Final Remedial Investigation Report

Culebra Island Site Puerto Rico

Underwater Acres of:

Soldado Point Mortar and Bombing Area (MRS 09) –
Project Number I02PR006809

Cayo Luis Peña Impact Area (MRS 13) –
Project Number I02PR006813

Prepared for:

U.S. Army Engineering & Support Center, Huntsville
and
U.S. Army Corps of Engineers, Jacksonville District

Contract No. W912DY-04-D-0006
Task Order No. 0022
Property No. I02PR006800
Geographical District: Jacksonville

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FINAL

June 2016

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SUMMARY PAGE

Project Title:	Remedial Investigation/Feasibility Study, Culebra Island Site Puerto Rico. Underwater Acres of: MRS 09 – Soldado Point Mortar and Bombing Area; MRS 13 – Cayo Luis Peña Impact Area
FUDS Property/Project No.:	I02PR0068
Client Name:	U.S. Army Engineering and Support Center, Huntsville (USAESCH) and U.S. Army Corps of Engineers, Jacksonville District
Contract Name:	Remedial Investigation/Feasibility Study, Culebra Island Site Puerto Rico. Revision 8 Mod 7
Contract Number:	W912DY-04-D-0006; Task Order No. 0022
Contractor:	USA Environmental, Inc.
Task Order Period:	12 April 2012 – 30 December 2016
Date of Original:	28 August 2014
Date of Final:	24 June 2016

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REMEDIAL INVESTIGATION REPORT

Final Remedial Investigation Report, Culebra Island Site Puerto Rico. Underwater Acres of: MRS 09 – Soldado Point Mortar and Bombing Area; MRS 13 – Cayo Luis Peña Impact Area

Report Approval:

This report is accurate and complies with contractual requirements and accurately represents work completed.

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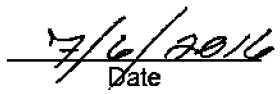

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LIST OF ACRONYMS

°F	Degree Fahrenheit
amsl	above mean sea level
APPL	Agriculture and Priority Pollutants Laboratory, Inc.
AR	Army Regulation
ARARs	Applicable or Relevant and Appropriate Requirements
ASI	Aqua Survey, Inc.
ASR	Archives Search Report
ATSDR	Agency for Toxic Substances and Disease Registry
bgs	below ground surface
BTAG	Biological Technical Assistance Group
BTV	Background Threshold Value
C&T	Curtis & Tompkins, Inc.
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CESAJ	U.S. Army Corps of Engineers, Jacksonville District
CFR	Code of Federal Regulation
CHE	Chemical Warfare Materiel Hazard Evaluation
cm	centimeter, centimeters
CMUA	Concentrated Munitions Use Area
COC	Chemicals of concern
COPC	Chemical of Potential Concern
CSEM	Conceptual Site Exposure Model
CWM	Chemical Warfare Materiel
CX	Center of Expertise
DA	Department of the Army
DD	Decision Document
DDC	District Diving Coordinator
DDESB	Department of Defense Explosives Safety Board
DERP	Defense Environmental Restoration Program
DGM	Digital Geophysical Mapping
DGPS	Differential Global Positioning System
DHHS	Department of Health and Human Services
DMM	Discarded Military Munition
DoD	Department of Defense
DON	Department of the Navy
DOT	Department of Transportation
DQO	Data Quality Objective
DVR	Data Validation Report
EBS	Environmental Baseline Survey
EE/CA	Engineering Evaluation/Cost Analysis
EHE	Explosive Hazard Evaluation
ELAP	Environmental Laboratory Accreditation Program

EM	Electromagnetic; Engineer Manual
EP	Engineer Pamphlet
EPA	Environmental Protection Agency
EPC	Exposure Point Concentration
ESA	Endangered Species Act
ESV	Ecological Screening Value
FCR	Field Change Request
FDEP	Florida Department of Environmental Protection
FLEX	Fleet Landing Exercise
FS	Feasibility Study
ft	feet
FUDS	Formerly Used Defense Site
FY	Fiscal Year
GIS	Geographical Information System
GPS	Global Positioning System
GSV	Geophysical System Verification
HA	Hazard Assessment
HE	High Explosive
HHE	Health Hazard Evaluation
HI	Hazard Index
HQ	Hazard Quotient
HTRW	Hazardous, Toxic, and Radioactive Waste
IAW	In Accordance With
ICAL	initial calibration curve
INPR	Inventory Project Report
IRIS	Integrated Risk Information System
ISO	Industry Standard Object
IVS	Instrument Verification Strip
kg	kilogram
LANL	Los Alamos National Laboratory
lb	pound, pounds
LOAEL	lowest observed-adverse-effect level
LOD	Limit of Detection
LOQ	Limit of Quantitation
LUC	Land Use Control
LUU-2	Illumination Unit, Unit 2
MC	Munitions Constituent
MD	Munitions Debris
MDAS	Material Documented as Safe
MEC	Munitions and Explosives of Concern
mg	milligram
mm	millimeter
MMPA	Marine Mammal Protection Act

MMRP	Military Munitions Response Program
MPPEH	Material Potentially Presenting an Explosive Hazard
MQO	Measurement Quality Objective
MRS	Munitions Response Site
MRSPP	Munitions Response Site Prioritization Protocol
MS	matrix spike
MSD	matrix spike duplicate
mV	millivolt
NA	Not Available
NCP	National Contingency Plan; National Oil and Hazardous Substances Pollution Contingency Plan
NHA	National Heritage Areas
NHL	National Historic Landmarks
NIOSH	National Institute for Occupational Safety and Health
NMFS	National Marine Fishery Service
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no-observed-adverse-effect level
NOTMAR	Notice to Mariners
NPS	National Park Service
NRIS	National Register Information System
NTCRA	Non-Time Critical Removal Action
NWP	Northwest Peninsula
OE	Ordnance and Explosives
OSHA	Occupational Safety and Health Administration
PD	Point Detonating
PDT	Project Development Team
PETN	Pentaerythritol Tetranitrate
ppm	part per million
PRDNER	Puerto Rico Department of Natural and Environmental Resources
PREQB	Puerto Rico Environmental Quality Board
PSV	Preliminary Screening Value
QA	Quality Assurance
QC	Quality Control
RA	Risk Assessment
RAGS	Risk Assessment Guidance for Superfund
RfD	Reference Dose
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
ROV	Remotely Operated Vehicle
RSL	Regional Screening Level
RTI	Research Triangle Institute
RTK	Real Time Kinematic
SAP	Sampling and Analysis Plan

SARA	Superfund Amendments and Reauthorization Act
SCUBA	Self-Contained Underwater Breathing Apparatus
SERCC	Southeast Regional Climate Center
SHPO	Site Historic Preservation Office
SI	Site Inspection
SLRA	Screening level risk assessment
SOP	Standard Operating Procedure
SSS	Side Scan Sonar
SUXOS	Senior Unexploded Ordnance Supervisor
TBC	To Be Considered
TM	Technical Manual
TNT	Trinitrotoluene
TP	Technical Paper
TPP	Technical Project Planning
U.S.	United States
UFP-QAPP	Uniform Federal Policy – Quality Assurance Project Plan
USA	USA Environmental, Inc.
USACE	U.S. Army Corps of Engineers
USAESCH	U.S. Army Engineering and Support Center, Huntsville
USBL	Ultra-short baseline
USCB	U.S. Census Bureau
USCG	U. S. Coast Guard
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UTL	Upper Tolerance Limit
UTM	Universal Transverse Mercator
UXO	Unexploded Ordnance
UXOQCS	Unexploded Ordnance Quality Control Specialist
UXOQCS/SO	Unexploded Ordnance Quality Control Specialist/Unexploded Ordnance Safety Officer
UXOSO	Unexploded Ordnance Safety Officer
VSP	Visual Sample Plan
WERS	Worldwide Environmental Remediation Services
WP	Work Plan

EXECUTIVE SUMMARY

ES.1 INTRODUCTION

A Remedial Investigation (RI) is used to determine the nature (what) and extent (where) of munitions-related contamination at Munitions Response Sites (MRSs) in order to evaluate the need for remedial actions and to evaluate remedial alternatives as part of a Feasibility Study (FS). This RI Report explains how the investigation of the water acres was conducted and what was found for the following MRSs:

- Soldado Point Mortar and Bombing Area (MRS 09) – Project Number I02PR006809
- Cayo Luis Peña Impact Area (MRS 13) – Project Number I02PR006813.

The conclusions and recommendations within this report apply only to the underwater portions of MRS 09 and MRS 13. The FS Report evaluates methods for addressing the hazards identified in this RI Report and is provided in a separate document.

ES.2 SITE HISTORY

ES.2.1 The United States (U.S.) government began acquiring property in Culebra beginning in 1903. The Navy's use of Culebra, Culebrita, and other cayos that surround Culebra included an airport, coaling station, and bombing and gunnery ranges. The Marine Corps also used Culebra for maneuvers and ordnance training, and at one point, other than the property within the town of Dewey, Culebra, the Marine Corps leased most of the private property in Culebra.

ES.2.2 The following is a brief history of the Department of Defense (DoD) training and exercises that included the use of military munitions on Soldado Point Mortar and Bombing Area and the Cayo Luis Peña Impact Areas.

ES.2.2.1 Soldado Point Mortar and Bombing Area (MRS 09) was reportedly used as a small arms firing range, a mortar firing point, and a bombing target area. Bombing targets are suspected to have been located inside Sueño Cove and in the bay that lies northwest of Soldado Point. Historical documents identified the site as having been used by the Marine Corps for aerial bombardment and mortars fired from boats to shore targets during their various training exercises on Culebra [Supplemental Archives Search Report (ASR) Culebra Puerto Rico, USACE, 2005].

- Fleet Landing Exercise (FLEX) No. 2 was conducted in January 1936. One purpose of this exercise was to determine the effectiveness of fire of certain weapons as anti-boat guns when firing upon an advancing boat. An exercise report indicated that 30-pound and 1000-pound bombs were dropped from aircraft on waterborne targets near Soldado Point.
- Special aviation dive bombing was carried out during FLEX #2 on the beach in the bay northwest of Soldado Point. The bombing was done with 30- and 100-pound fragmentation bombs against silhouette targets and improvised weapons.
- FLEX No. 4 was conducted in January 1938 and it is reported that boat gun practice was conducted at targets on Stream Point, and on the beach near Soldado Point using .50 caliber machine guns and 81mm mortar fired with practice and high explosive (HE) shells.

ES.2.2.2 Cayo Luis Peña Impact Area (MRS 13), also referred to as South West Cay, was used as a target and training area and is also adjacent to Cayo Del Agua, Mono Cay, and Northwest Peninsula (NWP) bombardment areas and Naval Gunfire Targets. Unlike the case for MRS 09, no waterborne targets were identified for Cayo Luis Peña. The following list describes training events that identified Cayo Luis Peña, or training areas within the vicinity of Cayo Luis Peña, as objectives or targets (Supplemental ASR Culebra Puerto Rico, USACE, 2005).

- January 1924 – 75mm and 155 mm rounds (munition type not specified) were fired at the northern portion of South West Cay.

- February 1924 – Companies and battalions of the Expeditionary Force conducted firing problems from a position at Firewood Bay (Tamarindo Bay) using Mono Cay and designated portions of South West Cay as targets; munitions used were 75mm guns, and 155mm guns.
- May 1934 – FLEX XV included a marine landing on Cayo Luis Peña. The munitions used during the exercise included 30 caliber machine guns, 3 inch anti-aircraft guns, 6 inch gun batteries, 75mm gun batteries, and 6 inch Naval guns.
- February 1935 – FLEX No. 1 included an exercise scenario to eliminate insurgents in the NWP; Naval gunfire support for the scenario included 12 inch gun firing Armor Piercing projectiles, 5 inch gun firing Flat Nose and common projectiles, 6 inch gun firing flat nose projectiles, and 4 inch gun firing 4 inch projectiles.
- February 1941 – FLEX No. 7 included exercises in Culebra and Vieques. A scenario that was conducted within the vicinity of MRS 13 included the use of 5 inch anti-aircraft common projectiles, 6 inch flat nose projectiles firing from cruisers at beach targets to support landings at Seine Bay and, Firewood Bay (currently referred to as Tamarind Bay).

ES.3 PREVIOUS INVESTIGATIONS

ES.3.1 Site Inspection

Parsons completed a Site Inspection (SI) in 2007; the Culebra Island MRS was evaluated for Munitions and Explosives of Concern (MEC) and Munitions Constituents (MC). The MRSs included in the SI were established in the revised Inventory Project Report (INPR) that was completed in June 2005 [U.S. Army Corps of Engineers (USACE), 2005]. The Revised INPR further defined the military use of the Island of Culebra and divided the original site, Property No. I02PR0068, into 14 separate MRSs. Of the 14 MRSs identified in the Revised INPR, the following six MRSs were included for further evaluation under Contract W912DY-04-D-0006, Task Order No. 0022, Remedial Investigation/Feasibility Study (RI/FS) at the Culebra Island Site, Puerto Rico, IO2PR0068, 10 June 2009:

- MRS 06 – Artillery Firing Area (Terrestrial)
- MRS 08 – Cayo Norte Impact Area (Terrestrial)
- MRS 09 – Soldado Point Mortar and Bombing Area (Terrestrial/Water)
- MRS 10 – Defensive Firing Area No. 1 (Terrestrial)
- MRS 11 – Defensive Firing Area No. 2 (Terrestrial)
- MRS 13 – Cayo Luis Peña Impact Area (Terrestrial/Water).

The SI recommended conducting a RI/FS for all six MRSs.

ES.3.2 Terrestrial RI

Following the completion of the SI, MRS 13 – Cayo Luis Peña Impact Area and MRS 09 – Soldado Point Mortar and Bombing Area were included in a terrestrial RI/FS. In addition to conducting Terrestrial RI surveys and intrusive investigations for both MRS 09 and MRS 13, a limited number of underwater visual transects were conducted using a towed underwater camera and underwater remotely operated vehicle (ROV) with a high resolution video camera. These were visual transects only; the reconnaissance of suspected MEC discovered in MRS 13 during this investigation was not performed (these suspected MEC items were later identified as expended illumination projectiles) and underwater geophysical surveys with intrusive investigations were not planned to be conducted for either site during this effort. The Terrestrial RI Report did not provide any conclusions for the underwater visual transects but the visual survey results were presented in that same RI Report. The underwater investigations for MRS 09 and MRS 13 were deferred in a separate contract modification to the Task Order (Culebra MRS 09 and MRS 13 Underwater RI/FS Investigation). The findings for the Terrestrial RI/FS are presented below.

ES.3.2.1 MRS 09 – Soldado Point Mortar and Bombing Area

Two unexploded ordnance (UXO) items (MK 25 Marine Markers) were recovered from MRS 09 but were considered incidental to the site. MK 25 Marine Markers are used by DoD and non-DoD entities (such as cruise liners) for exercises, emergency action drills, or training events. The Marine Markers are thrown into the water by hand and then initiated by saltwater-activated batteries. The Marine Markers then smoke for 15 minutes, providing a visual mark for the location in which the MK 25 Marine Markers were deployed. Once the MK 25 Marine Marker has expended its smoke payload it eventually sinks to the ocean floor. The MK 25 Marine Marker can travel with currents and seas along the bottom for significant distances from where they were originally deployed to wash up on beaches/shores or eventually rest on the sea floor.

ES.3.2.1.1 Historical data provided in the Culebra ASR (USACE 1995) and Culebra ASR Supplement (USACE, 2005) for MRS 09 indicate former U.S. Marine Corps activities involving the use of 4.2-in. mortars and possible aerial bombing and strafing during military training and exercises. Eight Munitions Debris (MD) items were recovered from four land grids, indicating the possible use of some munitions on the land acres of MRS 09 to include the 4.2-inch HE mortar, given evidence of a remnant of a functioned M9 point detonating (PD) fuze. In addition, some of the fragments that were discovered may have been from 3 inch projectiles. However, no evidence of HE aerial bombs was discovered in MRS 09.

ES.3.2.1.2 There were no exceedances of ecological screening values identified in surface soil or surface water; however, aluminum and copper were detected in sediment at a concentration greater than the ecological screening value in a small pond inland of the MRS during the terrestrial RI.

ES.3.2.1.3 There were no exceedances of Human Health screening values, and therefore no unacceptable risks were identified to human health from exposure to surface soil, surface water, or sediment at MRS 09.

ES.3.2.2 MRS 13 – Cayo Luis Peña Impact Area

ES.3.2.2.1 During the post-award site visit, MD items [105 mm (HE and illumination); 5- and 3-inch projectiles; flares; and fuzes] were noted at 112 locations on MRS 13. During the subsequent RI field work, multiple MD items were recovered on MRS 13 including a BDU 33, empty 5-inch illumination projectile, and MD fragments. Based on historical documentation and the RI findings, an explosive hazard is present in the terrestrial portions of the MRS. The potential for human exposure to MEC in MRS 13 exists due to the recreational users that frequent the beach areas.

ES.3.2.2.2 There were no exceedances of MC screening values in the soil samples collected in MRS 13 during the Terrestrial RI.

ES.3.2.3 An underwater component for MRS 09 and MRS 13 was identified as an additional requirement following the start of the planning phase for the terrestrial RI for MRSs 06, 08, 09, 10, 11, and 13. A contract modification was added to the existing contract award to include the waters surrounding MRS 09 and 13. This additional requirement objective was to obtain acceptance of a Decision Document (DD) for both the land and the underwater portions of MRS 09 and MRS 13. The underwater task order includes an underwater RI Report, an FS, and all necessary activities required to accomplish this objective.

ES.4 UNDERWATER RI

The underwater RI for MRS 09 and 13 was completed during three phases of work:

- Phase 1: Environmental Baseline Survey (EBS) which produced the EBS Report Underwater Portions of MRSs 09 and 13 Culebra, Puerto Rico (USA 2014). The Phase 1 fieldwork, was completed in October 2013. USA Environmental Inc. (USA) developed a two-stage approach (Phase 1A and Phase 1B) for collecting data necessary to delineate the benthic habitats present within the RI areas, with the goal of utilizing the data to plan subsequent RI fieldwork.
  - Phase 1A included the hydrographic surveys using Side Scan Sonar (SSS) and multi beam bathymetry systems for the underwater acres of MRS 09 and MRS 13. After hydrographic data was collected, an analysis was performed to compare the location of the initial idealized RI transects (underwater geophysical survey lines) against the benthic terrain (i.e., coral

structures and sand beds) detailed by the SSS and multi-beam bathymetry data. Analysis of the hydrographic data was essential for selecting an appropriate platform for deploying geophysical equipment along the RI transects close to or on the sea floor surface during Phase 2.

  - Phase 1B documented the actual area where the RI activities would take place. In order to ground truth the hydrographic data (Phase 1A) USA deployed a vessel-based underwater camera system along the re-aligned RI transects to collect video footage. Given that the objective of the EBS is to document the benthic habitat where RI activities were planned, video was collected only along the re-aligned transects and in select areas of interest. The intent of this stage of Phase 1 was not to perform an in-depth biological study; rather, it was to document the actual area where the RI activities would take place. The results of Phase 1 was used for decision making purposes during the Technical Project Planning (TPP) meetings and in the development of the subsequent work plans for Phases 2 and 3.

- Phase 2: Underwater Geophysical Survey, Phase 2 field activities consisted of performing geophysical surveys along the RI transects realigned during Phase 1 to collect electromagnetic (EM) and analog anomaly data.
- Phase 3: Underwater Intrusive Investigations.

Phases 2 and 3 were performed concurrently, with a mobilization date of February 12, 2014 and demobilizations of March 23, 2014 for Phase 2 and April 26, 2014 for Phase 3.

ES.4.1 MEC Investigation

The RI field team, under the supervision of the Site Geophysicist, installed a shallow underwater Instrument Verification Strip (IVS) and a deep water IVS following the IVS design outlined in the Work Plan. The two IVSs were designed for the different types of underwater EM platforms that would be used during the Digital Geophysical Mapping (DGM) survey. The field team installed small and medium industry standard objects (ISOs) in the IVSs. The DGM sensors were then processed through the IVS which resulted in the development of the Geophysical System Verification (GSV) Report (see Appendix E: Geophysical Results), which was finalized and accepted on March 21, 2014. Based on the GSV Report, the DGM targets were classified into three priority levels (Priority 1, 2, and 3) based on the channel 2 responses.

The underwater intrusive teams investigated 100% of the Priority 1 anomalies, 50% of the Priority 2 anomalies, and 20% of the Priority 3 anomalies, as recommended in the GSV report (refer to Table ES-1). In the selection of Priority 2 and 3 anomalies, the Project Geophysicist made recommendations for anomaly selection. Some revisions of those recommendations were made on site by the Project Manager, taking into account (1) areas of each MRS where munitions use had been documented, (2) areas that receive heavy use by tourists and the community, (3) restrictive sea state conditions, or (4) other cultural or natural resource interferences (i.e., considerations for anomalies within critical habitat and anomalies that may cause the closing and evacuation of recreational areas).

Table ES-1: DGM Anomalies

MRS 09	DGM Targets	DGM Targets Investigated	% Investigated
Priority 1	11	11	100
Priority 2	17	12	71
Priority 3	23	7	30
Totals	51	30	59
MRS 13	**DGM Targets**	**DGM Targets Investigated**	**% Investigated**
Priority 1	83	83	100
Priority 2	77	40	52
Priority 3	226	47	21
Totals	386	170	44

ES.4.1.1 MRS 09 MEC Findings

No MEC or MD was discovered in MRS 09 water acres during the underwater RI; all anomalies investigated were identified as cultural debris. Field activities were conducted during the same project field work cycle as MRS 13. During the geophysical surveys, 51 anomalies were identified and 30 anomalies were selected for investigation by "priority," following the strategy outlined in the GSV Report. The DGM anomalies identified as cultural debris were initially recovered per the work plan; however, as the field work moved into predominantly turtle seagrass areas, it was determined that by leaving the cultural debris in place damage to the seagrass beds could be avoided. Cultural debris ranged in size from corrugated steel roofing sections to smaller items such as beer cans and bottle caps. Security to maintain exclusion zones was provided by the Culebra Mayor's Office. Only beaches affected by the intrusive operations conducted during that day were closed, allowing the remaining camp sites and beaches to be used by the public. Coordination meetings with the Mayor's office were conducted on a weekly basis to provide awareness of the RI progress and to anticipate possible impacts to the public.

ES.4.1.2. MRS 13 MEC Findings

No MEC was discovered in MRS 13 water acres during the underwater RI. During the geophysical surveys, 386 anomalies were identified and 170 were investigated, following the strategy outlined in the GSV Report. Security to maintain the exclusion zones was provided by the San Juan Police Department. MD was observed primarily in the northern half of MRS 13 (two MD items were discovered in the south eastern side of MRS 13 but the discovery did not indicate a target area or an area of concentrated munitions). The MD was in the form of expended Navy 5-inch illumination projectiles (102 ea), expended Aircraft Parachute MK 24 Mod 2 Flares (originally reported as Illumination Unit, Unit 2 (LUU 2) parachute flare bodies (4 each); one expended MK 25 Marine Marker; the pusher plates that separate the illumination candle (which is the payload for the illumination projectiles) from the expelling charge; and remnants of the projectiles nose fuze. The MD was inspected for corals prior to removal and the findings and proposed removal action for each MD item were provided to the natural resource agencies for evaluation. The MD that was approved by the National Marine Fishery Service (NMFS), the U.S. Fish and Wildlife Service (USFWS), and the Puerto Rico Department of Natural and Environmental Resources (PRDNER) for removal was collected and disposed of. MD items that did not have corals attached and were not affixed to the reef substructure were removed upon discovery or if identified for marine sediment sampling removed following the collection of the marine sediment sample. MD items were left in place if so recommended by the Natural Resource Agencies or if damage to the reef substructure was anticipated during removal (for additional information refer to Section

3.1.6.11). Field teams collected 1,964 lb of MD certified as Material Documented as Safe (MDAS), which was shipped for disposal. Smelting of the MDAS was completed on 6 June 2014. MD was also observed on MRS 13 during the Terrestrial RI which included 105mm projectiles (1-HE, 1-illumination, 4-unidentified), 5-inch projectiles (31 items), 3-inch projectiles (3 items), flares (8 items), fuzes, and other MD pieces. The greatest concentration of MD for the Terrestrial RI resides in the northern half of MRS 13. The significant quantity of expended illumination projectiles in the Northern half (273.3 acres) of the underwater acres of MRS 13 indicate illumination type munitions (projectiles and flares) were used during DoD training and exercises. Two expended 50 caliber cartridges were also discovered on the western side of MRS 13. There were no other indicators of DoD use discovered in the underwater acres of MRS 13.

ES.4.1.3 Qualitative MEC Hazard Assessment

The U.S. Environmental Protection Agency (USEPA) MEC Hazard Assessment (HA) was not used for this project since it is not designed for underwater use. A qualitative assessment of the hazard is provided in Section 6.5 and a summary is provided below.

ES.4.1.3.1 No MEC or MD was discovered within the water boundaries of MRS 09 during the RI field work. Historical research indicates that possible target areas may have been located inside Sueño Cove and the bay that lies west of Soldado Point. During the underwater field investigation there were no indicators of DoD activity and no discovery suggesting a possible target area. MRS 09 water acres provide recreational opportunities for the local population and the tourists visiting Culebra in the form of swimming, Self-Contained Underwater Breathing Apparatus (SCUBA) diving, boating, and fishing. The shallow reefs that serve as breakwaters for wind waves and swells attracts boaters seeking safe anchorages. Species that are listed as threatened or endangered are present or have the potential to occur in this area.

ES.4.1.3.1.1 Human and ecological receptors are present; however, since there was no MEC/MD discovered, and due to the lack of discovered evidence of DoD munitions use of the underwater acres, there is no source for MEC; the MEC exposure pathway is incomplete and MEC does not pose a potential hazard to human health.

ES.4.1.3.1.2 Human receptors that may be present in MRS 09 consist of Residents, Commercial or Industrial Workers, Site Visitors/Recreational Users and Trespassers.

ES.4.1.3.1.3 Ecological Receptors that are present in MRS 09 consist of Coral (which includes corals, sponges, and algae), fish and invertebrates, sea turtles, marine mammals and the Antillean Manatee. Within the revised Conceptual Site Exposure Model (CSEM), these ecological receptors have been separated by how exposure to MEC/MC is most likely to occur.

ES.4.1.3.2 No MEC was discovered within the water boundaries of MRS 13; however, the discovery of MD and the type of MD discovered (expended 5 inch illumination projectiles) indicates the possibility of MEC being present in the form of 5 inch illumination projectiles that had not functioned as designed. 5 inch Illumination (Expended) MK 45 Mod 0 Projectiles, and 5 inch Illumination (Expended) MK 48 Mod 0 Projectiles were discovered along with expended Aircraft Parachute MK 24 Mod 2 Flares in the northern half of MRS 13. MEC in the form of illumination projectiles or flares that did not function as designed and retained their full or partial payload may exist within MRS 13; however, none were discovered. Remnants of "mechanical time" nose fuze were discovered within the MRS water boundaries and on the expended 5 inch projectiles. "Mechanical time" fuzes were used as the primary means of initiating the black powder expelling charge and expelling the projectile's payload over the target to be illuminated. A "mechanical time" fuze presents a possible hazard of accidental initiation of a projectile that did not function as designed and the projectile's payload is present. If the fuze or munition is jarred or dropped, or receives an impact/shock, it may allow for the fuze to complete its firing sequence, initiating the black powder expelling charge and ejecting and initiating the illumination candles.

ES.4.1.3.3 Two MD items were discovered in MRS 13 southern half that are considered incidental to the site and are not an indication of the potential presence of a concentrated munitions use areas (CMUA) (see Section ES 5.5). Though there were some Priority 3-only, higher density areas uninvestigated in MRS13 southern half, all of those higher density areas were too small to be considered as CMUAs.

ES.4.1.3.4 MRS 13 water acres provide a waterborne recreation area for the local population and the tourists visiting Culebra in the form of swimming, SCUBA diving, boating, and fishing. There are several mooring areas in which boats can tie up. In the northern bay near shore area of MRS 13, residents and visitors frequent the beaches by anchoring either close to the beaches or off shore and then dinghy to the beaches. There are no residential properties or businesses on Cayo Luis Peña. Residential and business properties exist within 4,000 ft of the MRS boundary on the main island of Culebra.

ES.4.1.3.5 Human receptors that may be present in MRS 13 consist of Commercial or Industrial Workers, Site Visitors/Recreational Users, and Trespassers. Residents as receptors were evaluated for MC as a worst case; however, Residents are not present within the MRS.

ES.4.1.3.6 Ecological receptors that are present in MRS 13 consist of coral (which includes corals, sponges, and algae), fish and invertebrates, sea turtles, marine mammals, and Antillean Manatees. Within the revised CSEM these ecological receptors have been separated by how exposure to MEC/MC is most likely to occur.

ES.4.1.3.7 MRS 13 discoveries of MD and the potential for MEC within the northern half of the MRS exists and human receptors are present; therefore, the MEC exposure pathway is complete and there is a potential for human health hazards due to MEC.

ES.4.1.3. 8 Listed as threatened or endangered species are present or have the potential to occur within the underwater MRS boundary. Ecological receptors are present; therefore, the MEC exposure pathway is complete.

ES.4.1.3.9 There is no historical evidence of DoD targets having been located or the discovery of MEC within the water boundaries of the southern half of MRS 13. Human and ecological receptors are present; however, since there was no MEC and only two MD items discovered and, because of the lack of evidence of DoD use of the underwater acres for munitions training, there is no source for MEC; the MEC exposure pathway is incomplete and MEC does not pose a potential hazard to human health in the southern half of MRS 13.

ES.4.1.4 Munitions Constituents Investigation and Risk Assessment

ES.4.1.4.1 The MC sampling and risk assessment was conducted in accordance with (IAW) the approved RI Work Plan (WP), Sampling and Analysis Plan (SAP), and the Uniform Federal Policy – Quality Assurance Project Plan (UFP-QAPP), and was used to support a risk assessment approach as agreed upon by the TPP team. The results of the risk assessment aid in the development, evaluation, and selection of appropriate response alternatives.

ES.4.1.4.2 MRS 09 – Marine sediment sampling was not conducted within MRS 09. During the MEC investigation of the underwater portions of the MRS, no evidence of munitions use (i.e., no MEC or MD) was discovered within the water acres at this MRS. Therefore, since there was no evidence of a munitions source at this site, there is no potential release of MC and no sediment samples were collected. Since there is no source of MC contamination, there are no complete exposure pathways. Since there are no complete exposure pathways, there is no risk associated with exposure to MC at this site.

ES.4.1.4.3 MRS 13 – Based on the findings of the MEC investigation, marine sediments were evaluated during the underwater RI for MRS 13. Soil was previously evaluated for MRS 13 during the Terrestrial RI. Marine sediment samples were collected beneath 14 munitions items, each with a companion step-out sample collected 4 ft away for the purpose of evaluating whether potential detected contamination was localized or of a greater area or extent of MC. Eight background samples were collected to establish a Background Threshold Value (BTV) for MC metals, with the purpose of evaluating naturally occurring metals values. Background samples were analyzed for the same analytes as the investigative samples. The 95% upper tolerance limit (UTL) was used to establish the BTV. The samples were collected from an area the MEC investigation indicated had no impacts from prior munitions use, and explosives analysis was used to confirm no DoD impact. Quality Control (QC) and Quality Assurance (QA) samples were collected per the approved WP. All samples were analyzed for explosives, MC metals (aluminum, antimony, barium, chromium, copper, lead, mercury, and zinc), and ammonium picrate (a breakdown product of Explosives D).

ES.4.1.4.4 At MRS 13, no explosives or ammonium picrate were detected. All MC metals, except mercury, were detected. Only chromium was detected at concentrations exceeding Preliminary Screening Values (PSVs). Chromium exceeded the chosen PSV, which was the BTV (5.8 mg/kg), in most marine sediment samples collected in the MRS. The maximum concentration of chromium (total) detected in marine sediment was 13 mg/kg. Since chromium exceeded its PSV, it was identified as a Chemical of Potential Concern (COPC) at MRS 13 and further evaluated in the marine sediment risk assessment. The chromium screening value used in the risk assessment was the USEPA Regional Screening Level (RSL) for hexavalent chromium (VI or Cr6+) of 0.29 mg/kg established for human health. There were no exceedances of the ecological screening levels for any analytes. The estimated chromium (VI) concentration was determined by dividing chromium (total) by seven. The risk assessment also included exposure to chromium (III or Cr3+), determined by multiplying chromium (total) by (6/7).

ES.4.1.4.5 All estimates of chromium cancer risk for onsite current and future receptors at MRS 13 are within or below the cancer cumulative risk goal of 1×10^{-6} to 1×10^{-4}, and therefore, cancer risks due to exposure to marine sediment at the MRS are not expected. The cumulative non-carcinogenic hazard indices for each receptor are less than 1 for marine sediment. Because the hazard indices are not greater than 1, hazards due to exposure to marine sediment at MRS 13 are not expected for potential residents, commercial/industrial workers, or site visitors/recreational users/trespassers. Although residents are not present within MRS 13, they were included in the risk assessment to demonstrate there is no risk present even with a most conservative scenario, indicating that there should be no restrictions on use of the site for any activities due to MC.

ES.4.1.4.6 The one identified COPC, chromium, did not exceed ecological screening values (ESVs); therefore, no unacceptable risks are expected from exposure to marine sediment for ecological receptors.

ES.5 SUMMARY OF CONCLUSIONS

ES.5.1 MRS-09: During the Terrestrial RI, eight MD items were recovered from four land grids indicating the possible use of some munitions on the land acres of MRS 09 to include the 4.2-inch HE mortar given evidence of a remnant of a functioned M9 PD fuze and a munition fragment that is suspected to have originated from a 3 inch projectile. There wasn't any MEC or MD discovered along the beaches and shoreline transects during the Terrestrial RI. MEC/MD discoveries along the beaches and shoreline would support a beach or water target area in which MEC/MD would have the potential to migrate to the water from the beach or to the beach from the water.

ES.5.1.1 There were no MEC or MD items recovered in MRS 09 during the Underwater RI. Since a) there was no MEC/MD discovered in the underwater RI survey, b) no MEC has been historically reported in the area, and c) no evidence was found indicating DoD munitions use of the underwater acres as a target area, no MEC source to cause an explosive hazard was identified.

ES.5.1.2 Based on the RI findings, no unacceptable risk is present to human health and no further action is recommended with regard to explosive hazards in the underwater acres of MRS 09.

ES.5.2 The Terrestrial RI Report (USA 2016) for MRS 09 finds that there were no unacceptable ecological risks expected for soil or surface water; however, aluminum and copper (no explosives were detected) were detected in two sediment samples at a concentration greater than the ESV. The sediment sample locations were located at a pond inland from the coastal waters of the MRS.

ES.5.3 During the Underwater RI for MRS 09, no MEC or MD was discovered, indicating no MC source; therefore, no marine sediment sampling was conducted. Since there is not an MC source, no further action is recommended for MC in the underwater acres of MRS 09.

ES.5.4 MRS-13: A significant number of MD items were discovered in MRS 13, both in the water and during the previous Terrestrial RI (USA 2016) on the land. Based on the underwater intrusive investigation findings, a high-density area of MD was discovered which consisted of Navy 5 inch expended illumination projectiles and a small number of expended parachute flares within the underwater boundaries of MRS 13. During the Engineering Evaluation/Cost Analysis (EECA) [Environmental Science and Engineering, Inc. (March 2007)] and UXO Construction Support [Ellis Environmental Group, LC. (June 2004)] 15 illumination candles which were the payload for the Navy 5 inch illumination projectiles were discovered at the NWP

and disposed of as MEC. The Archive Search Report Findings for Culebra Island National Wildlife Refuge, Culebra, Puerto Rico (USACE 1995) describes the Naval Gunfire Target area on the NWP and identifies the safety line for Naval Gunfire which aligns with the MD items located in MRS 13 (see Figure ES-1).

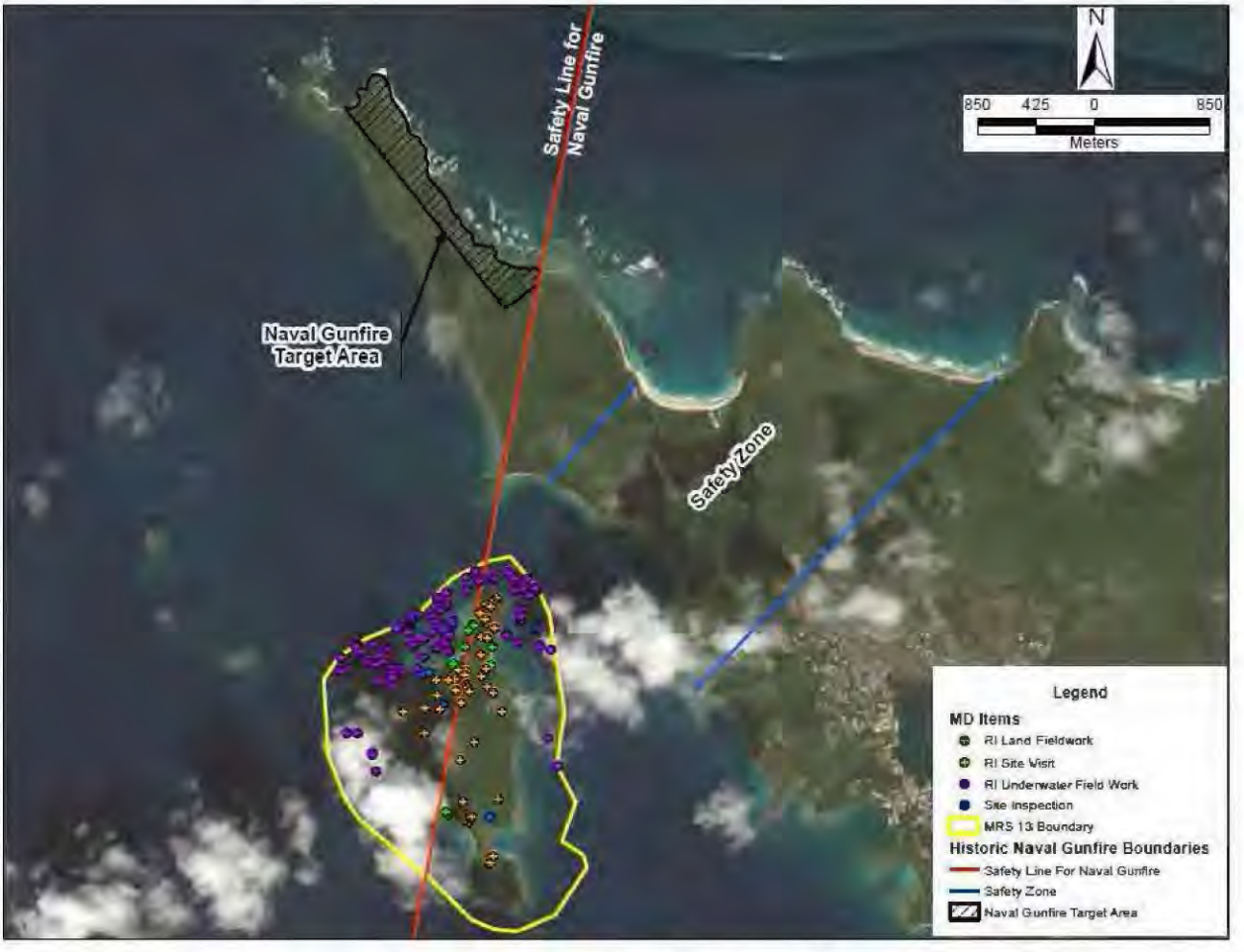

Figure ES-1: Naval Gunfire Target Area

ES.5.4.1 In evaluating these findings, the most likely scenario that justifies the presence of the expended 5 inch illumination projectiles within the MRS 13 underwater acres is the result of Navy 5 inch illumination projectiles fired over the Naval Gunfire Target Area (located on NWP), functioning as designed and then deploying the illumination payloads to illuminate the NWP. The momentum and trajectory of the now empty illumination projectiles carried the munitions to the waters adjacent to Cayo Luis Peña. The presence of the expended illumination projectiles within the waters of MRS 13 was confirmed by the underwater RI investigation teams.

ES.5.4.2 The presence of the expended illumination parachute flares may have been the result of training evolutions on Cayo Luis Peña. However it is also possible that the parachute illumination flares were used on NWP and landed near the shores of NWP. Then under the influence of sea currents, waves, and tidal action, the flare bodies migrated along the bottom to eventually be discovered by the underwater RI investigation teams within the MRS 13 underwater boundary.

ES.5.4.3 No underwater target areas or potential target areas were identified during the underwater RI. Additional scenarios as to the presence of the MD in MRS 13 are evaluated within the body of this RI Report (see sections 6.6.2 and 7.1.2).

ES.5.5 There were no MEC and only two MD items recovered in the 265.1 southern underwater acres of MRS 13. Of the two MD items discovered, one was a MK 25 Marine Marker and is considered incidental to the site and not part of the DoD using MRS 13 for training or exercises. The second MD item was a 5 inch Illumination (Expended) MK 45 Mod 0 Projectile, in which the assumed planned trajectory and distance was improperly calculated and resulted in a stray projectile. This conclusion was arrived at since the MD item is removed by a significant distance from the 5 inch Illumination (Expended) MK 45 Mod 0 Projectiles found in the northern acres of MRS 13. The most likely intended use for the illumination candles (the payload for the 5 inch Illumination projectile) was to illuminate the NWP Naval Gunfire Target area.

ES.5.6 MRS 13 has the potential for human receptors to come into contact with MEC and an FS is recommended for MRS 13 underwater acres to assess remedial alternatives for managing explosive hazards associated with potential human interaction with MEC.

ES.5.7 A risk assessment conducted to evaluate marine sediment samples determined there are no unacceptable risks or hazards present to human health or ecological receptors within MRS 13 from exposure to marine sediment in MRS 13. Therefore, MC will not be addressed in the FS for the underwater acres of MRS 13.

ES.5.8 Based on results of the baseline risk assessment and a review of the MC risk assessment objectives, unacceptable human health risks are not expected in marine sediment at the underwater portions of MRS 09 or MRS 13 investigated as part of this RI. Unacceptable ecological risks are not expected at MRS 09 or MRS 13 investigated as part of this RI. Therefore, with regard to MC, no further action is recommended for both MRSs

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CHAPTER 1. INTRODUCTION

1.1 PURPOSE

1.1.1 The Remedial Investigation (RI) at Culebra Island Site Puerto Rico Underwater Acres of: Soldado Point Mortar and Bombing Area (MRS 09) – Project Number I02PR006809, Cayo Luis Peña Impact Area (MRS 13) – Project Number I02PR006813 was conducted under the Military Munitions Response Program (MMRP). The MMRP was created by the Fiscal Year (FY) 02 National Defense Authorization Act by modifying the Defense Environmental Restoration Program (DERP) to address Munitions and Explosives of Concern (MEC) and Munitions Constituents (MC) contamination on inactive, non-operational military ranges. Under the MMRP, the U.S. Army Corps of Engineers (USACE) is conducting Environmental Response Activities for the Army. This RI addresses potential MEC and MC contamination within the underwater acres of MRS 09 and MRS 13.

1.1.2 The underwater RI consisted of the following three phases of work.

- Phase 1 Environmental Baseline Study (EBS): The primary purpose and scope for Phase 1 was to perform an in-depth study designed to gather the data necessary to determine the underwater habitat within the Culebra Island MRSs 09 and 13 (water areas) for use in the subsequent phases of the underwater Remedial Investigation and Feasibility Study (RI/FS). The EBS documented the marine environment and identified the benthic habitats within the transects where the RI activities were planned to take place. The EBS resulted in the Environmental Baseline Survey Report Underwater Portions of MRSs 09 and 13 Culebra, Puerto Rico (USA 2014), and was used for decision-making purposes during the Technical Project Planning (TPP) meetings for Phases 2 and 3 (the underwater geophysical surveys and intrusive investigations/environmental sampling, respectively). Phase 1 was subdivided into two sub-phases.
  - Phase 1A: Hydrographic Surveys [Deployment of Multi-beam Bathymetry and Side Scan Sonar (SSS) systems]; fieldwork completed in November 2012
  - Phase 1B: Underwater Visual Surveys (underwater Video/still camera systems and snorkeling); fieldwork completed in January 2013
- Phase 2 Digital Geophysical Mapping (DGM): Underwater Geophysical Survey, Phase 2 field activities consisted of performing geophysical surveys along the RI transects re-aligned during Phase 1 to collect electromagnetic (EM) anomaly data.
- Phase 3 Underwater Intrusive Investigations: Phase 3 included unexploded ordnance (UXO) SCUBA Divers intrusively investigating geophysical anomalies, marine sediment sampling, the collection and removal of Munitions Debris (MD), and the disposal of MEC as required (see Chapter 2 and Chapter 3of this RI report).

Phases 2 and 3 were performed concurrently, with a mobilization date of February 12, 2014, and demobilizations of March 23, 2014, for Phase 2 and April 26, 2014, for Phase 3.

1.1.3 An Inventory Project Report (INPR) was signed on 24 December 1991, establishing Culebra as a Formerly Used Defense Site (FUDS), defining a site boundary, and assigning FUDS Property Number I02PR006800. Culebra was subsequently investigated during a SI in 2007. The Final SI Report recommended an RI for MEC and MC to be conducted at 12 of the 13 Culebra MRSs which included MRS 09 – Soldado Point Mortar and Bombing Area and MRS 13 – Cayo Luis Peña Impact Area, which prompted the terrestrial RI. Upon the drafting of the Terrestrial RI Report, which included MRS 09 and MRS 13, it was determined that an additional RI needed to be conducted to include the water acres for MRSs 09 and 13.

1.1.4 The purpose of the RI documented in this report is to characterize potential MEC and MC within the water boundaries of MRS 09 – Soldado Point Mortar and Bombing Area and MRS 13 – Cayo Luis Peña Impact Area, located within the Culebra Island Site, Puerto Rico. The RI Report is designed to present the results from the investigation and to assess any potential risks to human health, safety, and the

environment. If a risk exists, data from the RI will be used to support a feasibility study (FS) so that a decision on a proposed remedy can be made.

1.1.5 This RI Report addresses characterization of MRS 09 and MRS 13 with regard to location, concentration, and nature of possible MEC/MC contamination through the collection of digital and limited analog geophysical mapping data, followed by intrusive investigation of anomalies to characterize MEC contamination and the collection of environmental samples to characterize MC contamination, all as prescribed in the approved Final WP (USA 2014). This RI was conducted under contract W912DY-04-D-0006, Task Order No. 0022. The overall goal of this Task Order is to obtain stakeholder concurrence on a Decision Document (DD) that summarizes the planned response to address any identified contamination. The objectives of the project will be met when the Government accepts a DD meeting the requirements of ER 200-3-1 and Engineer Pamphlet (EP) 1110-1-18, Attachment C, herein, EPA 540-R-98-031, and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

1.2 PROPERTY DESCRIPTION AND PROBLEM IDENTIFICATION

1.2.1 Project Location

1.2.1.1 The project location is Culebra Island, PR. Culebra is approximately 17 miles east of the main island of Puerto Rico and also includes surrounding islands. Cayo Luis Peña (MRS 13) is located approximately one-quarter mile off the western coast of Culebra Island. Soldado Point (MRS 09) is located on the southern peninsula of Culebra Island (see Figure 1-1 and Figure 1-2).

1.2.1.2 MRS 09, which is managed by the Puerto Rico Department of Natural and Evnironmental Resources (PRDNER), consists of 329.2 acres on the very southern tip of the southwestern peninsula of Culebra, of which 131.8 acres are water. Water areas around MRS 09 fall under the auspices of the National Oceanic and Atmospheric Administration (NOAA), U.S. Fish and Wildlife Service (USFWS), and PRDNER, who are all the trustees for its conservation and protection.

1.2.1.3 MRS 13 covers all of Cayo Luis Peña which encompasses 872.6 total land and water acres. Original underwater acreage (379 acres) was the equivalent to 100 yards from the Cayo Luis Peña shoreline. The MRS underwater acres were extended during the planning phases per the request from the Regulator Body to 546.22 acres and then following Phase 1 the outer boundary for MRS 13 was reduced by an average of 4.9 inches resulting in the reduction of the RI project acres to 538.4 acres. The Cayo is managed by the USFWS (land portion) and PRDNER (shoreline areas that are within maritime terrestrial zone). Water areas around MRS 13 fall under the auspices of the NOAA, USFWS, and PRDNER, who are all the trustees for its conservation and protection.

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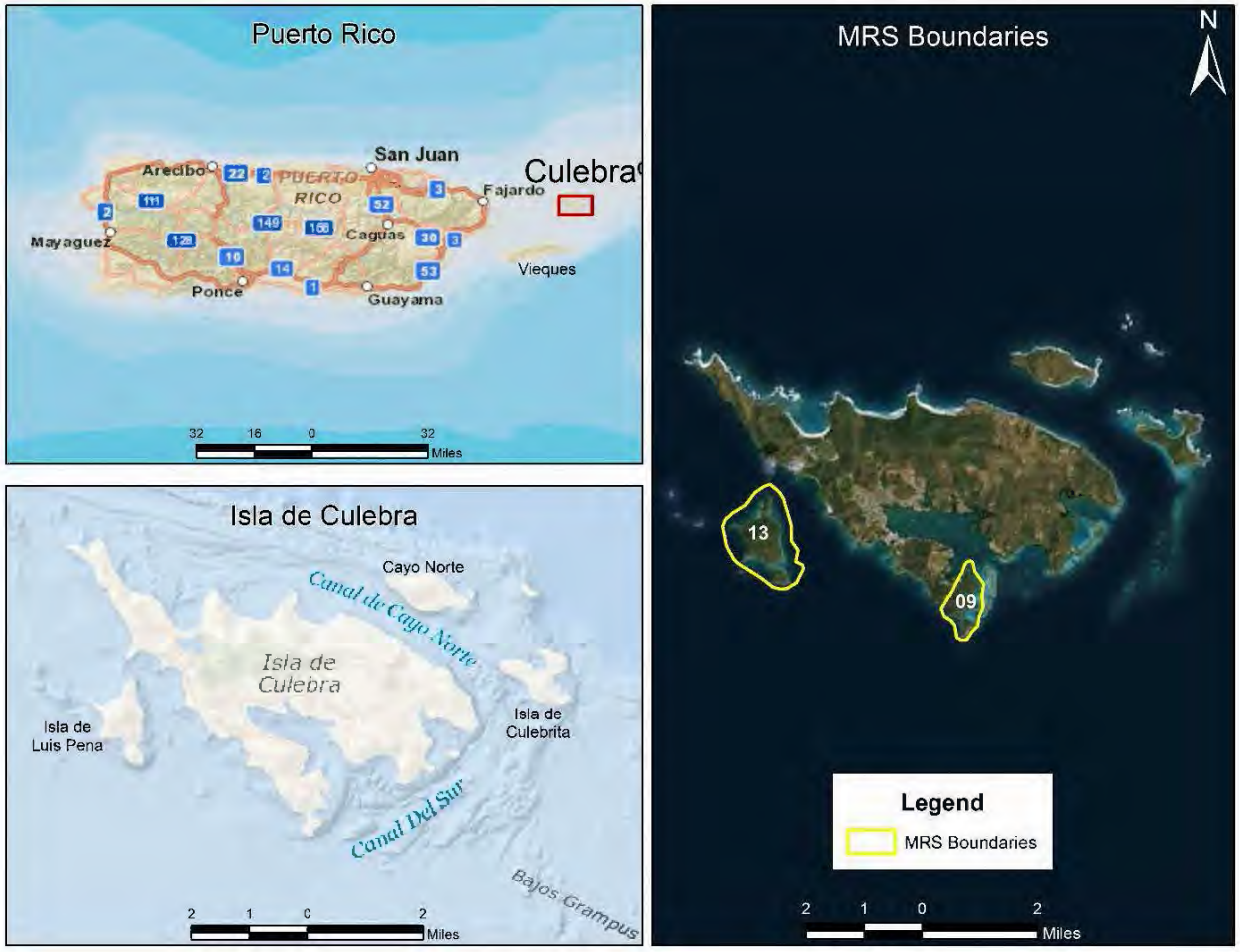

Figure 1-1: Project Location Map

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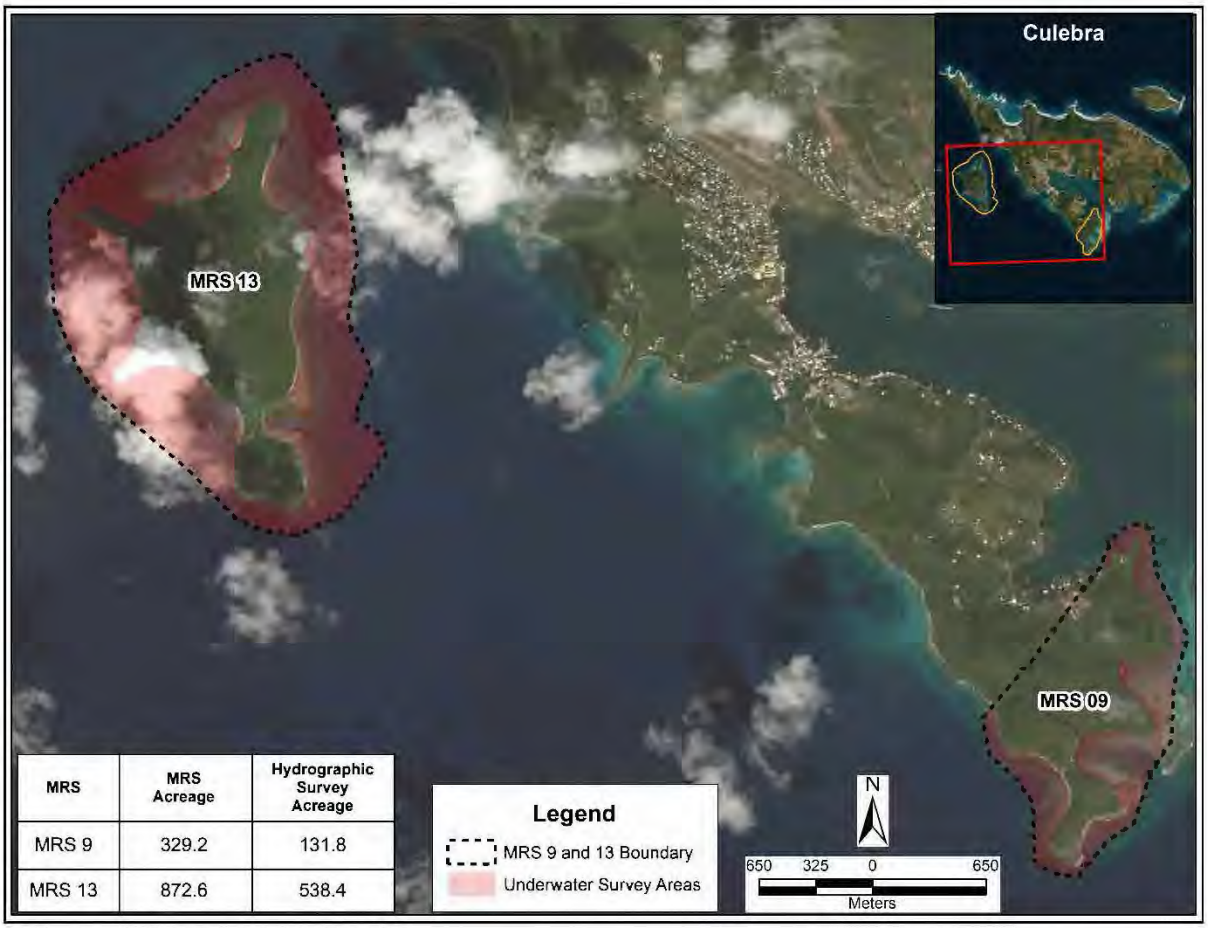

Figure 1-2: Site Location Map

1.2.2 Topography

1.2.2.1 Culebra Island and the surrounding cays are composed of sandy beaches, irregular rugged coastlines, lagoons, coastal wetlands, steep mountains, and narrow valleys. Ninety percent of the island is mountainous. The island contains an east-west trending ridge with an average elevation of 300 ft above mean sea level (amsl) in the northern part of the island. The highest point on Culebra is Mount Resaca, at approximately 640 ft above mean sea level (amsl).

1.2.2.2 Cayo Luis Peña (MRS 13) is composed of sandy beaches, irregular rugged coastlines, and steep mountains. A peak of 476 ft amsl is located in the center of the Cayo and a smaller peak of 171 ft amsl exists on the northern peninsula of the Cayo.

1.2.3 Climate

1.2.3.1 The weather on Culebra Island is generally warm year round due to its tropical marine climate. Based on the Charlotte Amalie HAR, Virgin Islands, weather station (1972 - 2012), located 20 miles to the east, yearly average rainfall is approximately 40.01 inches. The months of August through November are considered the wet season, and the driest months are January through April. Average daily temperatures range from an average maximum of 87.4 °F and an average low of 75.3 °F. Winds are generally from the east-northeast during November through January and from the east during February through October. Yearly average wind speed is 8 knots. Hurricane season is from June through November, and severe hurricanes hit Culebra every 10 to 20 years. The average rainfall is provided in Table 1-1 (SERCC, 2012).

Table 1-1: Average Rainfall, Culebra Island Puerto Rico

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
inches	2.03	1.45	1.46	2.74	3.35	2.75	2.66	3.83	5.42	5.94	5.54	2.84	40.01

Source: SERCC, 2012

1.2.3.2 Phase 1A fieldwork was executed during the month of November of 2012. Sea state is often the limiting factor for marine operations. The combination of wave swells and waves generated by winds did not impact the field work for Phase 1A. Winds averaged 10 to 14 knots. However, for Phase 1B (January 2013) the winds averaged 15 to 20 knots, creating small craft warnings throughout the length of the project. To take full advantage of the conditions presented, the field teams worked on the lee of the islands when the sea state was high, and when the sea state was light or moderate, the field teams would concentrate their efforts on the windward side of the MRSs. During Phase 2 and 3 (February – April 2014), high winds were much less of an issue than during Phase 1B. On a few occasions, the high winds made the MRS 9 lagoons unattainable. The significant weather events that had project impact were associated with the cold weather fronts that moved across the continental U.S. These storm systems generated a north swell that usually impacted the job site 3 to 4 days following the passing of the cold front. The size of the swell varied but in almost all cases northern portions of the MRSs would be under small craft warnings due to the swells created by these storms far to the North. When these conditions existed, field work was conducted in the leeward shore of the MRSs. From March 27 through March 30, a north swell of approximately 9 ft impacted Culebra and more specifically the Northwestern shore of Cayo Luis Peña. This north swell was one of the largest in recent memory, according to the local boat captains.

1.2.4 Observed Benthic Habitat

According to the NOAA Geographical Information System (GIS) effort (Kendall, M.S., et al, 2001), 26 distinct benthic habitats are located within near shore waters of Puerto Rico and the U.S. Virgin Islands. During the course of completing the EBS analysis, it was observed that the benthic habitats located within the water portions of MRSs 09 and 13 consist primarily of unconsolidated sediments (sand), submerged vegetation (sea grass/macroalgae), and coral reef/hardbottom (colonized and uncolonized pavement) habitats.

1.2.5 Current and Projected Site Use

1.2.5.1 MRS 09 – Soldado Point Mortar and Bombing Area

Current uses of the underwater portion of MRS 09 include recreational activities (boating, wading, snorkeling, diving, fishing). No future changes to site use are known. Residential development is not allowed on the site. However, squatters have taken up residence on MRS 09, thus populating Soldado Point. Public area structures and camp ground areas to include the building of cabins are being considered to be developed at some point in the future. If this construction project is conducted, within the scope of the project is the removal of the squatter structures within the MRS. There are no restrictions on using the beach areas or entering the surrounding waters for recreation activities. Boats frequently visit the bays and coves and in some cases anchor for long periods of time, taking up temporary residence within the MRS. Site conditions could change in the future with potential impact on land use. Examples might include excessive soil erosion on beaches or streams created by heavy rain runoff, or the increase in land development that could reduce distances from the site to inhabited areas, or otherwise increase accessibility. Seasonal surf action could cause changes to the bottom of the surrounding waters.

1.2.5.2 MRS 13 – Cayo Luis Peña Impact Areas

Current uses of the underwater portion of MRS 09 include recreational activities (boating, wading, snorkeling, diving, fishing). No future changes to site use are known. Residential areas do not exist on Cayo Luis Peña but have been developed on the main island immediately across the channel. Mooring balls have been placed at several locations within the MRS for boats to temporarily tie up to. Recreational

and commercial charter boats anchor within the MRS boundaries. The island is visited frequently by these boaters with the beaches on the Northwest side of the Cayo as a popular destination. Cayo Luis Peña access to the interior of the island is prohibited without USFWS authorization but there is no significant means to prevent unauthorized access. Site conditions could change in the future with potential impact on land use. Examples might include excessive soil erosion on beaches or streams, or land development on Culebra that could reduce distances from the site to inhabited areas or otherwise increase accessibility.

1.2.6 Site History and Project Background

1.2.6.1 In 1898, the Spanish American War concluded and the Kingdom of Spain ceded all of Puerto Rico to include Culebra and its adjacent cays to the U.S. Shortly after, in 1900, President Theodore Roosevelt placed Culebra under the jurisdiction of the Department of the Navy (DON). In 1903, the Navy acquired approximately 4,200 acres of land by transfer and purchase; further donations, transfers, and leases between 1939 and 1965 brought the total land acquired to approximately 4,800 acres. Although portions of the site were never formally acquired, military use included the entire Island of Culebra and all surrounding cays. The Navy retained 87.5 acres near Flamenco Point that are not eligible for FUDS. The 2005 revised Findings and Determination of Eligibility report states that the site, except for 87.5 acres recently transferred from the control of the Navy, has been determined to be formerly used by the Department of Defense (DoD).

1.2.6.2 Although reconnaissance trips, development of a base, and placement of gun mounts began as early as 1902, the first maneuvers at Culebra did not begin until January 1914, with the Marines' first Advance Base Expedition establishing several encampments and 3-inch and 5-inch temporary gun batteries at the mouth of Great Harbor. The Marines' use of the island continued over several more decades. In 1922, an exercise was conducted firing 7-inch, 8-inch, 3-inch, 155-millimeter (mm), 75mm, and 37mm guns. In 1924, maneuvers included establishment of ammunitions dumps throughout the island, firing of 75mm and 155mm guns, and mine placement in several water areas around Culebra.

1.2.6.3 In 1934, the Navy and Marines organized to carry out the Fleet Landing Problem XV. Weapons used during this exercise included .30-caliber machine guns, 3-inch anti-aircraft guns, 6-inch gun batteries, 75mm batteries, and 6-inch Naval guns. Six much more extensive Fleet Landing Exercises (FLEXs) were conducted on Culebra Island between 1935 and 1941. Photographic accounts document additional Marine landing exercises in 1946 and 1947. Marine training at Culebra is believed to have continued until the late 1950s. The Navy used Culebra and the surrounding cays for bombing and gunnery training from 1935 through 1975. Naval exercises included aerial bombardment, submarine torpedo fire, and naval gunfire directed at the Northwest Peninsula (NWP) and many cays. All military use of the island was terminated in 1975. In summary, the Island of Culebra, nearby cays, and surrounding water were used between 1902 and 1975 for training and live fire of bombs, mortars, rockets, torpedoes, projectiles, and small arms.

1.2.6.4 Beginning in 1978, all of the land acquired by the military on Culebra and the surrounding cays was excessed to the Department of the Interior or transferred to the government of Puerto Rico by quitclaim deed. These lands are currently managed by USFWS, PRDNER, or the Municipality of Culebra.

1.2.6.5 The Culebra FUDS consists of 13 MRSs, totaling 9,460 acres (8,430 land acres and 1,030 acres of water).

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CHAPTER 2. PROJECT REMEDIAL RESPONSE OBJECTIVES

2.1 INTRODUCTION

The RI was conducted in accordance with (IAW) the objectives and goals presented and accepted by stakeholders during the TPP meetings. The TPP Team for this RI included representatives from the Corps of Engineers, South Atlantic Division, Jacksonville District (CESAJ), the U. S. Army Engineering and Support Center, Huntsville (USAESCH), Puerto Rico Environmental Quality Board (PREQB), U.S. Environmental Protection Agency (USEPA), Puerto Rico Department of Natural and Environmental Resources (PRDNER), National Oceanic and Atmospheric Administrartion (NOAA,) NMFS, USFWS, USA, Aqua Survey, Inc. (ASI), and Parsons. The primary purpose of the RI is to adequately characterize potential MEC and MC within the MRS 13 Cayo Luis Peña Impact Areas and MRS 09 Soldado Point Mortar and Bombing Area water boundaries. The overall goal of this process is to obtain stakeholder concurrence on a DD that summarizes the planned response to address any identified contamination.

2.2 CONCEPTUAL SITE EXPOSURE MODEL AND PROJECT APPROACH

2.2.1 Preliminary Conceptual Site Exposure Model

2.2.1.1 The CSEM depicts and evaluates the potential interactions between human and ecological receptors and MEC and MC with knowledge known prior to the RI. The ways that MEC and MC can move in the environment and the means by which receptors may contact them are called migration and exposure pathways. The CSEM identifies potential migration/exposure pathways and the possible human and/or ecological receptors for those pathways, based on site-specific conditions. It is necessary to evaluate site-specific conditions and land use to evaluate risks posed to potential receptors under current and future land use scenarios. Exposure pathways for relevant media are evaluated.

2.2.1.2 The CSEM summarizes which potential receptor exposure pathways for MEC and MC are (or may be) complete and which are (and are likely to remain) incomplete. An exposure pathway is not considered complete unless all four of the following elements are present (USEPA 1989). An example regarding a hypothetical surface water exposure pathway for MC is included.

- A source of contamination (for example, a site has known MEC from which MC have leached and contaminated surface soil).
- An environmental transport and/or exposure medium (in the example, the MC in soil are mobile and can migrate to surface water via storm water runoff).
- A point of exposure at which the contaminant can interact with a receptor (a swimming hole is located close to the site).
- A receptor and a likely route of exposure at the exposure point (a local resident uses the swimming hole for recreation).

2.2.1.3 In the hypothetical example, all four factors are present and, therefore, the surface water exposure pathway is complete. If any single factor was not present (e.g., MC were not present in soil, or there were no swimming hole located in the vicinity), the pathway would be incomplete. An incomplete exposure pathway indicates that there are no current means by which a receptor (human or ecological) can come into contact with either MEC or MC and, therefore, no risks from exposure to MEC or MC would be expected.

2.2.1.4 A CSEM is dynamic and represents the current understanding of the site. The CSEM is evaluated and revised each time new information is received. As part of the TPP process for the RI, a preliminary CSEM was developed for MRS 13 and MRS 09 IAW Engineer Manual 1110-1-1200. These preliminary CSEMs are presented in Figure 2-1 and Figure 2-2 and annotated in tabular format in Table 2-1 and Table 2-2, and depict the possible contaminant migration and exposure pathways for the various receptors at MRS 13 and MRS 09. The known or suspected MEC/MC presented in the preliminary CSEMs were developed based on the results of previous investigations conducted at the site in conjunction with various

available Department of Defense (DoD) data sources, and the rationale was concurred by the TPP Team and was presented in the final approved WP (USA 2014).

2.2.1.5 The preliminary CSEMs show that MEC is a potential concern at the site based on historical evidence. With regard to MC, the preliminary CSEM indicates that MC are potentially present in MRSs 13 and 09. Direct release of MC from historic activities would have been to marine sediment. Potentially complete exposure pathways related to MEC are present at MRSs 09 and 13, and can result in residents, site visitors/recreational users, and ecological receptors being exposed to MC, if contamination is present.

2.2.1.6 The preliminary CSEM for the site is presented below. The revised CSEM, based on results of the RI MEC investigation and sampling results, is presented in Chapter 4 of this report. Further details on source, receptors, and exposure pathways follow.

2.2.2 MRS 09 Soldado Point Mortar and Bombing Area

2.2.2.1 The Pre-RI CSEM for MRS 09 (see Figure 2-1) identified a potentially complete MEC exposure pathway for human receptors and ecological receptors due to the potential presence of MEC in the underwater portions of the MRS from historical use and the investigation of terrestrial acres. Therefore, exposure pathways related to MC for human and ecological receptors were potentially complete prior to the underwater MEC investigation.

2.2.2.2 The majority of the terrestrial portions of the MRS are administered by PRDNER. Unauthorized developments have been constructed in the vicinity of Sueño Cove. In the northeast corner of the MRS, four residences and a portion of a hotel resort are present. There is no controlled access in the PRDNER administered portions of the MRS. A partially improved road runs through the center of the MRS and can transport visitors to beaches. Based on current and projected land use, public area structures and camp ground areas to include the building of cabins are being considered for developed at some point in the future. If this construction project is conducted, within the scope of the project is the removal of the squatter structures present within the MRS.

2.2.3 MRS 13 Cayo Luis Peña Impact Areas

2.2.3.1 The Pre-RI CSEM for MRS 13 (Figure 2-2) identified a potentially complete MEC exposure pathway for human receptors and ecological receptors due to the potential presence of MEC in the underwater portions of the MRS from historical use and the investigation of terrestrial acres. Therefore, exposure pathways related to MC for human and ecological receptors were potentially complete prior to the underwater MEC investigation.

2.2.3.2 MRS 13 is an island and is accessible only by boat. MRS 13 is administered by USFWS and is part of the Culebra Wildlife Refuge. MRS 13 contains very few improved areas consisting of a single road/path that leads up to the old helipad. MRS 13 contains established beach areas. Given that all beaches in the Commonwealth of Puerto Rico allow public access, additional human receptors are able to access MRS 13.

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Conceptual Site Exposure Model Diagram

Site/MRS Name: Culebra Island, PR – MRS 09 Underwater Acres

Completed By: Tom Bourque, USA ***Date Completed:*** June 30, 2015

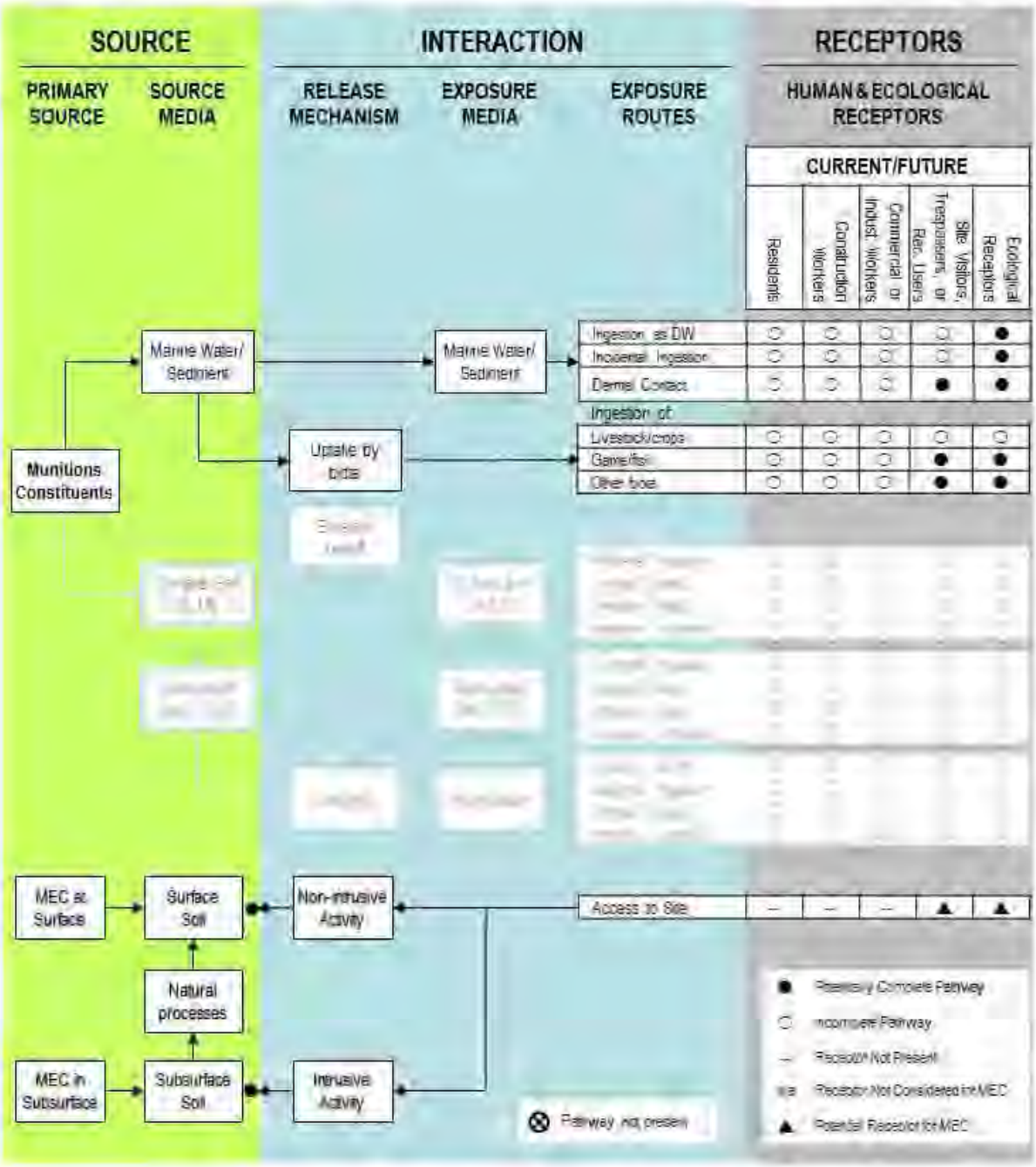

Figure 2-1: Preliminary Conceptual Site Exposure Model

Conceptual Site Exposure Model Diagram

Site/MRS Name: Culebra Island, PR – MRS 13 Underwater Acres

Completed By: Tom Bourque, USA ***Date Completed:*** June 30, 2015

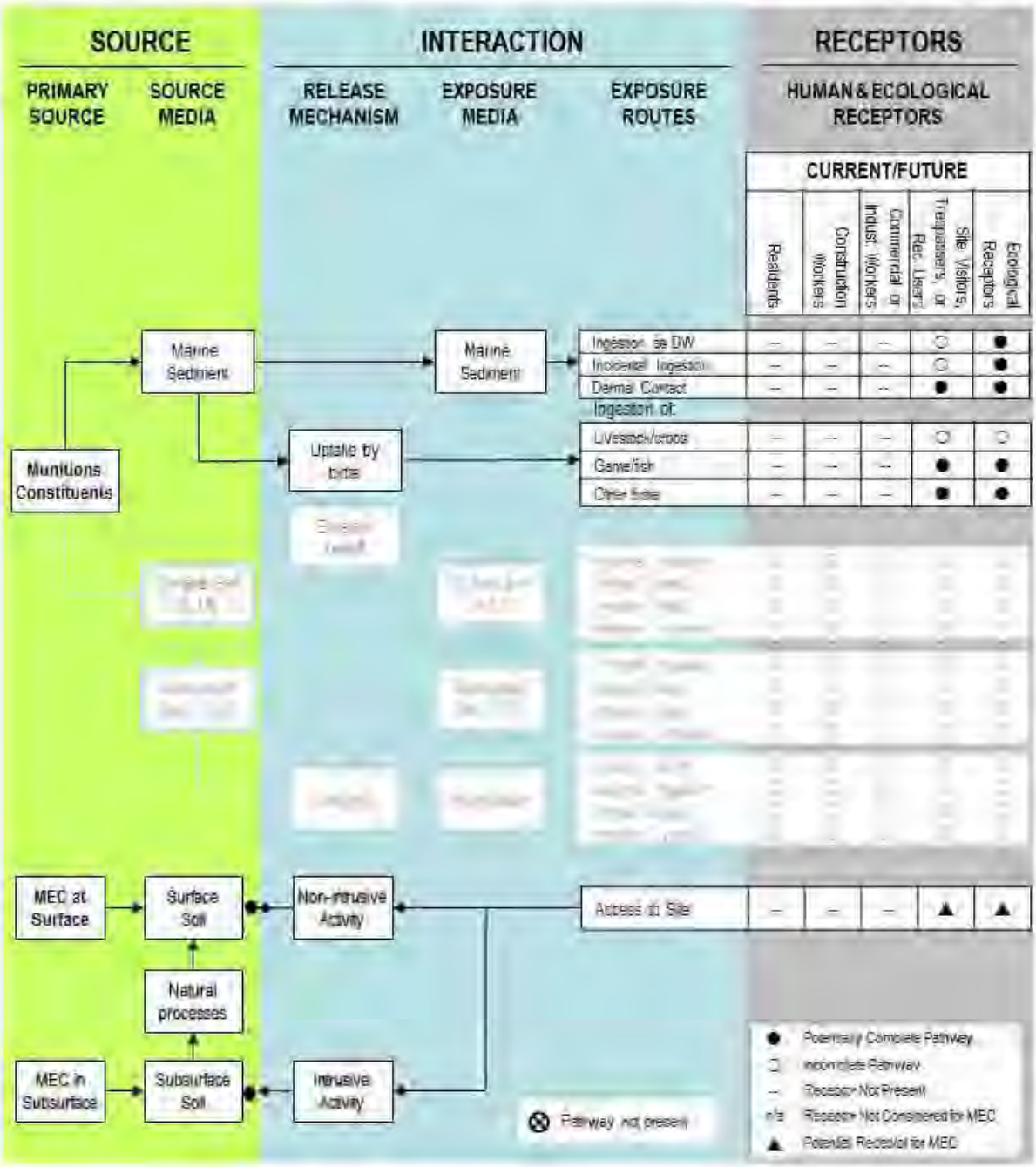

Figure 2-2: Preliminary MRS 13 MEC/MC CSEM

Table 2-1: Overview of CSEM and RI Technical Approach, MRS 09

Munitions Response Site	PRELIMINARY CSEM SUMMARY					RI TECHNICAL APPROACH			
	Known or Suspected Contamination Source(s)	Potential/ Suspected Location and Distribution	Source or Exposure Medium	Current and Future Receptors	Potentially Complete Exposure Pathway	Investigation Method	Investigation Location(s)	Investigation Acreage/ Number of Samples	Decision Rule(s)
MRS 09 Soldado Point Mortar and Bombing Area Underwater Acreage: *131.8* **Suspected Past DoD Activities (release mechanism):** *30- and 1,000-pound bombs were dropped in this area. Munitions used in the bay included 30-pound fragmentation bombs, 100-pound demolition bombs, 81mm mortars, and small arms [Supplemental ASR USACE 2005B)]* **Current and Future Land Use:** *Recreational*	**MEC:** *30, 100, and 1000 pound bombs* *81mm mortars and small arms [Supplemental ASR USACE 2005B)]* *MK 25 Marine Marker, 4.2 inch Mortar, Navy 3 inch projectiles [*(Draft/Final) Culebra RI Report, Municipality of Culebra, Puerto Rico (USA 2016)]	**MEC:** *If present, MEC would be the result of aircraft bombing training in Sueño Cove; firing 81mm mortars along the western shore and bay which was used as a mortar boat firing area*	Marine sediment	Site Visitors, Trespassers, Recreational Users, Ecological Receptors	Exposure to Underwater surface or subsurface MEC	Underwater DGM and intrusive investigation	Underwater DGM and Analog transect surveys positioned across the MRS water boundaries. Analog step-out transects strategically placed to determine the limit of a MEC high density area.	3.61 miles of DGM transect surveys; Transects are parallel, spaced 225 ft apart. Transects are used to locate targets of a density of 20 DGM targets per acre above background.	Characterization of Underwater Habitat: If endangered and/or threatened species and/or critical habitat within planned investigation areas are encountered, the field team will follow procedures for their protection IAW the Standard Operating Procedures (SOPs) for Endangered Species Conservation and their Critical Habitat during Underwater Investigations which can be found in SOPs for "Endangered Species Conservation and their Critical Habitat during underwater investigations at DERP-FUDS property No. I02PR0068, Culebra Island, Puerto Rico (CESAJ, 2015)". Characterization of MEC contamination: Geophysical investigation methods will be used to evaluate potential MEC presence. The Geophysical investigation determines that metallic anomalies are present, but doesn't identify the anomaly as MEC. An intrusive investigation will be conducted to determine which metallic anomalies are MEC. Types of equipment used will be chosen based on the type of environment in which the transect is located. Information related to types of equipment is located in the RI WP Chapter 3, Section 3.2, Underwater Geophysical Investigation and Section 3.3.3.1, Intrusive Investigation (USA 2014). Dig Selections: If an anomaly detected during the geophysical investigation meets anomaly selection criteria (i.e., is above a background threshold determined by the Instrument Verification Strip (IVS) and based on professional judgment) and is placed on the dig list, and used to generate an Anomaly Density map. If the anomaly is in a high density area (e.g. ≥ 30 targets/acre or ≥ 20 targets above background), then the anomaly will be investigated intrusively. USA funded assumptions: 10 high density areas with a total of 100 EM anomalies in MRS 09 (includes EM or Analog anomalies within step out transects) and 158 EM anomalies in MRS 13 (includes EM or Analog anomalies within step-out transects). A random selection of low density area transect EM targets (up to 10 targets in MRS 09 and up to 16 targets in MRS 13) will be investigated to confirm that these areas are not MEC contaminated. If no high density areas are identified, then more low density area targets may be investigated, up to a maximum of 100 targets in MRS 09 and 158 targets in MRS 13. MEC Hazard present: If no MEC-related items are found in an area based on intrusive investigation, then the area will be considered un-impacted by MEC. If anomalies are identified as MEC or MD indicative of HE, then the area will be considered contaminated by MEC. The extent of the hazard will be bound with step out transects placed at a distance of half the original transect spacing from the outer boundary of the contaminated area. If the area is contaminated with MEC, then the MEC hazard present will be evaluated in an assessment supported with data from a MEC Hazard Analysis (HA), historical data, and professional judgment. MEC Removal: If an item is determined to be MEC and is deemed unacceptable to move onshore for demolition, the item will be marked by a clump and video/photos will be taken of the item and the surrounding area, and the location will be captured by Global Positioning System (GPS) (the DGM anomaly location may also be used in place of marking with a separate GPS). If the MEC item has Listed Threatened or Endangered species attached or affixed to the reef adjacent to the MEC item, and it is determined that removing or detonating the MEC item will harm or injure the Listed Species, the item will be left in place for further determination by the government. If a MEC item is deemed acceptable to move, then procedures identified in the RI WP Chapter 3, Field Investigation Plan (USA 2014) will be followed.

Munitions Response Site	PRELIMINARY CSEM SUMMARY					RI TECHNICAL APPROACH			
	Known or Suspected Contamination Source(s)	Potential/ Suspected Location and Distribution	Source or Exposure Medium	Current and Future Receptors	Potentially Complete Exposure Pathway	Investigation Method	Investigation Location(s)	Investigation Acreage/ Number of Samples	Decision Rule(s)
	MC: *Explosives and MC metals (Analytes investigated can be found in Tables 3-7 and 3-8)*	Potentially present in marine sediment at the location of discovered MEC (by type)	Marine Sediment	Site Visitors, Trespassers, Recreational Users, Ecological Receptors	Exposure to MC in marine sediment (incidental ingestion, dermal contact, and ingestion of fish or biota)	Collect discrete marine sediment samples and analyze for MC; conduct sampling at MEC contaminated areas Collect post detonation samples and analyze for MC at locations of demolition events.	Discrete grab samples at MEC locations for each MEC type. A step-out grab sample will be taken four feet from the discrete sample at the MEC location. A step-out sample will be taken for each discrete sample at MEC locations. Collect 7-point wheel post-demolition samples at locations of demolition events.	A marine sediment sample will be collected by a UXO SCUBA diver each time a new munition type is found (i.e., 4.2-inch mortar, 5-inch projectile, BDU-33 practice bomb, etc.). For additional underwater findings of an already sampled munition type, samples will be collected at a rate of 10%.	Characterization of MC contamination: If an MC analyte is undetected or is detected at concentrations less than background levels, then the area will be considered uncontaminated by that MC analyte and it will not be investigated further. In areas where MC analytes are detected at concentrations greater than background levels and screening values, (investigative samples and post-demolition samples), as established in the RI WP SAP (USA 2014), the analyte will be considered a Chemical of Potential Conern (COPC) and retained for consideration in a baseline risk assessment. If the baseline risk assessment determines the contamination is localized to the location of the munition, based on information from the companion sample collected at the same time, there will be no further investigation. If the baseline risk assessment determines an unacceptable risk to human health or ecological receptors, and the contamination is also present at the companion step-out sample, then the TPP team will evaluate the magnitude of the unacceptable risk and further step-out sampling may be planned.
	MC (post detonation): *Explosives*	At MEC detonation locations	Marine or land Surface soil or marine sediment	Site Visitors, Trespassers, Recreational Users, Ecological Receptors	Exposure to MC in marine sediment (incidental ingestion, dermal contact, and ingestion of fish or biota)	Collect discrete marine sediment or soil samples as applicable and analyze for MC	MEC disposal locations	One pre- and one post-detonation sample per disposal location; additional samples as necessary to delineate extent.	If MC analytes are detected in post-detonation samples at concentrations above pre-detonation samples and PSVs, then collect additional samples to delineate extent of MC contamination; once delineation is complete, conduct MC risk assessment for soil pathway.

Table 2-2: Overview of CSEM and RI Technical Approach, MRS 13

Munitions Response Site	PRELIMINARY CSEM SUMMARY					RI TECHNICAL APPROACH			
	Known or Suspected Contamination Source(s)	Potential/ Suspected Location and Distribution	Source or Exposure Medium	Current and Future Receptors	Potentially Complete Exposure Pathway	Investigation Method	Investigation Location(s)	Investigation Acreage/ Number of Samples	Decision Rule(s)
MRS 13 Cayo Luis Peña IMPACT AREAS: *538.4* **Suspected Past DoD Activities (release mechanism):** *Records show that 75mm projectiles were fired at the Cayo in 1924, and that 155mm, 37mm, 8-inch, and 6-inch rounds may have also been used [Supplemental ASR (USACE 2005b)].* **Current and Future Land Use:** *Recreational*	**MEC:** *75mm, 155mm, 37mm, 8-inch, 6-inch* *MD items discovered during USA Site Visit for the Terrestrial RI*[(Draft/Final) Culebra RI Report, Municipality of Culebra, Puerto Rico (USA 2016)], *105 mm (HE and illumination); 5- and 3-inch projectiles; flares; and fuzes*	**MEC:** *If present, MEC would be the result of military training using targets on Cayo Luis Peña and/or MEC may be the result of overshoot of the NWP training area*	Marine sediment	Site Visitors, Trespassers, Recreational Users, Ecological Receptors	Exposure to Underwater surface or subsurface MEC	Underwater DGM and intrusive investigation	Underwater DGM and Analog transect surveys positioned across the MRS water boundaries. Analog step-out transects strategically placed to determine the limit of a MEC high density area.	15.73 miles of DGM transect surveys; Transects are parallel, spaced 250 ft apart. Transects are used to locate targets of a density of 20 DGM targets per acre above background.	Characterization of Underwater Habitat: If endangered and/or threatened species and/or critical habitat within planned investigation areas are encountered, the field team will follow procedures for their protection IAW the SOPs for Endangered Species Conservation and their Critical Habitat during Underwater Investigations which can be found in SOPs for Endangered Species Conservation and their Critical Habitat during underwater investigations at DERP-FUDS property No. I02PR0068, Culebra Island, Puerto Rico (CESAJ, 2015). Characterization of MEC contamination: Geophysical investigation methods will be used to evaluate potential MEC presence. The Geophysical investigation determines that metallic anomalies are present, but doesn't identify the anomaly as MEC. An intrusive investigation will be conducted to determine which metallic anomalies are MEC. Types of equipment used will be chosen based on the type of environment in which the transect is located. Information related to types of equipment is located in the RI WP Chapter 3, Section 3.2, Underwater Geophysical Investigation and Section 3.3.3.1, Intrusive Investigation (USA 2014). Dig Selections: If an anomaly detected during the geophysical investigation meets anomaly selection criteria (i.e., is above a background threshold determined by the IVS and based on professional judgment) and is placed on the dig list, and used to generate an Anomaly Density map. If the anomaly is in a high density area (e.g. ≥ 30 targets/acre or ≥ 20 targets above background), then the anomaly will be investigated intrusively. USA funded assumptions: 10 high density areas with a total of 100 EM anomalies in MRS 09 (includes EM or Analog anomalies within step-out transects) and 158 EM anomalies in MRS 13 (includes EM or Analog anomalies within step-out transects). A random selection of low density area transect EM targets (up to 10 targets in MRS 09 and up to 16 targets in MRS 13) will be investigated to confirm that these areas are not MEC contaminated. If no high density areas are identified, then more low density area targets may be investigated, up to a maximum of 100 targets in MRS 09 and 158 targets in MRS 13. MEC Hazard present: If no MEC-related items are found in an area based on intrusive investigation, then the area will be considered un-impacted by MEC. If anomalies are identified as MEC or MD indicative of HE, then the area will be considered contaminated by MEC. The extent of the hazard will be bound with step-out transects placed at a distance of half the original transect spacing from the outer boundary of the contaminated area. If the area is contaminated with MEC, then the MEC hazard present will be evaluated in an assessment supported with data from a MEC HA, historical data, and professional judgment. MEC Removal: If an item is determined to be MEC and is deemed unacceptable to move onshore for demolition, the item will be marked by a clump and video/photos will be taken of the item and the surrounding area, and the location will be captured by GPS (the DGM anomaly location may also be used in place of marking with a separate GPS). If the MEC item has Listed Threatened or Endangered species attached or affixed to the reef adjacent to the MEC item, and it is determined that removing or detonating the MEC item will harm or injure the Listed Species, the item will be left in place for further determination by the government. If a MEC item is deemed acceptable to move, then procedures identified in the RI WP Chapter 3, Field Investigation Plan (USA 2014) will be followed.

Munitions Response Site	PRELIMINARY CSEM SUMMARY					RI TECHNICAL APPROACH			
	Known or Suspected Contamination Source(s)	Potential/ Suspected Location and Distribution	Source or Exposure Medium	Current and Future Receptors	Potentially Complete Exposure Pathway	Investigation Method	Investigation Location(s)	Investigation Acreage/ Number of Samples	Decision Rule(s)
	MC: *Explosives and MC metals (Analytes investigated can be found in Table 3-7 and 3-8*	Potentially present in marine sediment at the location of discovered MEC (by type)	Marine Sediment	Site Visitors, Trespassers, Recreational Users, Ecological Receptors	Exposure to MC in marine sediment (incidental ingestion, dermal contact, and ingestion of fish or biota)	Collect discrete marine sediment samples and analyze for MC; conduct sampling at MEC contaminated areas Collect post-detonation samples and analyze for MC at locations of demolition events.	Discrete grab samples at MEC locations for each MEC type. A step-out grab sample will be taken 4 ft from the discrete sample at the MEC location. A step-out sample will be taken for each discrete sample at MEC locations. Collect 7-point wheel post-demolition samples at locations of demolition events.	A marine sediment sample will be collected by a UXO SCUBA diver each time a new munition type is found (i.e., 4.2-inch mortar, 5-inch projectile, BDU-33 practice bomb, etc.). For additional underwater findings of an already sampled munition type, samples will be collected at a rate of 10%.	Characterization of MC contamination: If an MC analyte is undetected or is detected at concentrations less than background levels, then the area will be considered uncontaminated by that MC analyte and it will not be investigated further. In areas where MC analytes are detected at concentrations greater than background levels and screening levels (investigative samples and post-demolition samples), as established in the RI WP SAP (USA 2014), the analyte will be considered a COPC and retained for consideration in a baseline risk assessment. If the baseline risk assessment determines the contamination is localized to the location of the munition, based on information from the companion sample collected at the same time, there will be no further investigation. If the baseline risk assessment determines an unacceptable risk to human health or ecological receptors, and the contamination is also present at the companion step-out sample, then the TPP team will evaluate the magnitude of the unacceptable risk and further step-out sampling may be planned.
	MC (post detonation): *Explosives*	At MEC detonation locations	Marine or land Surface soil or marine sediment	Site Visitors, Trespassers, Recreational Users, Ecological Receptors	Exposure to MC in marine sediment (incidental ingestion, dermal contact, and ingestion of fish or biota)	Collect discrete marine sediment or soil samples as applicable and analyze for MC	MEC disposal locations	One pre- and one post-detonation sample per disposal location; additional samples as necessary to delineate extent.	If MC analytes are detected in post-detonation samples at concentrations above pre-detonation samples and PSVs, then collect additional samples to delineate extent of MC contamination; once delineation is complete, conduct MC risk assessment for soil pathway.

2.2.4 Project Approach

2.2.4.0.1 The technical approach for this RI was based on the findings of previously conducted investigations and was designed to evaluate potentially complete MEC and MC exposure pathways as identified in the preliminary CSEM to determine the potential presence or absence of MEC and MC. Based on information currently available, the following munitions are known or suspected to have been used:

- MRS 09: small arms ammunition, 81mm mortars, 30-, 100-, and 1,000-pound bombs. The Terrestrial RI field teams discovered MD consistent with 3-inch Navy gun fired projectiles and 4.2 inch mortar. Only the 30-, 100-, and 1,000-pound bombs were suspected of being used against water targets within MRS 09.
- MRS 13: 75mm, 155mm, 37mm, 8-inch, and 6-inch projectiles per historical documents. During the Terrestrial RI site visit to MRS 13, the following munitions were discovered: 105 mm (HE and illumination); 5- and 3-inch projectiles; flares; and fuzes.

2.2.4.0.2 The overall approach to characterizing MEC contamination included DGM to identify areas of concentrated metallic anomalies (potential MEC) followed by intrusive investigations of anomalies. Transects that posed a safety risk for the DGM vessel or were too shallow for DGM platforms to operate were completed by either UXO Technician SCUBA divers or snorkelers using underwater analog instruments. UXO Technician SCUBA divers swam along the planned DGM transect with the analog all metals detectors to aid in a visual survey when the transect consisted of coral or consolidated hardbottom. Mag and dig procedures were performed when the transect consisted of unconsolidated sediment.

2.2.4.0.3 The specific approach for the MC investigation was to determine the nature and extent of any MC contamination by collecting discrete environmental samples at the location of discovered MEC. Further details are provided in the paragraphs below.

2.2.4.1 MEC

2.2.4.1.1 The approach to characterizing MEC began with collecting and mapping DGM data along transects. Transects were spaced (center to center) 250 ft apart for MRS 13 and 225 ft apart for MRS 09. In accordance with the approved USACE WP (USA 2014), transect spacing was designed to detect a 500-ft radius, circular target area with a background anomaly density of 10 DGM targets/acre, and a MEC contaminated area anomaly density of 30 DGM targets/acre. The transect width was set at 1m, the width of the EM61 coil. The transect spacing provides a 90% probability of traversing and detecting a 500 ft radius potential MEC contaminated area. Section 3.1.4.2.1 provides the transect design parameters used in Visual Sample Plan (VSP).

2.2.4.1.2 Approximately 15.73 miles of parallel transects circulating MRS 13 and 3.61 miles for MRS 09 were digitally mapped using an EM61-MK2 on various DGM platforms (EM ROV, EM Float, EM Sled). DGM Targets were selected for intrusive investigation by the Site Geophysicist and approved by the Project Geophysicist. Each DGM target, selected for intrusive investigation, was marked by a small weight (clump) and a buoy. After the DGM target was marked, the placement of the clump was verified by moving the boat back over the clump. No effort was made to plumb the buoy to verify the mark since the vessel could easily drag the clump off its original position. An error of approximately 10 ft was anticipated in the WP to account for placing the clump in rough seas, current, and winds, which would make it difficult to keep the boat on a sub-meter position. Due to the anticipated error in the process to reacquire a DGM Target, additional acreage was investigated in addition to the overall transects acreage planned (10-ft circular area searched for each DGM target investigated). In many cases, multiple MD items were recovered in the 10-ft circle searched when only one DGM Target was identified for investigation. Step-out transects were anticipated should MEC be discovered. The step-out transects would be placed half the distance between the planned transects on either side of the MEC item and be surveyed by analog (mag and dig) geophysical methods. Since there was no MEC discovered, no step-out transects were required. Identification information for each DGM Target was recorded in the GIS database and the project Access database (Appendix E: Geophysical Results). Additional results of MEC field activities can be found in Subsection 3.1.

2.2.4.2 MC

The primary objective of MC investigation was to collect data that met the project Data Quality Objectives (DQOs) to determine the presence or absence of MC contamination and, if present, the nature and extent of MC detected above the applicable regulatory criteria; in addition, another objective of MC investigation was to allow completion of human health and ecological risk assessments IAW the EPA Risk Assessment Guidance for Superfund (RAGS) and USACE 200-1-4, Volumes I and II. The sampling priorities and DQOs were established as part of the TPP process to create a site characterization that met the project objectives and to achieve stakeholder approval. A Sampling and Analysis Plan (SAP) was prepared and included in the approved WP. The SAP outlined the sampling and analysis procedures anticipated to be used in sampling media (marine sediment samples). During the TPP Meetings, the stakeholders agreed that if MC was to be evaluated, the dynamic actions of the ocean had to be considered. MC would likely be diluted in the water column, negating the possibility of discovering the presence of MC over a specific area (IS Sampling). If MC was present it would likely be localized around any MEC which would provide point source for the MC. It was also assumed that if the source (MEC) was removed prior to sampling, the MC may dilute over a period of time into the water column due to the sea currents, wave, and swell action, which required the discrete samples to be taken at the same time or prior to the MEC item being removed. A step-out sample of 4 ft was agreed to during the TPP meetings to identify if any MC contamination that may be present at the munition (discrete marine sediment sample) had spread away from the point source.

The following planned method of marine sediment sample collection was agreed to by the project stakeholders: A marine sediment grab sample collected by a UXO SCUBA diver each time a new munition type is found (i.e., 4.2-inch mortar, 5-inch projectile, BDU-33 practice bomb, etc.). For additional underwater findings of an already sampled munition type, samples will be collected at a rate of 10%. In addition, a companion sample collected approximately 4 ft from the original sample. Both samples collected in the same dive, with the step-out sample always collected first, followed by the munition sample. The diver was instructed to locate the step-out sample 4 ft from the munition sample (no primary current was identified providing a constant current flow for MRS 13). Since there was no obvious current flow noted, the sample was to be collected at a bearing of 270 degrees (west) from the munition item. No obvious currents were available at the time of sample collection, therefore all samples were collected at a bearing of 270 degrees. An auger (multi-stage sludge and sediment sampler) was on the boat at all times, and after inspection of the area, if enough sediment was present, the auger was to be used for sample collection. However, no location had enough sediment to effectively implement the auger, and the alternative method of collection by sterilized 4-oz plastic scoop was employed. To minimize potential for dissolution of fine particles in the sea water during collection, the diver carefully scooped the sediment into a 2-gallon zip-loc bag held immediately adjacent to the determined sample location until the bag was three quarters full, then sealed the top and transported to the surface. At the surface, the sample was homogenized on the boat by the sample coordinator, quartered and put into prelabeled sample containers, and immediately placed on ice.

2.3 PRELIMINARY REMEDIATION GOALS

2.3.1 Preliminary remediation goals were both site- and contaminant-specific and defined the conditions considered by stakeholders to be protective of human health and the environment. There were preliminary remediation goals for MEC and MC at each site that were evaluated during the RI. As with the CSEM, preliminary remediation goals were reevaluated and refined throughout the RI/FS process as new information became available.

2.3.2 The preliminary remediation goal for MEC is based on limiting interaction between any residual MEC and any receptors accessing the site. These are either to remove any MEC present to a depth at which it no longer presents a hazard to the anticipated human receptors, or to implement measures that will minimize the possibility of receptors coming into contact with MEC at the site.

2.3.3 The preliminary remediation goal for MC is based on the screening values that were agreed to by the TPP Team as being protective of the identified exposure pathways. The preliminary remediation goal is to ensure that any identified MC contamination at the site determined to pose an unacceptable risk to human health or the environment as addressed in a baseline risk assessment is addressed to minimize or mitigate those risks to both human health and ecological receptors in the environment.

2.4 PRELIMINARY IDENTIFICATION OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND "TO BE CONSIDERED" INFORMATION

2.4.1 As amended by the 1986 Superfund Amendments and Reauthorization Act (SARA), Section 121(d)(2) of the CERCLA requires that on-site remedial actions attain (or waive) Federal and more stringent state Applicable or Relevant and Appropriate Requirements (ARARs) of environmental laws upon completion of the remedial action. The revised National Oil and Hazardous Substances Pollution Contingency Plan (NCP) requires compliance with ARARs for all response actions including investigation and during remedial actions as well as at completion, and compels attainment of ARARs during remedial actions to the extent practicable, considering the specifics of the situation. The "Applicable" portion of the term is defined as: "Cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards identified by a state in a timely manner and that are more stringent than Federal requirements may be applicable."

2.4.2 The "Relevant and Appropriate" portion of the ARAR term is defined as:

> Cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or state environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those state standards identified by a state in a timely manner and that are more stringent than Federal requirements may be relevant and appropriate.

2.4.3 Although compliance is not required, in order to incorporate guidance and other information into the alternatives developed, some remedial actions identify "to be considered criteria" defined as:

> Non-promulgated advisories, criteria, and guidance are not ARARs, but may sometimes be useful in developing a CERCLA remedy. When this is the case, at the discretion of the lead agency, they can be specified as "To-Be-Considered (TBC)" criteria. TBC criteria can be taken into consideration during evaluation of remedial alternatives, but unlike ARARs, identification of TBCs is not mandatory, nor is compliance with TBCs a selection criterion for a remedial action.

2.4.4 Documents that are TBC are incorporated as appropriate into the RI report and not called out in a table (to avoid confusion with the ARARs). Compliance with these documents is not required under CERCLA or the NCP; therefore, no tabulation is provided.

2.4.5 Any substantive environmental or facility siting requirement has the potential to be an ARAR. To assist in identification, ARARs are divided into three categories: chemical-specific ARARs, location-specific ARARs, and action-specific ARARs. These three categories are defined as follows:

- Chemical-specific ARARs are promulgated health-based or risk-based numerical values that establish the acceptable amount or concentration of a chemical that may remain in, or be discharged to, the ambient environment. Where more than a requirement addressing a contaminant is determined to be an ARAR, the most stringent requirement should be used. Risk-based screening levels [for example, USEPA Regional Screening Levels (RSLs) are not considered chemical-specific ARARs because they are not promulgated].
- Location-specific ARARs generally are restrictions placed on the concentration of a hazardous substance or the conduct of activities solely because they are in special locations. Requirements addressing cultural resources, historic places, floodplains, wetlands, or sensitive ecosystems and habitats, are potential location-specific ARARs.
- Action-specific ARARs are usually technology- or activity-based requirements or limitations placed on actions taken with respect to remedial actions, or requirements to conduct certain actions to address particular circumstances at a site. Regulations that dictate the design, construction, and

operating characteristics of air stripping units, incinerators, landfills, or other waste management facilities are examples of action-specific ARARs.

2.4.6 ARARs are identified during the response process prior to issuance of the Record of Decision/Decision Document (ROD/DD), and they may continue to evolve over time. The NCP at 300.515 (d)(2) indicates that the lead and support agencies shall discuss potential ARARs during the scoping of the RI/FS; ARARs were presented in the WP for the Culebra Underwater RI/FS MRSs 13 and 09. The NCP also requires the lead agency to formally request ARARs from support agencies upon completion of the RI. Agency concurrence of ARARs will be part of the RI process. For an alternative to pass into the detailed analysis stage of the RI and thus become eligible for selection, it must comply with its ARARs or a waiver should be identified and the justification provided for invoking it. An alternative that cannot comply with ARARs, or for which a waiver cannot be justified, should be eliminated from consideration for further discussion as a potential alternative. Updates to ARARs are then requested as details of remedial alternatives become known. Thus, potential ARARs are initially identified on a fairly broad basis, are refined to specific requirements during the latter stages of the remedial action, and are finalized upon signature of the ROD/DD.

2.4.7 As the RI planning process continued, the list of ARARs was updated, particularly as the RI WP was reviewed by Puerto Rico and Federal agencies. ARARs were used to establish the Final Supplemental SOP for Endangered Species Conservation and their Critical Habitat (CESAJ 2015) and the appropriate extent of the RI field work; to aid in scoping, formulating, and selecting proposed treatment technologies; and to govern implementation and operation of the selected remedial alternative. As the remedial action is developed, primary consideration was given to remedial alternatives that attain or exceed the requirements of the identified ARARs. Throughout the RI, ARARs are identified and used by taking into account the following:

- Contaminants suspected or identified to be at the site
- Chemical analysis performed or scheduled to be performed
- Types of media (air, soil, groundwater, surface water, and sediment)
- Geology and other site-specific characteristics
- Use of site resources and media
- Potential contaminant transport mechanisms
- Purpose and application of potential ARARs
- Remedial alternatives considered for site cleanup.

2.4.8 Two Federal laws were identified and evaluated to determine their applicability as potential ARARs. These preliminary ARARs have action-specific requirements and their applicability, relevance, or appropriateness will be further evaluated in the FS. Table 2-3 lists the preliminary ARARs.

Table 2-3: Preliminary ARARs

Requirement	Status/Synopsis of Requirement	Action to be Taken to Attain Requirement
Endangered Species Act (USC Title 16 chapter 35§1538)	Relevant and Appropriate - Location-Specific/The Endangered Species Act (ESA) protects federally listed species (fish, wildlife, and plants) which are either endangered or threatened and preserves critical habitat. The substantive requirement within the Act prohibits the "taking" of listed species [reference: 16 USC 1538; 50 Code of	When evaluating remedial alternatives, consideration must be given to avoiding impacts to the endangered species and its habitat. USACE in coordination with NOAA, NMFS, USFWS and PRDNER authored the: Final Supplemental SOP for Endangered Species Conservation and their Critical Habitat (CESAJ 2015). The processes identified in the above-listed SOP provide procedures that allow for the RI to be completed and avoid impact to

Requirement	Status/Synopsis of Requirement	Action to be Taken to Attain Requirement
	Federal Regulation (CFR) 17.95; 50 CFR 226.208)]	endangered species. A remedial alternative which "takes" an endangered species or destroys its habitat does not qualify as a suitable remedial alternative because the ESA ARAR would not be satisfied. Either a different alternative which does not impact the endangered species should be pursued or an exception allowing the taking of the species is needed, or a waiver of the ARAR is required.
Marine Mammal Protection Act of 1972 USC Title 16 Chapter 31 §1372(a)	The MMPA provides: protection for marine mammals, marine mammal products, the sustainability of Marine Mammal Populations through conservation and management and the MMPA recognizes that the marine mammal population is below their optimum sustainable levels. 50 CFR Subchapter C Part 216	When evaluating remedial alternatives, consideration must be given to avoiding impacts to the endangered species and its habitat. USACE in coordination with NOAA, NMFS, USFWS and PRDNER authored the: Final Supplemental SOP for Endangered Species Conservation and their Critical Habitat (CESAJ 2015). The processes identified in the above-listed SOP provide procedures that allow for the RI to be completed and avoid impact to Marine Mammals. Any remedial alternative that causes injury or kills a marine mammal does not qualify as a suitable remedial alternative. Remedial alternatives that provide protection to Marine Mammals is preferred over seeking waivers from ARAR.

2.5 SUMMARY OF INSTITUTIONAL ANALYSIS

2.5.1 Introduction

2.5.1.0.1 Institutional analyses are prepared to support the development of institutional control strategies and plans of action as a munitions response alternative. These strategies rely on existing powers and authorities of government agencies to protect the public at large from MEC hazards and/or MC risks. An Institutional Analysis Report is provided in Appendix A of this RI document.

2.5.1.0.2 A review of government institutions and private entities that exercise jurisdiction and ownership of the areas indicated that the property encompassing MRS 13 and 09 is under the varying levels of jurisdiction of several agencies:

- MRS – 09: Municipality of Culebra PR, PREQB, PRDNER, USACE and the U.S. Coast Guard
- MRS – 13: Municipality of Culebra PR, PREQB, USFWS, PRDNER, USACE and the U.S. Coast Guard

The roles of each of these agencies are summarized below.

2.5.1.1 Municipality of Culebra Puerto Rico

MRS 13 and 09 lie within the municipality of the Island of Culebra Puerto Rico. The Culebra Mayor's Office and local government functions as a county seat, providing services and coordinating Puerto Rico government resources for Culebra. This includes building permits, emergency management responsibilities (Civil Defense), and land use controls (LUCs) of properties under Culebra's control. Fire departments, law enforcement agencies, and hospitals fall under Puerto Rico; however, Culebra assists in coordination as needed. The USACE maintains direct communication with the Mayor's Office for planning, providing public

awareness on issues dealing with military munitions and coordination for issues dealing with munitions discovered on Munitions Response Sites found on Culebra.

2.5.1.2 Puerto Rico Environmental Quality Board (PREQB)

The PREQB is the lead principal environmental protection regulatory agency in Puerto Rico. The Board is attached to the Office of the Governor of Puerto Rico. PREQB maintains environmental management and stewardship for the environmental protection of air, water, and land. The PREQB is responsible for enforcing compliance with Puerto Rico environmental regulations. Representatives from PREQB participated as part of the TPP, including attending meetings and reviewing and providing comments on project documents. The PREQB is the regulator agency for this project.

2.5.1.3 Puerto Rico Department of Natural and Environmental Resources (PRDNER)

The PRDNER is the executive department of the government of Puerto Rico tasked with protecting, conserving, developing, and managing the natural and environmental resources of Puerto Rico. This includes the coastal waters, bays, and estuaries for Puerto Rico. In addition, the PRDNER is the administrator of assigned land areas which includes MRS 09. The PRDNER provides a review of project documents, attends project meetings, and assists with coordination of use of lands and coastal waters, as needed, in support of the project. The PRDNER is a stakeholder and supporting agency for this project.

2.5.1.4 U.S. Fish and Wildlife Service (USFWS)

The USFWS assists in the development and application of an environmental stewardship, based on ecological principles and scientific knowledge of fish and wildlife. The USFWS provides management of the nation's fish and wildlife resources. This includes the management and the protection of endangered species and migratory birds in Culebra and Puerto Rico by the USFWS. MRS 13 is administered by the USFWS and is part of the Culebra Wildlife Refuge. The USFWS provides a review of project documents and attends project meetings in support of the project. The USFWS is a stakeholder and supporting agency for this project.

2.5.1.5 U.S. Army Corps of Engineers (USACE)

USACE is the lead agency for FUDS, which includes the FUDS sites in and around Culebra (MRS 13 and 09 are within the FUDS boundary of FUDS Project Number I02PR0068). USACE responsibilities include review of project plans and documents, obtaining rights-of-entry to properties in the work area, working with the news media and the public, and coordinating with Federal, state, and local agencies on issues pertaining to implementation of this project and protection of ecological and cultural resources. The USACE is the lead agency for execution of this project, providing technical expertise for MEC and MC activities, and serving as the technical manager for conducting the RI/FS.

2.5.1.6 U.S. Coast Guard (USCG)

The USCG falls within the Department of Homeland Security. The USCG safeguards the U.S. maritime interests and the marine environment. The USCG provides Notices to Mariners (NOTMARs) and updates to mariners on maritime hazards and restricted areas. The USCG has Federal law enforcement responsibilities for U.S. waters, to include the waters around Puerto Rico and Culebra. The USCG can have a role with institutional controls by issuing a NOTMAR, if deemed necessary.

2.6 SITE CHARACTERIZATION GOALS AND DATA QUALITY OBJECTIVES

2.6.1 Site Characterization Goals

2.6.1.1 The TPP team reviewed and agreed to the characterization goals for this RI, which is to characterize the nature and extent of the MEC and MC hazards.

2.6.1.2 The preliminary project goal was to determine if the surrounding coastal waters within each MRS are safe for continued use by property owners and the public. Based on this preliminary project goal, site characterization goals were as follows.

- Conduct an Environmental Baseline Study (EBS). The intent of this EBS was not to perform an in-depth biological study; rather, it was to document the benthic habitats within the transects where the RI activities would take place. Transects were also adjusted per the findings of the EBS to best complete RI objectives and protect the critical habitats
- Document available information pertaining to the nature and extent of MEC and MC within each MRS.
- Identify areas where further investigation is warranted.
- Conduct a field investigation of each MRS to characterize the nature and extent of MEC and MC within the MRS.
- Perform qualitative assessment of MEC and MC risk at each MRS. (The data collected during this investigation will be sufficient to conduct a hazard assessment for MEC.)

2.6.1.3 A secondary goal of the site characterization effort conducted during the RI is to produce sufficient data to facilitate future development and evaluation of necessary remedial alternatives. The field investigation is designed to support this effort by including sufficient DGM and analog surveys, and MC sampling. The data will support the response alternative cost estimates to be developed if an FS is determined to be necessary. The RI/FS will be considered complete upon USACE acceptance of a DD which meets the requirements of ER 200-3-1 and EM-Center of Expertise (CX) Interim Guidance Document 06-04.

2.6.2 Data Quality Objectives

An evaluation of the existing historical data and data from the EBS Report for the MRSs was conducted in the preparation of the Culebra RI/FS WP for MRS 09 and MRS 13 (USA 2014). It was determined that there was a potential for MEC and MC contamination within the investigation area and additional data were needed to characterize the nature and extent of that contamination. Data Quality Objectives (DQOs) presented in Table 2-4 were developed to make appropriate and supportable decisions and to define the parameters of the field investigation. DQOs are qualitative and quantitative statements that specify the quality and the level of the data required in support of the decision-making process. The DQOs were developed as part of the TPP process to ensure that the available data generated as part of previous investigations were of appropriate quality to support the anticipated end use of the data. DQOs seek to ensure that the right type, amount, and quality of data are collected to accomplish the objectives of the project. All DQOs established by the TPP team and presented below were met by the RI field effort and risk analysis.

Table 2-4: Data Quality Objective Statements

DQO Steps	MRS Locations
Underwater Areas of MRS 09 and MRS 13	
1. State Problem(s)	Based on historical data, previous investigations, suspected Material Potentially Presenting an Explosive Hazard (MPPEH) items identified during the EBS visual survey, reports of UXO sightings in the water by civilians, and documented UXO findings on land, MRS 09 and MRS 13 are confirmed to have been used for DoD training operations using munitions with an explosive potential. A. Receptors Human receptors include residents and tourists who use the underwater portions of MRS 09 and MRS 13 for diving, snorkeling, swimming and fishing. The underwater portions of MRS 09 and MRS 13 are known to contain ecological receptors including threatened and endangered species and critical habitats. B. MEC It is highly possible MEC is present in the underwater (benthic) portion of MRS 09 and MRS 13, and may present an explosive hazard to human and ecological receptors and critical habitats. C. MC It is possible that MC from munitions remaining on-site and deteriorating in the marine waters, may have contaminated marine sediments present within the MRSs.
2. Identify the Decisions	The decisions that need to be made to guide this investigation are in three general areas. A. Sensitive ecological receptors and critical habitats • Determine the species and habitats present in the study area. • Determine the presence of and identify Listed Endangered or Threatened Species and critical habitat present in the near vicinity or on MEC/MPPEH. • Determine what removal or disposal procedures, and equipment to be used, will best protect the ecological resources and still remove or dispose of the hazard. • Determine the acceptable level of hazard to expose UXO SCUBA divers to in the process of protecting environmental resources. B. Potential target areas Establish presence/absence of potential target areas within MRS underwater investigative areas; if present, characterize nature and extent of contamination present. • Intrusive investigations will determine whether or not MEC is present. . • Determine which procedures and equipment will be most appropriate to accurately detect MEC in the different marine environments present (shallow water, deep water). • Determine how investigative transects will be placed to characterize the presence of MEC with a 90%(1) confidence of determining elevated anomaly density areas while protecting ecological resources and adequately considering the safety of UXO SCUBA divers. • Determine the level of acceptable hazard for divers. • Establish which anomalies identified in the geophysical/analog investigation will be intrusively investigated. • Transects designed with VSP will determine areas of high density that may indicate a target area. • When MEC are found, determine the disposal method appropriate to the item found which will protect ecological resources and minimize hazard for divers.

DQO Steps	MRS Locations
	• Determine what methods and standards will be used to delineate the estimated extent of contamination identified. C. MC Establish presence/absence of MC contamination of marine sediment within MRS underwater investigative areas; if present, characterize nature and extent of MC contamination of marine sediment within MRS underwater investigative areas. • Determine what receptors are present. • Determine the number of samples and locations where samples will be collected. • Determine what analytes will be evaluated. • Determine what background values and screening values will be used to identify COPCs for risk assessment. • Determine if levels of detected MC present an unacceptable a risk to human or ecological receptors in a baseline risk assessment. • Determine how the extent of any contamination from MC determined to present an unacceptable risk to human or ecological receptors will be delineated.
3. Identify Information Inputs	A. To establish presence/absence (nature and extent if present) of MEC contamination: • Baseline Survey Report data (Relative position of identified endangered species/ critical habitat, suspected MEC items identified) • Current/future land use, potential receptors and accessibility (CSEMs) • Historical records review (ASR, previous investigations) • Terrestrial RI data • Presence of surface MEC items discovered within underwater investigations of the MRS (Bathymetry and SSS), visual data from geophysical investigation) • Presence of subsurface MEC items from information gathered in the intrusive investigation based on data from the geophysical investigation. • Validation of the geophysical equipment and positioning equipment area functioning correctly for daily instrument testing. • Information from additional transects as necessary to refine characterization of high density areas, if established. B. To establish presence/absence (nature and extent, if present) of MC contamination: • The nature of contamination will be determined from analytical data from discrete samples collected from marine sediments on the seafloor surface at transect locations where MEC items are found. – The list of MC Analytes will be developed from the types of munitions suspected or identified as used at the MRSs. – The background levels will be established from samples collected in areas within the MRS separated from locations of MEC/MD. • The screening values: – Human Health: USEPA RSL, residential soil, November 2013 (target risk of 1E-06, target HQ of 0.1); the November 2013 RSLs will be used in the RI Report for COPC identification and risk screening, unless the screening value changed significantly (i.e., greater than an order of magnitude difference between the screening values)[(2)]; – Ecological: USEPA Region 4 Ecological Screening Values (ESVs), November 30, 2001, supplemented with Los Alamos National Laboratory, EcoRisk Database (Release 3.1), October 2012 and USEPA Region 5 ESVs, August 22, 2003 when no value was available.

DQO Steps	MRS Locations
	• The extent of contamination identified will be determined from confirmation sampling conducted in a phased approach, according to the procedure described below in Paragraph 4.B. C. Production data from the RI will be used to support cost estimates for the FS and future remediation efforts.
4. Define the Boundaries of the Study	The overall horizontal extent of the RI study boundary consists of the underwater (benthic) areas of MRS 09 and MRS 13. The underwater boundaries were established as the area most likely to be used by the anticipated human receptors (residents and tourists swimming, snorkeling, diving, and fishing in the area) and the areas that DoD usage is suspected to have taken place. A. MEC • Horizontal Extent – The horizontal extent of the study is the MRS, with step-outs as needed based on RI findings. – Areas identified with MEC presence will be bounded by step-out transects that are half the investigated transect spacing. The transects will be placed on both sides of the transect that produced MEC. The only exception is when the step-out transect would endanger coral, due to the step-out transect being placed onshore or too shallow water. Step-out transects will be investigated as analog and dig with analog instruments. • Vertical Extent – The vertical extent of the MEC is from the surface of the seafloor to the maximum depth of detection of the geophysical instrument in use, or to coral reef, consolidated hard bottom or bedrock, whichever is reached first. It is possible MEC may be above the seafloor but embedded in coral growth. (The DGM platform or UXO SCUBA diver held analog metal detection instrument deployed and deemed appropriate for each situation is identified in the technical approach of the WP. The type of instrument and platform are based on amount of submerged vegetation, presence of coral, bottom relief, and depth of water.) • Intrusive Investigation – Intrusive investigation will be performed by hand, using hand tools, and will occur only in unconsolidated sediments. Procedures will vary depending on whether or not seagrass is present. The UXO SCUBA divers will follow the appropriate SOPs when performing intrusive investigations. – The population of MEC-like anomalies to be intrusively investigated will be those anomalies identified along the planned transects. The numbers of anomalies investigated will vary according to the anomaly density detected in the area. The definition of high, medium, and low density will be established using VSP statistical tools with data from the geophysical investigation. Anomalies removed will be based on type of anomaly and MEC hazard present, taking into consideration sensitive ecological receptors, critical habitats and hazards to UXO SCUBA divers. – If a MEC item is found embedded in or with listed as threatened or endangered coral colonies attached, the item will not be disturbed, and the hazard present will be discussed with the Project Development Team (PDT), to determine a path forward. B. MC • MC will be investigated at transect locations where MEC items are found. The number of samples and their location will be based on MEC findings. – An investigative sample will be collected within each MRS at each MEC finding of a new munition type. At locations of repeated findings of the same munition type, samples will be collected at a rate of 10%. – The vertical boundary for the MC investigation will include marine sediments from a depth interval of 0 to 6 inches below the seafloor. However, if a MEC item is

DQO Steps	MRS Locations
	found deeper than 6 inches, the sample will be collected beneath the item (if safe to move) or adjacent to the item at the same depth. – If a MEC item is found in coral or in consolidated sediments, no sample will be collected. • Extent of MC contamination will be investigated in the following phased approach. – Analytical data from one sample will be collected 4 ft from the location where a MEC investigation sample is collected, to establish if potential contamination is localized to the munitions finding. This sample will be collected immediately prior to collection of the MEC sample, to avoid cross contamination. – Additional step-out samples to be determined by project team based on level of unacceptable risk present. – Quality Assurance (QA) and Quality Control (QC) samples will be collected as defined in the RI WP Field SAP (USA 2014). C. Temporal Boundaries • In-water detonations will be avoided during coral spawning events (August) and Turtle Hatching events (identified by the team biologist as they occur).
5. Develop a Decision Rule	A. Characterization of Underwater Habitat: If endangered and/or threatened species and/or critical habitat within planned investigation areas are encountered, the field team will follow procedures for their protection IAW the SOPs for Endangered Species Conservation and their Critical Habitat during Underwater Investigations (CESAJ 2015). B. Characterization of MEC contamination: Geophysical investigation methods will be used to evaluate potential MEC presence. The Geophysical investigation determines that metallic anomalies are present, but doesn't identify the anomaly as MEC. An intrusive investigation will be conducted to determine which metallic anomalies are MEC. Types of equipment used will be chosen based on the type of environment in which the transect is located. Information related to types of equipment is located in Chapter 3, Section 3.2, Underwater Geophysical Investigation, and Section 3.3.3.1, Intrusive Investigation, of the RI WP (USA 2014). • Dig Selections: – If an anomaly detected during the geophysical investigation meets anomaly selection criteria (i.e., is above a background threshold determined by the IVS and based on professional judgment) and is placed on the dig list, and used to generate an Anomaly Density map. If the anomaly is in a high density area (e.g., ≥ 30 targets/acre or ≥ 20 targets above background), then the anomaly will be investigated intrusively. USA funded assumptions: 10 high density areas with a total of 100 EM anomalies in MRS 09 (includes EM or Analog anomalies within step-out transects) and 158 EM anomalies in MRS 13 (includes EM or Analog anomalies within step-out transects). – A random selection of low density area transect EM targets (up to 10 targets in MRS 09 and up to 16 targets in MRS 13) will be investigated to confirm that these areas are not MEC contaminated. If no high density areas are identified, then more low density area targets may be investigated, up to a maximum of 100 targets in MRS 09 and 158 targets in MRS 13. • MEC Hazard present – If no MEC-related items are found in an area based on intrusive investigation, then the area will be considered un-impacted by MEC. If anomalies are identified as MEC or MD indicative of HE, then the area will be considered contaminated by MEC. The extent of the hazard will be bound with step-out transects placed at a distance of half the original transect spacing from the outer boundary of the contaminated area.

DQO Steps	MRS Locations
	– If the area is contaminated with MEC, then the MEC hazard present will be evaluated in an assessment supported with data from a MEC HA, historical data, and professional judgment. • MEC Removal – If an item is determined to be MEC and is deemed unacceptable to move onshore for demolition, the item will be marked by a clump and video/photos will be taken of the item and the surrounding area, and the location will be captured by GPS (the DGM anomaly location may also be used in place of marking with a separate GPS). If the MEC item has Listed Threatened or Endangered species attached or affixed to the reef adjacent to the MEC item, and it is determined that removing or detonating the MEC item will harm or injure the Listed Species, the item will be left in place for further determination by the government. – If a MEC item is deemed acceptable to move, then procedures identified in Chapter 3, Field Investigation Plan, of the RI WP for MRS 09 and MRS 13 (USA February 2014) will be followed. C. Characterization of MC contamination: • If an MC analyte is undetected or is detected at concentrations less than background levels and preliminary screening values[3], then the area will be considered uncontaminated by that MC analyte and it will not be investigated further. • In areas where MC analytes are detected at concentrations greater than background levels and preliminary screening levels[4], as established in the RI WP SAP (USA 2014), the analyte will be considered a COPC and retained for consideration in a baseline risk assessment. – If the baseline risk assessment determines the contamination is limited to the location of the munition, based on information from the companion sample collected at the same time, there will be no further investigation. – If the baseline risk assessment determines an unacceptable risk to human health or ecological receptors, and the contamination is also present at the companion step-out sample, then the TPP team will evaluate the magnitude of the unacceptable risk and further step-out sampling may be planned.
6. Specify Limits on Decision Errors	Measurable decision errors are limited to the field and analytical QC processes for survey coverage. A. MEC Investigation • All geophysical activities will achieve applicable Measurement Quality Objectives (MQOs) as stated in Chapter 3, Field Investigation Plan of the RI WP for MRS 09 and MRS 13 (USA February 2014) and confirmed/modified by the IVS, unless MQO failures can be adequately explained or justified. B. MC Investigation • All sampling and analysis will achieve the MQOs outlined in the SAP, unless MQO failures can be adequately explained and/or justified.
7. Develop the Detailed Plan for Obtaining Data	A. Characterization of species and habitat The plan for evaluation of species and habitat within the underwater study area was developed in the WP for the EBS. B. MEC The investigation transects were designed in VSP software for detection of a MEC contaminated area by determining elevated anomaly density areas with a 90%[5] confidence level above a background density. The VSP-designed transects are realigned to consider bathymetric contours delineated in the 2013 EBS Report, sensitive ecological receptors and critical habitat. The transect design separation varies based on

DQO Steps	MRS Locations
	the specific area, from 225 ft to 250 ft. Transect width for the geophysical investigation is 3 ft. Data collection procedures and associated QC measurements are included in the Field Investigation Plan in Chapter 3 of the RI WP for MRS 09 and MRS 13 (USA February 2014). C. MC The detailed sampling plan for field procedures and laboratory analysis is outlined in the RI WP SAP (USA 2014).

Footnotes:

1. 95% Confidence level was referenced in the RI WP for MRS 09 and MRS 13 (USA February 2014). This was a typographical error and has been corrected in the RI Report. The RI Transect design is to determine an elevated anomaly density areas with a 90% confidence level above background density.
2. Screening Values were revised per PR EQB Requests:
    a. From: Human Health: USEPA RSL, residential soil, May 2013. Carcinogens divided by a factor of 10;
    b. To: Human Health: USEPA RSL, residential soil, November 2013 (target risk of 1E-06, target HQ of 0.1); the November 2013 RSLs will be used in the RI Report for COPC identification and risk screening, unless the screening value changed significantly (i.e., greater than an order of magnitude difference between the screening values)
3. Per PREQB request "and preliminary screening values" has been inserted to the Characterization of MC contamination following the WP review in which was not captured in the WP prior to mobilzation. This change is now reflected in the RI Report.
4. Per PREQB request "and preliminary screening levels" has been inserted to the Characterization of MC contamination following the WP review in which was not captured in the WP prior to mobilzation. This change is now reflected in the RI Report.
5. 95% Confidence level was referenced in the RI WP for MRS 09 and MRS 13 (USA February 2014). This was a typographical error and has been corrected in the RI Report. The RI Transect design is to determine an elevated anomaly density areas with a 90% confidence level above background density.

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CHAPTER 3. CHARACTERIZATION OF MEC AND MC

3.1 MEC CHARACTERIZATION

The following sections describe the processes employed during the field tasks which resulted in the characterization of MRS 09 and MRS 13 for MEC hazards.

To characterize the site, the results from the geophysical (Phase 2) and intrusive investigation (Phase 3) established either the presence or absence of potential target areas or Concentrated Munitions Use Areas (CMUAs) within MRS underwater investigative areas; if target areas had been present, then additional fieldwork would have been scheduled to characterize the nature and extent of the contamination present. The result then allows for the development of the necessary response alternatives. Geophysical investigation methods were used as described in this section to evaluate the potential for or the presence of MEC but does not confirm MEC presence. The geophysical investigation only determines that metallic anomalies are present. An intrusive investigation was used to determine which metallic anomalies were either MEC (no MEC was discovered), MD, or cultural debris. The MEC findings can be found in Sections 7.1 and 7.2.

3.1.1 Deviations from the WP (Appendix I: Field Change Requests)

Deviations from the WP were documented with FCRs and submitted for the following MEC tasks.

3.1.1.1 FCR 1: As the UXO Technician SCUBA Divers investigated the unconsolidated sediment areas of MRS 09 and MRS 13, it was apparent that excavating to the depth of detection was not feasible by or with hand tools as described in the WP. The WP DQOs identify the vertical extent as the surface of the seafloor to the maximum depth of detection. The DQOs also require the investigation of anomalies to be conducted by hand or by using hand tools. Following the reacquisition of the DGM anomaly, excavation to identify the anomaly was conducted. However, as the UXO Technician SCUBA divers dug into the unconsolidated sediment the excavation site would collapse in on itself. Though some excavations were completed to 36 inches in depth, this was a rare occurrence and the excavations to an approximate depth of 24 inches, though difficult, were achievable by hand. This generated FCR-1, limiting the depth of excavation for a DGM Target to 24 inches. The FCR allowed for the fieldwork to continue without multiple dive sets attempting to excavate to the depth of detection, and it also minimized the damage to the seagrass beds by reducing the excavation footprint. There were 101 DGM anomalies selected for investigation that were located within unconsolidated sediment areas. Of these anomalies, 16 were found to be too deep in the marine sediment for the UXO Technician SCUBA Divers to uncover (see Section 4.1.1.2). FCR-1 did not require a change to the MQO's as it did not have a direct effect on the MQOs, and the MQO's were followed. However the excavation of DGM anomalies to the depth of detection was revised to 24 inches, aligning the depth of intrusive excavation to the capabilities of the field teams when excavating anomalies by hand. FCR-1 allowed for the completion of the MEC investigation to satisfy the project objective for MEC. The nature of the contamination for MRS 13 included 5-inch expended illumination projectiles which had an average depth below the sea floor of 5.58-inches. All MD contamination including the 5-inch expended illumination projectiles, discovered within MRS 13 were related to illumination type munitions (e.g. parachute flares, pusher plates and fuze parts for illumination projectiles) providing further evidence that the nature of the contamination for MRS 13 as expended illumination type munitions. The average depth below the sea floor of all the MD contamination if combined is 4.57-inches.

3.1.1.2 FCR-2: WP procedures included the collection of DGM data along transects equally spaced across the site in order to determine the anomaly density and most likely locations of potential CMUAs. After the analysis of the DGM transect targets, the VSP anomaly density analysis indicated that all of the DGM targets resulted in a "high density area" and met the Dig Selection Criteria. This identified an ambiguity in the WP with the definition of "high density area". The intent of the phrase is to identify CMUAs that have (1) a higher anomaly density than background, and (2) have a sufficient area extent, consistent with a potential CMUA. This combination of anomaly density and spatial extent are documented in the VSP post-analysis reports. What became "unexpected" were the VSP high density areas around each individual, isolated DGM anomaly. Most of these "high density areas" were smaller than a potential CMUA. Because

the goal of the RI is to determine the nature and extent of MEC contamination, rather than to identify isolated MEC, FCR-2 was developed as a tool to optimize DGM anomaly investigations, even in "high density areas" that were too small to be potential CMUAs. The Geophysical System Verification (GSV) results (Appendix E: Geophysical Results) recommended an alternate dig selection from the dig selection described in the DQOs. The alternate dig selection was based on anomaly response values creating a priority scheme for intrusive investigation. This finding was then documented as an FCR, submitted to the USACE as FCR-2 and approved by the USACE. The anomaly response values were applied to the DGM Target Identity Number setting the priorities of 1 through 3, with 1 as the highest priority. The UXO Technician Intrusive Teams then investigated 198 DGM Targets by priority. However, slightly more DGM targets were investigated than were scheduled (30 Targets for MRS 09 and 170 Targets for MRS 13). Intrusive results for each DGM Target are annotated in the project's Access database and the Intrusive Investigation Results Table (Appendix E: Geophysical Results). The intrusive results include the description of the anomalies on the surface of the sea bottom and buried below it. The intrusive results were used to identify the nature and extent of MEC and MD. The implementation of FCR-2 was based on a clarification of the DQO definition of a "high density area".

3.1.1.2.1 The VSP post-analysis for MRS 09 used the same potential CMUA radius of 300-ft (6.5 acres) that was used for transect design. The background and target area (potential CMUA) anomaly densities used values based on actual RI results of 10 anomalies per acre background and 75 anomalies per acre CMUA. This post-analysis documented that the actual RI data had a 90% probability of traversing and detecting potential CMUAs, with one small (1.5 acre) data gap in inaccessible shallow water.

3.1.1.2.2 The VSP post-analysis for MRS 13 used the same potential CMUA radius of 500-ft (18 acres) that was used for transect design. The background and target area (potential CMUA) anomaly densities used values based on actual RI results of 10 anomalies per acre background and 75 anomalies per acre CMUA. This post-analysis documented that the actual RI data had a 95% probability of traversing and detecting potential CMUAs, with no data gaps. These two VSP post-analysis reports included in Appendix S, document that FCR 02 did not impact any of the project MQOs, and met the project objectives for MEC/MD investigations.

3.1.1.3 FCR-5: Per the approved WP, the IVS for the intrusive investigation was located at Soldado Point and the analog instruments were processed through the IVS each morning that they were programmed for use. The diver EM-61 requisition system was only required to be used for anomalies identified with the EM Sled and was required to be processed through the land IVS both in the morning and evening. The diver EM-61 reacquisition system, when employed, reacquired the anomaly but not with the precise accuracy to determine the spot in which the UXO Technician SCUBA divers needed to excavate. To correct this deficiency, the anomaly was reacquired with the diver EM-61 reacquisition system, and then the spot selected for excavation was determined by using the underwater analog all-metal detectors. Due to the morning equipment set-up, QC checks, diver/safety briefs, and the boat transit time to and from the work site, only 6 hours of field time was available out of a 10-hour day. In order to optimize time in the field, FCR-5 was submitted, eliminating the need for the end of the day processing through the IVS with the diver EM-61 reacquisition system. FCR-5 revises the MQO Static Repeatability test for the diver EM-61 and processing through the IVS to the frequency of the morning tests only. The FCR did not have a negative impact on the DQOs, since the system was used to reacquire 26 selected anomalies in which all were reacquired with zero "no finds." In addition, the analog all-metals detectors were used to refine the anomaly location once the diver EM-61 confirmed its location, providing further redundancy in the anomaly reacquisition.

3.1.2 Chronology of Field Events

USA Environmental, Inc. (USA) conducted its investigations for MEC from February 12, 2014 to April 26, 2014. USA initialized its mobilization to the site on February 12. February 19 mobilization was complete and the field team attended and participated in the site specific training. The site specific training included: Dive Medicine, Dive Operations, Diving Emergencies, UXO Safety, and the Project WP and its Appendices. In addition, special attention was provided to the review and discussion of the SOP, "Endangered Species Conservation and their Critical Habitat during underwater investigations at DERP-FUDS property number.

I02PR0068, Culebra Island, Puerto Rico (CESAJ 2015)". During this training evolution, the PRDNER provided a briefing and awareness training on topics covering the identification and protection of Marine Mammals, Coral, and Sea Turtles. Following the on-site training, the USACE Technical Manager and the USA Project Manager provided RI fieldwork briefings to the Culebra Mayor's Office, Police Department, Fire Department and PRDNER. The Site Specific Training also included the UXO SCUBA dive team evaluation by the USACE District Diving Coordinator (DDC). The UXO SCUBA Technician Dive Team evaluation by the DDC was conducted from February 20 to 24, 2014. DGM equipment set up and transect survey was initiated on February 22, 2014. The DGM Survey was completed on March 18, 2014. Intrusive investigation of DGM targets started on 25 February 2014 and was completed on 26 April 2014. Information and details relating to the environmental sampling are reported in section 3.2, MC Characterization. Table 3-1 provides a chronology of the MEC field investigation.

Table 3-1: MEC/MC Field Investigation Chronology

Date	Task	Description
12 to 19 February 2014	Mobilization/Site Setup	USA mobilized (team), Site Specific Training
20 to 24 February 2014	UXO Technician SCUBA Dive Team Evaluation Period	USACE DDC evaluates the USA execution of the project's Dive Plan and emergency procedures through witnessing the team executing dive emergency drills and managing the dive station. USA successfully completed the USACE evaluation on 24 February, allowing USA to conduct underwater field work while using SCUBA.
22 to 24 February 2014	DGM Equipment Set Up and Installation of shallow water IVS	DGM team set up and completed operational testing of underwater DGM equipment. DGM team conducted a pre-survey of the IVS on 23 February. UXO Technician Divers set up the shallow water DGM IVS on 24 February.
3 to 20 March 2014	GSV Report	Draft GSV Report was submitted on 3 March 2014. Final GSV Report was submitted on 20 March 2014
12 March to 2 June 2014	FCR-1	UXOT SCUBA Divers performing intrusive investigations are utilizing hand tools per the work plan. When excavating in sand the dig site collapses in on itself during excavation. The UXOT divers have had repeated success reaching the anomaly down to 24 inches but not beyond this depth. USACE Approved on 2 June 2014.
17 and 18 March 2014	Installation of deep water IVS	The deep water IVS pre-survey on 17 March and installed on 18 March with the assistance of the UXO Technician SCUBA Divers.
18 March 2014	EM Sled Transects	Deepwater unconsolidated sediment transects were started and completed (Transects 13B and 14B)
24 February to 27 March 2014	Transect DGM Surveys and Anomaly Mapping	USA completed geophysical surveys of each transect using an underwater EM61 MK 2 instrument with survey grade Real Time Kinematic (RTK) Differential Global Positioning System (DGPS) positioning in conjunction with the following platforms: EM Float (small and large), EM ROV and EM Sled. The EM ROV also integrated an ultra-short baseline (USBL) positioning system. The DGM team collected DGM data along transects to identify transect anomalies, and generated anomaly density maps. Based on the millivolt (mV) readings and the priorities provided by the Site and Project Geophysicist per the GSV report, the DGM Target list for intrusive investigation was developed. DGM transects were completed on 18 March 2014. Transects that posed a safety risk for the DGM vessel or were too shallow for DGM Platforms to operate were

Date	Task	Description
		completed by either UXO Technician SCUBA divers or snorkelers using underwater analog instruments. UXO Technician SCUBA diver transects were completed on 27 March 2014.
25 February to 15 April 2014	Intrusive Investigation of DGM Targets	Based on the dig list developed from the DGM surveys, USA performed intrusive investigations within each transect. Data was recorded on the location, type, condition, and depth of MEC. Concurrent with intrusive investigations, USA provided MPPEH management, disposal of MEC, and offsite disposal of Material Documented as Safe (MDAS).
21 March 2014	GSV	The USA geophysicist documented the results of the GSV in the Final GSV Report (Appendix E: Geophysical Results)
23 March 2014	DGM Team Demobilized	DGM Team demobilized from work site.
25 March to 2 April 2014	FCR-2	The VSP Anomaly Density analysis indicates that all DGM Transect Targets meet the work plan Dig Selection criteria. The Final GSV Report recommends an alternate Dig Selection based on anomaly priority, which is based on the sensor platform and anomaly response values. USACE approved FCR-2 on 2 April 2014.
28 March to 14 April 2014	FCR-3	FCR requests the removal of iron as an analyte for the U/W RI/FS and ammonium picrate tables to the QAPP. In addition the FCR requested that APPL to serve as both the Prime and QA lab. USACE approved FCR-3 on 14 April 2014.
2 April 2014	Marine Sediment Sampling	18 marine sediment samples were collected from MRS 13, plus two QA, and QC samples [two Duplicates and one Matrix Spike/Matrix SpikeDuplicate (MS/MSD)]. 8 background samples, and 5 samples beneath munitions, each with a step-out at 4 ft companion sample from main sample.
3 April 2014	Marine Sediment Sampling	6 marine sediment samples were collected from MRS 13, plus one QA, and one QC (Duplicate) samples. This included 3 samples beneath munitions, each with a companion sample at 4 ft from main sample.
16 April 2014	Marine Sediment Sampling	12 marine sediment samples were collected from MRS 13, plus one QA, and one QC (Duplicate) samples. This included 6 samples beneath munitions, each with a companion sample at 4 ft from main sample.
16 to 22 April 2014	Removal of MD from MRS 13	USA submitted a report associated with each expended military munition that had coral or other sea growth attached selected for removal. Upon receiving recommendations from the project stakeholders USA removed an estimated 2,190 lb of MD.
23 to 26 April 2014	Demobilization	USA completes the packaging and certification of MDAS, performs maintenance on equipment to be shipped, packages and demobilizes.
19 May to 6 June 2014	FCR-4	Replace method 6020A with 6010C for the antimony analysis for samples included in the second sample delivery group. APPL has ICP-MS problems conducting antimony analysis with SW6020A resulting in inconsistent antimony intensities for the calibration blank and the initial

Date	Task	Description
		calibration curve. The limit of quantitation of antimony by 6010C is lower than the screening value and APPL is both 6010C and 6020A certified by DoD Environmental Laboratory Accreditation Program (ELAP).
20 to 28 May 2014	FCR-5	The limited use of the Diver EM-61 during reacquisition, as an alternative to the analog underwater instrument was tested at the beginning of each work day vs at the beginning and end of each day. This FCR was signed post field work. The WP discrepancy was identified on 20 March 2014.

3.1.3 Instrument Verification Strip

3.1.3.1 The Site Geophysicist installed (with the assistance of the UXO Technician SCUBA Divers) the shallow underwater IVS on February 23 and 24, 2014 (see Figure 3-1). The site location was selected in MRS 09, which would be used for the EM61 ROV and Float (large and small) platforms. The deep water IVS was installed with the assistance of the UXO Technician SCUBA Divers on March 17 and 18, 2014 (see Figure 3-2). The deep water IVS was used for the EM61 sled and was built in MRS 13. Both IVSs were surveyed prior to installation to ensure the IVS strip was free of anomalies, leaving the IVS suitable for seeding. Once this background check was completed and verified by the Site Geophysicist, the USA team installed small and medium industry standard objects (ISOs) (simulates a 37mm and 60mm projectile). The as-installed locations were surveyed in with the RTK DGPS system. The GSV report was finalized and accepted on 21 March 2014.

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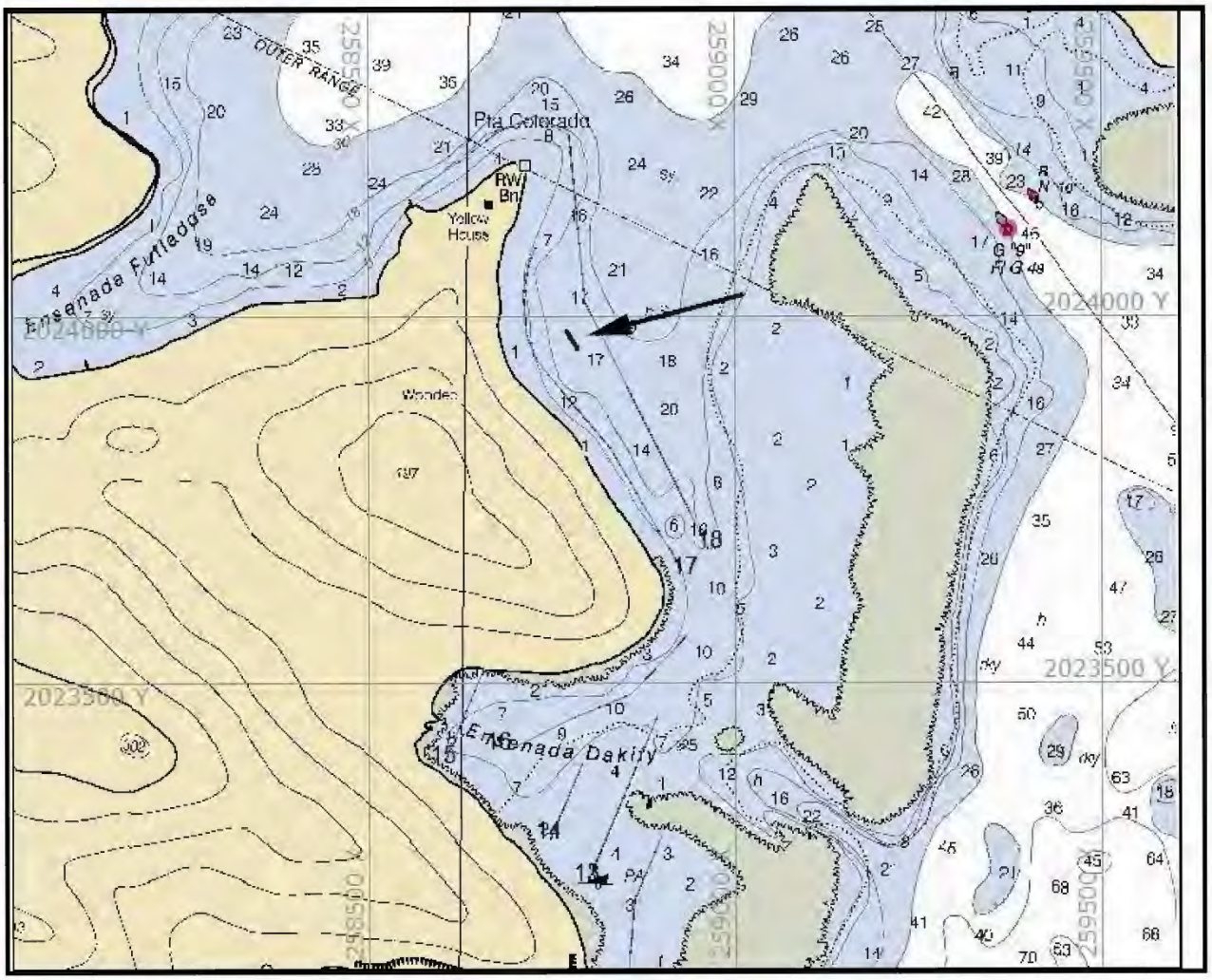

Figure 3-1: Shallow Water IVS Location

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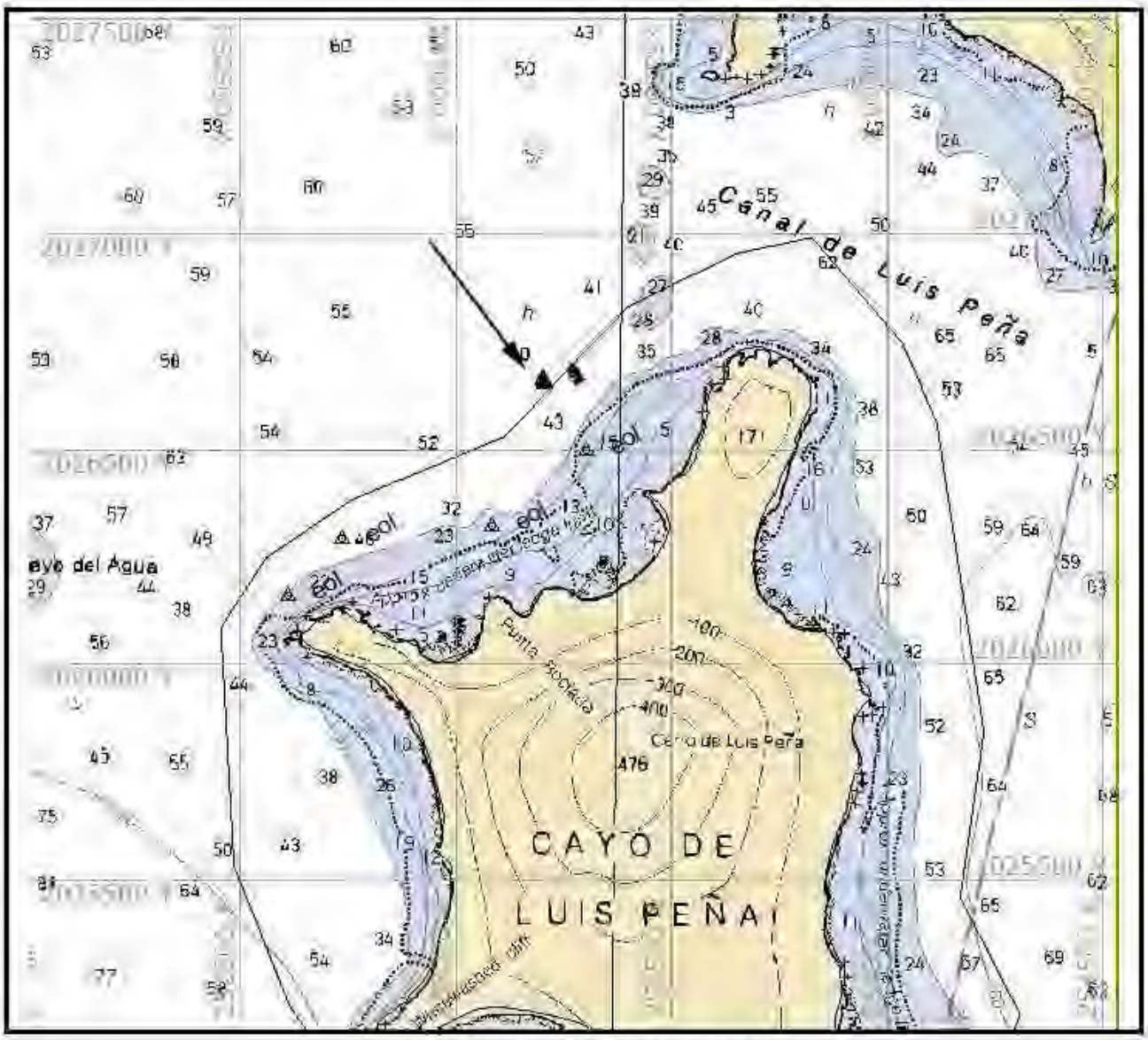

Figure 3-2: Deep Water IVS Location

3.1.3.2 Table 3-2 documents the "as built" IVS. GSV objectives included:

- Document that the geophysical system (sensor, positioning, operators, data processing and analysis) meet project objectives.
- Confirm and/or finalize geophysical performance metrics.
- Establish initial anomaly selection criteria.
- Provide a standardized test site to evaluate any changes to geophysical equipment and personnel, as well as a daily instrument response repeatability check.

3.1.3.3 The GSV objectives were met and documented. For further details, refer to the GSV Report included in Appendix E: Geophysical Results. The report describes IVS seeding, GSV surveys, results, and intrusive investigation list development, static check results, and performance metrics summary.

Table 3-2: As Built IVS (Shallow and Deepwater IVS)

IVS Seed Item	Item	X (ft)	Y (ft)	Inclination	Orientation	Depth to Center of Mass (cm)	X (Easting) m	Y (Northing) m
IVS_1	Small ISO	15	0	Horizontal	Along-Track	0	258774.49	2023973.73
IVS_2	Small ISO	30	0	Horizontal	Along-Track	0	258777.24	2023970.58
IVS_3	Medium ISO	45	0	Horizontal	Along-Track	0	258780.05	2023967.46
IVS_4	Medium ISO	60	0	Horizontal	Along-Track	0	258782.95	2023964.24
IVS_D1	Small ISO	0	0	Horizontal	Along-Track	7.6	253204.95	2026651.663
IVS_D2	Small ISO	16.4	0	Horizontal	Along-Track	17.8	253203.56	2026655.77
IVS_D3	Medium ISO	32.8	0	Horizontal	Along-Track	15.2	253202.46	2026660.43
IVS_D4	Medium ISO	49.2	0	Horizontal	Along-Track	35.6	253200.63	2026665.63

X, Y are in WGS84 Universal Transverse Mercator (UTM) 20 North, with units in meters
ft – feet
cm – centimeters
m – meters

3.1.4 Transect Geophysical Investigation Mapping

3.1.4.1 USA performed geophysical surveys along transects from February 24, to March 18, 2014. Daily equipment function checks were completed as described in the WP, with the results logged into the project database. During the transect survey, the DGM Team started data logging at the beginning of each transect and periodically confirmed both EM and positioning data continued to log in the EM software. During this visual system check, the GPS status code, as well as the relative position of the DGM vessel to both the EM Platform and shore, was confirmed.

3.1.4.1.1 Each morning, depending on the MRS and transects selected for that day's evolution, the RTK DGPS was compared against known National GEODETIC Survey control points located on Melones Point or Soldiers Point (Melones Point - Padang – 1 and 2 or Soldiers Point - Josue – 1 and 2). The RTK DGPS base station was placed at a control point providing a corrected GPS coordinate to the vessel's RTK DGPS rover. When the DGM team surveyed transects on the western side of MRS 13, a repeater on a small boat was required to relay the communication link to the DGM vessel from the control point.

3.1.4.1.2 The DGM platform identified for the day's operation was processed through the IVS each morning.

3.1.4.1.3 A static test was performed at the beginning and end of each work day.

3.1.4.2 The investigation transects were designed in VSP to detect areas of elevated anomaly densities. Intrusive investigation would then determine whether these areas of higher anomaly densities corresponded to MEC-contaminated areas. All elevated anomaly density areas, with spatial extents large enough to be potential CMUAs were investigated. Single high density anomalies, too small to represent potential CMUAs were investigated around each MRS. However there were some priority 3-only higher density areas left uninvestigated in the southern acres of MRS 13, in which all were much smaller than a potential CMUA.

3.1.4.2.1 Inputs into the original VSP for MRS 09 are as follows. An EM61 coil width is 1 meter; therefore, the transect width of 1 meter was selected. A circular target was chosen to better represent multiple firing points/flight paths. A target area radius of 150 ft was chosen based on the ordnance expected at MRS 09 (bombs and mortars). A background density of 50 anomalies per acre (based on higher public access and usage) and an expected target area density of 500 anomalies per acre above background was chosen

based on historical ordnance reported within this MRS (bombs and mortars). These VSP inputs resulted in a 225-ft transect spacing, that provides a 90% probability of traversing and detecting the 150-ft radius potential MEC contaminated area. This is the basis for the MRS 09 proposed transects.

3.1.4.2.2 During the planning phases for Phase 1, the ordnance expected for MRS 09 was reevaluated. The munitions anticipated for the underwater acres were 30-, 100- and 1000-pound bombs (USACE 2004) and the 4.2 inch mortar identified during the terrestrial RI was no longer considered as an input into VSP. Even though this change to the VSP inputs would allow a wider transect spacing, the original VSP transect spacing of 225 ft was maintained to ensure enough transect acreage to adequately characterize the site. The VSP designed transects were realigned to consider bathymetric contours delineated in the EBS Report (USA 2013), for the sensitive ecological receptors and critical habitat. The finalized transect design was applicable for detecting concentrated munitions use areas and areas with elevated anomaly densities.

3.1.4.2.3 Inputs into VSP for MRS 13 are as follows. An EM61 coil width is 1 meter; therefore, the transect width of 1 meter was selected. A circular target was chosen to better represent multiple firing points/flight paths. No waterborne DoD targets used for military training were identified in the surrounding waters of Cay Luis Peña during historical research. However there were indications of land targets on the NWP and on Cayo Luis Peña that may have resulted in high-density areas of MEC within the MRS underwater acres. A target area radius of 500 ft was chosen to locate concentrated munitions use areas created from DoD use of the land targets on NWP and Cayo Luis Peña. A background density of 10 anomalies per acre and a conservative expected target area density of 20 anomalies per acre above background were chosen based on the little knowledge or background information of the site. This anomaly density ratio results in a greater probability of detecting potential MEC contaminated areas. Because a conservatively low anomaly density ratio was used for the MRS 13 transect design, the false negative rate was not used to further decimate target densities. The transect spacing evaluation range of 166 to 750 ft was chosen to give enough evaluations to produce a usable Target Detection Performance graph. A Bivariate Normal Density was chosen as a reasonable assumption since distribution was unknown (note that the RI anomaly density for MRS 13, particularly around the northern boundary, appears to have a normal distribution). Other VSP variables such as Max Error, Min Precision and False Negative Rate (0%) were not changed from the default values, as these default values were evaluated and set during the development of VSP for UXO applications. Since a very conservative anomaly density ratio was used during transect design, the false negative rate was not used to further decimate this ratio. During VSP post-analysis, the false negative rate was not used, as actual RI data densities were used. The resulting 253-ft transect spacing provides a 90% probability of traversing and detecting the potential 500-ft radius MEC contaminated area. The VSP designed transects were realigned to consider bathymetric contours delineated in the EBS Report (USA 2013), sensitive ecological receptors, and critical habitat.

3.1.4.2.4 During the investigation, the DGM Survey Team completed the survey of the transects, designed to meet the project DQOs. Selected transect DGM anomalies were gridded to establish the anomaly density maps for each MRS and identify areas of elevated anomaly densities. Areas of elevated anomaly densities were intrusively investigated to identify the source of the anomalies (MEC, MD, or other debris). The DGM Survey team, and UXO Technician SCUBA/Snorkeling teams completed the transects per the WP, exceeding the planned acreage while maintaining the VSP recommended spacing. The MQOs were adhered to, ensuring the quality of the data obtained. The initial anomaly density above background used in VSP (and in the project DQOs) was too low (30 anomalies/acre), and resulted in just about every anomaly falling in a high density area, based on the VSP gridding results. Each high density area, composed of Priority 1 and Priority 2 anomalies (equal to or larger than the small and medium ISOs in the IVS), were intrusively investigated. Only a few high density areas that were produced from Priority 3-only anomalies (smaller than a small ISO) were not investigated (see Figure 3-3 and Figure 3-4, below). These uninvestigated Priority 3-only higher density areas are limited to areas where no land MEC/MD was discovered, and where no historical use is documented. Note: Even though there were some Priority 3-only high density areas uninvestigated in MRS13 southern acres, all of those high density areas were too small to be concentrated munitions use areas (CMUAs). Intrusive investigation of these debris fields for MRS 09 identified cultural debris as the source of the DGM anomalies and in MRS 13 a mixture of cultural debris and MD made up the anomalies identified.

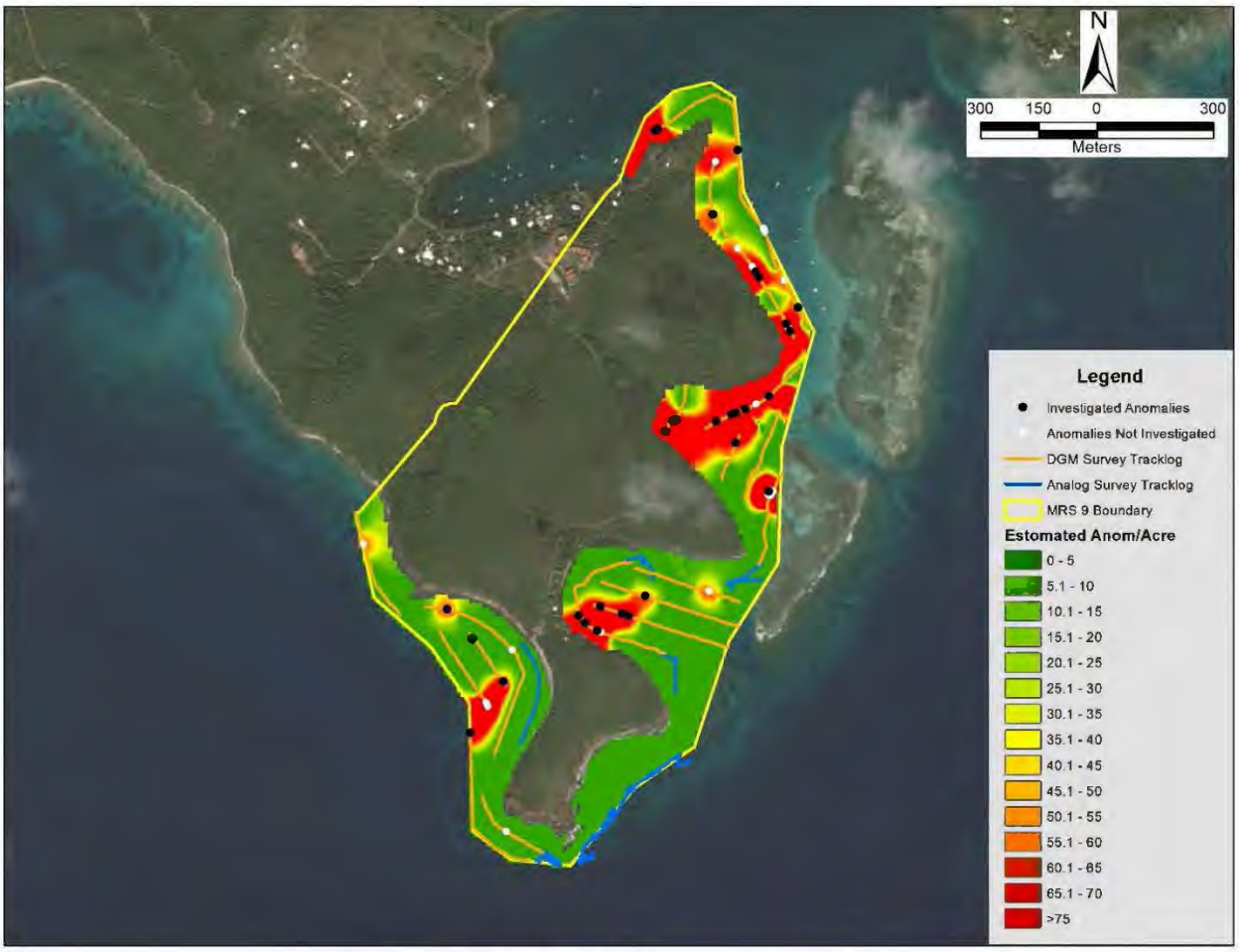

Figure 3-3: MRS 09 DGM Anomaly Density Map

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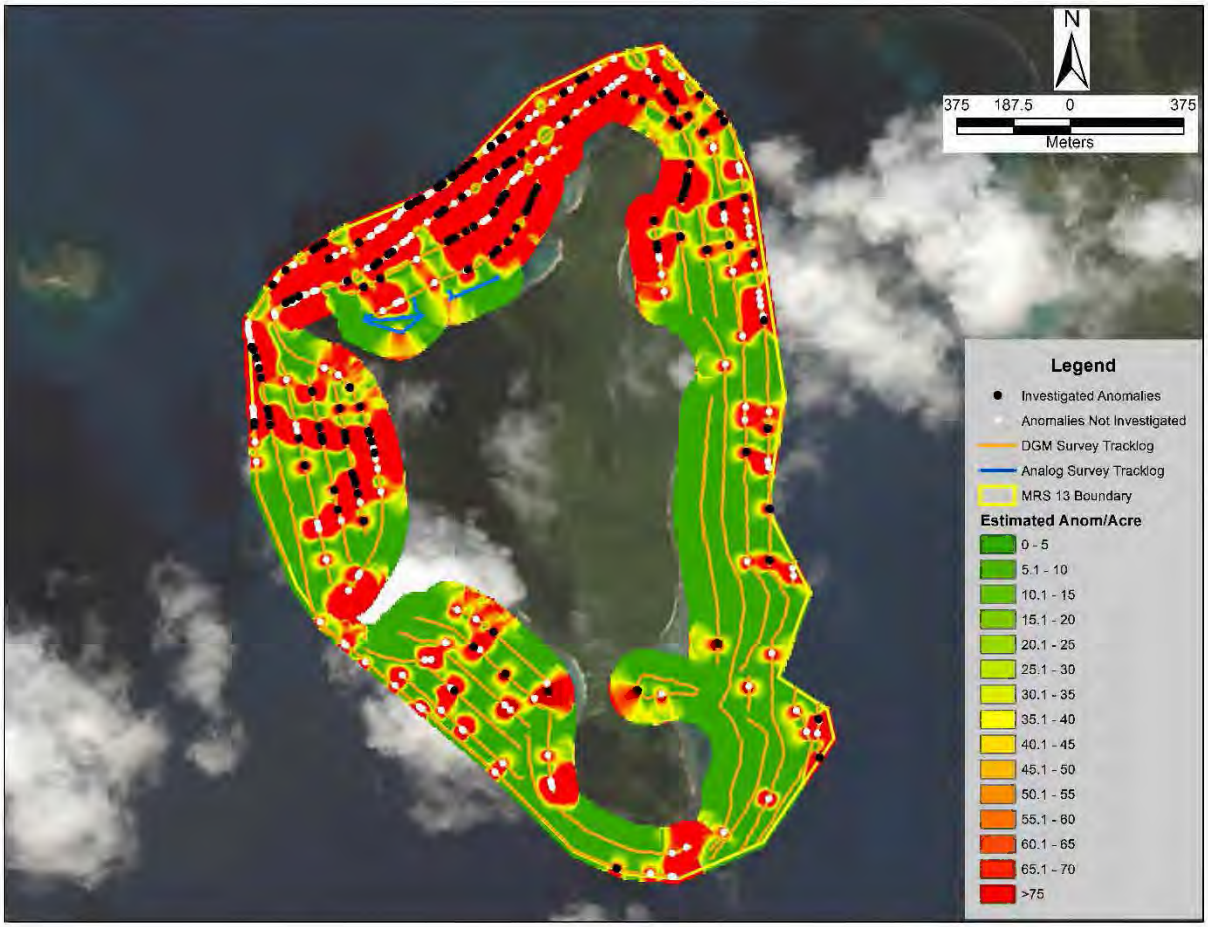

Figure 3-4: MRS 13 DGM Anomaly Density Map

3.1.4.2.5 The VSP post-analysis assessed the likelihood of detecting CMUAs or potential target impact areas) with the actual transects surveyed for both MRSs. For MRS 09, a 300-ft radius circular impact area size and shape was used. This impact area is smaller, more conservative, than the smallest dimension MEC impact area pre-programed in VSP (333-ft radius). Anomaly density was based on the actual RI data, with a background of 10 anomalies/acre and an impact area density of 75/acre Target average. For MRS 13 VSP post-analysis, a 500-ft radius circular impact area was used. This impact area size is smaller than the expected size for a 5" projectile (e.g., 758-ft radius) and provides a more conservative evaluation of site coverage. A background anomaly density of 10/acre and an impact area density of 75/acre Target average were used, based on actual MRS densities. The false negative rate was left at zero, because reduced, more conservative impact area sizes were used, and actual RI anomaly densities were used. Using these VSP inputs for CMUA size and shape, anomaly density ratios, and false negative rate, the VSP tool "Create transects to augment previous surveys" was used to evaluate the DGM and analog transect coverage for both MRS 09 and MRS 13. The VSP post-analysis for MRS 09 revealed three small data gaps (smallest gap = 0.69 acres, largest gap = 2.63 acres), all in very shallow areas that were excluded from the transect designs as inaccessible or sensitive habitat/endangered species areas. The MRS 09 data gaps are much smaller than a CMUA with a radius of 300 ft, and therefore are not considered significant. MRS 13 showed no data gaps. These results confirmed that all necessary transects were surveyed to meet the designed survey requirements. The VSP inputs for background anomaly density and the expected munitions use area density above background were adjusted to better match the survey results, and the expected munitions use area radius for MRS 09 was reduced. Even with these conservative input parameter

changes, VSP reports that wider transect spacing could have been used to meet project objectives. The Transect Augmentation Sampling VSP Reports are included in Appendix S: Post VSP Analysis.

3.1.4.3 The DGM platforms for the geophysical transects were selected based on results from the Phase 1 surveys. Some changes in DGM platforms were made during the fieldwork due to sea conditions or other site conditions that impacted the ability to use the scheduled DGM platform. Rough sea conditions caused the EM Floats to rise and fall with the wind waves, creating unusable data; in a few of these cases, the EM ROV was used in place of the EM Float as it was relatively unaffected by the sea state but still provided the ability to maintain the EM Coil at the appropriate distance above the sea floor and still maintain its height above coral and consolidated hard bottom. The planned transitional depth between the EM Float and the EM ROV was 20 ft of seawater. However the EM ROV USBL positioning system performed as designed in water as shallow as 15 ft. Depth of water was a consideration when changing DGM Platforms from the EM Float to the EM ROV as the EM ROV USBL positioning system degrades in less than 15 ft of water. The USBL positioning system uses acoustics to communicate its position and when in shallow water (less than 15 ft of sea water) the two-way acoustic signal (interrogations from the vessel and transponder response from the ROV) bounce off the sea floor and the waves, which can create a poor communication signal called multipath. To help avoid multipath from the water's surface, the USBL transceiver is typically mounted with its transponders positioned between 1.5 and 2 meters below the water's surface. In order for an accurate position solution to be calculated, an angle in all three axes (X, Y, and Z) is required. In shallow water, as the vertical angle between the ROV and the vessel decreases, the position solution degrades.

3.1.4.4 An additional modification in the EM platform selection occurred when the DGM vessel, while on planned transect routes, was exposed to shoreline rock formations and shallow reef areas that in calm water would not have posed a hazard to the crew; however, during the time of the DGM survey, rough sea conditions exposed the DGM vessel and crew to unacceptable risk. Per the work plan, in these unforeseen situations, the UXO Technician SCUBA Divers or snorkelers conducted analog assisted transects as described in Section 3.1.5.1. EM Float transects were surveyed with the RTK DGPS system. ROV EM Transects used the USBL positioning system. The analog transects' start and stop points were surveyed with the Trimble Pro-XRT DGPS, while their course over ground was surveyed by the Trimble GEO-XT. Appendix B: RI Maps, Figures B-1 through B-7, illustrate the geophysical surveys completed.

3.1.4.5 All transect DGM data was analyzed based on the anomaly selection criteria established per the GSV Letter Report. All anomalies meeting the selection criteria were imported into VSP. The Geostatistical Estimation of Anomaly Density tool was used to create the density maps shown in Figure 3-3 and Figure 3-4. The higher concentrated areas are located in the north western portion of MRS 13. The Kriging results showed that each transect anomaly produced its own high density area corresponding to greater than 30 anomalies/acre. This result precipitated the change in dig selections as discussed in Sections 3.1 and 3.1.3.2.4, which would have required the investigation of 100% of the DGM anomalies. To address the issue of each DGM transect anomaly producing its own high density area (but too small for a potential CMUA), USA submitted FCR #2, intended to optimize and improve the investigations, using the DGM target priorities that were developed and established in the approved GSV Report. All IVS seed items (small and medium ISOs) were classified as Priority 1 or 2 anomalies, for all three sensor platforms. DGM anomaly Priority 3 was used to capture all anomaly sources above the selection threshold for each platform, but expected to be smaller than any target of interest. This DGM anomaly prioritization ensured that field investigations would focus on high density areas with DGM anomalies that were more likely to contain targets of interest (equal to or greater than small and medium ISOs). In MRS 09, all high-density areas were investigated, regardless of size (spatial extent). In MRS 13, all high-density areas produced by a combination of priority 1, 2, and 3 DGM targets were investigated, regardless of size (spatial extent). Only a few MRS-13 high-density areas around only Priority 3 DGM targets (too small to be a potential CMUA) were not completely investigated. These uninvestigated Priority 3-only high-density areas (produced by anomaly sources expected to be smaller than a small ISO and with spatial extents too small to be potential CMUAs) are limited to areas where no land MEC/MD was discovered, and where no historical use is documented. This approach allowed the timely completion of field work, limited the excavation in critical habitat areas (sea grass areas) for priority 3 items, and also ensured an adequate investigation was completed. Table 3-3 provides the DGM Target Investigations by priorities established by FCR #2.

Table 3-3: DGM Target Investigation Summary

MRS 09	DGM Targets	DGM Targets Investigated	% Investigated
Priority 1	11	11	100
Priority 2	17	12	71
Priority 3	23	7	30
Totals	51	30	59
MRS 13	**DGM Targets**	**DGM Targets Investigated**	**% Investigated**
Priority 1	83	83	100
Priority 2	77	40	52
Priority 3	226	47	21
Totals	386	170	44

3.1.4.6 Based on the GSV Report recommendations and the response values of the small and medium ISOs during multiple passes with the DGM Platforms, the DGM targets were classified into three priority levels based on the channel 2 responses. This DGM anomaly prioritization ensured that field investigations would focus on high density areas that were more likely to contain targets of interest (equal to or greater than small and medium ISOs).

- ROV: Priority 1 = Large: >200 mV
- ROV: Priority 2 = Medium: 100 to 200 mV
- ROV: Priority 3 = Small/Very Small: 11.2 to 100 mV
- Float: Priority 1 = Large: >200 mV
- Float: Priority 2 = Medium: 30 to 200 mV
- Float: Priority 3 = Small/Very Small 8.8 to 30 mV
- Sled: Priority 1 = Large: >200 mV
- Sled: Priority 2 = Medium: 100 to 200 mV
- Sled: Priority 3 = Small/Very Small 18.2 to 100 mV

3.1.4.7 As a means to control the number of DGM transect anomalies investigated, the USA team investigated 100% of the Priority 1 anomalies, 50% of Priority 2 anomalies, and 20% of Priority 3 anomalies. In the selection of Priority 2 and 3 anomalies, the Project Geophysicist made recommendations for anomaly selection. Some revisions of those recommendations were made on site by the Project Manager, taking into account (1) areas of each Munitions Response Site where Munitions use had been documented, (2) areas that receive heavy use by tourists and the community, (3) restrictive sea state conditions, or (4) other cultural or natural resource interferences (i.e., considerations for anomalies within critical habitat and anomalies that may cause the closing and evacuation of recreational areas). Figure 3-5 and Figure 3-6 identify the locations of the DGM Priorities and if the DGM Priority was selected for intrusive investigation.

Figure 3-5: MRS 09 DGM Anomaly Priorities Selected for Investigation

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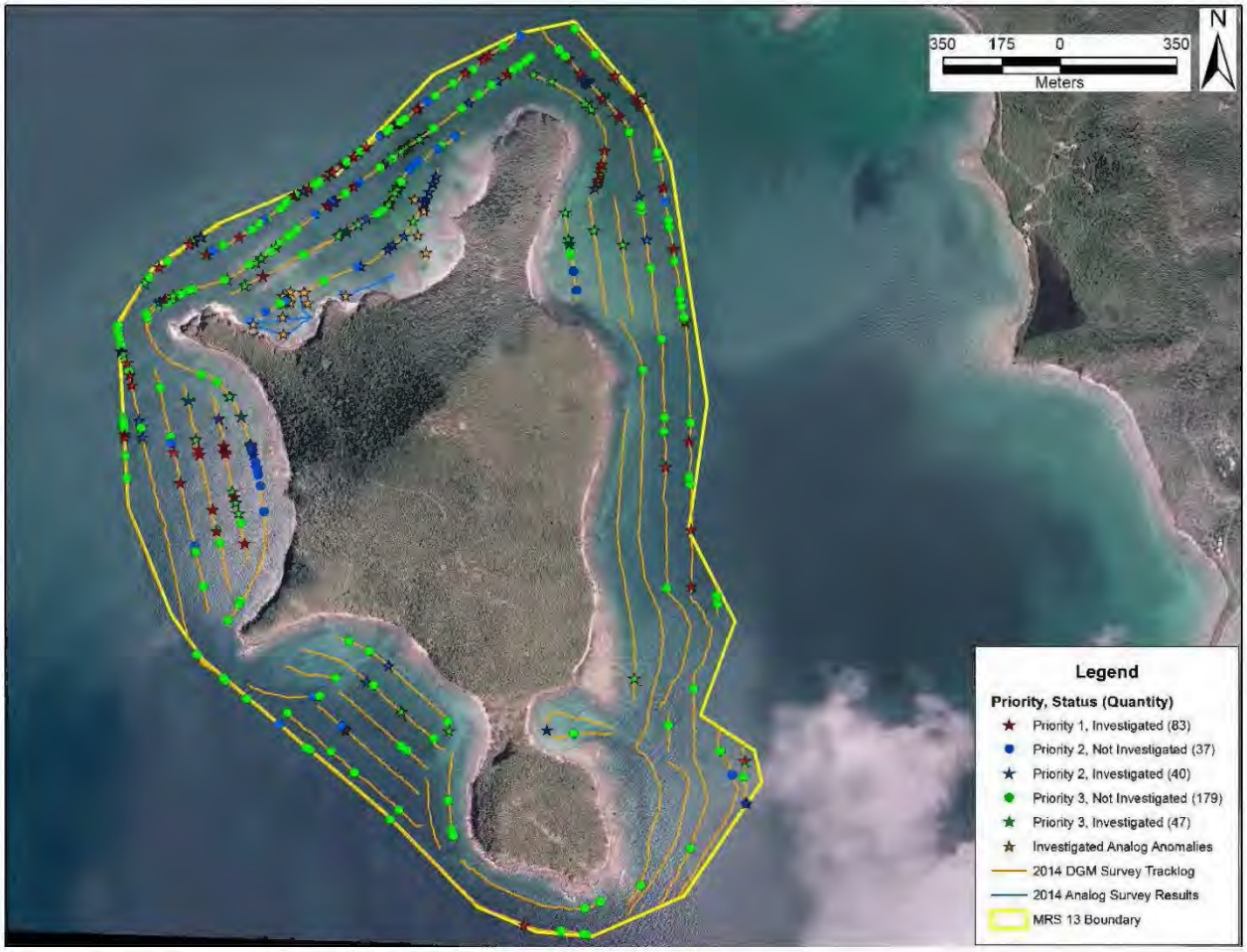

Figure 3-6: MRS 13 DGM Anomaly Priorities Selected for Investigation

3.1.5 DGM Survey Results

3.1.5.1 DGM Target selection for intrusive investigation was developed from the DGM transect data; Appendix E: Geophysical Results, provides the DGM anomalies/targets that were identified during the DGM survey, selected by the Site Geophysicist, and approved by the Project Geophysicist for intrusive investigation. A total of 51 DGM anomalies for MRS 09 and 386 DGM anomalies for MRS 13 were identified during the DGM survey. Intrusive investigations of 30 selected DGM anomalies in MRS 09 and 170 selected DGM anomalies in MRS 13 were conducted by the intrusive investigation team.

3.1.5.2 The data from each day was initially processed on Culebra by the Site Geophysicist. This involved converting the files into a Geosoft Oasis Montaj compatible format, creating separate Oasis Montaj projects for the daily static tests, IVS, and transect data. The data was processed in Oasis Montaj, the QC results were entered in a QC database which included pass/fail status, and then the processed data was sent to the Project Geophysicist. On a daily basis, the Site Geophysicist uploaded the following data to the Project Geophysicist; the Along Line Spacing, Background Noise, transect coverage distances, Geodetic QC results, the IVS results/readings for the DGM Platform used, Speed Table, and the results of the static repeatability test (AM and PM). These data sets were then evaluated against the required pass/fail metrics for Quality Control by the Project Geophysicist. Any failure in the data sets that could not be reconciled resulted in rework. Three DGM transects failed the initial QC assessment performed by the Site Geophysicist (MRS 09 Transects 1 and 7; MRS 13 Transect 6). In all three cases the DGM transect was performed with the EM Float in rough seas and the data was determined to be unusable. To correct for the rough sea conditions the EM ROV was used to recollect the transect data.

3.1.6 Analog Geophysical Surveys

3.1.6.1 USA executed analog geophysical transect surveys with the use of UXO Technician SCUBA Divers. The UXO Technicians and the analog instruments intended for geophysical transects were processed through the land IVS at the start of the work day and documented by the UXOQCS and in the Project Access Data Base. In the execution of the geophysical transects UXO Technician SCUBA Divers performed a visual survey over rock and coral, avoiding contact to protect the corals from injury. The UXO Technicians used analog all metals detectors for the investigation of unconsolidated sediment along the transect and excavated any anomalies as the anomalies were discovered. To mark cultural debris or MD items discovered along the transects a Trimble GEOXT was plumbed over the item and its position was recorded and added to the project data base.

3.1.6.2 In MRS 09, transect numbers 5 and 8 were completed entirely by UXO Technicians. Segments of transects 7, 9, and 13 were completed by the UXO Technicians deployed in either snorkeling or SCUBA modes (see Appendix B: RI Maps, Figures B-1 and B-2).

3.1.6.3 In MRS 13, transects 17A and 17B were completed by the UXO Technicians during the execution of an analog transect (mag and dig) in either SCUBA or snorkeling depending on the depth of the water along the transect. Transect 17A/B produced three 5-inch Illumination (Expended) MK 45 Mod 0 Projectiles (see Appendix B: RI Maps, Figure B-5).

3.1.6.4 In order to track the distance and routes swum by the UXO Technicians, a Trimble GEOXT GPS was attached to the SCUBA divers with a polypropylene line and floated above them while they swam their underwater transect. When UXO Technicians were snorkeling a transect the Trimble GEOXT was placed on a swim board and the UXO Technicians pushed the board along the transect. To guide the UXO Technicians when they were in SCUBA along the proper route, a 100-ft polypropylene (floating) line was suspended in the middle or top of the water column between two clumps with buoys (see Figure 3-7). The UXO Technicians SCUBA Divers followed the line to ensure they stayed on the transect. The line and buoys were pulled upon completion of the transect segment and deployed at the next transect segment. This process continued until the survey of the transect was complete. Snorkeled transects required the use of a second GPS with waypoints programmed into the unit; the UXO Technicians followed the route as the Trimble GEOXT tracked the actual progress. At the end of each day, the Trimble GEOXT track log was uploaded to the USA GIS Manager and provided for QC review by the Project Geophysicist. On several occasions, the UXO Technicians swam outside of the 10-meter transect error allowed by the WP, requiring that segment in error to be reworked.

3.1.6.5 Video from the EBS fieldwork (Phase 1) and the Terrestrial RI underwater ROV transects conducted in May 2011 resulted in the discovery of suspected MPPEH items. 100% of the items reacquired and investigated were identified as expended military munitions and confirmed as MD. All of the Phase 1 items were reacquired and investigated. However, not all of the Terrestrial RI suspected MPPEH items could be confirmed as the item previously discovered; or if the item the UXO Technicians were performing their reconnaissance on was a newly discovered item. Photographs of the surrounding coral and coral patterns and types of coral growing on the munition were used to identify if the investigation team had the correct item for investigation, since all of the munitions were 5-inch projectiles. Changes in the reef and coral pattern are suspected to be the cause for the lack of confirmation of the 2011 discovered items. However, in all of the cases in which the UXO technicians investigated the 2011 items, MD in the form of 5-inch expended illumination projectiles were identified within 10-ft of the 2011 items coordinate. Of the confirmed items identified during past field efforts, 12 of the items were identified as 5-inch Illumination (Expended) MK 45 Mod 0 Projectile and 1 item was an expended Aircraft Parachute MK 24 Mod 2 Flare. These items were all located in the vicinity of MRS 13 Transect 16, but did not necessarily line up with the transect, as some of them were discovered prior to Phase 1 field work (Appendix B: RI Maps, Figure B5).

Figure 3-7: Polypropylene Floating Line Suspended over the UXO Technicians Marking the Transect Route

3.1.7 Intrusive Investigations

3.1.7.1 Visual reconnaissance by the Intrusive Team of suspected MPPEH items identified during earlier underwater investigations was conducted from February 25 to 27, 2014. No analog metal detectors were used during this portion of the work. Intrusive investigations were initiated on March 3 and continued until April 15, 2014. On March 3, 2014, the land IVS was built per the WP. The as-built IVS was placed on the west beach area of MRS 09. The UXO Technicians and the analog instruments were all processed through the IVS and the results were documented in the project Access database. Table 3-4 describes the land, as-built IVS.

Table 3-4: As Built IVS (Analog Instrument)

IVS Seed Item	Item	X (ft)	Y (ft)	Inclination	Orientation	Depth to Center of Mass	X (Easting) m	Y (Northing) m
IVS_1	Small ISO	15	0	Horizontal	Along-Track	7.6 cm	258263.646	2022854.640
IVS_2	Small ISO	30	0	Horizontal	Along-Track	17.8 cm	258262.088	2022857.080
IVS_3	Medium ISO	45	0	Horizontal	Along-Track	15.2 cm	258260.070	2022859.838
IVS_4	Medium ISO	60	0	Horizontal	Along-Track	35.6 cm	258257.524	2022863.138

X, Y are in WGS84 UTM 20 North, with units in meters
ft – feet
cm – centimeters
m – meters

3.1.7.2 The DGM anomaly lists were developed from the DGM data collected from each transect using the EM61-MK2. The anomaly selection criteria established by the GSV report was then used to refine the DGM Targets selected for intrusive investigation. Intrusive investigation lists and target maps for each MRS were provided to the USACE PDT for review and approval. Appendix E: Geophysical Results provides the DGM Anomaly Tables and the Intrusive Investigation Results Tables.

3.1.7.3 The Intrusive Investigation consisted of four separate teams: 1) Navigation team, which marked the DGM targets with buoys per the WP using the Trimble Pro-XRT DGPS (sub-meter accuracy); 2) UXO Technician SCUBA Dive Team to investigate the mark provided by the Navigation team; 3) The chase boat, which provided security on the site and maintained the exclusion zones; 4) The GIS Manager, Site Geophysicist, and Program Manager to review and submit the intrusive results to the Project Geophysicist for QC. The team biologist worked from the UXO Technician SCUBA Dive Team vessel but on occasion moved to the other vessels, as needed.

3.1.7.4 Prior to daily field operations, a tailgate safety briefing was conducted, along with an operations brief. Equipment and performance checks were conducted on the Analog instruments and the operators at the land IVS. The GPSs scheduled for use during the day's evolution were compared at the Soldiers Point - Josue – 1 and 2 monuments. The results of the QC checks were documented in the project Access database.

3.1.7.5 While the QC checks were conducted on the analog instruments and GPSs, the SCUBA Dive Equipment was inspected and loaded onto the dive boat. Upon completion of the load out and QC checks, the dive team and support teams gathered for the Dive Safety Briefs. The schedule for the work day was from 0730 to 1730, with the first dive of the day usually occurring around 0930. The team worked a 50 hour work week.

3.1.7.6 All anomalies meeting the selection criteria and selected for intrusive investigation were investigated.

3.1.7.7 The results for intrusive investigation activities are reported in Chapter 4. The data collected for each DGM Target that was investigated was recorded in the project Access database. The project Access database can be found in Appendix E: Geophysical Results.

3.1.7.8 The following data were recorded for each target anomaly investigated:

- Target ID
- Item Count
- Pre-Excavation Response, mV
- Dig Date
- Anomaly Type
- MD Type
- Nomenclature
- Description
- Depth, inches
- Weight (pounds)
- Final Disposition
- Post Excavation Response, mV (if applicable)
- Acceptance Sampling QC
- Photo log
- The presence of Coral on the MEC/MD by type (no MEC was discovered)
- The depth and width of the excavation site, if in seagrass.

3.1.7.9 The Unexploded Ordnance Quality Control Specialist/Unexploded Ordnance Safety Officer (UXOQCS/SO) executed QC of all of the fieldwork processes to include the reacquisition process and the positioning/deployment of the dive buoys which marked the DGM anomaly by the Navigation Team. The reacquisition process included a daily upload of the waypoint files into the Trimble Pro-XRT DGPS provided by the GIS Manager. Upon completion of the Geodetic and equipment QC checks and the safety, dive, and operational briefs, the Navigation Team (along with the UXOQCS/SO) departed for the work site to place the first dive buoys for the day. The work boat coxswain proceeded to the waypoint marking the DGM anomaly. Upon arrival, the buoy's anchor (clump) was lowered to the bottom directly under the antenna of the Pro-XRT DGPS. Buoy anchors varied depending on the benthic habitat, e.g., a mushroom anchor was used for sand, and a 3-lb dive weight filled with lead shot was used for consolidated hard bottom. If the bottom consisted of coral, snorkelers would place the dive weight, ensuring they avoided the coral. After the buoy was in place, the position of the buoy's anchor was verified by moving the work boat back over the anchor and comparing the anchor position with the GPS waypoint. Once the UXOQCS/SO was satisfied that the buoy's anchor was resting on the approximate location of the GPS waypoint, the dive team deployed down the buoys line to start the intrusive investigation. If the sea state had the potential to move the clump, the divers would add an additional weight once they arrived on the bottom. In this way, impact to coral was avoided by the buoy's anchor dragging along the bottom but allowed the smallest of anchors to be lowered at the time of reacquisition. The UXO Technician SCUBA Divers initiated the search around the buoy's anchor with analog metal detectors and worked outwards in concentric circles until the DGM anomaly was identified. If the bottom consisted of consolidated hard bottom or coral, the search was usually conducted visually as the anomalies were on the surface. Per the work plan, a 10-ft area around the buoy's anchor was searched for each anomaly. For some of the DGM anomalies, this resulted in multiple items being identified. In one case, four 5-inch Illumination (Expended) MK 45 Mod 0 Projectiles were discovered for one DGM anomaly.

3.1.7.10 The results of each DGM anomaly intrusively investigated were uploaded into the project Access database and evaluated by the Project Geophysicist. Factors evaluated were the recovered anomaly's identity, the size of the anomaly, the distance from the DGM anomaly coordinates in which the anomaly was discovered, and the depth below the sea floor in which the anomaly was excavated. The Project Geophysicist then compared the above factors with the millivolt readings for the DGM anomaly. If the Project Geophysicist determined that the DGM anomaly required reinvestigation, the Project Manager and the Senior Unexploded Ordnance Supervisor (SUXOS) reinserted the anomaly back into the list of anomalies to be investigated.

3.1.7.11 Prior to the removal of MD items, each item was inspected for listed threatened or endangered species, such as Elkhorn or Staghorn corals. Digital photographs were taken of the MD and the corals or marine life on the item. If corals were present, an Anomaly Investigation Reconnaissance Form (Appendix N: Anomaly Investigation Reconnaissance Form) was generated and submitted to the USACE and the Stakeholders for evaluation of the proposed disposition. The NMFS, USFWS and PRDNER provided a response to each Anomaly Investigation Reconnaissance Form submitted, providing recommendations and guidance for the field teams to follow during removal (Appendix N: Anomaly Investigation Reconnaissance Form). Photographs were taken for the location in which the MD was removed as was required. Stakeholder recommendations occasionally requested the removal and relocation of coral from the MD item prior to MD removal. This was completed by cutting the coral at its base or removing a portion of the algae that encompassed the MD items in which the coral was attached. The UXO Technicians SCUBA Divers would then relocate the coral near its original location by using a two-part epoxy and adhering the coral to a solid bottom structure such as a large rock. Digital photographs and measurements were taken of the coral both before and after it was located, per the WP (USA 2014). Corals were removed from MD items and relocated on three occasions for six corals. All of the coral transplants were completed as described above. Table 3-5 lists the MD items in which corals were removed. Though more MD items were identified with corals, removal of the corals didn't take place due to the MD item being firmly attached to the underlying reef structure and removal of the MD item would likely have resulted in damage to the reef. If the MD items were left in place the corals attached to the items were also left in place. The UXO Technicians rehearsed the coral transplant steps and the use of the two part epoxy at the field office prior to conducting the coral transplants. The UXOQCS observed the UXO Technicians performing the coral

Table 3-5: MD Items That Had Coral Removed and Reattached

Item Number	Corals Removed from MD	Method used for reattachment	Comments
13-T 16_0003	• *Millepora alcicornis*	Two part epoxy	Coral appeared to be dead and had been broken off for an unknown period of time.
13-T20_0012	• *Uerongula rigida* • *Holopsamma helwigi* • *Porites asteroids*	Two part epoxy	
Item 13	• *Gorgonia ventalina;* • *Porites astreoides.*	Two part epoxy	

transplants. The size or type of coral did not alter the ability of the epoxy to attach the coral being transplanted to the reef. However the larger the coral the more epoxy was needed to build a sufficient base for attachment. In cases in which the MD did not have any coral present, the MD item was removed without requesting concurrence from stakeholders and the item was documented with digital photographs (refer to Appendix F: Photographic Log). The removal of MD in which Anomaly Investigation Reconnaissance Forms were required was conducted from April 16 to 22, 2014. Figure 3-8 provides the locations for MD that were left in place in order to protect corals or the coral reef underlying structure. Appendix N: Anomaly Investigation Reconnaissance Forms provides final disposition of each anomaly evaluated for corals.

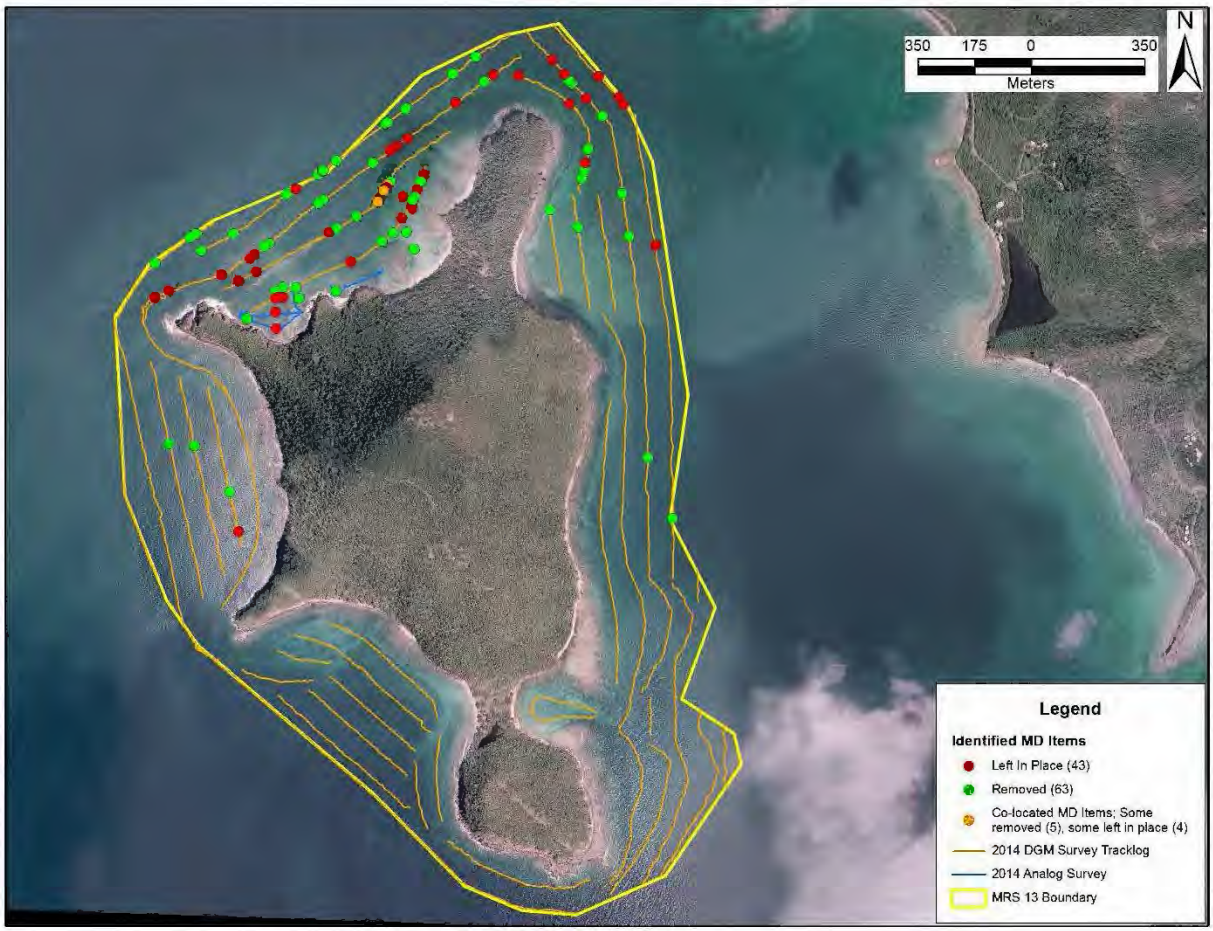

Figure 3-8: MD locations that were left in place in order to protect corals or the coral reef underlying structure.

3.1.7.12 Seagrass is a critical habitat for sea turtles, manatees, and other marine species. During excavation of anomalies in seagrass areas, the field teams were directed to replant seagrass that had been removed during the excavation. The procedures provided by the Supplemental SOPs for endangered Species Conservation and their Critical Habitat (USACE 2014) proved unsuccessful in some seagrass areas. The PDT coordinated with the Resource Agencies and received concurrence that in areas in which seagrass was not possible to replant the field teams would document and photograph the areas excavated. In addition, the field teams avoided damaging seagrass areas by leaving cultural debris partially buried in place that, if removed, would uproot large quantities of seagrass. The spoils from the DGM anomaly excavation sites were pushed back into the holes upon the removal of the item discovered. Priority 3 DGM targets discovered to be buried beneath seagrass were rejected by the field teams for intrusive investigation and a replacement Priority 3 DGM target was intrusively investigated. When excavation in seagrass areas occurred, measurements were taken of the excavation site (width, length and depth) (refer to Appendix F: Photographic Log). Discontinuous seagrass was prevalent in the majority of the seagrass areas in which excavation took place. Figure 3-9 and Figure 3-10 provide the locations in which DGM anomalies were investigated where seagrass was present. Figure 3-9 has the addition of inset photos of the bottom type at the point of excavation to demonstrate areas of investigation that were not just solid seagrass beds but also consisted of patchy seagrass areas within MRS 09. DGM Target 9-T16_0006 was the only MRS 09 target excavated in seagrass resulting in total acreage of disturbed seagrass in MRS 09 of 24 ft^3, all of which was *Thalassia testudinum* (turtle seagrass); 523.7 ft^3 of disturbed seagrass in MRS 13, of which 32.2 ft^3 was *Thalassia testudinum* (turtle seagrass) and 491.5 ft^3 was of *Syringodium filiforme* (manatee seagrass) (see Appendix B, Figures B-14 and B-15, for maps of disturbed seagrass areas by site name). In the cases of the *Syringodium filiforme* (manatee seagrass) the seagrass beds were discontinuous and the *Thalassia testudinum* (turtle grass) areas varied from discontinuous to continuous but none of the areas were thick enough to allow for the UXO Technicians to roll the seagrass areas up per the SOPs (see Figure 3-9). Table 3-6 summarizes the seagrass that was disturbed during the RI.

Table 3-6: Seagrass Disturbed by Type/Volume/Area

MRS	Type of seagrass disturbed	Seagrass disturbance area by volume (cuft) (length/width/ depth of excavation	Seagrass disturbance area by area (sqft) (length/ width of excavation
MRS 09	*Thalassia testudinum* (turtle seagrass)	24 ft^3	12 ft^2
MRS 13	*Thalassia testudinum* (turtle seagrass)	32.2 ft^3	28.8 ft^2
	Syringodium filiforme (manatee seagrass)	491.5 ft^3	224 ft^2

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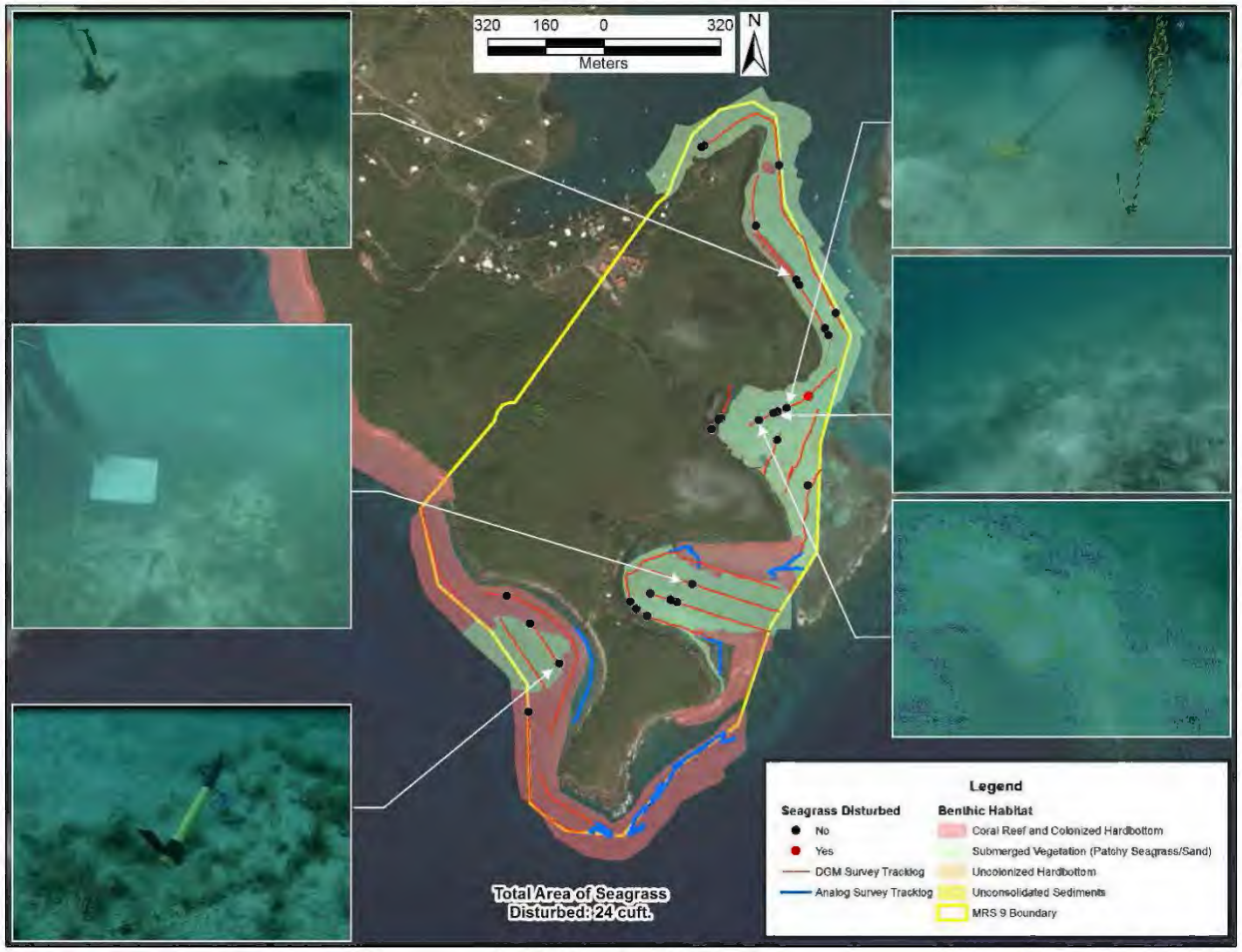

Figure 3-9: MRS 09 Disturbed Seagrass Areas and Photo Representation of the Patchy Seagrass Bottom at Various DGM Anomalies

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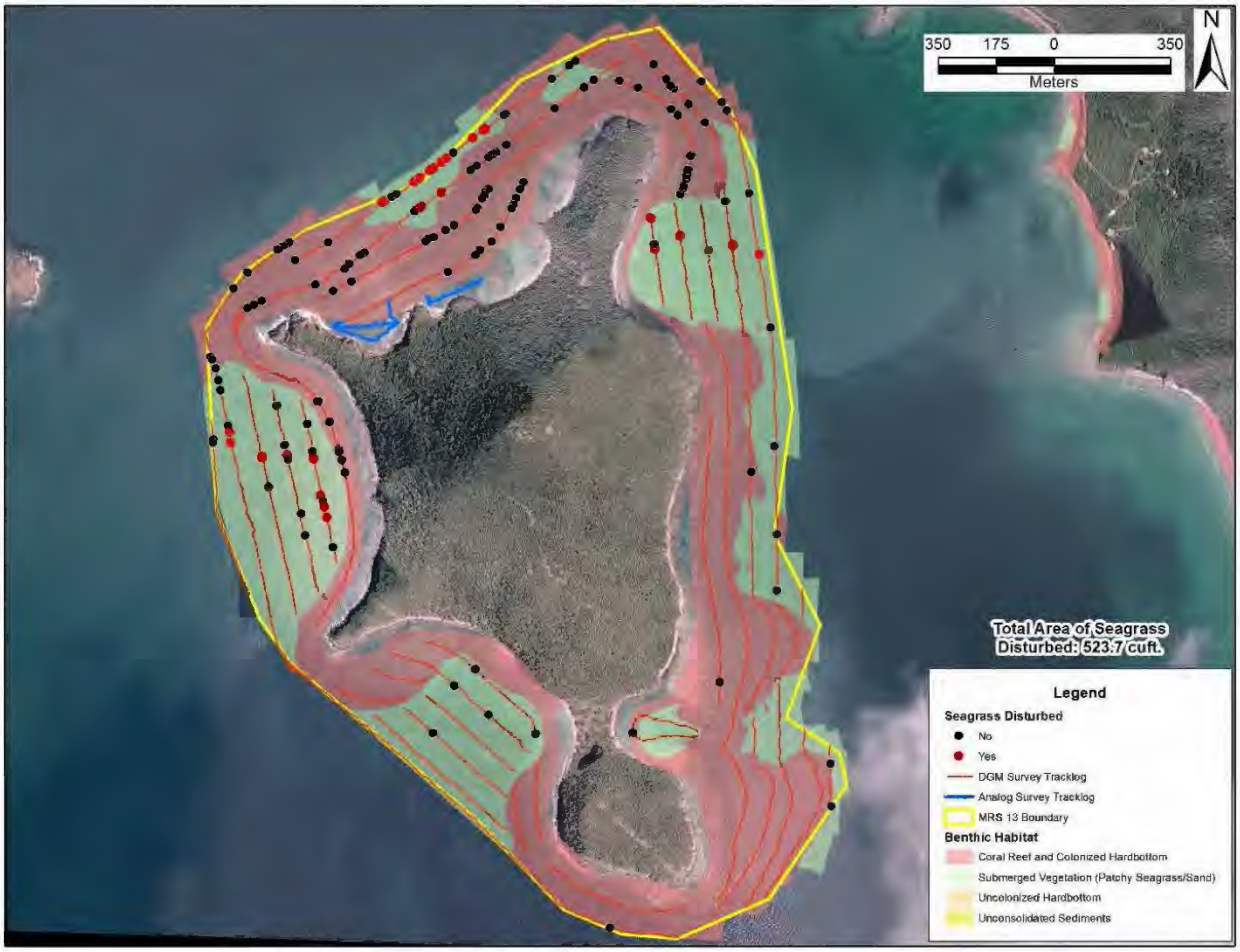

Figure 3-10: MRS 13 Disturbed Seagrass Areas

3.1.7.13 A team biologist was included as an integral part of the field teams for both the DGM team and the Intrusive team. The biologist logged the presence of marine mammals, turtles and other natural resources present on the work site by completing the "Daily Observer Log Sheet" (Appendix O: Daily Observer Log Sheets). The biologists also provided briefs and guidance on protecting the natural resources associated with the field work. Additional duties included inspecting the beaches for turtle nesting activities that were proposed to be used as the MEC beaching and disposal sites. The beach inspections were initiated on January 24, 2014 and continued until April 19, 2014 (Appendix D: Field Logs). The team biologist also inspected the beaches adjacent to intrusive investigations for evidence of turtle hatchings.

3.1.8 MDAS

MDAS (in the form of expended 5-inch illumination rounds, flare bodies, and parts of projectile nose fuze bodies) was recovered from MRS 13. Marine growth was removed from inside and outside of the MD to allow for visual inspection and ensure the MD was free of hazards. MD was inspected by the SUXOS and the Unexploded Ordnance Safety Officer (UXOSO)/Unexploded Ordnance Quality Control Specialist (UXOQCS) and documented as safe. The MDAS was estimated at 2,190 lb [actual weight as reported by Bonetti Explosives (demilitarization subcontractor) 1,964 lb] and was placed in six steel 55-gallon drums. A DD Form 1348-1A was filled out and signed by the SUXOS and UXOSO/UXOQCS for each drum then attached to the drum. The drums were locked with a padlock and a security seal was attached. The seal identifying number was recorded. The MDAS was trucked via ferry from Culebra to San Juan and shipped

by FEDEX to Bonetti Explosives located in Columbus Texas, for smelting. Smelting was completed on June 6, 2014. MDAS Documents can be found in Appendix M: MDAS.

3.2 MC CHARACTERIZATION

3.2.1 Introduction

The following sections describe the rationale for the samples collected during these field tasks and the analytical results. Any MC detected at concentrations above background levels and their respective human health or ecological PSVs are considered to be COPCs and have been retained for further evaluation in the baseline risk assessment presented in Chapter 6.

3.2.1.1 The MC characterization tasks performed during this underwater RI used results of the MEC investigation to determine whether a potential MC source was present. There were no MEC or MD findings or other indications of DoD use (target areas, MEC, MD, etc.) in the underwater portions of MRS 09; therefore, sampling at MRS 09 was not conducted. Numerous MD items were found in the northern portion of MRS 13, and therefore marine sediment sampling was conducted at select locations where intact identifiable MD was discovered. The samples were collected by a UXO SCUBA diver for each type of munition found (i.e., 5-inch Illumination (Expended) MK 45 Mod 0 Projectile, 5-inch Illumination (Expended) MK 48 Mod 0 Projectile, MK 25 Marine Marker). Samples were collected at a rate of 10% for items of a munitions type previously sampled in this sampling effort (i.e., for Munition Type 1, the first item found is sampled, and one more sample was collected per every 10 more items of this type found). Marine sediment samples were collected to define the nature and extent of potential contamination associated with any COPCs associated with MEC. The MC characterization methods are described in the following subsections.

3.2.1.2 The primary objective of the RI with regard to MC is to first determine if there was evidence of MC release to the environment (i.e., to identify COPCs) and then to characterize the nature and extent of any COPCs found to be present resulting from past DoD use of the site. The data obtained during the investigation were used to assess whether the COPCs present pose a potential risk to human health and the environment and, therefore, should be considered to be chemicals of concern (COCs). The intent of this characterization is to determine if there is a need for remedial response due for MC and, if so, to provide the required information for the development and evaluation of any necessary response alternatives.

3.2.1.3 For purposes of this RI, "Preliminary COPCs" are those chemical contaminants that may be present at the site, based on historical munitions-related activities conducted at the site. Preliminary COPCs are those selected for analysis, but which have not yet been analyzed and evaluated. For this site, the selected preliminary COPCs can be found in Section 3.2.3.2. COPCs are defined as any preliminary COPCs that are determined to be present at concentrations above background and the human health or ecological preliminary screening values (PSVs). COCs are defined as the COPCs that are present at sufficient concentrations to pose a risk to human health or the environment requiring remedial action.

3.2.1.4 To achieve these objectives, underwater sediment samples were collected. A total of 44 marine sediment samples were collected: 14 primary samples (collected beneath munitions), 14 companion step-out samples, 3 QA and 3 QC samples associated with primary samples, 8 background samples, and 1 QA and 1 QC associated with the background samples. All samples were collected IAW the approved WP (USA, 2014). The sample locations and sampling results are discussed in Chapter 4.

3.2.1.5 The data results for each sample were validated IAW the procedures identified in the WP. Data validation was performed IAW SW846 methodologies and DoD Quality System Manual, version 4.2.

3.2.2 Deviations from the WP (Appendix I: Field Change Requests)

Deviations from the WP were documented with FCRs and submitted for the following MC tasks.

3.2.2.1 FCR 3: Removed Iron as an analyte for the underwater RI (due to the naturally occurring high concentrations and non-uniform distribution of iron in an igneous environment) and add Ammonium Picrate (due to the historical use of munitions that contained Explosives D, which degrades to ammonium picrate) tables to the applicable UFP-QAPP Worksheets. In addition, Agriculture and Priority Pollutants Laboratory,

Inc. (APPL) (the prime lab) was approved to serve as both the prime and Quality Assurance (QA) lab for ammonium picrate due to the limited numbers of labs that can adequately analyze ammonium picrate and also process media from a high salinity environment. The FCR allowed APPL to serve as both primary lab and QA lab for the ammonium picrate analysis under the following conditions: (1) APPL to use a different standard as the primary and second source as the parent sample; (2) APPL to establish a different initial calibration curve (ICAL) with a different standard as the parent sample; (3) a different internally qualified technician to extract the QA sample than the primary sample; and (4) APPL to issue a separate lab data package for the QA sample with its own associated lab QC runs.

3.2.2.2 FCR 4: APPL had ICP-MS problems conducting antimony analysis with SW6020A resulting in inconsistent antimony intensities for the calibration blank and the ICAL. Instead of using ICP-MS, APPL analyzed all metal digestate with ICP per SW6010C for antimony. The Limit of Quantitation (LOQ) of antimony by SW6010C is lower than the screening value and APPL is both SW6010C and SW6020A certified by DoD ELAP. The FCR added 6010C UFP-QAPP worksheets for antimony replacing SW6020A.

3.2.3 Marine Sediment Sampling

3.2.3.1 Marine sediment sampling was performed for MRS 13 only. MRS 13 contains large quantities of MD in the form of expended illumination projectiles and flares, requiring a determination if MC has been released into the marine sediment as a result of DoD activities. A companion marine sediment sample was collected 4 ft from each of the discrete samples collected. The objective of the companion sample was to determine if COPCs identified (if any) in the primary sample collected from marine sediment located beneath an intact munition item indicate a localized exceedance, or if contamination is present at concentrations that pose a significant risk to human or ecological receptors. The diver was instructed to locate the step-out sample 4 ft from the munition sample (no primary current was identified providing a constant current flow for MRS 13). Since there was no obvious current flow noted, the sample was to be collected at a bearing of 270 degrees (west) from the munition item.

No MEC or MD was found in the underwater intrusive investigation for MRS 09; therefore, marine sediment sampling was not performed for MRS 09. Background sampling was conducted within MRS 13 to provide a reference for naturally occurring metals concentrations. No sampling was conducted in MRS 09 and therefore, no background samples were collected.

3.2.3.2 Based on historical munitions that are potentially present at the site, the preliminary COPCs evaluated in samples and their method of analysis were explosives (Method SW8330B) and MC metals "aluminum, barium, chromium, copper, lead, and zinc (Method SW6020A); mercury (Method SW7471B); and antimony (Method SW6010C)." Additionally, ammonium picrate (Method SW8321A) was analyzed as a breakdown product of Explosives D.

3.2.3.3 Analytical results, the laboratory data reports and validation reports (DVR) are found in Appendix L: Laboratory Data.

3.2.4 Establishment of Background and PSVs

Background and PSVs were established as presented in Table 3-7.

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Table 3-7: Background Concentrations and Risk Assessment Screening Values used for the Determination of PSVs

Media	Background Threshold Values	Human Health Screening Values	Marine Sediment Ecological Screening Values
Marine Sediment	ProUCL 5.0 calculated 95% Upper Tolerance Limit (UTL) values	USEPA RSLs, Residential Soil Criteria	-CH2M Hill, Vieques "Master Sampling and Analysis Plan"(1) -Pascoe, Gary et al. "Munitions Constituents: Preliminary Sediment Screening Criteria"(2)

(1) CH2M Hill, "Addendum 2 Master Sampling and Analysis Plan- East Vieques Terrestrial UXO Sites" (April 2013). SAP Worksheet #15-2, Reference Limits and Evaluation Table. While the cited report is for terrestrial UXO sites, the report included ESVs for marine sediment.

(2) Pascoe, Gary A.; Kroeger, Keith; Leisle, Dwight; and Feldpausch, Robert J., "Munitions constituents: Preliminary sediment screening criteria for the protection of marine benthic invertebrates" (2010). U.S. Navy Research. Paper 40. Table 3, column for 1% organic carbon. (http://digitalcommons.unl.edu/usnavyresearch/40).

3.2.4.1 Background Concentrations for Metals in Marine Sediment

3.2.4.1.1 No historical site-specific statistical evaluation of background metals concentrations was available for MRS 13. Therefore, eight background samples of marine sediment were collected as part of this RI to establish Background Threshold Values (BTVs) for metals. The locations identified for sampling were a mixture of consolidated hardbottom and unconsolidated sediment. The samples were collected in the unconsolidated sediment areas and were free of coral or consolidated hard bottom and in a location historical records and the geophysical investigation indicated was not impacted by DoD activities.

3.2.4.1.2 The background samples were analyzed for the same analytes as the primary samples collected beneath munitions and the step-out samples. Explosives were analyzed to further confirm the area is not impacted by historical munitions use. There were no detections of explosives or ammonium picrate. Only results for metals were used for background comparison purposes. Complete analytical results for these analyses are included in Appendix L: Laboratory Data.

3.2.4.1.3 BTVs for metals were determined by using ProUCL version 5.0 to calculate the 95% UTL. This procedure identifies the statistical distribution type (that is, normal, gamma, lognormal, or non-parametric) for each constituent within the defined exposure area and computes the corresponding 95% UTL for the identified distribution type. From this analysis, the most applicable UTL was chosen based upon the individual data distribution of eight metals sampled at MRS 13. ProUCL input and output data as well as sampling results used to calculate UTLs are included in Appendix G: MC Analytical Data and Risk Tables. The BTVs calculated for MRS 13 are presented in Table 3-8.

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Table 3-8: MRS 13 Marine Sediment Background Threshold Values

Analyte	Units	Background Threshold Value[1]
Metals		
Aluminum	mg/kg	1,409
Antimony	mg/kg	0.30
Barium	mg/kg	10
Chromium	mg/kg	5.8
Copper	mg/kg	3.2
Lead	mg/kg	0.90
Mercury	mg/kg	0.040
Zinc	mg/kg	4.6

[1] Background threshold values obtained by calculating 95% UTL with ProUCL version 5.0. Results included in Appendix G: MC Analytical Data and Risk Tables.

3.2.5 Selection of PSVs

3.2.5.1 For this RI/FS, the human health and ecological PSVs were selected after consideration of the relevant background concentrations and relevant and appropriate human health and ESVs. PSVs for MC metals in marine sediment are selected using a two-step process: 1) First, the most conservative screening value is determined from the applicable human health and ESVs (Table 3-9 and Table 3-10). 2) Second, this screening value is compared to the applicable site-specific background concentration and the greater of the two values is selected as the PSV. Explosives do not have background concentrations; therefore, screening values for explosives were determined by choosing the more conservative value between the applicable human health and ESVs.

3.2.5.2 Since chromium analytical results reflect chromium (total) concentrations, and screening values are available for chromium (III) and chromium (VI), evaluation of chromium will differ slightly from other analytes. The biased analytical results for chromium (total) will be compared to the BTV prior to comparison to a screening value. If chromium (total) concentrations are greater than the BTV, then the speciated chromium Exposure Point Concentrations (EPCs) will be estimated, assuming that chromium (total) is composed of chromium (VI) and chromium (III) in a one to six ratio. Therefore, the estimated chromium (VI) concentration is calculated by dividing the measured chromium (total) concentration by seven and the chromium (III) concentration is estimated by subtracting the calculated chromium (VI) concentration from the chromium (total) concentration.

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Table 3-9: PSVs for Explosives (Marine Sediment)

Analyte Explosives - SW8330	Human Health Screening Values (mg/kg) USEPA RSLs [1]	Ecological Screening Values (mg/kg)	PSV (mg/kg) [4]
1,3,5-Trinitrobenzene	220	**7.0**[2]	7.0
1,3-Dinitrobenzene	0.61	**0.0050**[3]	0.0050
2,4,6-Trinitrobenzene	**3.6**	20[2]	3.6
2,4-Dinitrotoluene	**1.6**	2.1[3]	1.6
2,6-Dinitrotoluene	0.33	**0.55**[2]	.33
2-Amino-4,6-dinitrotoluene	15	**0.013**[3]	0.013
2-Nitrotoluene	**2.9**	6.2[3]	2.9
3-Nitrotoluene	**0.61**	1.9[3]	0.61
4-Amino-2,6-dinitrotoluene	15	**0.035**[3]	0.035
4-Nitrotoluene	24	**0.68**[3]	0.68
Hexahydro-1,3,5-trinitro-1,3,5-triazine	**5.6**	891[2]	5.6
Nitrobenzene	4.8	**0.072**[2]	0.072
Nitroglycerin	0.61	**0.021**[2]	0.021
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine	380	**1.3**[3]	1.3
Pentaerythritol Tetranitrate (PETN)	**12**	115[2]	12
Methyl-2,4,6-trinitrophenylnitramine(tetryl)	**12**	330[3]	12
Ammonium Picrate – SW8321A			
Ammonium Picrate [5]	N/A[5]	NA	NA

Notes:

(1) USEPA RSL Summary Table, residential soil, November 2013 (target risk of 1E-06, target HQ of 0.1).

(2) CH2M Hill, "Addendum 2 Master Sampling and Analysis Plan- East Vieques Terrestrial UXO Sites" (April 2013). SAP Worksheet #15-2, Reference Limits and Evaluation Table.

(3) Pascoe, Gary A.; Kroeger, Keith; Leisle, Dwight; and Feldpausch, Robert J., "Munitions constituents: Preliminary sediment screening criteria for the protection of marine benthic invertebrates" (2010). U.S. Navy Research. Paper 40. Table 3, column for 1% organic carbon. (http://digitalcommons.unl.edu/usnavyresearch/40).

(4) For explosives, the PSVs for this RI were selected as the most conservative screening value of the applicable human health screening values (USEPA RSLs) and ESVs (CH2M Hill Vieques Sampling Plan or in the absence of data, Pascoe, Gary A, et al. PSV Screening Criteria). Explosives are not naturally occurring and therefore no comparison is made to BTVs. The selected PSV is shown in bold.

(5) No PSV is available for Ammonium Picrate.

Table 3-10: PSVs for Metals (Marine Sediment)

Analyte Metals - SW6020A/SW3050B	Human Health Screening Values (1) (mg/kg) USEPA RSLs	Ecological Screening Values (2) (mg/kg)	Background Threshold Value (3) (mg/kg)	PSV(4) (mg/kg)
Aluminum	***7,700***	18,000	1,409	7,700
Antimony	*3.1*	**2.0**	0.30	2.0
Barium	*1,500*	**48**	10	48
Chromium	*0.29 (5)*	81	5.8	5.8
Copper	310	**34**	3.2	34
Lead	*400*	**47**	0.90	47
Mercury	*2.3*	**0.13**	0.040	0.13
Zinc	*2,300*	**150**	4.6	150

Notes:

(1) USEPA RSL Summary Table, residential soil, November 2013 (target risk of 1E-06, target HQ of 0.1).

(2) CH2M Hill "Vieques Sampling Plan" or in the absence of data, Pascoe, Gary A, et al. "PSV Screening Criteria"

(3) The BTVs are ProUCL version 5.0 calculated 95% UTL values.

(4) The PSVs for this RI were selected using a two-step process: a) first, the most conservative screening value was determined from the applicable human health screening values (USEPA RSLs) and ESVs (CH2M Hill "Vieques Sampling Plan" or in the absence of data, Pascoe, Gary A, et al. "PSV Screening Criteria"); b) second, this screening value was compared to the applicable marine sediment-specific BTV, and the greater of the two was selected as the PSV. The selected PSV is shown in bold.

(5) Value for Chromium (VI)

3.2.6 Field MC Sampling Activities Summary

3.2.6.1 In accordance with the project WP, marine sediment samples were collected at the MRS if MEC/MD was discovered to establish the presence of and determine the nature and extent of MC contamination. MD was discovered in significant quantities in the Northern half of MRS 13. No MEC or MD was discovered in the underwater portions of MRS 09; therefore, no sampling was conducted. The collection of discrete samples from MD locations, along with companion step-out samples and background samples, was conducted on April 2 and April 16, 2014.

3.2.6.2 A total of 44 marine sediment samples were collected. These were composed of 14 primary samples (collected beneath munitions), 14 companion step-out samples, 3 QA and 3 QC (duplicates) samples associated with primary samples, 8 background samples, and 1 QA and 1 QC (duplicates) associated with the background samples. Two MS/MSD samples were collected.

3.2.6.3 The sample locations were based on the results of the MEC investigation and are therefore presented in Chapter 4.

3.2.7 Sample Handling and Packaging

3.2.7.1 All sampling, handling, packaging, shipping, and analyses were conducted in strict accordance with the approved WP (USA 2014). Following collection by a UXO Technician SCUBA Diver, samples were

homogenized at the surface and placed into jars supplied by the laboratory. The jars were immediately placed on ice until shipment to the laboratory. Samples were transported by ferry to San Juan, PR, and shipped priority overnight by FedEx to laboratories noted below.

3.2.7.2 Sample locations were accurately recorded using the coordinates for the DGM Target (RTK – DGPS) that resulted in the identification of an MD item. The companion samples were collected 4 ft from the location where the MEC investigation samples were collected, to establish if potential contamination is localized to the munitions. Since currents are tidal but can also vary in direction, the purpose of the companion sample was to determine if any unacceptable exceedances were localized or widespread. The companion samples did not serve that purpose as exceedances of chromium were also detected in companion samples, and no unacceptable risks were noted in either sample type. To ensure accuracy in identifying the companion sample location all samples were measured 4 feet from the munition at a magnetic compass bearing of 270 degrees (due West). The coordinates of the background sample locations were provided by the Trimble Pro-XRT DGPS.

3.2.8 Analytical Laboratory and Analyses

3.2.8.1 The primary samples were shipped to APPL, Inc., in Clovis, CA. All analytical data were verified prior to being released by APPL. Verification included both editorial and technical reviews. Laboratory extraction, analysis methods, and target analytes were conducted IAW the WP.

3.2.8.2 The marine sediment QA samples were shipped to Curtis & Tompkins, Inc. (C&T), in Berkeley, CA, and analyzed for the same analytes as the prime samples sent to APPL, with the exception of ammonium picrate. The QA samples of ammonium picrate were shipped to APPL for analysis as approved in an email dated November 22, 2014, from the USACE Technical Manager of USAESCH. APPL was approved to serve as both primary lab and QA lab for the ammonium picrate analysis under the following conditions: (1) APPL would use a different standard as the primary and second source as the parent sample; (2) APPL would establish a different ICAL with a different standard as the parent sample; (3) a different internally qualified technician performed the extraction for the QA sample than the technician that extracted the primary sample; and (4) APPL would issue a separate lab data package for the QA sample with its own associated lab QC runs. This was documented in an FCR.

3.2.9 Data Validation

Once finalized by the laboratories, the Parsons Project Chemist, Ms. Tammy Chang, validated all the analytical data generated during the sediment sampling effort IAW the requirements identified in the WP and UFP-QAPP. The validation included requirements in DoD Quality System Manual (QSM) version 4.2, USEPA SW 846 methods. DVR were generated by Ms. Chang for all data packages and are provided in Appendix L: Laboratory Data. The DVRs noted that all data are usable.

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CHAPTER 4. REVISED CSEM AND RI RESULTS

The following sections describe the results of the MEC and MC RI for the underwater portions of MRS 09 and MRS 13. Following the RI results, a revised CSEM is presented, where the CSEM previously presented in Chapter 2 is updated with the results of the RI.

4.1 RI RESULTS

As described in Chapter 3, the RI involved excavation of anomalies selected from DGM data and anomalies identified using handheld metal detectors (analog mag-and-dig) as well as MC sample collection. This section provides a summary of the distribution of MEC, MD, and MC identified from the intrusive investigations. This distribution is evaluated in terms of the historical information related to the munitions demonstrations and munitions-related training that was conducted at the site. This information is, in turn, used to update the pre-RI CSEM that was presented in Subsection 2.2.

4.1.1 Munitions and Explosives of Concern

4.1.1.1 The DGM Target Intrusive Results Table can be found in Appendix E: Geophysical Results, and provides the findings for the MRS 09 and MRS 13 intrusive investigations. The Analog Grid Intrusive Summary Table (also found in Appendix E: Geophysical Results) depicts the following:

- The results from the UXO Technicians completing geophysical transects that the DGM team could not complete due to shallow water or site conditions, which proved to be too dangerous for the DGM vessel.
- Suspected MPPEH items identified in Culebra RI Phase 1 and the post-contract award site visit.
- Item 12 and Item 13 were reported by San Juan Police Department and the items were investigated by the Intrusive Team. Both items were identified as 5-inch Illumination (Expended) MK 45 Mod 0 Projectiles.

4.1.1.2 The maximum depth at which MD was recovered was 36 inches. Excavation in the soft sand using hand tools on the sea floor was difficult to achieve once the depth exceeded 24 inches. As the holes were dug they would collapse in on themselves, filling in the dig site as quickly as the UXO Technician SCUBA Divers could remove the sand. Sixteen DGM Targets, 15 in MRS 13 and one in MRS 09, were not identified due to the item being too deep in the sand for the UXO Technician SCUBA Divers to uncover with hand tools. DGM Target ID Numbers in MRS 13 transects 13, 14, 15, and 16 produced over 67% of MD discovered in MRS 13. Ten DGM Target ID Numbers for transects 13, 14, 15, and 16 were too deep for the UXO Technician SCUBA Divers to excavate.

4.1.1.3 From March 20 through March 25, the intrusive investigations were being conducted on MRS 13 transects 13B and 14B. This area was prioritized for investigation using the Man Portable Underwater EM61 for reacquisition and was designated by the WP to be used for EM Sled produced DGM anomalies (the EM Sled was used only on segments of transects 13B and 14B). On March 19, the field teams reported the methods for replanting seagrass after excavation was not working per work plan SOPs. USACE provided direction to avoid any excavations in seagrass areas until coordination with the Natural Resource Agencies and Regulator team could identify a solution. Most of the DGM anomalies reacquired during the period of March 20 through March 25 were located in Manatee Seagrass areas. The millivolt reading, and the distance and bearing from the buoy's clump, were recorded; however, excavation of the anomaly did not take place. From March 27 through March 30, Luis Peña experienced a severe North swell resulting from a winter storm crossing the Northern Atlantic. The swell in the northwest bay of MRS 13 exceeded 9 ft (some reports by the local fishermen was that it was in excess of 12 ft). The swell is believed to have deposited or shifted sands in the area of Transect 14B and 13B. Following the swell event, on April 1, 2014, the restriction from excavating in the seagrass areas was removed and the intrusive team went back to the DGM anomalies previously reacquired but not investigated due to the presence of the Manatee seagrass. The SUXOS and UXOQCS reported that up to 24 inches of sand had been deposited in the area

of transect 13B and 14B. Most of the DGM Targets previously reacquired but not excavated could not be reacquired. The field team assumed the anomalies either shifted in location or the DGM targets were now deeper than instrument detection. Large sections of the Manatee seagrass had also been buried. Throughout the course of the field work the intrusive team revisited the DGM anomalies that were affected by the swell event. Of the 19 DGM anomalies covered by additional sand from the swell event, all were eventually reacquired. Ten of the DGM anomalies were identified as MD and recovered. One of the DGM anomalies was identified as cultural debris and was recovered. The remaining eight anomalies were located but were beyond the depth in which the divers were able to excavate. The Field Team believed that the additionally deposited sands receded in the following days after the swell event through normal sea movement and allowed the reacquisition of the 19 DGM anomalies.

4.1.1.4 During the investigation of the 198 DGM anomalies identified for intrusive investigation in both MRS 09 and MRS 13, there were five DGM anomalies that could not be located and were designated as "No Finds." All DGM anomalies designated as "No Finds" were located in MRS 13; they were confirmed to be a "No Find" by the UXOQCS/SO after he performed an inspection dive and performed his own intrusive investigation on the DGM anomaly using an analog metal detector. Prior to the Site and Project Geophysicist approval of the anomaly as a "No Find," the UXOQCS/SO would instruct the Navigation Team to remark the DGM anomaly and the UXOQCS/SO would confirm the process used and the location of the buoy and anchor, once placed. Then the anomaly would be intrusively investigated for a second time. Once the DGM anomaly was confirmed as a "No Find" by the UXOQCS/SO for a second time, the Site and Project Geophysicist entered the results into the Access Data Base, per the WP, as a "No Find". The MRS 13 (170 DGM anomalies targeted for intrusive investigation) "No Find" rate was 2.9%, which did not flag a root cause analysis as the percentage did not exceed the threshold of 15%.

4.1.2 Nature and Extent of Ordnance Contamination

4.1.2.1 During the RI fieldwork, MEC was not discovered; however, Table 4-1 provides the types and quantities of MD discovered in MRS 13. Additional data on the MD discovered in MRS 13 can be found in Appendix E: Geophysical Results

Table 4-1: MRS 13 MD by Type (Totals Include Both DGM and Analog Targets)

Nomenclature	Quantity
5 inch Illumination (Expended) MK 45 Mod 0 Projectile	102
5 inch Illumination (Expended) MK 48 Mod 0 Projectile	2
Aircraft Parachute MK 24 Mod 2 Flare (originally identified as an Illumination Unit, Unit 2 (LUU – 2) Flare deployed by the SUU-44/A FLARE Dispenser)	4
MK 25 Marine Marker. Note: MK 25 Marine Markers are considered incidental to the site. MK 25 Marine Markers are used by DoD and non-DoD entities (such as cruise liners) for exercises, emergency action drills or training. The MK 25 Marine Markers can travel significant distances from where it was deployed to wash up on beaches/shores or eventually sink and rest on the sea bottom.	1
Small Arms Ammunition Debris (expended 50 caliber cartridges)	2
Misc. MD (Fuze parts, pusher plates etc.)	12

4.1.2.2 Based on the findings from the field investigations, starting with the anomaly density map developed from the transect DGM survey and ending with the findings during the underwater intrusive investigation, the nature and extent of ordnance contamination can be estimated. Figure B-8 in Appendix B: RI Maps shows locations of discovered MD in MRS 13; Appendix B: Figure B-10 shows the estimated extent of contamination identified during the MRS 13 terrestrial findings.

4.1.3 Contamination Area Extent

4.1.3.1 The most heavily contaminated area is clearly indicated to be within the Northern half of Cayo Luis Peña and the associated water boundaries. This is evident from the MD findings within this area. Due to the type and quantity of MD discovered (intact 5 inch projectile bodies with the base plates and illumination candle payloads having been ejected) indicates the possibility of MEC being present in the form of 5 inch illumination projectiles that had not functioned as designed and impacting the water in the northern acres of MRS 13. MRS 13 northern half which presents the largest quantity of MD discovered equating to 273.3 acres which is equivalent to 51% of MRS 13 water acres designated for the RI and is assumed to contain MEC.

4.1.3.2 Based on the intrusive results, evidence is strong that MD may exist throughout most of the northern half of MRS 13. This is further supported by high quantities of MD being found by the terrestrial RI Field Teams in the northern half of the MRS during the Culebra RI, which addressed the land portions of MRS 13. The extent of the MD and the assumed MEC contamination is believed to expand northward beyond the MRS 13 northern boundary and may likely continue to the adjacent MRS (MRS 12), the waters in-between MRS 12 and MRS 13 and the Naval Gunfire Target ranges located on Culebra's NWP. MRS 13 is most likely the extent of MEC/MD contamination from the NWP target areas (see Figure 4-1).

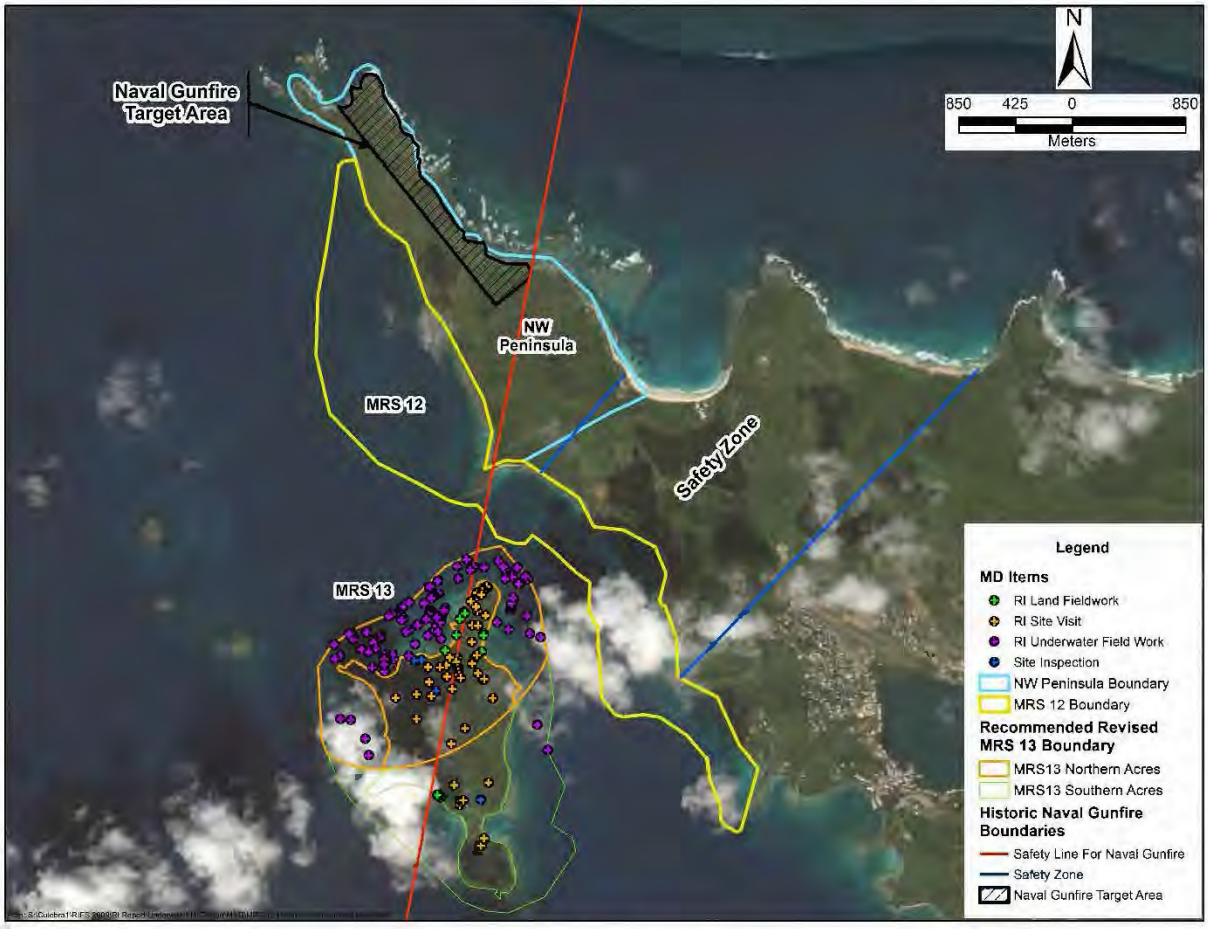

Figure 4-1: MRS 13 is the Possible Extent of Munition Related Contamination which originates from the Targets Located on NWP

4.1.3.3 Within the estimated MEC/MD contamination area boundary, the depth of MD contamination was dependent on the bottom type (rock, coral, sand, etc.). MD discovered in rock and coral bottom types were found on the surface of the sea floor. In some cases, the MD item was partially or fully encrusted with coral or algae and on two occasions the MD item had become part of the rock bottom, almost fully engulfed. The deepest MD contamination was confirmed at 36 inches and MD was suspected to be present at deeper depths in the sand and unconsolidated sediment areas of MRS 13. The average depth of MD discovered within the unconsolidated sediment area was 4.57 inches. Forty MD items were excavated in the unconsolidated sediment areas of MRS 13. Figure 4-2 demonstrates the locations of the fifteen MD in unconsolidated sediment and DGM Targets that were too deep to excavate that could not be ruled out as MEC or MD.

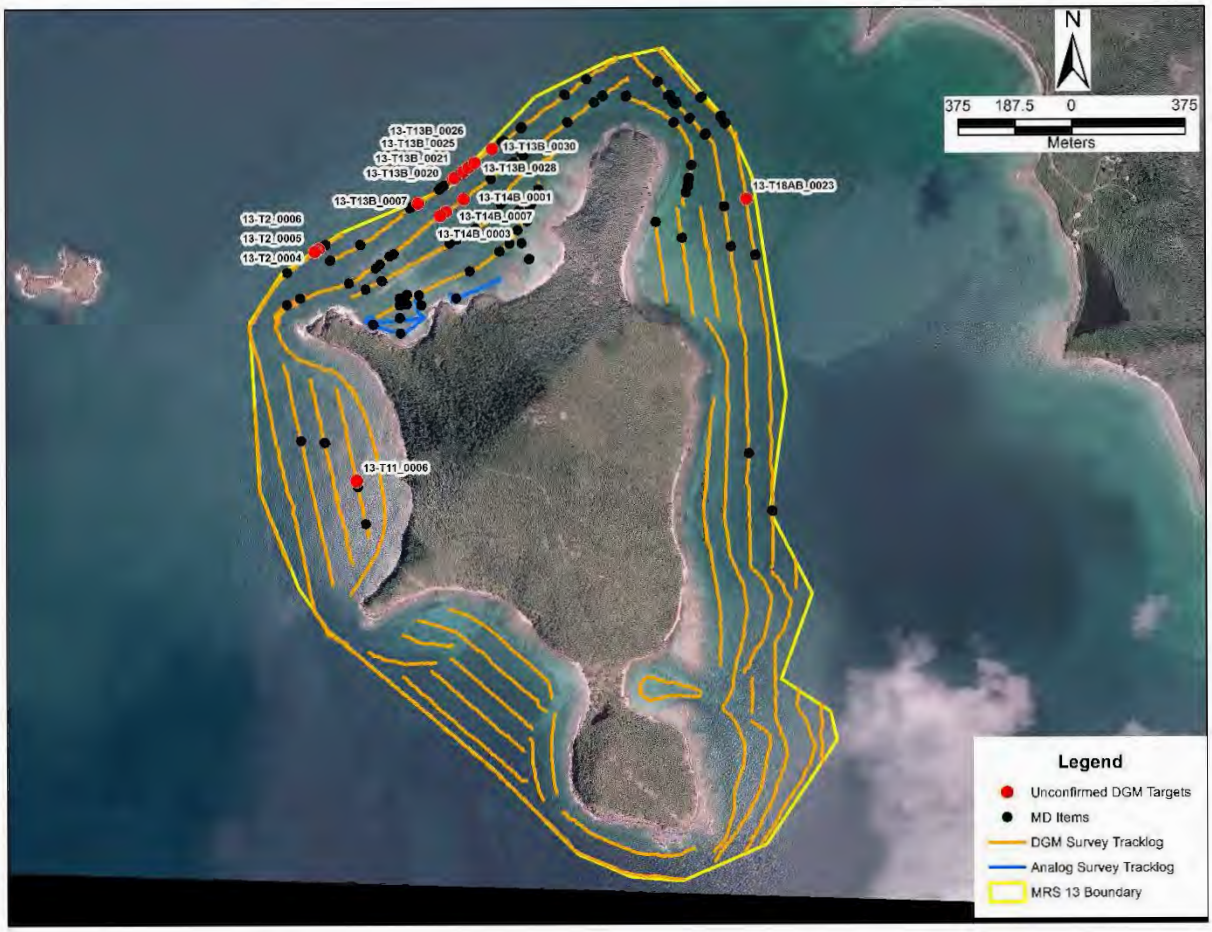

Figure 4-2: Unconfirmed DGM Targets Selected for Intrusive Investigation

4.1.3.4 Combining the findings from the Terrestrial RI and the Underwater RI for MRS 13 provides a more complete delineation of the contamination. Appendix B: Figure B13 demonstrates the MD density of the combined efforts in MRS 13. MRS-13's northern half is composed of 273.3 water acres and is contaminated by MD. Though MEC was not discovered on land or in the water it cannot be ruled out, Figure 4-3 demonstrates the MD discovered as described in the northern half of the MRS versus the southern acres.

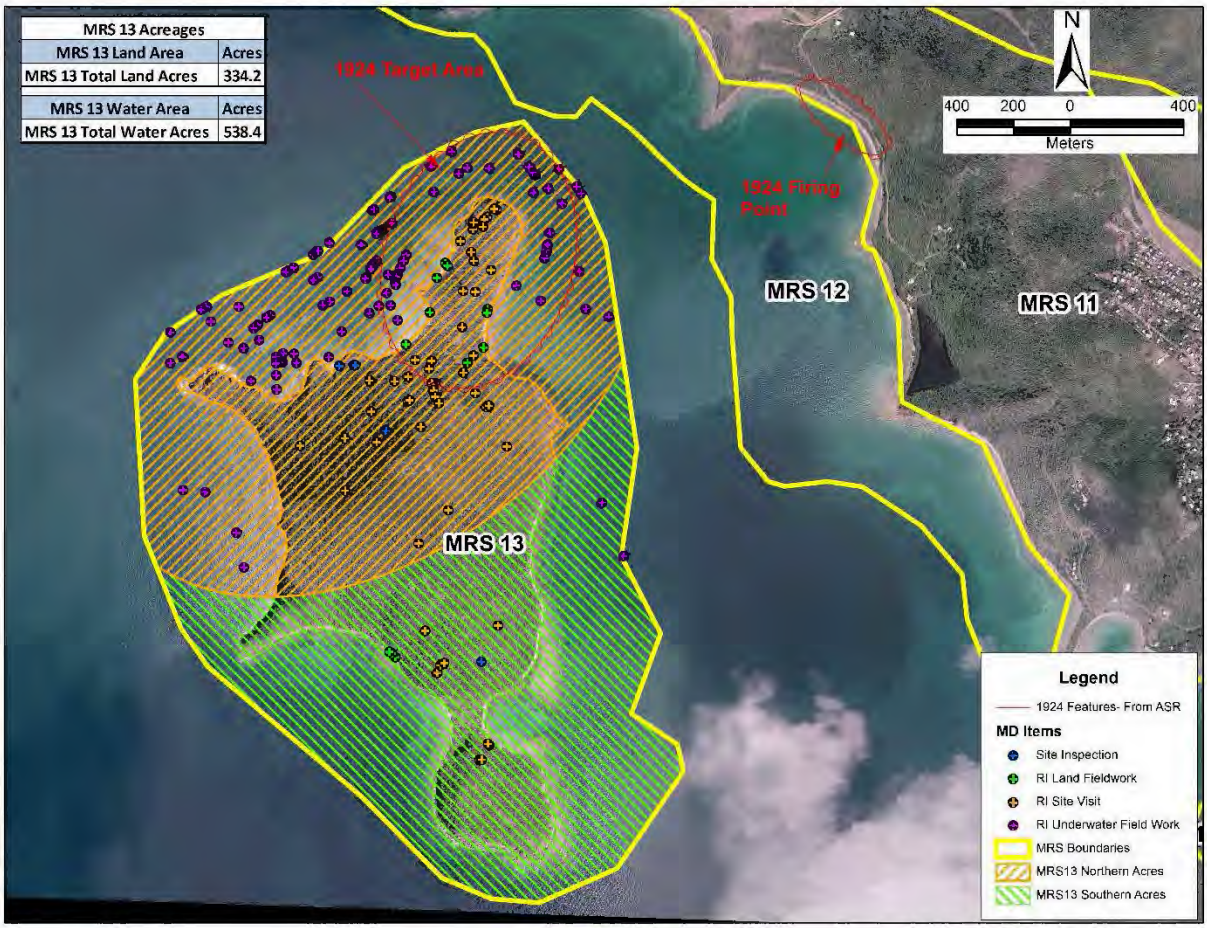

Figure 4-3: MRS 13 MD Results from Both Land and Underwater Investigations

4.1.3.5 MRS 13 southern acres demonstrated a lesser amount of MD discoveries and does not have a MEC exposure pathway since no MEC was discovered. Though the MK 25 Marine Marker was discovered in the southern acres, MK 25 Marine Markers are considered incidental to the site and do not indicate DoD use specific to an MRS. The second MD item was a 5-inch Illumination (Expended) MK 45 Mod 0 Projectile in which by itself does not indicate a CMUA. The MD item is removed by a significant distance from the 5-inch Illumination (Expended) MK 45 Mod 0 Projectiles found in the northern acres of MRS 13. Therefore the 5 inch Illumination (Expended) MK 45 Mod 0 Projectile is considered to be a single anomaly and not representative of a target area or CMUA.

4.1.4 Munitions Constituents

4.1.4.1 Marine Sediment Background Sampling

Eight background samples, one QA, and one duplicate sample were collected along Transect 21 in MRS 13 on April 3, 2014. Underwater video from Phase 1B for the EBS was used to confirm bottom type and determine if marine sediment was present to be sampled. The sea floor in the area selected along Transect 21 for the background sampling was a mixture of consolidated hardbottom and unconsolidated sediment. The samples were collected in the only area within the MRS which exhibited no impacts from DoD use, was free from coral, seagrass and had enough media present to sample. The Southeast section of the island had the fewest DGM Targets and there were no indicators of DoD use. Background samples were collected 82 ft apart along the transect line. The location of background sampling was at the southeastern

end of MRS 13, away from the MD findings at the northern end of the. It is possible the dynamic nature of the ocean currents could have transported sediment from the northern areas to this portion of the island, however, any contaminants transported from MEC locations were likely diluted in the large volume of ocean water and did not impact the background sample location.

Appendix B RI Maps Figure B-9, provides the location for the background samples collected. Figure 4-4 and Figure 4-5 show UXO Technician SCUBA Divers collecting background samples. Samples were collected with a sterile plastic scoop and placed in a 2-gallon zip-loc bag. The samples were then homogenized, quartered, and transferred from the plastic bag to a sterile glass jars on the surface. All samples were collected from a depth range of 0 to 6 inches below ground surface (bgs). If a munition was buried, the sample was collected from directly beneath the item immediately after removal. Analysis for background samples was for the same analytes as the investigative samples: explosives, MC metals (aluminum, antimony, barium, chromium, copper, lead, mercury, and zinc), and ammonium picrate (a breakdown product of Explosives D).

Figure 4-4: UXO Technician SCUBA Diver Prepares to Take a Background Sample

Figure 4-5: UXO Technician SCUBA Diver Collects a Marine Sediment Background Sample

4.1.4.2 Discrete Marine Sediment and Companion Step-out Sampling

4.1.4.2.1 Fourteen discrete marine sediment samples were collected at selected MD locations per the WP. Fourteen companion samples were collected 4 ft away from the original discrete marine samples. In addition three QA, and three duplicate samples were collected in association with these selected MD items. The discrete marine sediment samples were collected in MRS 13 on April 2 and 3 and on April 16, 2014. Discrete marine sediment samples were collected from beneath MD prior to the MD removal. One primary sample and a companion sample were collected for each type of munition discovered in the MRS. The companion sample was collected 4 ft from the original sample. The step-out sample (the area anticipated to contain the least potential contamination) was collected first to avoid potential cross-contamination. Additional samples were collected for each additional 10 munitions of the same type, maintaining a 10% sampling rate per munition type. During intrusive investigation operations, MD items discovered on the surface of unconsolidated sediment were left in place as potential locations for marine sediment sampling. Following sample collection, the MD item was removed from the MRS. If an item was discovered subsurface, the sample was collected from the bottom of the hole dug to retrieve it.

4.1.4.2.2 Two 50-caliber expended cartridges were discovered together in MRS 13. Sampling for the cartridges was not conducted since the small arms ammunition debris was located on consolidated hard bottom. Table 4-2 lists each sample and describes the date and time collected, the lab where analyzed, the

type of sample, the munition type associated with the sample and the transect where collected. Sample locations are also shown in Appendix B: RI Maps (Figure B-9).

Table 4-2: MRS 13 Investigative Samples

Sample ID	Sample Collection Date & Time	Laboratory	Comments
PR-1404-SDM-13-1B	4/02/2014 at 0945	APPL	Step-out to sample PR-1404-SDM-13-1A
PR-1404-SDM-13-1A	4/02/2014 at 0951	APPL	MS/MSD Sample. Collected beneath 5-inch Illumination (Expended) MK 45 Mod 0 Projectile, Anomaly 13-T14CD_0024
PR-1404-SDM-13-1A QA	4/02/2014 at 0951	Curtis and Tompkins (Metals and Explosives) APPL (Ammonium Picrate)	QA Sample for PR-1404-SDM-13-1A
PR-1404-SDM-13-7A	4/02/2014 at 0958	Curtis and Tompkins (Metals and Explosives) APPL (Ammonium Picrate)	Duplicate Sample for PR-1404-SDM-13-1A
PR-1404-SDM-13-2B	4/02/2014 at 1000	APPL	Step-out to sample PR-1404-SDM-13-2A
PR-1404-SDM-13-2A	4/02/2014 at 1015	APPL	Collected beneath Aircraft Parachute MK 24 Mod 2 Flare (originally identified as an Illumination Unit, Unit 2 (LUU-2) Flare. Anomaly 13-T14_0005
PR-1404-SDM-13-3B	4/02/2014 at 1030	APPL	Step-out to sample PR-1404-SDM-13-3A
PR-1404-SDM-13-3A	4/02/2014 at 1035	APPL	Collected beneath a 5-inch Illumination (Expended) MK 45 Mod 0 Projectile. Anomaly 13-T15_0004
PR-1404-SDM-13-4B	4/02/2014 at 1100	APPL	Step-out to sample PR-1404-SDM-13-4A
PR-1404-SDM-13-4A	4/02/2014 at 1105	APPL	Collected beneath a 5-inch Illumination (Expended) MK 45 Mod 0 Projectile. Anomaly 13-T11_0008
PR-1404-SDM-13-5B	4/02/2014 at 1149	APPL	Step-out to sample PR-1404-SDM-13-5A
PR-1404-SDM-13-5A	4/02/2014 at 1154	APPL	Collected beneath a 5-inch Illumination (Expended) MK 45 Mod 0 Projectile. Anomaly 13-T10_0007
PR-1404-SDM-13-11B	4/16/2014 at 1047	APPL	Step-out to sample PR-1404-SDM-13-11A
PR-1404-SDM-13-11A	4/16/2014 at 1050	APPL	Collected beneath 5-inch Illumination (Expended) MK 45 Mod 0 Projectile. Anomaly 13-T19ABCDEF_0011
PR-1404-SDM-13-12B	4/16/2014 at 1103	APPL	Step-out to sample PR-1404-SDM-13-12A

Sample ID	Sample Collection Date & Time	Laboratory	Comments
PR-1404-SDM-13-12A	4/16/2014 at 1107	APPL	Collected beneath 5-inch Illumination (Expended) MK 45 Mod 0 Projectile. Anomaly 13-T19ABCDEF_0007
PR-1404-SDM-13-13B	4/16/2014 at 1209	APPL	Step-out to sample PR-1404-SDM-13-13A
PR-1404-SDM-13-13A	4/16/2014 at 1212	APPL	Collected beneath 5-inch Illumination (Expended) MK 45 Mod 0 Projectile. Anomaly 13-T14B_0005
PR-1404-SDM-13-14B	4/16/2014 at 1315	APPL	Step-out to sample PR-1404-SDM-13-14A
PR-1404-SDM-13-14A	4/16/2014 at 1323	APPL	Collected beneath 5-inch Illumination (Expended) MK 45 Mod 0 Projectile. Anomaly ITEM 12
PR-1404-SDM-13-14A QA	4/16/2014 at 1323	Curtis and Tompkins (Metals and Explosives) APPL (Ammonium Picrate)	QA Sample for PR-1404-SDM-13-14A
PR-1404-SDM-13-15A	4/16/2014 at 1118	APPL	Duplicate Sample for PR-1404-SDM-13-14A
PR-1404-SDM-13-16B	4/16/2014 at 1238	APPL	Step-out to sample PR-1404-SDM-13-16A
PR-1404-SDM-13-16A	4/16/2014 at 1242	APPL	Collected beneath 5-inch Illumination (Expended) MK 45 Mod 0 Projectile. Anomaly 13-T13B_0023
PR-1404-SDM-13-17B	4/16/2014 at 1331	APPL	Step-out to sample PR-1404-SDM-13-17A
PR-1404-SDM-13-17A	4/16/2014 at 1335	APPL	Collected beneath 5-inch Illumination (Expended) MK 45 Mod 0 Projectile. Anomaly ITEM 13

4.1.4.2.3 Figure 4-6 and Figure 4-7 show UXO Technician SCUBA Divers collecting marine sediment samples. Samples were collected with a sterile plastic scoop and placed in a plastic bag. The samples were then transferred from the plastic bag to a sterile glass jar on the surface. All samples were collected from a depth range of 0 to 6 inches bgs. If a munition was buried, it was collected from directly beneath the item. Analysis was for explosives, MC metals (aluminum, antimony, barium, chromium, copper, lead, mercury, and zinc), and ammonium picrate (a breakdown product of Explosives D).

4.1.4.2.4 The summary of the analytical results of the marine sediment samples is presented in Appendix L: Laboratory Data. All MC metals except mercury were detected. There were no detections of explosives or ammonium picrate. There were no exceedances of ESVs. The MC metal chromium was detected in all marine sediment sampling locations, and at concentrations exceeding the background concentration in all locations except three (Table 4-3). The significance of the exceedances will be evaluated in the risk assessment.

Figure 4-6: MD Item (ITEM 12/Sample number PR-1404-SDM-13-14A) Selected for a Discrete Marine Sediment Sample

Figure 4-7: UXO Technician SCUBA Diver Collects a Discrete Marine Sediment Sample (ITEM 12/Sample number PR-1404-SDM-13-14A was moved to collect the sample)

Table 4-3: Marine Sediment Source Evaluation MRS 13

Analyte	Units	Maximum Detected Concentration		Potential MC?	PSV mg/kg	Exceeds PSV?	Further Evaluation Required?	Primary Reason for Exclusion From Evaluation
Explosives - SW8330								
1,3,5-Trinitrobenzene	mg/kg	0.2	U	Yes	7.0	No	No	Not detected at MRS
1,3-Dinitrobenzene	mg/kg	0.2	U	Yes	0.0050	No	No	Not detected at MRS
2,4,6-Trinitrobenzene	mg/kg	0.2	U	Yes	3.6	No	No	Not detected at MRS
2,4-Dinitrotoluene	mg/kg	0.2	U	Yes	1.6	No	No	Not detected at MRS
2,6-Dinitrotoluene	mg/kg	0.2	U	Yes	0.33	No	No	Not detected at MRS
2-Amino-4,6-dinitrotoluene	mg/kg	0.2	U	Yes	0.013	No	No	Not detected at MRS
2-Nitrotoluene	mg/kg	0.2	U	Yes	2.9	No	No	Not detected at MRS
3-Nitrotoluene	mg/kg	0.2	U	Yes	0.61	No	No	Not detected at MRS
4-Amino-2,6-dinitrotoluene	mg/kg	0.2	U	Yes	0.035	No	No	Not detected at MRS
4-Nitrotoluene	mg/kg	0.2	U	Yes	0.68	No	No	Not detected at MRS
Hexahydro-1,3,5-trinitro-1,3,5-triazine	mg/kg	0.2	U	Yes	5.6	No	No	Not detected at MRS
Nitrobenzene	mg/kg	0.2	U	Yes	0.072	No	No	Not detected at MRS
Nitroglycerin	mg/kg	0.2	U	Yes	0.021	No	No	Not detected at MRS
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine	mg/kg	0.2	U	Yes	1.3	No	No	Not detected at MRS
PETN	mg/kg	1	U	Yes	12	No	No	Not detected at MRS
Methyl-2,4,6-trinitrophenylnitramine (tetryl)	mg/kg	0.43	U	Yes	12	No	No	Not detected at MRS
Ammonium Picrate - SW8321A								
Ammonium Picrate	mg/kg	0.13	U	Yes	NA	NA	No	Not detected at MRS

Analyte	Units	Maximum Detected Concentration		Potential MC?	PSV mg/kg	Exceeds PSV?	Further Evaluation Required?	Primary Reason for Exclusion From Evaluation
Metals - SW6020A/6010C/7471B								
Aluminum	mg/kg	5,700		Yes	7,700	No	No	Does not exceed PSV
Antimony	mg/kg	0.4	J	Yes	2.0	No	No	Does not exceed PSV
Barium	mg/kg	11		Yes	48	No	No	Does not exceed PSV
Chromium (Total)	mg/kg	13		Yes	5.8	Yes	Yes	--
Copper	mg/kg	10		Yes	34	No	No	Does not exceed PSV
Lead	mg/kg	1		Yes	47	No	No	Does not exceed PSV
Mercury	mg/kg	0.04	U	Yes	0.13	No	No	Not detected at MRS Does not exceed PSV
Zinc	mg/kg	11		Yes	150	No	No	Does not exceed PSV

U = undetected at the stated reporting limit.

J = Estimated concentration

NA = Not available

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4.1.5 MC Characterization Data

An evaluation of the findings from the MEC investigation and the analytical data for MRS 13 were used to characterize the presence of MC in marine sediment. The evaluation determined whether there was evidence of a release of contaminants at each MRS and identified COPCs requiring further consideration in the risk assessment process.

4.1.5.1 MRS 09

During the MEC investigation, no evidence of munitions use (i.e., no MEC or MD) was discovered offshore at this MRS. Therefore, since there was no evidence of a munitions source at this site, there is no potential release of MC and no sediment samples were collected. Since there is no source of MC contamination, there are no complete exposure pathways. Since there are no complete exposure pathways, there is no risk associated with exposure to MC at this site. Therefore, the risk at MRS 09 was not evaluated further in this risk assessment.

4.1.5.2 MRS 13

4.1.5.2.1 In support of the RI, based on the results of the MEC investigation, marine sediment samples were collected beneath 14 munitions to support the evaluation at MRS 13. Each sample collected beneath a munition was accompanied by a step-out sample collected 4 ft away. All marine sediment samples were analyzed for explosives, eight MC metals (aluminum, antimony, barium, chromium, copper, lead, mercury, and zinc), and ammonium picrate (a breakdown product of Explosives D). The analytical results are presented in Appendix L: Laboratory Data.

4.1.5.2.2 Chapter 2 presents the evaluation process used to determine the COPCs present in the marine sediment in MRS 13. The maximum detected concentration of each analyte is compared to PSVs. Explosives and ammonium picrate were not detected in any of the marine sediment samples collected at MRS 13. Therefore, explosives and ammonium picrate were not retained for further consideration in this risk assessment. All metals except mercury were detected at or above their stated reporting limits. The maximum detected concentration of six metals (aluminum, antimony, barium, copper, lead, and zinc) did not exceed their respective PSVs at MRS 13 and were not evaluated further. The maximum detected concentration of chromium (13 mg/kg at sample PR-1404-SDM-13-11A) was greater than its PSV (5.8 mg/kg) at MRS 13. Therefore, chromium was considered a COPC and evaluated further in the risk assessment (see Table 4-3).

4.1.5.2.3 Values detected in the range between the Limit of Detection (LOD) and the LOQ were reported as “estimated” values (J flagged) and were used in the risk assessment. Any U-flagged value is treated as “not detected,” and is assumed to not be present in the sample. In some cases, the LOD is greater than the screening value. This is common in some analyses due to sample preparation and analytical limitations. This could lead to a situation where the analyte is present at a concentration greater than the screening value, but is reported as "not detected or estimated" leading to an underestimate of risk. However, such occasions are expected to be rare and are not likely to drive the recommendation for the RI. LOD and LOQ values can be found in the Laboratory Data Reports (Appendix L: Laboratory Data).

4.2 REVISED CSEM

4.2.0.1 An exposure assessment includes identification of potential exposure pathways, receptors, and exposure scenarios, as well as quantification of exposure. Characterization of the exposure setting and identification of all potentially exposed receptors and exposure pathways are discussed in this section. Based on results of the MEC and MC characterizations, the preliminary CSEMs previously described in Chapter 2 were reviewed and updated to reflect new applicable information. The revised CSEMs (Figures 4-8 through 4-13) summarize the most current information for the MRS. MEC and MC exposure pathways shown on these revised CSEMs are discussed further in the following sections.

4.2.0.2 The following sections evaluate the potential exposure pathways for MEC and MC at MRS 09 and MRS 13, based on the results of the RI.

4.2.1 Known Contamination Areas and Source Media

4.2.1.1. MRS 09: As previously described, no MEC or MD were found during the Underwater MEC investigation of MRS 09. Therefore, there is no source present for MC contamination in the underwater acres of the MRS.

4.2.1.2 MRS 13: A significant amount of MD was encountered within the MRS. MEC in the form of illumination projectiles that did not function as designed and retained their full or partial payload may exist within MRS 13; however, none was discovered. It is assumed a small percentage of the illumination projectiles' nose fuzes that were fired may have failed to initiate the black powder, expelling charge over the target area to be illuminated. The projectiles with their intact black powder expelling charge and illumination candles are assumed to have maintained their path of trajectory and to have impacted within the northern-most underwater acres of MRS 13. Therefore, there is an assumed potential for MEC in MRS 13. Chromium was identified as a COPC and was presented in the CSEM as a potentially complete pathway for human and ecological receptors. No other contamination or source media were identified during this RI.

4.2.2 Potential Receptors

4.2.2.1 The majority of MRS 09 is managed by the PRDNER. Potential receptors include the following.

Human Receptors

- Residents who live within the boundaries of MRS 09 to include live-aboard boaters who anchor their vessels within the MRS water boundaries over long periods of time
- Commercial and industrial workers such as natural resource agencies and other research companies and firms that use the waters of MRS 09 to conduct underwater research and underwater habitat improvements
- Puerto Rico residents who utilize the beaches and waters around MRS 09 and are considered recreational users for the site
- Visitors from outside Puerto Rico who frequent the waters of MRS 09, gaining access through the beaches and by boating in large numbers throughout the year
- Trespassers are considered as a receptor due to the potential for any unauthorized use of the properties.

Ecological Receptors

Ecological receptors are present in MRS 09 and they have been subdivided into categories in which MC exposure routes may occur:

- Coral (which includes Corals, Sponges, and Algae), which have the potential for incidental ingestion of MC if MC is present within the marine sediment
- Fish and invertebrates, through uptake of marine sediment, or the ingestion of aquatic plants, fish, other biota, or other food sources contaminated with MC.
- Sea Turtles, like fish, may become exposed to MC through the intake of its food sources. For example, the Green Sea Turtle may ingest MC by incidental ingestion of marine sediment while feeding on seagrass, ingestion of vertebrates and invertebrates, or from the seagrass itself if it has absorbed the MC. Hawksbill Sea Turtles are predators and may ingest MC through feeding on prey that may have ingested MC.
- Marine Mammals, a category that has been added in part due to the field team's witness of dolphins within the MRS waters; may be exposed to MC through feeding on fish or other biota that may have been exposed to MC.
- Antillean Manatee could be exposed to MC through incidental ingestion or from the uptake of MC through the aquatic plants in which it feeds.

4.2.2.2 MRS 13, which is managed by USFWS as a wildlife refuge, is an island accessible by boat; it is undeveloped, with steep terrain and heavy vegetation. The MRS contains very few improved areas, but does contain beach areas fully accessible to the boating public.

4.2.2.3 Human receptors considered for MRS 13 are listed below.

- Residents are not present within the boundaries of MRS 13. Residents were evaluated during the MC Risk Assessment (RA) as the worst case for exposure to MC.
- Commercial and industrial workers such as natural resource agencies and other research companies and firms that use the waters of MRS 13 to conduct underwater research and underwater habitat improvements.
- Puerto Rico residents utilize the beaches and waters around MRS 13 and are considered recreational users for the site.
- Visitors from outside of Puerto Rico frequent the waters of MRS 13, gaining access by boating.
- Trespassers are considered as a receptor due to the potential for any unauthorized use of the properties.

4.2.2.4 Ecological Receptors for the underwater acres of MRS 13 are the same as described for MRS 09 (Section 4.2.2.1).

4.2.3 Potential Exposure Pathways for Human and Ecological Receptors in Marine Sediment

4.2.3.1 Potential exposure pathways to both human and ecological receptors are presented below and summarized on the CSEMs presented in Figures 4-8 through 4-11.

4.2.3.2 MRS 09: No MEC or MD were found during the underwater MEC investigation of MRS 09 and only minimal amounts of MD were found in the terrestrial investigation. Since there is no source present there can be no exposure pathways for MEC/MC contamination in the MRS.

4.2.3.3 MRS 13: A significant amount of MD was encountered within the MRS; therefore, there is an assumed potential for MEC. Chromium was identified as a COPC. A potentially complete pathway for human and ecological receptors exists within MRS 13.

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Conceptual Site Exposure Model Diagram

Site/MRS Name: Culebra Island, PR – MRS 09 Underwater Acres

Completed By: Nick Rodriguez, Parsons / Tom Bourque, USA ***Date Completed:*** July 28, 2015

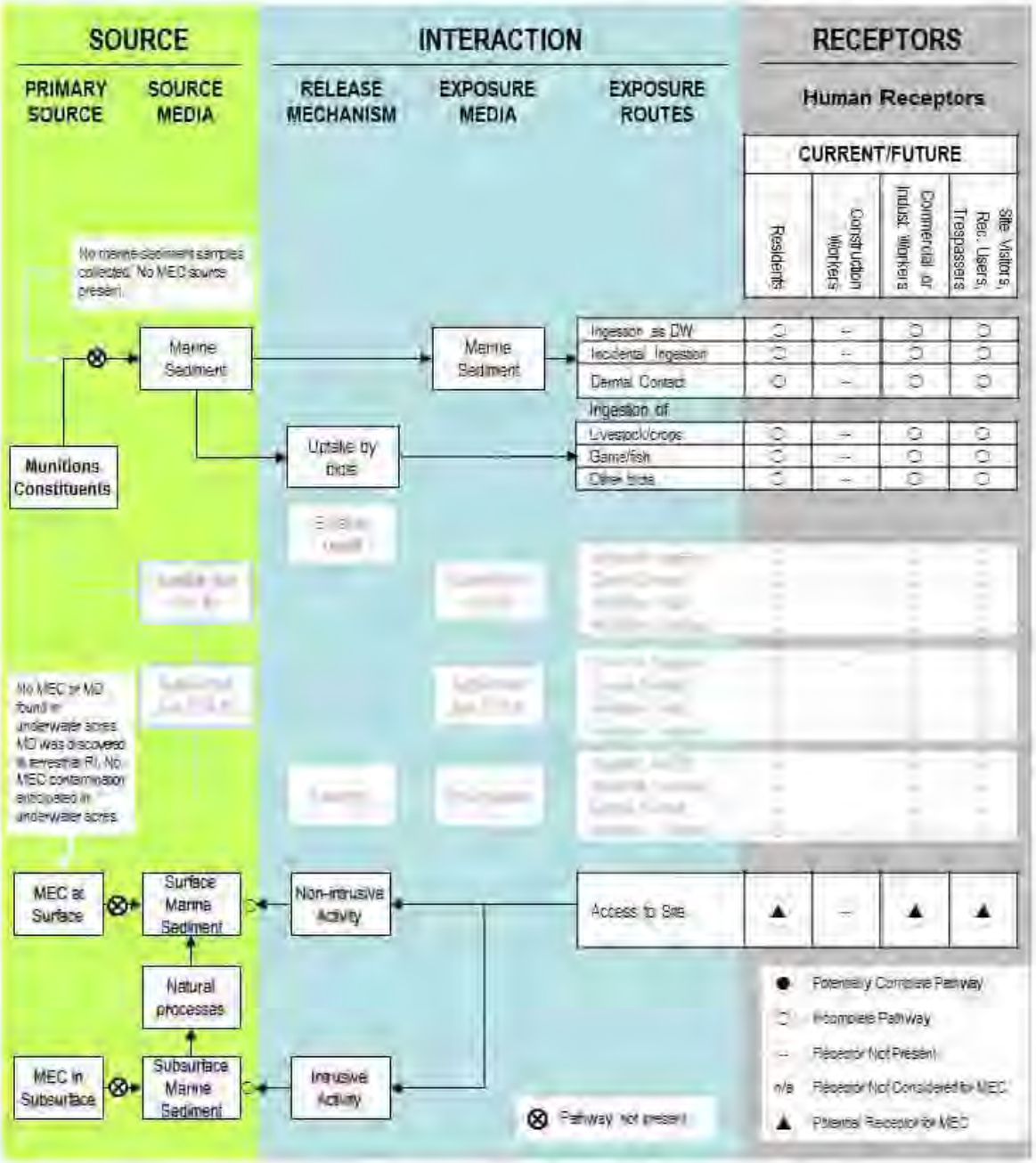

Figure 4-8: Revised MRS 09 Human Conceptual Site Exposure Model

Conceptual Site Exposure Model Diagram

Site/MRS Name: Culebra Island PR – MRS 13 Underwater Acres

Completed By: Nick Rodriguez Parsons / Tom Bourque, USA ***Date Completed:*** July 28, 2015

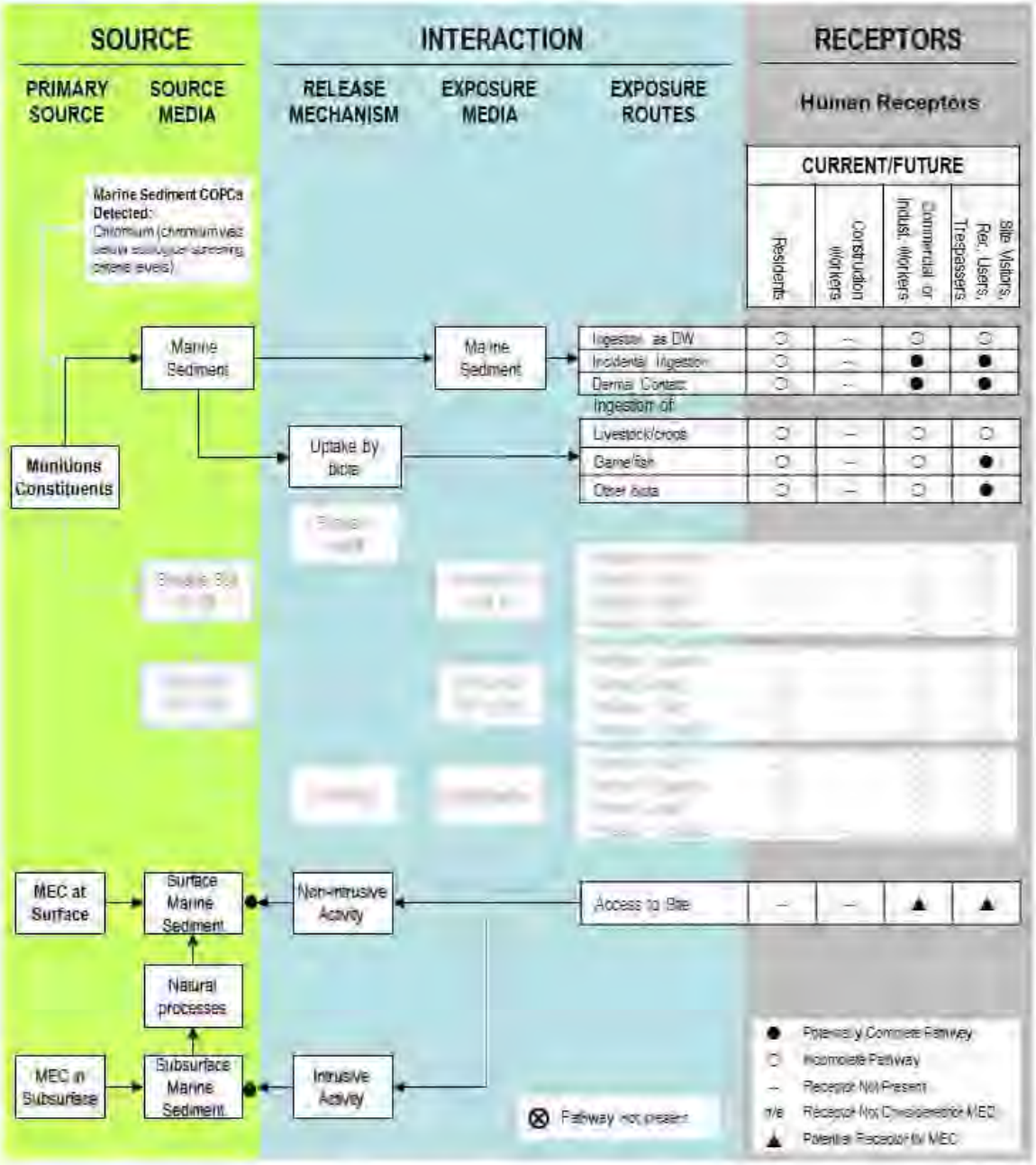

Figure 4-9: Revised MRS 13 Human Conceptual Site Exposure Model

Conceptual Site Exposure Model Diagram

Site/MRS Name: Culebra Island, PR – MRS 09 Underwater Acres

Completed By: Nick Rodriguez, Parsons / Tom Bourque, USA ***Date Completed:*** July 28, 2015

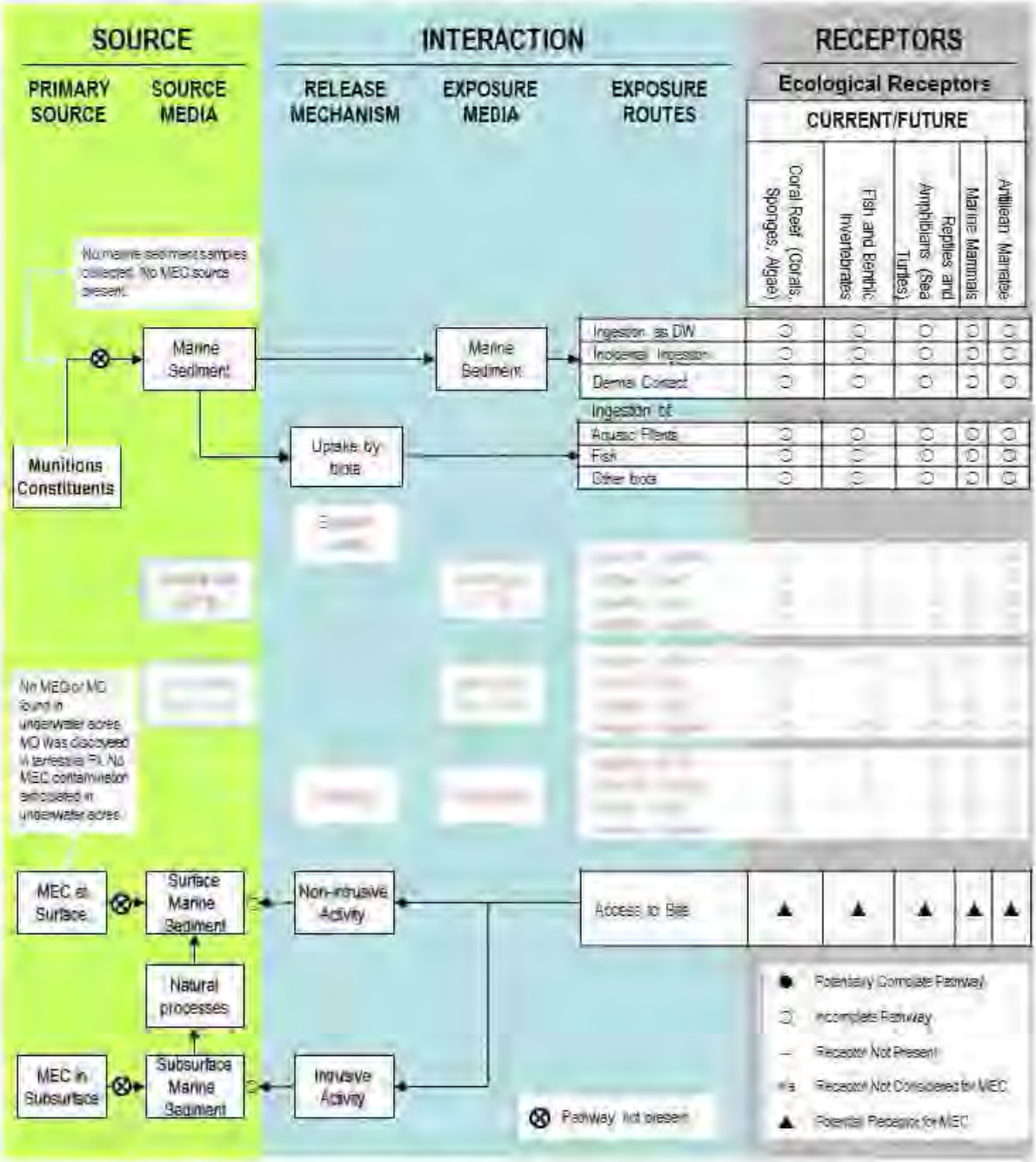

Figure 4-10: Revised MRS 09 Ecological Conceptual Site Exposure Model

Conceptual Site Exposure Model Diagram

Site/MRS Name: Culebra Island, PR – MRS 13 Underwater Acres

Completed By: Nick Rodriguez, Parsons / Tom Bourque, USA ***Date Completed:*** Dec 18, 2015

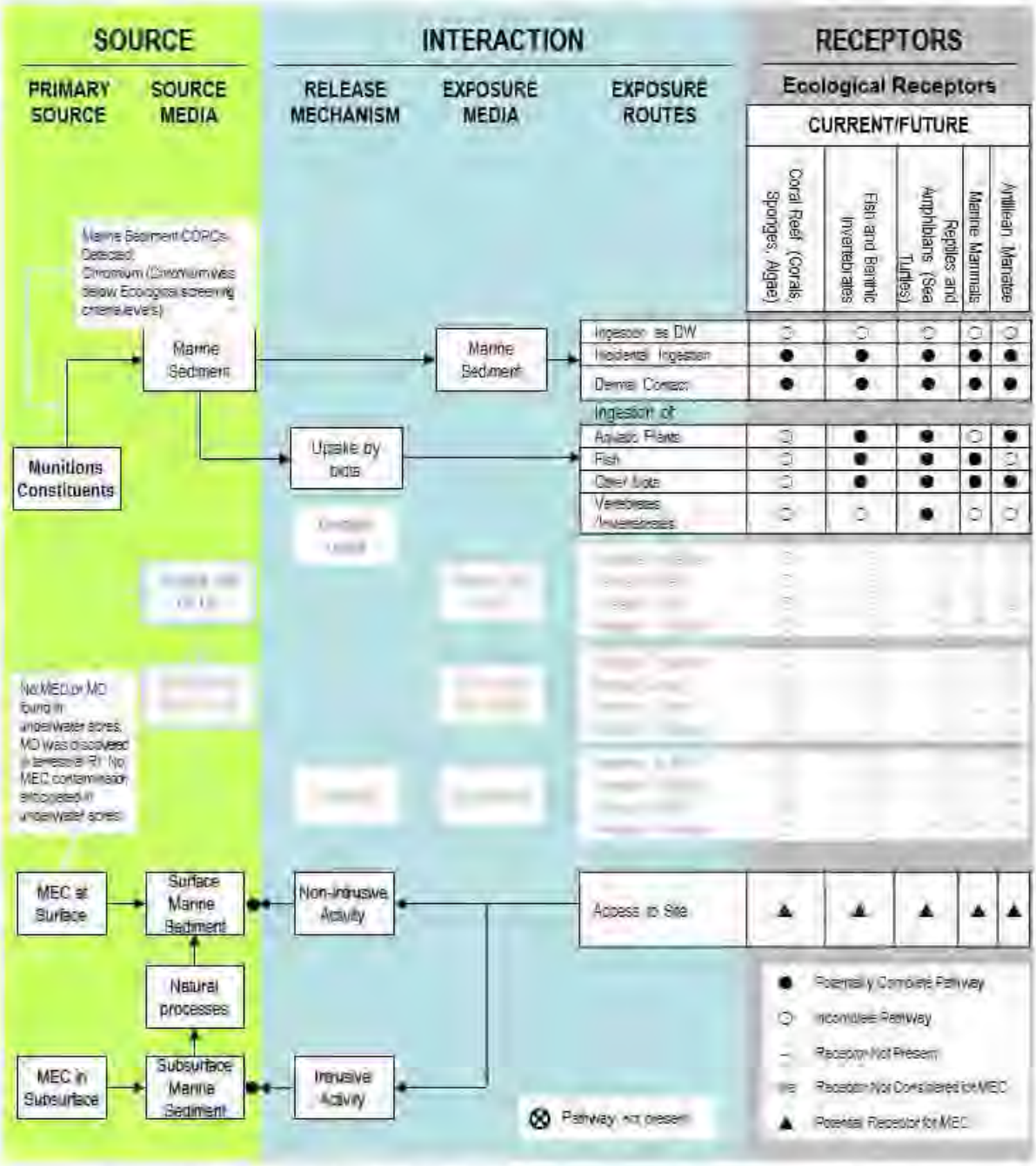

Figure 4-11: Revised MRS 13 Ecological Conceptual Site Exposure Model

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CHAPTER 5. CONTAMINANT FATE AND TRANSPORT FOR MEC/MC

5.1 INTRODUCTION

5.1.1 Understanding the fate of the various MEC and MC contaminants present in or released to the environment is important to evaluate the potential hazards or risk posed by those contaminants to human health and/or the environment. For example, MEC may be found on the ground surface or be buried in the subsurface; however, it is possible for natural processes to result in the movement, relocation, or unearthing of the MEC, thereby increasing the chance of its subsequent exposure to human receptors. Furthermore, MC may remain inside intact munitions or chemicals that may have been released to the environment during training activities.

5.1.2 The following paragraphs discuss the potential route of migration, the persistence of the various constituents, and the contaminant migration. The primary risk posed by MC at this site is through exposure to contaminated media and from the migration of chemicals through the environmental media. For the purposes of this RI, a general discussion of MC fate and transport follows. One metal (chromium) was detected at concentrations greater than PSVs and is evaluated in this chapter.

5.2 MEC

Munitions are known to present explosive hazards long after being fired. Within the underwater environment, natural forces caused by daily current and wave action or from storm surge can move these munitions (MEC) into areas previously deemed clear, increasing the potential for human contact. Marine sediment can also cover and uncover munitions through tidal, current, seasonal changes, and/or storm events possibly exposing munitions that previously were undetected.

5.3 MC

Many different environmental processes act upon MC, which may influence or alter their availability to interact with receptors. These processes depend on the media in which the source (MEC or MD) exists and the exposure of MC to the processes. These processes work through the different media: air, soil, surface water, groundwater, or biota. The following are short descriptions of these processes as they apply to marine sediments.

Suspension/Resuspension – addition of suspended particles to the water column through wave, tidal, and storm energy.

Sedimentation –the removal from the water column of suspended particles by gravitational settling.

Sediment Transport –movement of suspended particles to new locations through currents and wave action.

Plant root uptake – the transport of chemicals into plants through the roots of aquatic plants.

In the marine environment, the following processes are also at work, but to a lesser extent, as described in Hewitt, et al. (2003).

Advection – the passive movement of a solute with flowing water.

Dispersion – the observed spreading of a solute plume, generally attributed to hydrodynamic dispersion and molecular diffusion.

Adsorption/desorption – the process by which dissolved, chemical species accumulate (adsorption) at an interface or are released from the interface (desorption) into solution.

Diffusion – the migration of solute molecules from regions of higher concentration to regions of lower concentration.

Biotic transformation – the modification of a chemical substance in the environment by a biological mechanism.

Oxidation/reduction – reactions in which electron(s) are transferred between reactants.

Covalent binding – the formation of chemical bonds with specific functional groups in soil organic solids.

Photolysis – the chemical alteration of a compound due to the direct or indirect effects of light energy.

5.3.1 Contaminant Persistence

The MC discussed in this section are only those that, upon completion of the Screening Level Risk Assessment (SLRA), were determined to be COPC and warranted further consideration and consequently, have the potential to present an unacceptable risk to human health or the environment. For MRS 13, the only MC that met this criterion was chromium.

5.3.1.1 Metals

5.3.1.1.1 Metals, although naturally occurring, can be a concern when casings, projectiles, or other components of military munitions corrode in the environment. Chromium was the only metal detected at concentrations above the human health PSV during the RI underwater investigation at MRS 13. There were no exceedances of ESVs.

5.3.1.1.2 Chemical and physical properties affect the mobility of metals in soil and groundwater. A variety of reactions can occur that influence the speciation and transport of metal contaminants in soil and groundwater environments including acid/base, precipitation/dissolution, oxidation/reduction, sorption or ion exchange. The rate and extent of these reactions depends on factors such as pH, complexation with other dissolved constituents, sorption and ion exchange capacity of the geological materials, and organic matter content. Under pH ranges between 4.0 and 8.5, metal cations are mobile, while anions tend to transform to oxide minerals. At high pH levels, cations adsorb into mineral surfaces and metal anions are mobilized. Other changes in soil environment conditions over time, such as the degradation of the organic waste matrix, oxidation-reduction potential, or soil solution composition, due to natural weathering processes, also may enhance the mobility of metals. The immobility of metals is primarily caused by reactions that cause metals to precipitate or chemical reactions that keep metals in a solid phase (Evanko and Dzombak, 1997).

5.3.1.1.3 To determine the potential existence of these MC within the sites investigated, marine sediments were collected and analyzed during the RI field efforts.

5.3.1.2 Chromium

5.3.1.2.1 Chromium is found naturally in rocks, ores, minerals, volcanic dust, and gases from the earth's crust. Chromium is often found in the environment stemming from anthropogenic sources; however, those sources are not present at this site. Chromium is a constituent of armor-piercing bullets, pyrotechnics, and some steel alloys. Pyrotechnic munitions were used for training at Culebra and were documented at MRS 13. Under natural conditions, chromium is dispersed throughout the environment, primarily as a result of anthropogenic activity. The concentration of chromium varies widely in soil. For example, in a study within the conterminous U.S., concentrations ranged from 70 ppm (mg/kg) to 700 ppm (mg/kg).

5.3.1.2.2 Chromium occurs in two major forms: trivalent or Chromium (III) and hexavalent or Chromium (VI). Chromium (III) is considered an essential nutrient. Chromium (VI) is eventually reduced to chromium (III) by the organic material present in surface water and generally forms stable complexes with organic matter. Therefore, based on the potential source of chromium (i.e., munitions) chromium is expected to be present in marine sediment at Culebra Island as chromium (III). To be conservative, however, hexavalent and trivalent chromium were both further evaluated in the risk assessment.

5.3.1.2.3 Chromium toxicity in natural waters is highly influenced by physical conditions such as hardness, pH, temperature, and salinity. In natural waters, hydrolysis and precipitation are the dominant processes that influence fate and transport of chromium. The Redox conditions in continent margin marine sediments can become reducing at relatively shallow depths below the surface (mm to typically < 10cm) depending

on organic carbon content of the sediments. Bioturbation impacts the depth of oxidation, as does the presence of plant roots.

5.3.1.2.4 The general population is exposed to chromium primarily through the ingestion of food and, to a lesser extent, through the ingestion of drinking water and inhalation of ambient air. Chromium (VI) has the highest biological toxicity. Inhalation and dermal exposure to chromium can be fatal in humans. Chromium toxicity to aquatic organisms generally occurs at higher concentrations in marine waters.

5.3.2 Summary

As established in Chapter 4, one metal, chromium, which was detected in marine sediment at concentrations above its PSV, is associated with munitions that were used during military operations at Culebra and is therefore determined to be a COPC. Constituents leaching from MEC or MD present the possibility of a contaminant release into the environment, which could potentially affect human or ecological receptors coming into contact with the contaminant. The potential impacts of this exceedance are evaluated in the risk assessment in the following chapter.

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CHAPTER 6. BASELINE RISK ASSESSMENT FOR MC AND HAZARD ASSESSMENT FOR MEC

6.1 INTRODUCTION

6.1.1. The need for remedial actions to reduce hazards and risks to human health or the environment must be demonstrated through the use of either quantitative or qualitative risk assessments. A baseline risk assessment evaluates potential current and future adverse health effects caused by MEC hazards or MC released from a site in the absence of any actions to control or mitigate these releases. In addition, the risk assessment evaluates the magnitude of the risks or hazards at the site and the primary causes of that risk. The baseline risk assessment does not include releases associated with actions taken to mitigate imminent hazards (e.g., detonations to remove MEC). Results of the risk assessment aid in the development, evaluation, and selection of appropriate response alternatives.

6.1.2 Risk assessments are site-specific evaluations and may vary in both detail and extent to which qualitative and quantitative inputs are used. Generally, risk assessments follow a phased approach, starting with generic assumptions and moving toward a more complex site-specific evaluation as necessary. Characteristics of the risk assessment depend on the complexity and particular circumstances of the site as well as the availability of ARARs and other guidance. Risk assessments also consider the potential risks associated with current land use and activities, as well as reasonably anticipated future land use.

6.2 BASELINE RISK ASSESSMENT FOR MC

The following section presents the baseline risk assessment for MC.

6.3 POTENTIAL FOR ADVERSE EFFECTS FROM MC

6.3.0.1 The MC baseline risk assessment was conducted IAW *USEPA RAGS*, and USACE EM 200-1-4 *Risk Assessment Handbook*. The MC baseline risk assessment described in the following sections evaluates the potential for adverse effects on both human and ecological receptors associated with each exposure pathway. An exposure pathway is considered complete if there is a clear potential for human and/or ecological receptors to be exposed to a chemical hazard. The MC baseline risk assessment first identifies those constituents that require further evaluation in a SLRA. The MC baseline risk assessment then assesses the potential significance of complete exposure pathways (that is, whether there is an unacceptable risk). The objectives of this MC baseline risk assessment are to:

- Determine if there is evidence of a release of a contaminant at the site
- If a release has occurred, determine whether an unacceptable risk is present
- Provide a quantitative baseline human health risk assessment and an ecological risk assessment if unacceptable risks have been identified in baseline risk assessment screening steps.

6.3.0.2 The sections below discuss the protocols used in the baseline risk assessment. COPCs are site-related chemicals that have been retained for analysis in the baseline risk assessment. COCs are those chemicals identified for consideration in a FS, based on results of the baseline risk assessment.

6.3.1 Phased Risk Assessment Approach

6.3.1.1 The results of the prior investigations conducted for the Culebra Island MRSs were used to develop a sampling strategy for the RI. An initial characterization of the analytical data determined whether there was evidence of a release of contaminants at the MRSs. At the Culebra Island MRSs, explosives or ammonium picrate were not detected in any samples (see Section 4.1.5.2). For metals, a concentration greater than the PSV indicates a potential release has occurred (see Section 3.2.5 for identification of PSVs). If the maximum detected concentration of a metal does not exceed its PSV, then there is no evidence of a release and further risk evaluation is not conducted for the analyte.

6.3.1.2 If evaluation of the data indicates that a release has likely occurred, a baseline risk assessment is conducted in a stepwise manner, moving from a relatively simple SLRA to a more complex deterministic risk assessment, as needed.

6.3.1.3 If a release was determined, the potential exposure pathways and potential receptors identified in the CSEM were evaluated. If a release was indicated, and complete exposure pathways were identified, then representative concentrations of each metal found above PSV (these metals are now considered COPCs), were used to determine the potential for a human health or ecological risk.

6.3.2 Potential Exposure Pathways for Human and Ecological Receptors

The Culebra Island FUDS consists of 8,430 acres of land, primarily privately owned, with portions managed by the USFWS and PRDNER. All areas within the Culebra Island FUDS have unrestricted public access; however, vegetation and terrain are very restrictive and as such MRSs 09 and 13 are considered "limited restriction to access." Much of the island is accessed regularly by the 2,000-plus local residents and many yearly visitors. Potential human receptors for these sites include residents (MRS 09 only), commercial/industrial workers, and recreational users/site visitors/trespassers. Ecological receptors can also come into contact with MC. An EBS was conducted and both MRS's include sensitive, threatened, and endangered species and critical habitats. Therefore, ecological receptors including sensitive and endangered species are considered present within both of these MRSs. Potential exposure pathways to both human and ecological receptors are presented below. The MC CSEM identifies affected media, transport mechanisms, exposure routes, and potential receptors; CSEMs developed for the underwater portions of Culebra Island MRS 09 and MRS 13 are included in Chapter 5.

6.3.2.1 Marine Sediment

6.3.2.1.1 The marine sediment in the underwater portions of MRS 09 and MRS 13 is impacted by runoff from the MRS. However, MC contamination was not identified at MRS 13 Land Acres. The marine sediment in the underwater portions of MRS 13 could be impacted by potential leaching of MC from MEC located on the ocean floor or buried in the marine sediment. The marine setting of continuous wave and current action and strong storm activity provides a highly dynamic environment. Potential exposure to MC contamination in sediment could occur through the following pathways:

- Incidental ingestion of marine sediment
- Dermal contact with marine sediment
- Ingestion of game/fish and other biota.

6.3.2.1.2 Potential human receptors that may encounter marine sediment through the course of their activities include residents (MRS 09 only), commercial/industrial workers, and recreational users/site visitors/trespassers (see Section 4.2.2).

- "Residents" have been added to evaluate the highest potential for human exposure. Residents include young child (0 to < 6 years of age) and adult receptors residing onsite for 20 years as an adult and 6 years as a young child. Residents may be exposed to marine sediment during aquatic activities (e.g., wading). It is understood that there are currently no residents on-site, and since the evaluation is for marine sediment, it is unlikely that there will be residents on-site in the future. However, at MRS 09 the presence of residents that are adjacent to the site is possible. Therefore, the residential scenario was evaluated.

- Commercial/industrial workers are adult, outdoor workers that are present within the MRSs. These workers could include employees of natural resource agencies, research companies, and firms that use the waters of MRS 09 and MRS 13 to conduct underwater research and underwater habitat improvements. These workers are expected to be exposed to marine sediment during their activities. Due to the location of the site, it was assumed that these workers will be present on-site to complete a specific project for a duration of approximately 250 days. It was also conservatively

assumed that these workers would return to the site to complete similar projects each year for a period of 25 years.

- Recreational users/site visitors/trespassers are adolescent (aged 6 to <16 years) and adult receptors that may be exposed to marine sediment onsite for short durations for recreational or other purposes, including unauthorized access to the site. These receptors are assumed to be present on-site for 104 days/yr. (i.e., 2 days per week throughout the year) and return to the site each year for 30 years.

6.3.2.1.3 Potential ecological receptors exist at MRS 09 and MRS 13. Receptors in these areas would potentially be affected through the ingestion and dermal contact of marine sediment.

6.4 MC RISK EVALUATION

6.4.1 Screening Level Risk Assessment

6.4.1.1 The direct contact exposure pathway for residential soil was used to develop the most conservative estimate of potential risk associated with exposure to marine sediment. The maximum detected concentrations of COPCs are compared to the residential soil RSLs to determine the potential for a human health risk. If the maximum detected concentration of the COPC does not exceed the RSL, it is assumed that there is no unacceptable risk and the risk assessment process is considered complete. The use of RSLs provides a conservative means of identifying those analytes that should be evaluated further in sediment. Since the RSLs assume exposures of 350 days/yr. for 30 years for children and adults, any analyte present at concentrations less than that would not be expected to pose a risk in sediment, due to the less extensive exposures expected to sediment. Maximum detected concentrations of COPCs less than RSLs are not expected to pose an unacceptable risk to human receptors, including residential receptors.

6.4.1.2 To evaluate human health risk due to exposure to marine sediment, the maximum detected concentration of identified COPC in each MRS is compared to the appropriate human health screening value. Cumulative carcinogenic risks and noncarcinogenic Hazard Quotients (HQ) were calculated and evaluated for each COPC listed for marine sediment.

6.4.1.3 The potential for noncarcinogenic effects is evaluated by comparing an exposure level or intake derived for a similar exposure period. The ratio of the exposure concentration to the noncarcinogenic toxicity value is the HQ. In other words, HQ equals the intake divided by the corresponding reference value: The HQs for each COPC within the MRS are totaled to create a Hazard Index (HI). An HI in excess of 1 indicates the potential for noncarcinogenic health effects.

6.4.1.4 Carcinogenic risk is expressed as an increased probability of developing cancer as a result of lifetime exposure to a COPC. For simultaneous exposure to several carcinogens, the USEPA assumes that risks are additive: USEPA's (1991) target carcinogenic risk management range for environmental remediation sites is one-in-one million (1E-06 also expressed as 1×10^{-6}) to one-in-ten thousand (1E 04, also expressed as 1×10^{-4}).

6.4.1.5 To evaluate ecological risk in marine sediment for the site, the maximum detected concentration of each COPC is evaluated using the appropriate ESV. This comparison results in the calculation of HQs for each analyte. An HQ is calculated by determining the ratio of the representative concentration to the screening value. Calculated HQ values are rounded to the nearest whole number. If the HQ is equal to or less than one, the potential for ecological risk is considered to be negligible. If the HQ is greater than one, then unacceptable ecological risk should not be ruled out based on the screening comparison alone. An HQ greater than one should be reviewed to evaluate the significance of the exceedance.

6.4.2 Risk Evaluation

A risk evaluation was conducted for those COPCs identified in the characterization step. The MC baseline risk assessment evaluated the potential for adverse effects on both human and ecological receptors

associated with each exposure pathway. In the following sections, COPCs that were identified for each MRS are evaluated in the following order:

- Site-by-site, sediment SLRAs were conducted.
- COPC concentrations for each medium at a site were evaluated, using both human health screening values and ESVs.
- Each COPC identified in the SLRA as exceeding human health or ESVs was then evaluated in more detail.
- As appropriate, past and present land uses were considered to determine if alternate screening values were applicable.
- The final step in the baseline risk assessment included quantitative risk calculations for those COPCs that were found to exceed relevant human health and/or ESVs.

6.4.2.1 MRS 09

During the MEC investigation, no evidence of munitions use (i.e., no MEC or MD) was discovered off shore at this MRS. Therefore, since there was no evidence of a munitions source at this site, there is no potential release of MC and no marine sediment samples were collected. Since there is no source of MC contamination, there are no complete exposure pathways. Since there are no complete exposure pathways, there is no risk associated with exposure to MC at this site. Therefore, the risk at MRS 09 was not evaluated further in this risk assessment.

6.4.2.2 MRS 13

6.4.2.2.1 Based on the marine sediment source evaluation, the detected concentration of one metal, chromium, was greater than its PSV. Therefore, marine sediment at MRS 13 was retained for further evaluation in the human health risk assessment. Thirty marine sediment samples (excluding count for QC and QA samples) were collected at MRS 13. However, the maximum detected concentration of chromium did not exceed its ESV. Therefore, there is no evidence of an unacceptable environmental risk or hazard associated with exposure to chromium at MRS 13. For sample PR-1404-SDM-13-11A, the maximum detected concentration of chromium (total) (13 mg/kg) exceeded the selected human health screening value for chromium (VI) (0.29 mg/kg). The maximum detected concentration of chromium (13 mg/kg) also exceeded the background 95% UTL (5.8 mg/kg). Therefore, chromium was evaluated further in the risk assessment. Both chromium (VI) and chromium (III) were considered in the risk assessment. The chromium (total) result was assumed to be comprised of chromium (III) and chromium (VI) in a 6 to 1 ratio (Bagdon and Hazen, 1991; NJDEP, 1998; Zewdie, 1998). Chromium (VI) is eventually reduced to chromium (III) by the organic material present in surface water and generally forms stable complexes with organic matter. Therefore, chromium in aquatic environments is likely to convert to chromium (III) and deposit as a precipitate (EPA, 1998). Based on the potential source of chromium (i.e., munitions), the chromium observed in marine sediment is most likely to be present as chromium (III). The assumption that any of the chromium present in sediment is chromium (VI) is a conservative assumption. The estimated chromium (VI) concentration is calculated by dividing the total measured chromium concentration (13 mg/kg) by seven. Results were then compared to valence-specific screening criteria. .

6.4.2.2.2 Chromium was evaluated assuming two potentially complete pathways for human exposure: incidental ingestion and dermal contact with marine sediment. Potential receptors at MRS 13 currently include commercial/industrial workers and site visitors/recreational users/trespassers. Residents were included in the risk assessment for MRS 13 to provide the most conservative scenario possible. Ingestion was evaluated for each receptor using the exposure assumptions provided in Tables G.3.1 through G.3.3 in Appendix G: MC Analytical Data and Risk Tables. However, dermal contact with marine sediment was not quantitatively evaluated at MRS 13 since the USEPA does not provide a dermal absorption factor for chromium. Based on USEPA's guidance in RAGS Part E, and consistent with the RSL calculations, COPCs without dermal absorption factors should not be evaluated for dermal risk.

6.4.2.2.3 Recreational users may consume fish caught within the MRS 13. As described above (paragraph 6.4.2.2.1), chromium (VI), the more toxic valence state of chromium, is eventually reduced to chromium (III) by the organic material present in surface water and generally forms stable complexes with organic matter. Therefore, based on the potential source of chromium (i.e., munitions), chromium is expected to be present in marine sediment at Culebra Island as chromium (III). The reduced form of chromium, chromium (III), is less readily bioavailable than the highly oxidized form, chromium (VI) (World Health Organization, 2006). Therefore, the recreational user fish consumption exposure pathway is potentially complete, but is not significant due to the limited bioavailability of chromium in sediment and not quantitatively evaluated in the risk assessment. Uncertainty associated with this is described below (see Section 6.4.3).

6.4.2.2.4 If a constituent has been determined to cause cancer by a mutagenic mode of action (MOA), USEPA has noted that it is possible that exposures to that chemical in early life may result in higher lifetime cancer risks than an adult exposure of comparable duration (USEPA, 2015). Chromium (VI) is a mutagen. In assessing the risk for which a mutagenic MOA has been identified by USEPA, default age-dependent adjustment factors (ADAFs) were applied for those chemicals lacking chemical-specific data on susceptibility from early life exposures (e.g., chromium (VI)). The *Supplemental Guidance for Assessing Cancer Susceptibility from Early Life Exposure to Carcinogens* (USEPA, 2005) recommends the following default ADAFs:

- 10-fold adjustment for exposures during the first two years of life
- 3-fold adjustment for exposures from ages 2 to <16 years of age
- No adjustment for exposures after turning 16 years of age

6.4.2.2.5 These ADAFs are used to prorate the toxicity factors for the respective age ranges, to account for more or less sensitivity during that life stage. For example, there is assumed by default to be 10-fold greater sensitivity over the first two years of life than for an equivalent level of exposure after turning 16 years of age. Consideration of early life stage exposure was limited to the residential and recreational user exposure scenarios (see Tables G.3.5 and G.3.8 of Appendix G).

6.4.2.2.7 For current residents, a cancer risk of 3E-06 and hazard index of 0.001 were generated assuming incidental ingestion of marine sediment. Both values are within or less than the acceptable range established by the USEPA for carcinogenic risk (1E-04 to 1E-06) and non-carcinogenic hazards (less than 1). Results can be found on Table G.3.4 in Appendix G: MC Analytical Data and Risk Tables.

6.4.2.2.8 For commercial/industrial workers, a cancer risk of IE-06 and hazard index of 0.002 were generated assuming incidental ingestion of marine sediment. Both values are less than the acceptable range established by the USEPA for carcinogenic risk (1E-04 to 1E-06) and non-carcinogenic hazards (less than 1). Results can be found on Table G.3.6 in Appendix G: MC Analytical Data and Risk Tables.

6.4.2.2.9 For recreational users, a cancer risk of 3E-07 and hazard index of 0.0002 were generated assuming incidental ingestion of marine sediment. Both values are less than the acceptable range established by the USEPA for carcinogenic risk (1E-04 to 1E-06) and non-carcinogenic hazards (less than 1). Results can be found on Table G.3.7 in Appendix G: MC Analytical Data and Risk Tables.

6.4.3 Risk Assessment Uncertainties

All risk assessments involve use of assumptions, professional judgments, and imperfect data to varying degrees, which result in uncertainty in the final estimates of risk. Risk assessment in general is often based on conservative assumptions and scenarios. Uncertainty can be introduced into a risk assessment at every step of the process outlined in this document. Uncertainties are present in a risk assessment because it requires integration of the following:

- Release of constituents into the environment, and the areal and vertical distribution of these materials in marine sediment
- Fate and transport of constituents in a variety of different and variable environments by processes that are often poorly understood or too complex to quantify accurately

- Potential for adverse health effects in humans based on extrapolations from animal studies
- Probability of adverse effects in a human population that is highly variable with respect to genetics, age, activity level, and lifestyle.

6.4.3.1 Uncertainty in Data Collection and Evaluation

6.4.3.1.1 The analysis of uncertainties focuses on determining whether the available data are representative of contaminant concentrations and site conditions, and whether features of sampling, analyses, or statistical treatment of the data result in an over- or underestimation of potential risk.

6.4.3.1.2 Constituents that were never detected in any samples were eliminated from the risk assessment. It is possible that some constituents that were eliminated from consideration in the risk assessment may have actually been present in samples at concentrations lower than the reporting limit. If constituents that were eliminated from the risk assessment were actually present in the environmental medium, the cumulative risk could be underestimated. To minimize the possibility that risk was underestimated, efforts were made to ensure that the lowest reasonably achievable reporting limits were obtained by the laboratory providing analytical services.

6.4.3.1.3 Constituents that were detected at concentrations less than the selected screening criteria were eliminated from the risk assessment. It is possible that some of these constituents may have been present at greater concentrations in areas that were not sampled, and thus the potential exposure concentrations might have been underestimated. However, the sampling plan attempted to reduce this uncertainty through the use of a consistent analytical approach as well as a biased sampling approach. Since samples were collected from areas identified in the CSEM as areas most likely to be contaminated based on the understanding of past site activities, it is unlikely that any constituents were present at health-significant levels and not detected.

6.4.3.1.4 The COPC screening criteria used in the risk assessment are consistent with those presented by USEPA in the November 2013 RSL table (i.e. current at the time the risk assessment was first completed). Updates to the USEPA RSL table are made twice annually, so the toxicity criteria from the November 2013 RSL table used herein may not represent the most currently available criteria. This could affect which chemicals are selected as COPCs. Therefore, the risk may be under- or overestimated.

6.4.3.1.5 Steady-state conditions (i.e., the observed concentrations remain the same in the environmental media for the foreseeable future) were assumed for evaluation of potential future exposures. The assumption of steady-state conditions may tend to overestimate long-term exposure and health risk because contaminant concentrations may decline over time due to natural dissipation processes (e.g., biological and chemical degradation) or dilution through transport processes. In some cases, depending on the contaminant and or the release mechanisms involved, steady-state assumptions could potentially underestimate risk (e.g., breakdown products that are more toxic than the parent compound or a continuous source contributing to contamination in another medium).

6.4.3.2 Uncertainty in Toxicity Assessment

6.4.3.2.1 Some uncertainty is also inherent in the toxicity values used in the risk assessment. Carcinogenic slope factors and route-specific values were derived only for compounds that have been shown to cause an increased incidence of tumors in either human or animal studies. This dose-response curve is then assumed to be linear at low doses (e.g., those found in situations of environmental contamination) and is used to predict tumor incidence at low exposure levels. When an animal study is used, the final slope factor is adjusted to account for extrapolation of animal data to humans. If the studies used to derive the slope factor were conducted for less than the life span of the test organism, the final slope factor had also been adjusted to reflect risk associated with lifetime exposure.

6.4.3.2.2 The slope factor is generally an upper 95th percentile confidence limit of the probability of a response based on experimental animal data in the multistage model. This means that the site-specific constituent risk is not likely to exceed the risk estimate derived through the model and is likely to be less than the predicted risk.

6.4.3.2.3 The chronic reference dose (RfD) for a compound is based on studies where either human or animal populations were exposed to a given compound by a given route of exposure for a major portion of the life span (as a USEPA guideline, seven years to a lifetime; EPA, 1989). RfDs are derived by determining dose-specific effect levels from available quantitative studies and applying uncertainty factors to the most appropriate effect level to determine an RfD for humans. Uncertainty factors are generally applied as multiples of 10 to represent specific areas of uncertainty in the data. Typically, an uncertainty factor of 100 to 1,000 is used in the professional judgment of uncertainties. General uncertainties in the derivation of RfDs may be associated with factors such as (1) variations in the general population (to protect sensitive receptors), (2) extrapolation of animal data to humans, (3) use of a subchronic study versus a chronic study to determine the no-observed-adverse-effect level (NOAEL), or (4) use of a lowest-observed-adverse-effect level (LOAEL) versus a NOAEL. Both the uncertainty and modifying factors are conservative in nature and tend to overestimate risk.

6.4.3.2.4 Site-specific valence-specific data for chromium was unavailable and toxicity criteria are not available for chromium (total). Therefore, the risk due to exposure to both chromium (III) and chromium (VI) was estimated using the chromium (III) and chromium (VI) toxicity data and the chromium (total) results. Chromium (III) was considered in the cumulative risk calculations (provided chromium was determined to be present within the applicable exposure area at concentrations greater than background). Chromium (III) is associated only with noncarcinogenic effects, while chromium (VI) is associated with both carcinogenic and noncarcinogenic effects. Assuming one valence state over the other may either under- or over-estimate risk.

6.4.3.2.5 In absence of valence-specific sample results, the EPCs for chromium (III) and chromium (VI) were estimated assuming a ratio of six (chromium (III)) to one (chromium (VI)). The estimated chromium (VI) concentration was determined by dividing chromium (total) by seven. The risk assessment also included exposure to chromium (III or Cr3+), determined by multiplying chromium (total) by (6/7). The assumption that there is any chromium (VI) present at the site is conservative and likely overestimates risk.

6.4.3.2.6 Dermal contact with marine sediment was not quantitatively evaluated at MRS 13 since the USEPA does not provide a dermal absorption factor for chromium. Based on USEPA's guidance in RAGS Part E, and consistent with the RSL calculations, COPCs without dermal absorption factors should not be evaluated for dermal risk. Since USEPA does not have enough confidence in the existing literature to adopt a dermal absorption factor for chromium, the dermal contact exposure pathway was not quantitatively evaluated for exposure to chromium in marine sediment. Therefore, the cumulative risk may be underestimated.

6.4.3.3 Uncertainty in Estimating Chemical Risk

6.4.3.3.1 Additional uncertainties are incorporated into the risk assessment when exposures to several substances are summed. Exposure to multiple chemicals may result in interactions between the chemicals in ways that may not be predictable. The assumption is that exposure to multiple chemicals is additive, that is, the carcinogenic risk or hazard quotient for each constituent is simply added together to estimate the cumulative risk or hazard. However, in reality some constituents may produce a synergistic effect, where the risk associated with exposure to these chemicals is actually greater than the sum of the carcinogenic risk or hazard quotients. In such a case, the risk assessment will underestimate the risk. In other cases, some constituents may interact antagonistically, such that the risk associated with exposure to these chemicals is less than the sum of the carcinogenic risk or hazard quotients. In these cases, the risk assessment will overestimate the risk associated with exposure to these chemicals.

6.4.3.3.2 Chromium can exist in the environment as chromium (III) and chromium (VI). The analytical results presented in this report are for chromium (total) and do not distinguish between the different valence states. Toxicity criteria have been established for chromium (III) and chromium (VI). The total chromium analytical result was used to estimate the risk/hazard associated with the two chromium valence states (chromium (III) and chromium (VI)). That is, two risk/hazard estimates were calculated for chromium using the total chromium analytical result and valence-specific toxicity criteria. Because it is highly unlikely that chromium (VI) is present at the site due to DoD activities, the risk/hazard estimates for chromium (VI) were not included in the cumulative risk estimates. The hazard estimates for chromium (III) were included in the

cumulative risk estimates if chromium was detected at a concentration greater than the BTV (for soil). Using the total chromium analytical results to estimate a risk/hazard estimate for the specific valence states of chromium may overestimate the risk.

6.4.3.4 Uncertainty in Exposure Assessment

6.4.3.4.1 The risk assessment estimates are conditional on actual and potential exposure pathways identified at the site. If exposure does not occur, no risks are present. Furthermore, the risk assessment process does not factor in the probability of exposure occurring. For example, there may not be a reason for a commercial worker to be present on site 250 days per year. The actual exposure for the commercial worker is likely to be less often than 250 days per year.

6.4.3.4.2 Current land uses and characterization of the site's current physical setting provided the basis for predicting future land use at and in the vicinity of the site. Steady-state conditions were assumed for evaluation of potential future exposures. The assumption of steady-state conditions may tend to overestimate long-term exposure and health risk because contaminant concentrations may decline over time due to natural dissipation processes. In some cases, depending on the contaminant and or the release mechanisms involved, steady-state assumptions could potentially underestimate risk (e.g., a continuous source contributing to contamination in another media). However, no evidence of this situation was observed.

6.4.3.4.3 There is also some concern as to how well an exposure scenario approximates the actual conditions that a receptor may be exposed to at a given site. Potential human exposures could deviate from those used in the risk assessment through differences in exposure frequency, contact rates, exposure durations, body weight, and life span. Each of these factors has a degree of uncertainty associated with it that could over- or underestimate risk. Risks related to dermal absorption of chromium were not calculated, hence potentially underestimating chromium exposure risk.

6.4.3.4.4 Evaluation of risk for resident and recreational user exposure to sediment includes calculation of the risk to children and adolescents, respectively. Other sensitive subpopulations such as elderly people, pregnant or nursing women, and people with chronic illnesses were not specifically evaluated in this risk assessment. These subpopulations may be more sensitive to certain chemical exposures. However, USEPA generally considers sensitive subpopulations when developing toxicity factors. Additionally, there are not any daycare or school facilities, healthcare facilities, nursing homes, retirement communities, or residential areas with children or adolescents currently onsite. Therefore, evaluation of a residential scenario, including children and adolescents, is a conservative evaluation.

6.4.3.4.5 Recreational users may consume fish caught within the MRS 13. Chromium (VI), the more toxic valence state of chromium, is eventually reduced to chromium (III) by the organic material present in surface water and generally forms stable complexes with organic matter. Therefore, based on the potential source of chromium (i.e., munitions), chromium is expected to be present in marine sediment at Culebra Island as chromium (III). The reduced form of chromium, chromium (III), is less readily available then the highly oxidized form, chromium (VI) (World Health Organization, 2006). Therefore, the recreational user fish consumption exposure pathway is potentially complete, but is not significant due to the limited bioavailability of chromium in sediment and not quantitatively evaluated in the risk assessment. The risk presented herein may, therefore, be underestimated.

6.4.4 Conclusions of the MC Risk Assessment

The results of the baseline risk assessment are presented in the following subsections.

6.4.4.1 MRS 09

The risk at MRS 09 was not evaluated in this risk assessment since no evidence of munitions use (i.e., no MEC or MD) was discovered off shore at this MRS during the MEC investigation. There is no potential release of MC and no sediment samples were collected. Since there is no source of MC contamination, there are no complete exposure pathways.

6.4.4.2 MRS 13

Based on results of this RI and a review of the MC risk assessment objectives, there is no unacceptable risk to human health or ecological receptors from exposure to marine sediment at MRS 13 within the Culebra Island site.

6.5 HAZARD ASSESSMENT FOR MUNITIONS AND EXPLOSIVES OF CONCERN

The USEPA MEC HA model is not designed for underwater sites and therefore was not used to assess the hazard posed by MEC at MRS 09 and MRS 13. A qualitative MEC hazard assessment is provided to assess the hazards of MEC to the sites investigated. The approach provides an assessment of the acute explosive hazards associated with remaining MEC at an MRS by analyzing site-specific conditions and human issues that affect the likelihood that a MEC accident will occur. The qualitative MEC hazard assessment method focuses on hazards to human receptors and does not directly address environmental or ecological concerns that might be associated with MEC. The hazard analysis was developed for the baseline (existing) conditions at the site.

6.5.1 Qualitative MEC Hazard Assessment

6.5.1.1 Under the qualitative MEC hazard assessment method, the potential hazards posed by MEC are evaluated qualitatively by evaluating three primary factors. These factors, noted below, are related.

- Severity: the potential consequences of the effect on a human receptor should a MEC item detonate
- Accessibility: the likelihood that a human receptor will be able to come into contact with a MEC item
- Sensitivity: the likelihood that a MEC item will detonate if a human receptor interacts with it.

6.5.1.2 To complete the baseline qualitative MEC hazard assessment, the various input factors are reviewed, and suitable categories are selected based on historical documentation and field observations made during the RI and previous studies. The following paragraphs provide an overview of the MRSs and how these factors were evaluated to form the hazard assessment.

6.5.2 Qualitative MEC Hazard Assessment for Soldado Point Mortar and Bombing Area (MRS 09)

6.5.2.1 No MEC or MD was discovered within the water boundaries of MRS 09 during the RI field work. There were no indicators of DoD activity and no discovery suggesting a possible high-density area in which MEC or MD were present. Historical research indicates that possible bombing targets may have been located inside Sueño Cove and the bay that extends west of Soldado Point. During the Terrestrial RI, eight MD items were recovered after investigating 1.9 acres covered by transects and 1 acre of investigation in grids. There were no MEC items recovered in MRS 09 during the Terrestrial RI, with the exception of two MK 25 Marine Markers. MK 25 Marine Markers do not indicate a direct link to DoD activity for MRS 09 since the MK 25 Marine Markers are deployed by both military and civilian users to mark a location by using smoke on the surface of the water during military and civilian training. Upon the marine marker completing its 15-minute burn duration, it sinks to the ocean floor and may wash up on beaches or get lodged on underwater obstructions long distances from where they were originally deployed. No MEC or MD was discovered along the beaches and shoreline transects during the Terrestrial RI. The Terrestrial RI also performed underwater visual transects using an ROV without the discovery of MEC/MD. During the Site Investigation (Parsons, 2007), no MEC was discovered; however, one mortar boom was identified as MD. Appendix B: Figure B-12 depicts the Terrestrial RI field efforts and this Underwater RI overlaid on one map.

6.5.2.2 MRS 09 water acres provide recreational opportunities for the local population and the tourists visiting Culebra in the form of swimming, SCUBA diving, boating, and fishing. The shallow reefs that serve as breakwaters for wind waves and swells attract boaters seeking safe anchorages. Discussions of establishing cabins and state-run camp grounds are ongoing; such development will require vegetation clearance operations and the removal of squatter shacks. The completion of the camp grounds may increase the use of the underwater acres of MRS 09 if the project is approved and funded.

6.5.2.3 The water provides a limiting barrier to the sea floor where MEC would reside if it existed. The deeper the water, the more of a limiting factor it becomes. As a factor in considering the potential for human receptors to come into contact with MEC, water provides a natural barrier, although it can be overcome with recreational snorkeling and SCUBA diving equipment. Only the shallow water areas that coincide with public beaches are considered to have no barriers. The water does not provide a barrier to ecological receptors.

6.5.2.4 The migration of MEC through current, tide, wind waves, swells, and storm surge was evaluated; however, since no MEC was discovered within the MRS boundaries it was determined not to be applicable.

6.5.3 Qualitative MEC Hazard Assessments Results for Soldado Point Mortar and Bombing Area (MRS 09)

No MEC was encountered that can be linked to DoD activity on MRS 09 in the water or land acres and no MD or DoD target remnants were identified within the MRS water boundaries. Human receptors are present. Since a) there was no MEC/MD discovered in the underwater acres of the RI survey, b) no MEC has been historically reported in the area, and c) no evidence was found indicating DoD munitions use of the underwater acres as a target area, no MEC source to cause an explosive hazard was identified. Based on the RI findings, no unacceptable risk to human health was identified and no further action is recommended with regard to explosive hazards in the underwater acres of MRS 09.

6.5.4 Qualitative MEC Hazard Assessment for Cayo Luis Peña Impact Area (MRS 13)

6.5.4.1 No MEC was discovered within the water boundaries of MRS 13; however, the discovery of MD indicates the possibility of MEC being present. 5-inch Illumination (Expended) MK 45 Mod 0 Projectiles and 5-inch Illumination (Expended) MK 48 Mod 0 Projectiles were discovered, along with expended Aircraft Parachute MK 24 Mod 2 Flares in MRS 13. MEC in the form of illumination projectiles or parachute flares that did not function as designed and retained their full or partial payload may exist within MRS 13; however, none was discovered. Remnants of "mechanical time" nose fuzes were discovered within the MRS water boundaries and on the expended 5-inch projectiles. "Mechanical time" fuzes were used as the primary means of initiating the black powder expelling charge and the dispersal of the projectiles payload over the target to be illuminated. A "mechanical time" fuze presents a possible hazard of accidental initiation of a projectile that did not function as designed if the fuze or munition is jarred or dropped or receives an impact/shock that allows the fuze to complete its firing sequence. The Terrestrial RI (USA 2016) and the SI (Parsons 2007) results indicated large quantities of MD on the northern terrestrial acres of the MRS; however, no MEC was discovered. No indicators of a target were identified during the underwater RI; however, historical research indicates that the NWP may have been the target for the 5-inch illumination projectiles due to the 5-inch illumination candles (the payload for the 5-inch illumination projectile) that were discovered and disposed of during the EECA (Environmental Science and Engineering, Inc., March 2007) and a construction support project (Ellis Environmental Group, LC., Final Field Sampling and Analysis Report: Construction Support Phase I(b), Culebra Island National Wildlife Refuge, Puerto Rico 2004b). Other less likely scenarios are discussed within this report.

6.5.4.2 The MD discovered in MRS 13 ranged in depth from surface-borne MD to MD discovered as deep in the marine sediment as 36 inches with MD items suspected to be buried deeper. MEC is potentially present due to the presence of MD. The only suspected activity in which buried MEC will be accessed by human receptors is through boaters setting their anchors. Therefore, human receptors have the potential to come into contact with possible surface MEC and subsurface MEC.

6.5.4.3 MRS 13 water acres provide a waterborne recreation area for the local population and the tourists visiting Culebra in the form of swimming, SCUBA diving, boating, and fishing. Boats can tie up at several mooring areas. Residents and visitors frequent MRS 13 by anchoring their boats in the North Bay near shore area or beyond the 12 meter depth curve in the North Bay and dinghy to shore to enjoy the beaches and snorkeling. MRS 13 has a small bay on the southeastern shore that provides mooring buoys for visiting boats. There are also mooring fields on the western side of the MRS. There are no residential properties or businesses on Cayo Luis Peña. The main island of Culebra is across the Luis Peña Channel and within 4000 ft of the MRS boundary where residential and business properties are present.

6.5.4.4 The water provides a limiting barrier to the sea floor where MEC would reside if it existed but it doesn't prevent access to the MRS and once a "user" of the site acquires the use of a boat either through ownership, charter etc., full access to the MRS can be achieved. The deeper the water the more of a limiting factor it becomes. As a factor in considering the assessment in which human receptors could come into contact with MEC, water provides a natural barrier, although it can be overcome with recreational snorkeling and SCUBA diving equipment. Only the shallow water areas that coincide with public beaches are considered to have no barriers. The water does not provide a barrier to ecological receptors. The waters within the MRS boundary contain Listed as Threatened or Endangered Species to include Corals, Green and Hawksbill Sea Turtles, marine mammals, and other marine species.

6.5.4.5 If there is a possibility of MEC, then the migration of MEC through current, tide, wind waves, swells, and storm surge should be considered during the development of the FS. The Northern half of MRS 13 is exposed to the North swell season that coincides with winter storms that move across the continental U.S. These swell events have the ability to move and relocate marine sediment to cover or uncover both MEC and MD. Tidal currents in excess of 2 knots occur daily through the Luis Peña Channel and may have the ability to move marine sediment, thus exposing MEC or MD or covering exposed MEC and MD items. The currents may also be capable of moving smaller or lighter MEC and MD items over time.

6.5.5 Qualitative MEC Hazard Assessment Results for Cayo Luis Peña Impact Area (MRS 13)

6.5.5.1 MRS-13 northern acres is composed of the primary area contaminated by MD and covers approximately 273.3 underwater acres. Discoveries of MD have been made in MRS-13 and the potential for MEC exists within the northern half of the MRS. Human receptors are present; therefore, the MEC exposure pathway is complete and there is a potential for human health hazard due to MEC.

6.5.5.2 MRS 13 southern acres (approximately 265.1 acres) did not produce MEC and only two MD items; MD was also discovered on the terrestrial acres. These southern water acres for MRS 13 may be considered as buffer areas for the use of the terrestrial acres of MRS 13 as there is no historical evidence of DoD targets having been located or the discovery of MEC within these southern water acres of MRS 13.

6.6 MUNITIONS RESPONSE SITE PRIORITIZATION PROTOCOL (MRSPP)

6.6.0.1 In 2001, Congress directed that the DoD identify and then prioritize their MRSs. The protocol was published as a rule on 5 October 2005 (35 Code of Federal Regulations Part 179). The protocol was designed to: 1) maximize use of the latest MRS-specific data, and 2) be applied early in the munitions response process. The protocol assigns a relative priority to each location in the DoD's inventory of defense sites known or suspected of containing UXO, Discarded Military Munitions (DMM), or MC, and prescribes procedures for prioritizing the defense sites and general component responsibilities. The site priority ranking is based on the risk posed by potential hazards captured in data entered for three hazard evaluation modules of the MRSPP: explosive hazard evaluation (EHE) module, chemical warfare materiel (CWM) hazard evaluation (CHE) module, and the health hazard evaluation (HHE) module. Separate MRSPP tables (EHE Tables 1 through 10, CHE Tables 11 and 20, HHE Tables 21 through 28, MRS Priority Table 29, and MRS Background Information Table A) were completed for MRS 09 and MRS 13. MRSPP tables can be found in Appendix H: MRSPP. MRS priorities range from 1 (highest priority) to 8 (lowest priority). Alternative module scoring may include qualitative responses, such as evaluation pending, no longer required, or no known or suspected explosive (explosive, CWM, and/or MC) hazard, instead of numerical scoring. The results of the MRSPP for MRS 09, and MRS 13 are as follows.

6.6.0.2 The MRSPP for MRS 09 and MRS-13 were developed during the SI (Parsons, 2007). Due to munitions history of both sites, the MRS priority was determined to be 4 for MRS 09 and priority 4 for MRS 13. The MRSPP was updated for MRS 09, and MRS-13 based on the findings of this RI.

6.6.1 MRS 09: Underwater Acres

The MRS priority for MRS-09 is an Alternative Module Rating of "No Known or Suspected Hazard," based on the low probability of MEC and the fact that no MEC or MD was discovered in the underwater acres of

MRS 09. MRS 09 water boundaries are considered to be a target buffer area for the terrestrial acres of MRS 09 in which some MD was discovered.

- MRS 09 EHE Module Rating (score 0). There were no discoveries of DoD munitions use during the underwater RI; therefore, the EHE alternate module rating of "No Known or Suspected Explosive Hazard" was selected.
- MRS 09 is not known or suspected to have CWM and thus the CHE module rating is classified as "No Known or Suspected Chemical Warfare Materiel Hazard."
- MC was not evaluated during the RI for MRS 09 underwater acres and the alternate module rating of "No Known or Suspected MC Hazard" was selected since there was no evidence of DoD munition use discovered during the RI field work.

6.6.2 MRS-13: Munitions Debris Areas

MRS-13 underwater acres have been evaluated and have been determined as an MRS priority 5. The original MRS priority rating of 4 was determined during the SI (Parsons 2007) for the terrestrial acres. The CHE, which evaluates the presence of Military Chemical Weapons, module rating is "No Known or Suspected CWM Hazard." MRSPP worksheets are included in Appendix H: MRSPP.

- MRS 13 EHE Module Rating (score 6671) of C. The EHE module rating of C is based on the confirmation of MD presence within the underwater acres of the MRS, the presence of human receptors, and the accessibility of the MRS. The EHE module rating was then compared in the MRS Priority Table (MRSPP Table 29) resulting in the EHE priority of 54. The quantity of expended illumination projectiles may indicate illumination type munitions (projectiles and flares) were used during DoD training and exercises. The most likely scenario is MRS 13 falls within an overshoot area for the Naval Gunfire Target ranges located on Culebra's NWP and Illumination rounds may have continued on their trajectory to Cayo Luis Peña after dispensing their illumination payload over the NWP. 5-inch Illumination candles, which are the payloads of the Navy 5-inch illumination projectile, were discovered and disposed of on the NWP during past investigations and munitions removal projects. The use of the illumination projectiles to illuminate the NWP is the most likely scenario and is supported by the discovery of the 5-inch illumination candles and then the munitions carried on their trajectory to land within the MRS 13 underwater MRS boundary.
- MRS 13 is not known or suspected to have CWM and thus the CHE module rating is classified as "No Known or Suspected Chemical Warfare Materiel Hazard."
- The discovery of Chromium within the marine sediment of MRS 13 led to the evaluation of Chromium exposure for human and ecological receptors (MRSPP Tables 23 and 25). The maximum concentration of Chromium was measured against the U.S. Army MRSPP Primer comparison value to determine the ratio between the two, arriving at the value of the Contaminant Hazard Factor. This resulted in an HHE rating of F. The HHE module rating was then matched to the associated MRS Priority Table (MRSPP Table 29). The MRSPP evaluation of the HHE priority 7 represents the discovery of Chromium in MRS 13.

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CHAPTER 7. SUMMARY OF RESULTS

7.1 REMEDIAL INVESTIGATION

7.1.1 Objectives

The objective of the RI was to determine whether there is sufficient evidence of the presence of MEC and/or MC in either MRS 13 or MRS 09 underwater acres to warrant further action. Relevant data collected from the Terrestrial RI for these MRSs was applied to the findings in this RI Report when it was applicable to do so. The objective is considered complete when an investigation of MEC and MC is sufficient to characterize the site, identify and quantify any associated risk, and support a FS if significant risks are identified at the site. The DQOs for MEC and MC sampling activities were met.

7.1.2 Activities and Results

7.1.2.1 MEC Investigation

Investigation for MEC was completed during February through April, 2014. The investigation included collection of DGM data along transects equally spaced across each of the MRSs in order to measure the anomaly density and to select DGM targets for intrusive investigation. The collected DGM transect data was used to develop an anomaly density map of the MRSs. Intrusive investigation of geophysical anomalies was conducted to identify the nature and extent of MEC and MD.

7.1.2.1.1 MRS 09 MEC RI Findings

- MRS 09 underwater acres were a buffer for land-based targets since there was no indication of DoD use discovered during the underwater RI but there were indications of use during the Terrestrial RI field work.
- The residual risk presented by MRS 09 was evaluated using a qualitative risk assessment. Human receptors are present; however, based on the RI findings, no unacceptable risk to human health was identified.
- MRSPP tables were evaluated for MRS 09 resulting in an MRS Priority of "No Known or Suspected Hazard."

7.1.2.1.2 MRS 13 MEC RI Findings

Historical research indicates that Cayo Luis Peña was used as an artillery impact area, and possibly a bombing and gunnery range, by the Marine Corps during its various training exercises on Culebra. The presence of the expended illumination projectiles support that night training was conducted within the general area of Cayo Luis Peña. The target requiring illumination has not been identified since the projectiles will continue to travel once its illumination payload has been expelled from the munition. However the illumination of the NWP may be the most likely scenario. The following exercises and training events occurred in the vicinity of Cayo Luis Peña.

- A firing point was established on the beach area of Firewood Bay (currently referred to as Tamarindo Bay) along with a target area on the Northeastern Point of Cayo Luis Peña in 1924. Historical documentation does not indicate that 5-inch illumination projectiles were used during the exercise targeting Cayo Luis Peña.
- Additionally, the Cayo is located in the immediate vicinity of the NWP that served as a main military bombardment and impact area. MRS 13 is likely to have been an overshoot for the NWP target area in which the illumination rounds expelled their payload over the NWP, illuminating the peninsula during night-time exercise evolutions and the trajectory of the projectile carried it towards the northern underwater acres of MRS 13.
- US Navy exercises conducted in Culebra from 1924 to 1941 reportedly used 5-inch projectiles along with other size projectiles in support of exercise mission scenarios. In addition, 5-inch Naval

Gun Batteries (Number 3: located at defensive area A in MRS 10 and Number 4: located at Carenero Point) are within range of Cayo Luis Peña. It is not clear if Cayo Luis Peña was a target during these exercises.

- Training events during DoD exercises targeted Cayo Del Agua or Mono Cay from Culebra with the range boundary passing along the northern MRS 13 boundary. However, the munitions used for the training events did not include 5-inch Navy projectiles.

7.1.2.1.3 Out of a total of 170 DGM anomalies intrusively investigated in MRS 13, no MEC items were recovered. Sixty-three percent of all anomalies investigated were reported as MD. Nineteen additional MD items were identified as anomalies by means other than DGM (3 MD items by Analog Transects, 2 items reported by San Juan Police Department, and the 14 MD items identified during Phase 1 and the May 2011 investigation).

7.1.2.1.4 The recreational users, natural resource workers, and others accessing MRS 13 waters have the potential to come into contact with MD in the form of 5-inch Illumination (Expended) MK 45 Mod 0 Projectiles discovered during this investigation but were left in place due to the presence of attached coral or if removal of the MD item may have caused damage to the underlying reef structure. As was demonstrated during the RI, the San Juan Police Department, Federal Bureau of Investigation (FBI) and Explosive Ordnance Disposal Mobile Unit SIX Detachment Mayport may be requested to investigate MD items which the public has mistakenly reported as MEC.

7.1.2.1.5 A higher density of MD was discovered in the Northern half of MRS 13 as evidenced by DGM surveys of transects across the entire site, combined with the findings of the Terrestrial RI for MRS 13. The high-density area of MD is estimated to cover approximately 273.3 acres, or 51%, of the investigated underwater acres (538.4 acres) of the MRS.

7.1.2.1.6 MRS 13 MEC RI Findings

- Within the estimated MD contaminated area (MRS-13 northern half), the MD was confirmed at depths of 36 inches. The average depth of MD vertical extent within the MRS was 4.57 inches.
- MRS 13 average density of MD is 44 MD items per acre Figure 7-1 provides a density map that describes the average MD density within the marine acres for MRS 13. Figure 7-2 provides the average density per acre for the north bay area as 37 MD per acre; Mid portion of the MRS to include land and water acres as 15.5 MD per acre: and the southern half of MRS 13 land and water acres as 2.53 MD per acre.
- The residual hazards presented by MRS 13 were evaluated using a qualitative risk assessment. MRS 13 discoveries of MD and the potential for MEC (however, no MEC was discovered) within the northern half of the MRS exists and human receptors are present; therefore, the MEC exposure pathway is complete and there is a potential for human health hazard due to MEC.
- MRSPP tables were evaluated for MRS 13 resulting in an MRS priority of 5.

7.1.2.1.7 MC Investigation

- MC investigation was completed concurrent with the MEC investigation. No munitions were found in the underwater acreage of MRS 09; therefore, no source is present and no sampling was conducted.
- Munitions were found in the northern portion of MRS 13 and marine sediment sampling was conducted. Samples were collected underneath munitions, each with a companion step-out sample. QA and QC sampling was conducted. Background samples were collected to establish a BTV for screening purposes. The data were evaluated and assessed with respect to fate and transport and risks to human health and ecological receptors.
- Samples were analyzed for explosives, MC metals (aluminum, antimony, barium, chromium, copper, lead, mercury, and zinc), and ammonium picrate. No explosives or ammonium picrate were detected. All MC metals were detected, except mercury. Only chromium was present at concentrations exceeding background levels and was evaluated in a baseline risk assessment. Both chromium (VI) and (III) were considered. There were no exceedances of ESVs.

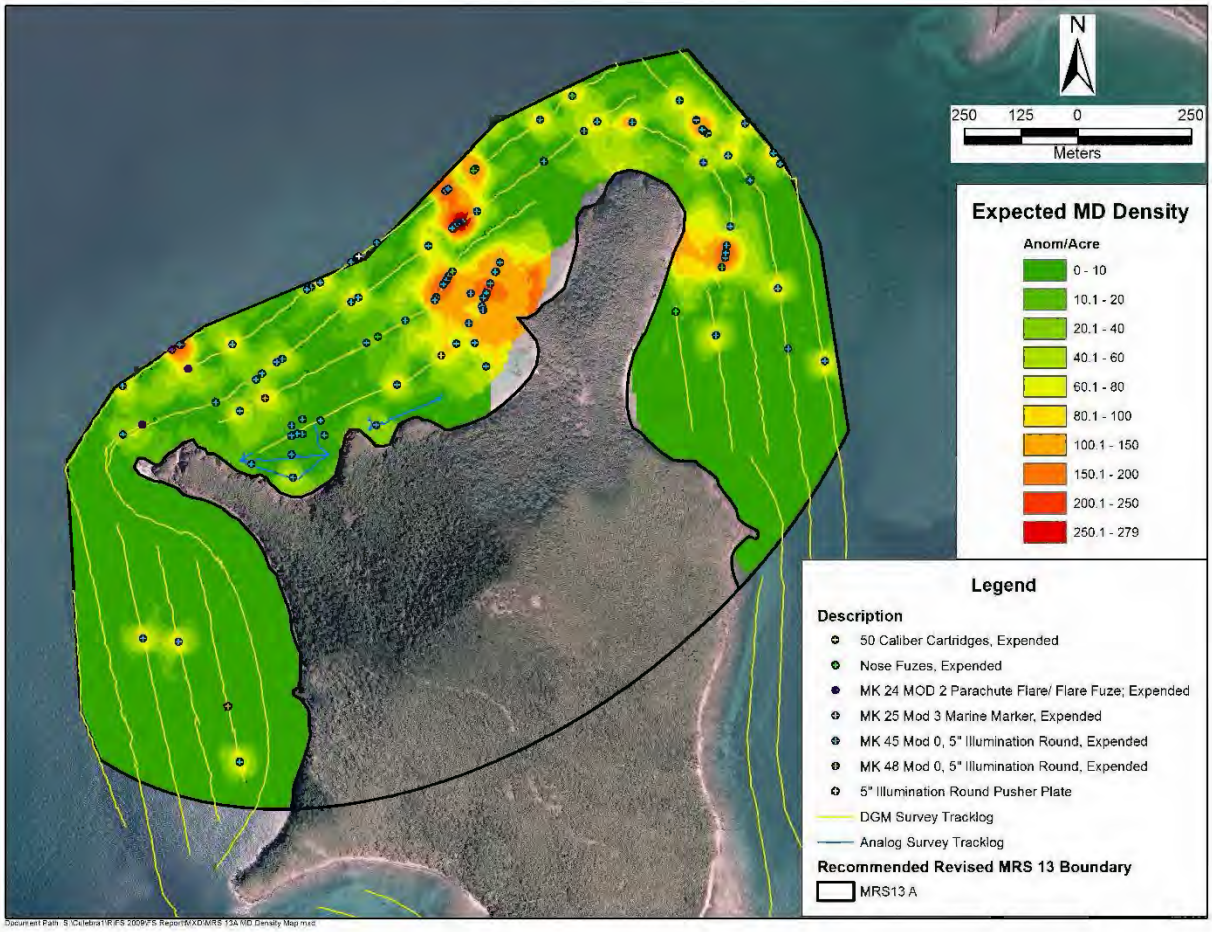

Figure 7-1: Density map that describes the MEC/MD density in the water acres for MRS 13

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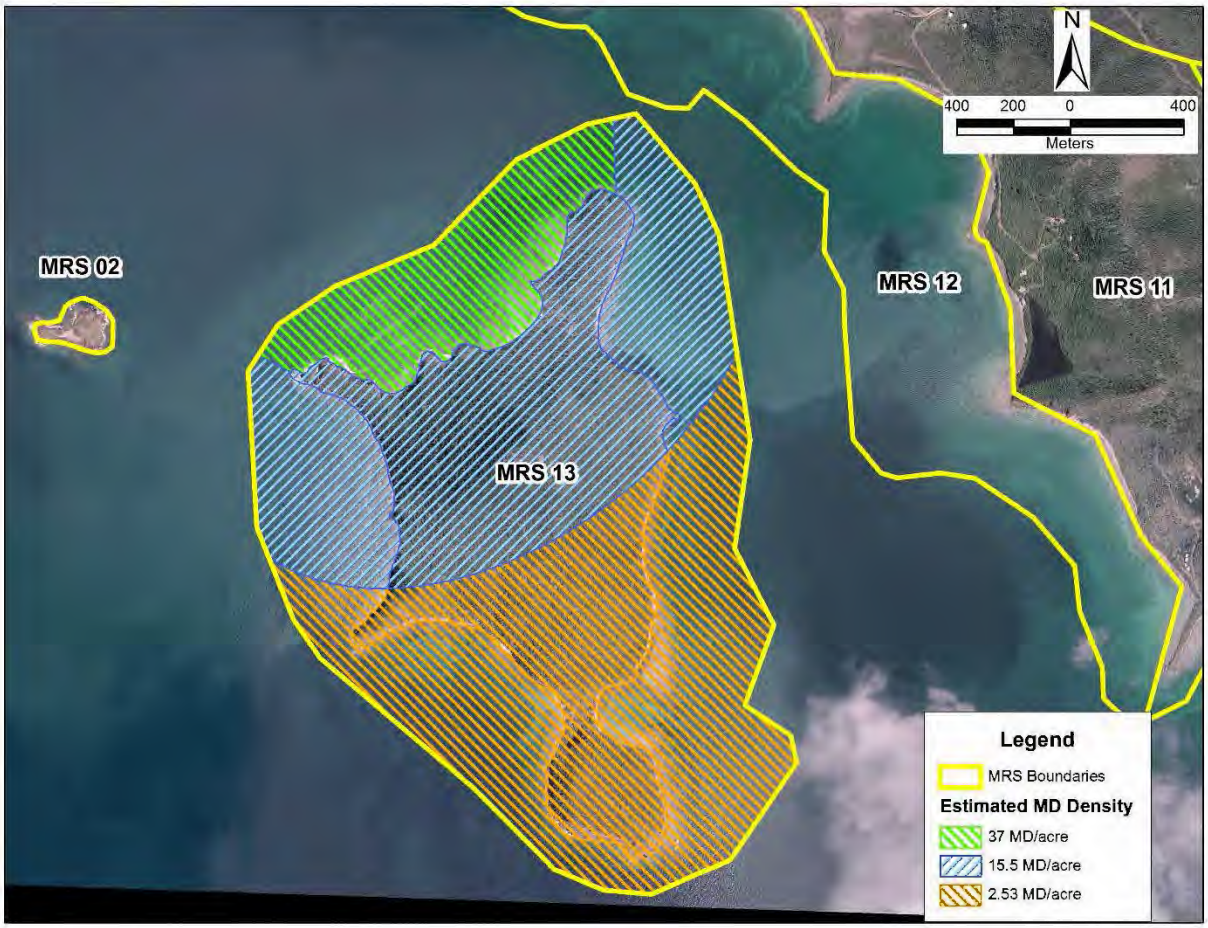

Figure 7-2: Average MD Densities for both Land and Water Acres for MRS 13

7.1.2.2 Human Health Risk Assessment

7.1.2.2.1 The MC RA presented the information required to evaluate the potential for adverse effects on both human and ecological receptors associated with each exposure pathway. It identified those constituents that required further evaluation in a SLRA and assessed the potential significance of completed pathways (that is, whether there was an unacceptable risk). The objectives of this MC RA were to:

- Determine if there is evidence of a release of a contaminant at the site
- If a release has occurred, determine whether an unacceptable risk is present
- Provide a quantitative baseline human health RA and/or ecological RA if unacceptable risks have been identified in baseline RA screening steps.

7.1.2.2.2 A quantitative human health risk assessment was performed in MRS 13 for chromium.

7.1.2.2.3 The MC risk assessment considered receptors potentially present and determined no human health or ecological risk is present within the underwater acreage MRS 13.

7.1.2.2.4 All estimates of chromium cancer risk for onsite current and future receptors at MRS 13 are within or below the cancer cumulative risk goal of 1×10^{-6} to 1×10^{-4}, and therefore, cancer risks due to exposure to marine sediment at MRS 13 are not expected. The cumulative non-carcinogenic hazard indices for each receptor are less than 1 marine sediment. Because the hazard indices are not greater than 1, hazards due to exposure to marine sediment at MRS 13 are not expected for potential residents, commercial/industrial

workers, or site visitors/recreational users/trespassers. Although residents are not present within MRS 13, they were included in the risk assessment to demonstrate there is no risk present even with a most conservative scenario, indicating that there should be no restrictions on use of the site for any activities due to MC.

7.1.2.2.5 The one identified COPC, chromium, did not exceed ESVs; therefore, no unacceptable risks are expected from exposure to marine sediment for ecological receptors.

7.1.2.3 Cultural and Archeological Resources

7.1.2.3.1 According to the National Register Information System (NRIS), National Historic Landmarks (NHL) list, National Heritage Areas (NHA) list, and National Park Service (NPS), there is only one registered cultural resource within the boundaries of the Culebra Island site. On the Isla Culebrita is an historic lighthouse called Faro Isla de Culebritas. The lighthouse is not open to the public due to building deterioration. According to the Puerto Rico State Historic Preservation Office (SHPO), there are no known architectural resources within the boundaries of the Culebra Island site; however, an architectural survey has not yet been conducted for Culebra (Parsons 2007).

7.1.2.3.2 During the underwater RI, there were no discoveries or indications of cultural or archeological sites or artifacts.

7.2 CONCLUSIONS

7.2.1 MEC

7.2.1.1 Based on the findings during the investigation, a risk to human health has been identified for MRS 13 and proceeding to a FS is recommended. The objective of the FS is to evaluate potential remedial alternatives and to recommend the most appropriate remedial approach to address risks posed to human health by MEC within the underwater acreage at MRS 13.

7.2.1.2 MRS 13 resides to the south of MRS 12 and the NWP. MRS 12 underwater acres has been selected for an RI/FS. MRS 12 is adjacent to the southern shore of the NWP. It is believed that the MD discovered in MRS 13 is the extent of the contamination for NWP and MRS 12. The USACE will evaluate the findings of the MRS 12 RI Report and further evaluate the extent of contamination for MRS 13 to identify any data gaps between MRS 12 and MRS 13.

7.2.1.3 No MEC/MD was discovered in the underwater portions of MRS 09. Since a) there was no MEC discovered in the RI survey, b) no MEC has been historically reported in the area, and c) no evidence was found indicating DoD munitions use of the underwater acres as a target area, no MEC source to cause an explosive hazard was identified. Based on the RI findings, no unacceptable risk to human health was identified and no further action is recommended with regard to explosive hazards in the underwater acres of MRS 09.

7.2.1.4 The terrestrial portions of both MRSs were recommended to proceed to a FS from the findings of the terrestrial RI. MRS 09 MEC do not appear to pose a potential risk to either human health or the environment. The underwater acres for MRS 09 is not recommended for a FS.

7.2.2 MC

7.2.2.1 The data collected during the RI sufficiently characterized the underwater portions of MRS 09 and MRS 13 at the Culebra Island site IAW the project DQOs. The data were used to support an approach as agreed upon by the TPP team.

7.2.2.2 The MC RA indicated that no unacceptable human health or ecological risk is present in the underwater portions of MRS 09 or MRS 13. The underwater portions of MRS 09 and MRS 13 are recommended for no further action with respect to MC and are not recommended for further evaluation in an FS.

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