonstedt.
- Grid AH11, Seed 9681589 (RCA 18 Appendix H), during analog clearance the dig team investigated a highly saturated area and recovered car parts and metal trash, but failed to recover a seed. Excavation of the trash pit resulted in a significant amount of soil being removed and relocated within the grid, which may have prevented the detection and recovery of the seed by the analog dig team. The seed location was included within the trash pit boundary as documented by the dig team. Although the seed should not have been buried adjacent to the saturated area per SOP DGM-02, the unrecovered seed was considered a failure by the dig team.

3.13.2 The grids that failed UXOQCS inspection were re-swept and subsequently passed final QC and QA inspection. Table 3.4 summarizes QC activities at the NWP.

Table 3.4
Quality Control Inspection Results

	Total Grids	Pass	Fail
QC Inspection	259	259*	5

* A total of 19 grids were completed with AC and were monitored by the UXOQCS, but the UXOQCS was not the final inspection process for AC. The QC Geophysicist conducted QC inspections on AC grids. All 259 passed either UXOQCS or QC geophysicist inspection.

3.13.3 Verification of the AC work depends on the ability of the process to correctly identify all non-TOI and that the results of the modeling reflect reality. Specifically, that:

- 100% of the modeled locations are less than or equal to 0.25m from recovered object positions (x, y, z);
- 100% of predicted size estimates qualitatively match the recovered object size; and
- 100% of the predicted non-TOI intrusively investigated are non-TOI.

3.13.4 Over 200 targets were dug with a lower ranking than the last confirmed TOI, which had a rank of 194. Numerous MQO failures were noted for offset between the predicted and recovered locations for sources. These MQO failures are considered explainable based on the

time between the collection of the cued data and the intrusive investigation and the dynamic conditions at the site, including hurricane impacts. RCAs 5, 10, and 21 detail the site-specific conditions considered responsible for the offsets and the corrective actions taken to remove the uncertainty posed by the offset results. No size comparison failures were noted for recovered TOI, and any discrepancies noted by the Data Analyst for non-TOI were re-checked by the dig team. None of the re-checks resulted in a source significantly different than the original result, and none of the discrepancies was considered serious enough to warrant any changes to the classification process.

3.13.5 The validation process assessed whether the Data Analyst was able to classify non-TOI correctly by comparing the Analyst's rationale for not selecting a source to the recovered objects. The Data Analyst provided their rational for not selecting 201 validation sources selected by the Project Delivery Team. The results from the intrusive investigation of the validation targets indicated no mismatches to the rationale provided by the Data Analyst. No additional TOI were identified through the verification or validation process; therefore, the AC process is considered verified and validated.

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4.0 QUALITY ASSURANCE ACTIVITIES AND RESULTS

4.0.1 Final QA inspections of MEC clearance operations were completed by the USACE Ordnance and Explosives Safety Specialist and/or the USACE QA Geophysicist. CEHNC Form 948s and QA acceptance forms can be found in Appendix D4. All 259 grids were accepted by CEHNC. Table 4.1 summarizes the QA activities for the TCRA.

4.0.2 Validation seeding was performed by the USACE QA Geophysicist in accordance with the Validation Seeding Plan. Forty-five (45) validation seeds were emplaced along Flamenco Beach and within Flamenco Campground. Fourteen of those seeds ended up in areas excluded from AGC and were discarded. All remaining validation seeds, except for two that were displaced due to the dynamic environment of Flamenco Beach and Campground, achieved relevant UFP-QAPP Worksheet 22 MQOs.

Table 4.1
Quality Assurance Inspection Results

	Total Grids	Pass	Fail
QA Inspection	259	259	0

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5.0 MUNITIONS CONSTITUENT DATA QUALITY EVALUATION

5.0.1 A data quality evaluation (DQE) was performed on the laboratory analytical data obtained during the TCRA performed on the NWP of Culebra Island. The objective of this task was to determine whether MEC detonation operations at the site resulted in a release of munition constituents that exceeded the project action levels (PALs), which were set at 100 times the EPA Regional Screening Levels (RSLs) (May 2016) for residential soil (hazard quotients equal to 0.1 for non-carcinogens).

5.0.2 These activities were conducted from October 4, 2016, through March 22, 2018, with sample collection occurring on February 13, 2018, and March 7, 2018. Seven soil samples and one field duplicate sample were collected from 0-6 inches bgs at MEC post-detonation locations. Samples were collected IAW the UFP-QAPP Worksheet 17B. The seven soil samples and field duplicate sample were included in two sample delivery groups (SDGs) and analyzed by Eurofins Lancaster Laboratories Environmental, LLC in Lancaster (Eurofins), Pennsylvania for explosives using SW-846 Method 8330B.

5.0.3 The data submitted by Eurofins has been reviewed and verified for compliance with the guidelines outlined in the Department of Defense Quality Systems Manual, Version 5.0, and the project-specific UFP-QAPP. A Stage 4 validation was performed IAW the project UFP-QAPP.

- The validator compared the performance of the QC elements presented in the laboratory analytical reports to the criteria presented in the UFP-QAPP to verify whether the project data quality indicators (DQIs) for precision, accuracy, and representativeness met acceptance requirements.
- The validator examined the laboratory signed chain-of-custody records and sample receiving documentation to verify sample receipt and condition. Data points associated with non-conformances were qualified IAW the UFP-QAPP.
- The validator compared the laboratory limit of detection (LOD) to ensure the UFP-QAPP was followed and the project-specific DQIs and DQOs were met.

5.0.4 Selected results were recalculated. The final validation reports were reviewed by a Senior Chemist and were provided with the SSFR.

5.1 RESULTS

5.1.1 The explosives data were reviewed and found to be in general compliance with the UFP-QAPP and good analytical practices. All explosive results were non-detect down to the laboratory detection limit (DL). However, qualification of an individual explosive data point was necessary. A low percent recovery (%R) in the matrix spike (MS) and matrix spike duplicate (MSD) for tetryl may demonstrate a low bias in the parent sample result. The tetryl result in sample NWP-TCRA-CPST-021318-003 was qualified UJ (non-detect) by the validator due to the associated QC discrepancies. Table 5.1 presents the sampling results from the February and March 2018 events.

5.1.2 The following QC elements were outside of the acceptance criteria, but no qualification was necessary. A summary of the details follows and additional details are included in the data validation reports that will be provided to CEHNC with the SSFR.

- The %R in the laboratory control sample (LCS) ID 1805100008A was above the acceptance criteria for 4-amino-2,6-dinitrotoluene, which demonstrated a high bias. However, 4-amino-2,6-dinitrotoluene was not detected in any samples and no qualification was necessary.
- The MS/MSD %R was high for 4-amino-2,6-dinitrotoluene, but the analyte was non-detect in the parent sample NWP-TCRA-CPST-021318-003 and no qualification was necessary.
- The relative percent difference (RPD) was high for 2-amino-4,6-dinitrotoluene and tetryl in the MS/MSD for NWP-TCRA-CPST-021318-003; however, since the parent sample results were non-detect for these compounds, no qualification was necessary.

5.1.3 Per the UFP-QAPP, based on these results, there are no immediate risks due to MEC post-detonation contamination, and no further action is needed.

5.2 MUNITIONS CONSTITUENTS DATA USABILITY ASSESSMENT

5.2.1 All MEC post-detonation data generated during the February and March 2018 sampling events were in compliance with the requirements of the project UFP-QAPP. Below is a summary of the usability of the data.

- All of the eight scheduled surface soil samples were collected and had usable data; therefore, the sample collection completeness is calculated to be 100%.
- Comparability was achieved by using standard methods for sampling and analysis, reporting data in standard units, and using standard reporting formats.
- Despite the accuracy and precision issues indicated by the LCS and MS/MSD results, the DQIs have been met, and all data are useable with no limitations of use.
- A total of 128 data points were generated by the analysis of seven environmental samples and one field duplicate sample collected during the February and March 2018 sampling events. Overall project completeness of the explosives results was 100%.

Table 5.1
Validated Data Summary for Soil Samples Collected

SAMPLE ID: / DATE SAMPLED:		PROJECT ACTION LIMIT	LANL ESV (µg/kg)	NWP-TCRA-CPST-021318-001 02/13/2018		NWP-TCRA-CPST-021318-002 02/13/2018		NWP-TCRA-CPST-021318-004 02/13/2018		NWP-TCRA-CPST-021318-003 02/13/2018		NWP-TCRA-CPST-030718-005 03/07/2018		NWP-TCRA-CPST-030718-006 03/07/2018		NWP-TCRA-CPST-030718-007 03/07/2018		NWP-TCRA-CPST-030718-008 03/07/2018	
LAB SAMPLE ID:				9459698		9459699		9459703		9459700		9496533		9496534		9496535		9496536	
SAMPLE TYPE:				Normal		Normal		Field Duplicate		Normal		Normal		Normal		Normal		Normal	
Explosives - SW8330B	**Unit**																		
1,3,5-Trinitrobenzene	µg/kg	22,000,000	10,000	85	U	88	U	85	U	85	U	84	U	86	U	80	U	82	U
1,3-Dinitrobenzene	µg/kg	63,000	73	85	U	88	U	85	U	85	U	84	U	86	U	80	U	82	U
2,4,6-Trinitrotoluene (TNT)	µg/kg	360,000	7,600	95	U	99	U	96	U	95	U	210	U	210	U	200	U	200	U
2,4-Dinitrotoluene	µg/kg	170,000	290	85	U	88	U	85	U	85	U	84	U	86	U	80	U	82	U
2,6-Dinitrotoluene	µg/kg	36,000	4,100	240	U	250	U	250	U	240	U	160	U	160	U	150	U	150	U
2-Amino-4,6-dinitrotoluene	µg/kg	1,500,000	14,000	87	U	90	U	88	U	87	U	210	U	210	U	200	U	200	U
2-Nitrotoluene	µg/kg	320,000	9,900	160	U	160	U	160	U	160	U	160	U	160	U	150	U	150	U
3-Nitrotoluene	µg/kg	63,000	12,000	230	U	240	U	230	U	230	U	160	U	160	U	150	U	150	U
4-Amino-2,6-dinitrotoluene	µg/kg	1,500,000	12,000	87	U	90	U	88	U	87	U	84	U	86	U	80	U	82	U
4-Nitrotoluene	µg/kg	2,500,000	22,000	230	U	240	U	230	U	230	U	160	U	160	U	150	U	150	U
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	µg/kg	610,000	2,300	85	U	88	U	85	U	85	U	110	U	110	U	100	U	100	U
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	µg/kg	1,600,000	1,500	210	U	220	U	210	U	210	UJ	160	U	160	U	150	U	150	U
Nitrobenzene	µg/kg	510,000	2,200	210	U	220	U	210	U	210	U	84	U	86	U	80	U	82	U
Nitroglycerin	µg/kg	63,000	13,000	2,300	U	2,400	U	2,300	U	2,300	U	2,100	U	2,100	U	2,000	U	2,100	U
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	µg/kg	39,000,000	16,000	460	U	470	U	460	U	460	U	160	U	160	U	150	U	150	U
Pentaerythritol Tetranitrate (PETN)	µg/kg	1,300,000	100,000	2,300	U	2,400	U	2,300	U	2,300	U	2,100	U	2,100	U	2,000	U	2,100	U

µg/kg – micrograms per kilogram
LANL ESV – Los Alamos National Laboratory EcoRisk Database v.3.3, 2015

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6.0 EXPOSURE DATA

6.0.1 All MMRP-related tasks associated with Contract No. W912DY-10-D-0023, Task Order No. 0022 were completed. All phases of work passed QA inspection and were accepted by the U.S. Government. All MPPEH were inspected, certified, documented as safe, and removed from the prescribed areas as required in the PWS. Table 6.1 summarizes site-specific exposure data, as reported in monthly progress reports.

Table 6.1
Exposure Data Report

Cumulative Hours Worked*	Lost Workday Accidents	Cumulative Lost Workday Accidents	Lost Workdays Due to On-the-Job Accidents	Cumulative Lost Workdays Due to On-the-Job Accidents	Property Damage Accidents with Property Loss Value $2,000 or Greater
49,288	0	0	0	0	0

*Includes subcontractor exposure hours

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