N40003.AR.001630
PUERTO RICO NA
5090.3a

FINAL FULL RCRA FACILITY INVESTIGATION WORK PLAN SWMU 70 – DISPOSAL AREA NORTHWEST OF LANDFILL

For NAVAL ACTIVITY PUERTO RICO
EPA I.D. No. PR2170027203
CEIBA, PUERTO RICO

Prepared for:

Department of the Navy
NAVFAC SOUTHEAST
North Charleston, South Carolina

Prepared by:

Baker

Michael Baker Jr., Inc.
Moon Township, PA

Contract No. N62470-10-D-3000
DO JM01

November 5, 2010

IQC for A/E Services for Multi-Media Environmental Compliance Engineering Support

FINAL

FULL RCRA FACILITY INVESTIGATION WORK PLAN
SWMU 70 – DISPOSAL AREA NORTHWEST OF LANDFILL

NAVAL ACTIVITY PUERTO RICO
EPA I.D. NO. PR2170027203
CEIBA, PUERTO RICO

NOVEMBER 5, 2010

Prepared for:

DEPARTMENT OF THE NAVY
NAVFAC SOUTHEAST
North Charleston, SC

Under:

Contract No. N62470-10-D-3000
DELIVERY ORDER JM01

Prepared by:

MICHAEL BAKER JR., INC.
Moon Township, Pennsylvania

I certify under penalty of law that I have examined and am familiar with the information submitted in this document and all attachments and that this document and its attachments were prepared either by me personally or under my direction or supervision in a manner designed to ensure that qualified and knowledgeable personnel properly gather and present the information contained therein. I further certify, based on my personal knowledge or on my inquiry of those individuals immediately responsible for obtaining the information, that the information is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowingly and willfully submitting a materially false statement.

Signature: Mark E. Davidson

Name: **Mark E. Davidson**

Title: **BRAC Env. Coordinator**

Date: **November 5, 2010**

TABLE OF CONTENTS

Page

LIST OF ACRONYMS AND ABBREVIATIONS v

1.0 INTRODUCTION 1-1
1.1 NAPR Description and History 1-1
1.2 Site Location and Description 1-2
1.3 Objectives 1-2
1.4 Organization of the Work Plan 1-3

2.0 CURRENT CONDITIONS AND BASIS FOR A FULL RFI 2-1
2.1 Current Site Conditions 2-1
2.1.1 Terrestrial and Aquatic Habitats 2-1
2.1.2 Biota 2-2
2.2 Previous Investigations 2-5
2.2.1 Phase II ECP 2-5
2.2.2 Phase I RFI 2-6
2.3 Preliminary Conceptual Models for Ecological and Human Receptors 2-8
2.3.1 Preliminary Conceptual Model for Ecological Receptors 2-8
2.3.2 Preliminary Conceptual Model for Human Receptors 2-11

3.0 SCOPE OF INVESTIGATION 3-1
3.1 Soil Sampling and Analysis Program 3-1
3.2 Monitoring Well Installation 3-3
3.3 Groundwater Sampling and Analysis Program 3-5
3.4 Sediment Sampling and Analysis Program 3-6
3.5 Surface Water Sampling and Analysis Program 3-7
3.6 Quality Assurance/Quality Control Samples 3-8
3.6.1 Trip Blanks 3-9
3.6.2 Equipment Rinsates 3-9
3.6.3 Field Blanks 3-9
3.6.4 Field Duplicates 3-9
3.6.5 Matrix Spike/Matrix Spike Duplicates 3-9
3.7 Other Investigation Considerations 3-9
3.7.1 Clearing and Grubbing 3-10
3.7.2 Utility Clearance 3-10
3.7.3 Groundwater Elevation Measurements 3-10
3.7.4 Slug Tests 3-10
3.7.5 Investigation Derived Waste Management 3-10
3.7.6 Decontamination 3-11
3.7.7 Delineation of Wetland Boundaries 3-12
3.7.8 Surveying 3-12
3.7.9 Health and Safety Procedures 3-12
3.7.10 Chain-of-Custody 3-12

4.0 REPORTING 4-1
4.1 Introduction 4-1
4.2 Background 4-1
4.3 Physical Characteristics of Study Area 4-1

TABLE OF CONTENTS
(continued)

4.4 Full RFI Activities 4-1
4.5 Physical Results 4-1
4.6 Analytical Results 4-2
4.6.1 Media-Specific Ecological Screening Values 4-2
4.6.2 Human Health Screening Values 4-8
4.6.3 Background Screening Values 4-9
4.7 Conclusions and Recommendations 4-9
4.8 References 4-10

5.0 SCHEDULE 5-1

6.0 SITE MANAGEMENT 6-1
6.1 Project Team Responsibilities 6-1
6.2 Field Reporting Requirements 6-1

7.0 REFERENCES 7-1

LIST OF TABLES

2-1 List of Birds Reported From or Having the Potential to Occur at Naval Activity Puerto Rico

3-1 Summary of Sampling and Analytical Program – Environmental Samples
3-2 Summary of Sampling and Analytical Program – QA/QC Samples
3-3 Method Performance Limits

4-1 Ecological Soil Screening Values
4-2 Ecological Groundwater and Surface Water Screening Values
4-3 Ecological Sediment Screening Values
4-4 Human Health Screening Values
4-5 NAPR Background Screening Values

LIST OF FIGURES

1-1 Regional Location Map
1-2 SWMU/AOC Location Map
1-3 Site Layout and ECP/Phase I RFI Sample Location Map – 2006 Aerial Photograph
1-4 Sample Location Map with 2000 Aerial Photograph

2-1 Terrestrial and Aquatic Habitat Occurring at Naval Activity Puerto Rico
2-2 Wetland Location Map
2-3 The Cowardin Wetland Classification System
2-4 Historical Manatee Sightings in Eastern Puerto Rico
2-5 Sea Turtle Sightings at Naval Activity Puerto Rico
2-6 Potential Turtle Nesting Sites
2-7 Preliminary Conceptual Model for Ecological Receptors
2-8 Preliminary Conceptual Model for Human Receptors

LIST OF FIGURES

(continued)

3-1 Proposed Full RFI Sample Location Map

5-1 Proposed Project Schedule

6-1 Project Organization

LIST OF APPENDICES

A Site Photographs
B Summary of Positive Detects – Phase II ECP
C Summary of Phase I RFI Analytical Results
D USEPA Region II - Groundwater Sampling Procedure Low Stress (Low Flow) Purging and Sampling
E Equilibrium Partitioning Approach

LIST OF ACRONYMS AND ABBREVIATIONS

AET	Apparent Effects Threshold
APA	Aerial Photo Analysis
AVS	Acid Volatile Sulfides
Baker	Michael Baker Jr., Inc.
bgs	below ground surface
BRAC	Base Realignment and Closure
CCC	Continuous Criteria Concentrations
CCME	Canadian Council of Ministers of the Environment
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CERFA	Community Environmental Response Facilitation Act
CMS	Corrective Measures Study
CSF	Cancer Slope Factor
DMMP	Dredged Material Management Program
DO	Delivery Order
DPT	Direct Push Technology
DRO	Diesel Range Organics
EC_{50}	Median Effective Concentration
Eco-SSL	Ecological Soil Screening Level
ECP	Environmental Condition of Property
ER-L	Effects-Range Low
ER-M	Effects Range-Median
E2SS3	Estuarine-Intertidal-Scrub/Shrub (Broad-Leaved Evergreen)
E2US3/4/5	Estuarine-Intertidal-Unconsolidated Shore Mud, Organic, Dead Matter
ESL	Ecological Screening Levels
FCVs	Final Chronic Values
GIS	Geographic Information System
GPS	Global Positioning System
GRO	Gasoline Range Organics
HSA	Hollow-Stem Auger
HQ	Hazard Quotient
ILCR	Incremental Lifetime Cancer Risk
ID	Inside Diameter
IDW	Investigation Derived Waste
ISQG	Interim Freshwater Sediment Quality Guidelines
IUR	Inhalation Unit Risk
kg	Kilograms

LIST OF ACRONYMS AND ABBREVIATIONS
(continued)

LEL	Lowest Effects Level
LLPAH	Low-Level Polynuclear Aromatic Hydocarbons
LOEC	Lowest Observed Effect Concentration
LOEL	Lowest Observable Effect Level
LC_{50}	Median Lethal Concentration
MATC	Maximum Acceptable Toxicant Concentration
MCL	Maximum Contaminant Level
MHSPE	Ministry of Housing, Spatial Planning and Environment
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NAPR	Naval Activity Puerto Rico
NAVFAC	Naval Facilities Engineering Command Atlantic Division
NAWQC	National Ambient Water Quality Criteria
NFESC	Naval Facilities Engineering Service Center
NOEC	No Observed Effect Concentration
NOEL	No Observed Effect Level
NOAA	National Oceanic and Atmospheric Administration
NSRR	Naval Station Roosevelt Road
NTR	Navy Technical Representative
PAH	Polynuclear Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PEL	Probable Effect Levels
PI	Photo Identified
PID	Photoionization Detector
PMO	Program Management Office
PREQB	Puerto Rico Environmental Quality Board
PSQG	Provincial Sediment Quality Guidelines
PVC	Polyvinyl Chloride
PWD	Public Works Department
QA/QC	Quality Assurance/Quality Control
RAGS	Risk Assessment Guidance for Superfund
RBC	Risk Based Concentrations
RCI	Reactivity, Corrosivity and Ignitability
RCRA	Resource Conservation and Recovery Act
RfC	Inhalation Reference Concentrations
RfD	Reference Dose
RFI	Full RCRA Facility Investigation
SCV	Secondary Chronic Values
SE	Southeast

LIST OF ACRONYMS AND ABBREVIATIONS
(continued)

SEM	Simultaneously Extracted Metals
SL	Screening Levels
SQG	Sediment Quality Guidelines
SQAG	Sediment Quality Assessment Guidelines
SQUIRT	Screening Quick Reference Tables
SWMU	Solid Waste Management Unit
SVOC	Semivolatile Organic Compounds
TCLP	Toxicity Characteristic Leaching Procedure
TEL	Threshold Effects Level
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
UCL	Upper Confidence Limit of the Mean
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
VOC	Volatile Organic Compounds

1.0 INTRODUCTION

This document presents the activities required for the performance of a Full Resource Conservation Recovery Act (RCRA) Facility Investigation (RFI) at Solid Waste Management Unit (SWMU) 70 – Disposal Area Northwest of Landfill located at Naval Activity Puerto Rico (NAPR), Ceiba, Puerto Rico (Figure 1-1). This Work Plan has been prepared by Michael Baker Jr., Inc. (Baker), for the Navy Base Realignment and Closure (BRAC) Program Management Office (PMO) Southeast (SE) office under contract with the Naval Facilities Engineering Command (NAVFAC), SE (Contract Number N62470-10-D-3000, Delivery Order [DO] JM01). This Work Plan was developed in accordance with the RCRA § 7003 Administrative Order on Consent (United States Environmental Protection Agency [USEPA] Docket No. 02-2007-7301). The work will be implemented in accordance with the Final RFI Management Plans (Baker, 1995), with updates to appropriate sampling and analytical methods as indicated in this Work Plan.

1.1 NAPR Description and History

NAPR occupies over 8,800 acres on the northern side of the east coast of Puerto Rico, along Vieques Passage with Vieques Island lying to the east about 10 miles off the harbor entrance (see Figure 1-1). NAPR also occupies the immediately adjacent islands of Piñeros and Cabeza de Perro, as presented on Figure 1-2. The northern entrance to NAPR is about 35 miles east along the coast road (Route 3) from San Juan. The property consists of 3,938 acres of upland (developable) property and 4,955 acres of environmentally sensitive areas including wetlands, mangrove, and wildlife habitat. The closest large town is Fajardo (population approximately 41,000), which is about 5 miles north of NAPR off Route 3. Ceiba (population approximately 18,000) adjoins the west boundary of NAPR (see Figure 1-1).

The facility was commissioned in 1943 as a Naval Operations Base, and finally re-designated a Naval Station in 1957. Naval Station Roosevelt Roads (NSRR) operated as a Naval Station from 1957 until March 31, 2004. NSRR was one of the largest naval facilities in the world with more than 100 miles of paved roads, approximately 1,300 buildings, a large scale airfield (Ofstie Field), a deep water port and over 30 tenant commands. NSRR played a major role in providing communication support to the Atlantic and Caribbean areas and also served as a major training site for fleet exercises.

Section 8132 of fiscal year 2004 Defense Appropriations Act, signed into law on September 30, 2003, directed that NSRR be disestablished within 6 months, and that the real estate disposal/transfer be carried out in accordance with procedures contained in the BRAC Act of 1990. This legislation required that the base closure be conducted in accordance with the Comprehensive Environmental Response Compensation and Liability Act (CERCLA), as amended by the Community Environmental Response Facilitation Act (CERFA). NSRR has undergone operational closure as of March 31, 2004 and has been designated as Naval Activity Puerto Rico. The mission of NAPR is to protect the physical assets remaining, comply with environmental regulations, and sustain the value of the property until final disposal of the property. NAPR will continue until the real estate disposal/transfer is completed.

The USEPA issued a RCRA 7003 Administrative Order on Consent 'Consent Order' (USEPA Docket No. RCRA-02-2007-7301) to NAPR. The Order sets out the Navy's corrective action obligations under RCRA and replaces the 1994 RCRA permit for NAPR. Following a public comment period, the Consent Order became effective on January 29, 2007.

1.2 Site Location and Description

SWMU 70 – Disposal Area Northwest of Landfill is located adjacent to Ensenada Honda, southeast of Building 394, and northwest of the closed base landfill (SWMU 3) and covers a large area (approximately 55 acres) of flat lying land consisting of open areas and areas covered by secondary growth vegetation as shown on Figure 1-3.

The Aerial Photo Analysis (APA) presented in the Phase I Environmental Condition of Property (ECP) Report (LANTDIV, 2004) identified this area as Photo Identified (PI) Site 22, due to the observation of a large suspect disposal area with disturbed ground, debris, a cleared or graded area, and stressed vegetation from 1976-1980s. Figure 1-4 presents the conditions of the site with a 2000 aerial that shows the polygon features from 1976, 1977, 1985, and 1995 identified during the APA. These polygons identify the suspect areas from the respective aerial photographs. In addition, containers or drums reportedly had been discarded in a vegetated area north of the main disposal area. The records review did not identify any activities in this area. The physical site inspection observed numerous piles of construction debris (metal, concrete, polyvinyl chloride [PVC] piping), but no drums or evidence of stains or stressed vegetation. Interviews confirmed the area as a construction and/or solid waste disposal site, including potential disposal of petroleum, oils, and lubricant or hazardous materials containers.

During the Phase II ECP investigation, numerous piles of construction debris (metal, concrete, and PVC piping) were observed in different portions of the site, as was the case during the physical site inspection. The Final Phase I/II ECP report also noted that there were no drums or evidence of stains or stressed vegetation.

The RCRA 7003 Administrative Order on Consent (USEPA Docket No. RCRA-02-2007-7301) identified SWMU 70 (formerly referred to as ECP 16) as having documented releases of solid and/or hazardous waste and hazardous constituents (USEPA, 2007a). The Administrative Order required the preparation and submittal to the USEPA for their approval, of an acceptable work plan to complete the equivalent to a Phase I RFI investigation. The Phase I RFI Work Plan was prepared to conduct the field investigation necessary to determine whether or not releases of solid and/or hazardous wastes or hazardous constituents are present due to past operations at SWMU 70. The Phase I RFI Work Plan (Baker, 2007) included a surface and subsurface soil sampling program to further characterize metals detected during the ECP Phase II Investigation. A groundwater sampling program was also implemented to further characterize volatile organic compounds (VOCs) and metals that were detected during the Phase II ECP sampling. A sediment sampling program was also implemented to further investigate metals detected during the Phase II ECP. The Final Phase I RFI Work Plan (Baker, 2007) was submitted to the USEPA on December 20, 2007. The field work for the Phase I RFI was conducted from January 14, 2009 to January 22, 2009. The Phase I RFI report was approved by the USEPA on December 15, 2009 and confirmed that surface soil, subsurface soil, estuarine sediment and groundwater have been impacted by past site activities. Refer to Section 2.2.2 for a more complete discussion of the Phase I RFI results.

1.3 Objectives

The purpose of this work plan is to further characterize the environmental impact to media found during the Phase I RFI conducted at SWMU 70 (Baker, 2009).

Specifically, the objectives of this Full RFI are as follows:

- Delineate metals in the surface soil, subsurface soil, estuarine sediment, and groundwater. Specifically, the Full RFI should focus around Phase I RFI sample locations in the northern

portion of the SWMU (70SB01, 70SB02, 70SB04, and 70SB05) and around sample location 70SB07 in the southern portion of the SWMU.

- Further characterize groundwater flow and quality across the SWMU.
- Characterize wetlands in the southern portion of the SWMU by the collection of sediment samples within the 1976, 1977, 1985 and 1995 polygons within the areas classified as wetlands.
- Define the likely source area(s) of contamination.

1.4 Organization of the Work Plan

This work plan is organized into seven sections. Section 1.0 of this document includes the site history and objectives of this full RFI. Section 2.0 provides a description of the current conditions and use of the site as well as a summary of the previous investigations, including the Phase I RFI performed in January 2009. Section 3.0 provides a description of the scope of investigations that will be implemented during the upcoming fieldwork including a soil, sediment and groundwater sampling and analysis program, quality assurance/quality control (QA/QC) sampling and analysis, as well as other investigation considerations. The reporting activities that will be conducted following the completion of the field investigation are described in Section 4.0. Section 5.0 discusses the proposed project schedule for the Full RFI process for SWMU 70. The site management structure that will be used during this investigation, including project team responsibilities and field reporting requirements, is presented in Section 6.0, while Section 7.0 presents the report references.

2.0 CURRENT CONDITIONS AND BASIS FOR A FULL RFI

The following sections provide a discussion of the current conditions that exist at SWMU 70 along with a summary of the results of the Phase I RFI (Baker, 2009). Also included are descriptions of the terrestrial and aquatic habitats, as well as associated biota, at and contiguous to SWMU 70. Preliminary conceptual models for ecological and human receptors are provided for further clarification. The findings and recommendations of the Phase I RFI, comments from the USEPA and the Puerto Rico Environmental Quality Board (PREQB) on the draft reports, and the preliminary conceptual models form the basis for the Full RFI.

2.1 Current Site Conditions

SWMU 70 covers an area of approximately 55 acres. The former disposal area is currently not utilized; the operational closure of Naval Station Roosevelt Roads occurred on March 31, 2004. The area is located in near-shore flat lands and consists of flat lying land with open areas and areas covered by secondary growth vegetation. During a physical site inspection and the Phase II ECP investigation (NAVFAC Atlantic, 2005), numerous piles of construction debris (metal, concrete, and PVC piping) were observed in different portions of the site. General solid waste debris (i.e., metal, rope, etc.) was present, and the central portion of the site appeared to have excavation type of debris (i.e., concrete, rocks, etc.). However, there were no drums or evidence of stains or stressed vegetation. A majority of this site is covered in thick secondary growth vegetation. In addition, the central and southern portions of the site are classified as wetlands consisting of either estuarine-intertidal-scrub/shrub (broad-leaved evergreen) (E2SS3), or estuarine-intertidal-unconsolidated shore mud, organic, dead matter (E2US3/4/5). Three separate areas of surface water appear to encompass approximately 0.46 acres on the subject site. These three areas of surface water appear to be inundated for at least a portion of the year.

Appendix A provides photographs that were obtained during the Phase I RFI in January 2009 to show current site features/conditions. Photo 1 presents an example of the debris observed. As shown in Photo 2, SWMU 70 is bordered on the southwest by Ensenada Honda. A majority of this site is covered in thick secondary growth vegetation, as shown on Photo 3.

2.1.1 Terrestrial and Aquatic Habitats

The upland habitat bounded by NAPR is classified as subtropical dry forest (Ewel and Witmore, 1973). Similar to other forested areas of Puerto Rico, this region was previously clear-cut in the early part of the century, primarily for pastureland (Geo-Marine, Inc., 1998). After acquisition by the Navy, a secondary growth of thick scrub, dominated by lead tree (*Leucaena* spp.), Christmas tree (*Randia aculeata*), sweet acacia (*Acacia farnesiana*), and Australian corkwood (*Sesbania grandiflora*) grew in the previously grazed sections (Geo-Marine, Inc., 1998). Secondary growth communities (upland coastal forest communities and coastal scrub forest communities) exist today throughout the station's undeveloped upland.

The upland vegetative community within undisturbed areas of SWMU 70 and surrounding areas is classified as a coastal scrub forest community. Specific vegetation occurring within the coastal scrub forest community has not been documented during previous investigations. However, based on observations recorded at other SWMUs containing similar upland habitat (i.e., SWMUs 1 and 2), herbaceous and shrub species, including *Panicum maximum* (guinea grass), lead tree (*Leucaena leucocephala*), almácigo (*Bursera simaruba*), Christmas tree (*Randia aculeate*are, are likely present. Dominant vegetation within the coastal scrub forest community will be documented during the Full RFI field investigation.

Cobana negra (*Stahlia monosperma*), a federally threatened tree species, is known to occur between the boundary of black mangrove communities and coastal upland forest communities. This species is also known to occur in coastal forests of southeastern Puerto Rico (Little and Wadsworth, 1964). A single individual was encountered at NAPR during recent surveys conducted by Geo-Marine, Inc. (NAVFAC, 2006). This individual is located within a coastal scrub forest community near the Capehart housing area, west of American Circle (approximately 3.0 miles from SWMU 70). No other plant species listed under the provisions of the Endangered Species Act of 1973 are known to occur or have the potential to occur at NAPR (Geo-Marine, Inc., 2000 and NAVFAC, 2006).

The aquatic habitats (open water marine and wetland habitat) occurring in the vicinity of SWMU 70 are depicted on Figure 2-1. The wetland units depicted on Figure 2-2, identified by the Cowardin Wetland Classification System (Cowardin et al., 1979; see Figure 2-3), were delineated by Geo-Marine, Inc. in December 1999 from 1993 color infrared and 1998 true color aerial photography. Twenty percent of the wetlands delineated by aerial photography were field checked by Geo-Marine, Inc. to verify the accuracy of the delineations. Field verification was based on the 1987 Corps of Engineers wetland delineation manual (United States Army Corps of Engineers [USACE], 1987). As evidenced by Figure 2-2, about half of the 55 acre area within SWMU 70 is classified as estuarine wetland. Nearly all of this is a large E2SS3 unit, with smaller E2US3/4/5 units scattered within it. All of these estuarine wetland units are oriented toward the southwestern and central area of the SWMU, bordering the Ensenada Honda, while the northeastern portion is upland habitat. The E2SS3 unit extends 500 feet northwest of the SWMU, along the coast of the Ensenada Honda, but is not hydrologically connected to any other wetland units. The nearest downgradient surface water body is the Ensenada Honda (immediately contiguous to the western boundary of SWMU 70). Seagrass beds are prevalent throughout much of the Ensenada Honda. Seagrass meadows within the Ensenada Honda are dominated by a nearly continuous cover of turtle grass with a high abundance of calcareous green algae (*Avranvilla* spp., *Ventricaria ventricosa*, *Caulerpa* spp., *Valonia* spp., and *Udotea* spp.) (Reid et al., 2001). As evidenced by Figure 2-1, sea grass meadows are present in the portion of the embayment downgradient from SWMU 70.

2.1.2 Biota

A description of the biota occurring within Puerto Rico and the landmass encompassed by NAPR (including the surrounding marine environment) is provided in the sections that follow. Although the specific terrestrial biota occurring at SWMU 70 have not been recorded during previous investigations, generalizations are provided based on available habitat. Specific biota occurring at SWMU 70 will be documented during the Full RFI field investigation.

2.1.2.1 Mammals

A total of 22 terrestrial mammal species are known historically from Puerto Rico; however, all mammals except bats (13 species) have been extirpated (Mac et al., 1998). The specific bat species known to occur in Puerto Rico are listed below. None of the bats found in Puerto Rico are exclusive to the island, nor are they listed under provisions of the Endangered Species Act of 1973.

- Fruit-eating bats: Jamaican fruit bat (*Artibeus jamaicensis*), Antillean fruit bat (*Brachyphylla cavernarum*), and red fig-eating bat (*Stenoderma rufum*)

- Nectivorous bats: brown flower bat (*Erophylla sezekoni bombifrons*) and greater Antillean long-tounged bat (*Monophyllus redmani*)

- Insectivorous bats: Antillean ghost-faced bat (*Mormoops blainvillii*), Parnell's mustached bat (*Pteronotus parnellii*), sooty mustached bat (*Pteronotus quadridens*), big brown bat

(*Eptesicus fuscus*), red bat (*Lasiurus borealis*), velvety free-tailed bat (*Molossus molossus*), and Brazilian free-tailed bat (*Tadarida brasiliensis*)

- Piscivorous bats: Mexican bulldog bat (*Noctilio leporinus*)

Of the endangered/threatened marine mammals that may occur in Puerto Rico, only the West Indian manatee is known to occur in the coastal waters surrounding NAPR (DoN, 2007). Manatee populations in Puerto Rico's coastal waters have been documented during three aerial surveys conducted from 1978 to 1979, 1984 to 1985, and in 1993 (United Nations Environmental Program [UNEP], 1995), a radio tracking study of manatee distribution and abundance (Reid and Kruer, 1998), and a year-long study of manatee distribution and abundance (Woods et al., 1984). Historical manatee sightings at NAPR are summarized on Figure 2-4. The figure (reproduced from DoN, 2007) includes information from most of the studies identified above. As evidenced by Figure 2-4, manatees have been sited within the Ensenada Honda downgradient from SWMU 70. This can be attributed to the presence of seagrass within this portion of the embayment.

Several terrestrial mammals have been introduced into Puerto Rico, including the black rat (*Rattus rattus*), Norway rat (*Rattus norvegicus*), and small Indian mongoose (*Herpestes javanicus*). These nonindigenous mammals are nuisance species that have been implicated in the decline of native bird and reptile populations (Mac et al., 1998 and USFWS, 1996a).

2.1.2.2 Birds

A total of 239 bird species are native to Puerto Rico (Raffaele, 1989). This total includes breeding permanent residents and non-breeding migrants. In addition, many nonindigenous bird species have been introduced into Puerto Rico, including the shiny cowbird (*Molothrus bonariensis*) and several parrot species, such as the budgerigar (*Melopsittacus undulates*), orange-fronted parrot (*Aratinga canicularis*), and monk parrot (*Myiopsitta monaqchus*). Of the 239 species native to Puerto Rico, 12 are endemic to the island (Raffaele, 1989).

Numerous native and migratory bird species have been reported at NAPR (Geo-Marine, Inc., 1998). A list compiled from literature-based information pre-dating 1990 (see Table 2-1) includes the great blue heron (*Ardea herodias*), snowy egret (*Egretta thula*), little blue heron (*Florida caerulea*), black-crowned night heron (*Nycticorax nycticorax*), belted kingfisher (*Ceryle alcyon*), spotted sandpiper (*Actitis macularia*), greater yellowlegs (*Tringa melanoleauca*), black-bellied plover (*Squatarola squatarola*), clapper rail (*Rallus longirostris*), Royal tern (*Thalasseus maximus*), sandwich tern (*Thalasseus sandvicensis*), least tern (*Stema albifrons*), yellow warbler (*Dendroica petechia*), palm warbler (*Dendroica palmarum*), prairie warbler (*Dendroica discolar*), magnolia warbler (*Dendroica magnolia*), mourning dove (*Zenaida macroura*), red-legged thrush (*Mimocichla plumbea*), common nighthawk (*Chordeiles minor*), and red-tailed hawk (*Buteo jamaicensis*). Endemic species reported from NAPR include the Puerto Rican lizard cuckoo (*Saurothera vieilloti*), Puerto Rican flycatcher (*Myiarchus antillarum*), Puerto Rican woodpecker (*Malanerpes portoricensis*), Puerto Rican emerald (*Chlorostilbon maugaeus*), and yellow-shouldered blackbird (*Agelaius xanthomus*).

The yellow-shouldered blackbird is a federally endangered species. One of the principal reasons for the status of this species is attributed to parasitism by the nonindigenous shiny cowbird, which lays its eggs in blackbird nests and sometimes punctures the host's eggs (USFWS, 1983). Other factors contributing to the status of this species include nest predation by the introduced black rat, Norway rat, and mongoose, as well as habitat modification and destruction (USFWS 1996a). The entire land area of NAPR was declared critical habitat for the yellow-shouldered blackbird in 1976; however, a 1980 agreement with the USFWS exempted certain areas from this categorization (Geo-Marine, Inc., 1998). SWMU 70 is located within the critical habitat designation for the yellow-shouldered

blackbird. A study conducted by the Naval Facilities Engineering Service Center (NFESC, 1996) reported that the mangrove forests surrounding NAPR should be considered the most important nesting habitat for the yellow-shouldered blackbird and SWMU 70 has a designated mangrove region within it (see Figure 2-1). Based on the arboreal feeding behavior of the yellow-shouldered blackbird, there is also potential feeding habitat (shrub layers) within the coastal scrub forest community present at the SWMU (Geo-Marine, Inc., 2000).

Other federally listed bird species that occur or have the potential to occur at NAPR are the roseate tern (*Sterna dougallii dougallii*) and piping plover (*Charadrius melodus*) (Geo-Marine, Inc., 1998). The piping plover is a rare, non-breeding winter visitor in Puerto Rico (Raffaele, 1989). This species breeds only in North America in three geographic regions (Atlantic Coast population [threatened], Great Lakes population [endangered], and Northern Great Plains population [threatened]; USFWS, 1996b). No piping plover observations were reported at NAPR during the 1990s or during sea turtle nesting surveys conducted in 2002 and 2004 (Geo-Marine, Inc., 2005). No historic evidence is available to indicate whether the roseate tern (threatened in Puerto Rico) has ever nested at NAPR and no roseate tern observations have been noted in or over coastal waters adjacent to NAPR (DoN, 2007). The nearest active roseate tern colony likely occurs on the eastern end of Vieques (more than 20 miles east of NAPR) (DoN, 2007). Based on the habitat preferences and observations recorded at NAPR, neither of these species has the potential to use the open water habitat downgradient from SWMU 70 (i.e., Ensenada Honda) as a food source.

2.1.2.3 Reptiles and Amphibians

A total of 23 amphibians and 47 reptiles are known from Puerto Rico and the adjacent waters (Mac et al., 1998). Fifteen of the amphibians and 29 of the reptiles are endemic, while four amphibian species and three reptilian species have been introduced (Mac et al., 1998). Puerto Rico's native amphibian species include 16 species of tiny frogs commonly called coquis. On the coastal lowlands, almost all coqui species are arboreal. The only amphibians listed under provisions of the Endangered Species Act of 1973 are the Puerto Rican crested toad (*Peltophryne lemur*) and the golden coqui (*Eleutherodactylus jasperi*). Both species are listed as threatened (USFWS, 2010). Distribution of the golden coqui is restricted to areas of dense bromeliad growth. All specimens to date have been collected from a small semicircular area of a 6-mile radius south of Cayey (approximately 30 miles southwest of NAPR), generally at elevations above 700 meters (USFWS, 1984). The Puerto Rican crested toad occurs at low elevations (below 200 meters) where there is exposed limestone or porous, well drained soil offering an abundance of fissures and cavities (USFWS, 1987). A single large population is known to exist from the southwest coast in Guánica Commonwealth Forest, while a small population is believed to survive on the north coast near Quebradillas, Arecibo, Barceloneta, Vega Baja, and Bayamón (USFWS, 1987). It also has been collected on the southeastern coastal plain near Coamo (USFWS, 1987). Given the habitat preferences and locations of known occurrences, these two species are not expected to occur at NAPR.

Puerto Rico's native reptilian species include 31 lizards, 8 snakes, 1 freshwater turtle, and 5 sea turtles (Mac et al., 1998). Of the five sea turtles, only the green sea turtle, hawksbill sea turtle (*Eretmochelys imbricata*), and loggerhead sea turtle (*Dermochelys coriacea*) nest within Puerto Rico. These three sea turtles, as well as the leatherback sea turtle (*Caretta caretta*) are listed under the provisions of the Endangered Species Act of 1973 (hawksbill sea turtle and leatherback sea turtle are listed as endangered, while the green sea turtle [Caribbean population] and loggerhead sea turtle are listed as threatened) (USFWS, 2010). Aerial surveys of turtles were performed from March 1984 through March 1995 along the Puerto Rican Coast. This information was summarized by Geo-Marine, Inc. (2005) in the Draft NAPR Disposal Environmental Assessment (EA). Figures 2-5 and 2-6 (reproduced from Geo-Marine, Inc., 2005) present cumulative sea turtle sightings and potential turtle nesting sites at NAPR. Significant turtle observations were made near the mouth of the

Ensenada Honda, the northern shore of Pineros Island, Pelican Bay, and the Medio Mundo Passage, with the frequency of turtle observations listed as green > hawksbill > loggerhead > leatherback. Identical to the West Indian manatee, this can be attributed to the presence of seagrass (forage material) within this portion of the embayment.

The Puerto Rican boa (*Epicrates inornatus*) is a federally endangered species throughout its entire range (critical habitat has not been designated for this species [USFWS, 1986]). Four Puerto Rican boa sightings were reported at NAPR prior to 1999 and an additional four occurrences were reported between 2001 and 2003 (Geo-Marine, Inc., 2005). However, no boas were observed during 211 man-hours of surveys conducted within potential boa habitat in 2004 (Tolson, 2004). The Puerto Rican boa uses a variety of habitats but is most commonly found in Karst forest habitat (forested limestone hills). Based on the absence of preferred habitat, there is low probability of occurrence of this species at SWMU 70.

2.1.2.4 Fish and Aquatic Invertebrates

A diverse fish and invertebrate community can be found in the marine environment surrounding NAPR. This can be attributed to the varied habitats that include marine and estuarine open water habitat, mud flats, seagrass beds, and mangrove forests. The fish community is represented by stingrays, herrings, groupers, needlefish, mullets, barracudas, jacks, snappers, grunts, snooks, lizardfishes, parrotfishes, gobies, filefishes, wrasses, damselfishes, and butterflyfish (Geo-Marine, Inc., 1998). The benthic invertebrate community includes sponges, corals, anemones, sea cucumbers, sea stars, urchins, and crabs. A list of known species residing within the Ensenada Honda is not available from the literature.

2.2 Previous Investigations

In addition to the APA presented in the Phase I ECP Report (LANTDIV, 2004) as discussed in Section 1.2, previous investigations at SWMU 70 include the Phase II ECP (NAVFAC Atlantic, 2005), and the Phase I RFI (Baker, 2009). Results and recommendations from the Phase II ECP and the Phase I RFI investigations are summarized below.

2.2.1 Phase II ECP

The Phase II ECP investigation included the sampling and analysis of surface soil at six locations, subsurface soil at two locations, groundwater at three locations, and surface water with co-located sediment from two locations along the shoreline of the surface water body, Ensenada Honda. Analytical data from the Phase II ECP are presented in Appendix B, including comparisons to human health and ecological screening criteria used at that time. The tables also include comparison to the then applicable facility background levels for metals. Listed below is a summary of the samples collected as part of the Phase II ECP Investigation.

- Surface soil samples were collected from six soil boring locations (16E-01 through 16E-06) from a depth of 0 to 1 foot below ground surface (bgs).

- Subsurface soil samples were collected from soil borings 16E-01 and 16E-02 to depths of 15 feet bgs and 5 feet bgs, respectively. Subsurface soil samples were proposed but not collected from soil boring locations 16E-03 through 16E-06 because the groundwater at these four locations was encountered at depths ranging from 0.3 foot bgs to 1.2 feet bgs.

- A temporary monitoring well was installed at soil boring location 16E-01, and a groundwater

sample was collected. Due to the shallow depth of groundwater at soil boring locations 16E-05 and 16E-06, groundwater samples were collected by digging a sump in the area of the soil boring and utilizing the direct dip method immediately upon the sump filling with water.

- Two surface water and sediment samples were collected from the shoreline of this site along Ensenada Honda.

The surface and subsurface soil, groundwater, surface water and sediment samples were analyzed for Appendix IX VOCs, Semivolatile Organic Compounds (SVOCs), pesticides/polychlorinated biphenyls (PCBs), organo-phosphorus- pesticides, chlorinated herbicides, and metals (and dissolved metals for the groundwater samples).

The following constituents exceeded their USEPA Region III Residential Risk Based Concentrations (RBC) for soil or their USEPA Region III Tap Water RBCs for groundwater:

- Surface Soil
  - arsenic
  - chromium
  - vanadium

- Subsurface soil
  - arsenic
  - vanadium

- Groundwater
  - indeo(1,23-cd)pyrene
  - vanadium (dissolved)

- Sediment
  - copper
  - silver
  - tin

There were no detections of pesticides/PCBs, OP-pesticides, or chlorinated herbicides in the samples collected during the Phase II ECP investigation performed at SWMU 70. The Final Phase I/II ECP report (NAVFAC Atlantic, 2005) concluded that the soil, groundwater, and sediment were impacted from previous site activities and recommended further investigation.

2.2.2 Phase I RFI

The objectives of the Phase I RFI were to:

- Determine if contaminants are present at SWMU 70 from past activities, to the extent practical, from the completion of field activities (surface soil, subsurface soil, open water and estuarine sediment, and groundwater sampling) as described in the Final Phase I RFI Work Plan (Baker, 2007);

- Screen media for potential human health risks posed by the site; and

- Screen media for potential ecological risks posed by the site.

The field activities conducted at SWMU 70 primarily consisted of the collection of the following samples:

- Five surface soil samples and five subsurface soil samples from five boring locations.
- Three open water sediment samples along the shoreline of Ensenada Honda.
- Three estuarine sediment samples from three locations in the southwestern part of the SWMU.
- Eight groundwater samples; four groundwater samples were collected from permanent wells installed at the upland locations (70SB01, 70SB02, 70SB03, and 70SB04). The remaining samples were collected from temporary wells installed at the transitional/estuarine locations (70SB05, 70SB06, 70SB07, and 70SB08).

The samples were analyzed for: Appendix IX VOCs, SVOCs (including Low-Level Polynuclear Aromatic Hydrocarbons [LLPAHs]), PCBs, metals (including dissolved metals for the groundwater samples), and Total Petroleum Hydrocarbon (TPH) Diesel Range Organics (DRO)/Gasoline Range Organics (GRO). The estuarine sediment samples also were analyzed for Total Organic Carbon (TOC). Results for the Phase I RFI are included as part of Appendix C.

Arsenic was detected in the surface soil at sample locations 70SB01, 70SB04, and 70SB05 at concentrations exceeding both residential and industrial soil Regional Screening Levels (SLs) and its NAPR background concentration. In the subsurface soil samples, nickel was detected at a concentration above its ecological screening value and NAPR background concentration at sample location 70SB02.

Dissolved arsenic was detected in groundwater at sample locations 70SB01, 70SB02, and 70SB04 in the northern portion of the SWMU at concentrations exceeding its Regional Tap Water SL, USEPA Maximum Contaminant Level (MCL), and NAPR background concentration. Dissolved arsenic also exceeded its ecological screening value at 70SB01. Dissolved vanadium was also detected in groundwater at sample location 70SB02 at a concentration exceeding its Tap Water Regional SL, ecological screening value, and NAPR background concentration. Vinyl chloride was also detected in groundwater at sample location 70SB04 at a concentration exceeding the Regional tap water SL.

Total barium and chromium detections did not exceed corresponding Regional tap water SLs, MCLs, background screening values, or ecological groundwater screening values at any location. Total cobalt was detected in one sample (70GW03) at a concentration exceeding the Regional tap water SL and ecological screening value. Total copper was detected in one sample (70GW02) at a concentration exceeding the ecological screening value. Nickel was detected in two samples at concentrations exceeding the ecological screening value. Vanadium was detected in five of nine samples at concentrations exceeding the ecological screening value (70GW01, 70GW02, 70GW02D, 70GW07, and 70GW08). Vanadium also exceeded the Regional tap water SL in one sample (70GW02). However, none of these total metals were detected at concentrations in excess of the NAPR basewide background screening value for groundwater.

Exceedances of metals were identified in the estuarine sediment at one location (70SB07) in the southern portion of the SWMU. Chromium, nickel, and vanadium exceeded corresponding ecological screening values and NAPR background concentrations in sample 70SD07. Vanadium also exceeded its residential soil Regional SL in this sample. Acetone was also detected at concentrations exceeding its ecological screening value at three locations (70SB06, 70SB07, and 70SB08). However, there were no detections of acetone in up-gradient surface soil, subsurface soil, or groundwater samples. As such, there is no evidence that acetone is site-related. It is likely that the acetone is a result of laboratory contamination.

Acetone was also detected at all three open water sediment locations (70SD01, 70SD02, and 70SD03) at concentrations exceeding the ecological screening value. As noted above, acetone was not detected in up-gradient media and is not considered site-related. It is likely that the acetone is a result of laboratory contamination since it was detected at elevated concentrations in all sediment samples but no other media at the SWMU.

Cobalt was also detected in the open water sediment at sample locations 70SD02 and 70SD03 at concentrations exceeding its residential soil Regional SL and NAPR background concentration. Cobalt was detected in surface and subsurface soil at relatively low concentrations, with exceedances of only the Residential Soil Regional SL at sample locations 70SB02 and 70SB05. Additionally, cobalt was detected in the estuarine sediment at concentrations exceeding the residential soil Regional SL and ecological screening value. However, all cobalt concentrations in up-gradient media were less than associated background, indicating that any migration from SWMU 70 into the Ensenada Honda above what would be expected under background conditions is not occurring. While it is acknowledged that cobalt may be migrating from up-gradient media to open water sediment, it does not appear that the presence of cobalt in the open water sediment is site-related or the result of a past release at SWMU 70 because cobalt was not identified as site-related in any other medium.

It is evident from the analyses of samples obtained during the Phase I RFI that surface soil, subsurface soil, estuarine sediment, and groundwater have been impacted from past activities that have occurred at SWMU 70. A Full RFI was recommended in order to delineate the site contamination above screening levels in surface soil, subsurface soil, estuarine sediment, and groundwater, define the likely source area(s), and determine the potential for unacceptable risks to human health and/or the environment. If the surface soil, subsurface soil, estuarine sediment and groundwater samples from the Full RFI Report indicate that there are cobalt releases at SWMU 70, further investigation in the open water sediment may be required. The Phase I RFI Report was approved by the USEPA on December 15, 2009.

2.3 Preliminary Conceptual Models for Ecological and Human Receptors

Preliminary conceptual models for ecological and human receptors are presented on Figures 2-7 and 2-8, respectively. The conceptual models outline potential sources of contaminants, transport pathways, exposure media, potential exposure routes, and receptor groups. Specific components of each preliminary conceptual model (i.e., source areas, transport pathways, and exposure pathways and routes) are discussed in the sections that follow.

2.3.1 Preliminary Conceptual Model for Ecological Receptors

The former disposal area represents a potential source for the release of chemicals to surface soil. Contaminated surface soil also represents a potential source for the release of chemicals to subsurface soil, downgradient surface soil, and estuarine wetland surface water and sediment, which represent a

potential source for the release of chemicals to groundwater and the Ensenada Honda. Transport pathways associated with these source areas are identified and discussed in Section 2.4.1.1 below.

2.3.1.1 Transport Pathways

A transport pathway describes the mechanisms whereby chemicals may be transported from a source of contamination to ecologically relevant media. As depicted on Figure 2-7, potential mechanisms for contaminant transport from potential source areas at SWMU 70 are believed to include the following:

- Overland transport of chemicals with surface soil via surface runoff to downgradient surface soil.
- Leaching of chemicals from surface soil and/or subsurface soil by infiltrating precipitation and transport with groundwater to estuarine wetland surface water and sediment.
- Leaching of chemicals from surface soil and/or subsurface soil by infiltrating precipitation and transport with groundwater to Ensenada Honda surface water and sediment.
- Uptake by biota from surface soil and subsurface soil and trophic transfer to upper trophic level receptors.

2.3.1.2 Exposure Pathways and Routes

An exposure pathway links a source of contamination with one or more receptors via exposure to one or more media. Requirements for a complete exposure pathway are listed below.

- A source of contamination must be present
- Release and transport mechanisms must be available to move the contaminants from the source to an exposure point
- An exposure point must exist where ecological receptors could contact affected media
- An exposure route must exist whereby the contaminant can be taken up by ecological receptors

As depicted on Figure 2-7, potentially complete and significant exposure pathways exist at SWMU 70. An exposure route describes the specific mechanism(s) by which a receptor is exposed to a chemical present in an environmental medium. Exposure pathways and routes applicable to SWMU 70 are discussed in the paragraphs that follow.

The most common exposure routes are dermal contact, direct uptake, ingestion, and inhalation. Terrestrial plants may be exposed to chemicals present in surface soil directly through their root surfaces during water and nutrient uptake. Terrestrial invertebrates may be exposed to chemicals in soil through dermal adsorption and ingestion. Much of the toxicological data available for terrestrial invertebrates are based upon *in situ* studies that represent both pathways. Invertebrates also represent a link between surface soil and upper trophic level receptors through food web transfer. As such, they are often included as prey items for upper trophic level dietary exposures.

Birds and mammals may be exposed to chemicals through: (1) the inhalation of gaseous chemicals or chemicals adhered to particulate matter; (2) the incidental ingestion of contaminated abiotic media (e.g., soil) during feeding or cleaning activities; (3) the ingestion of contaminated water; (4) the ingestion of contaminated plant and/or animal tissues for chemicals that have entered food webs; and/or (5) dermal contact with contaminated abiotic media. These exposure routes, where applicable, are depicted on Figure 2-7. Their relative importance depends in part on the chemical being evaluated. For chemicals having the potential to bioaccumulate (e.g., polychlorinated biphenyls [PCBs]), the greatest exposure to wildlife is likely to be from the ingestion of prey. For chemicals having a limited potential to bioaccumulate (e.g., aluminum), the exposure of wildlife to chemicals is likely to be greatest through the direct ingestion of abiotic media, such as surface soil.

Direct ingestion of drinking water is only considered if the salinity of a potential drinking water source is less than 15 parts per thousand (ppt), the approximate toxic threshold for wildlife receptors (Humphreys, 1988). As evidenced by Figure 2-2, there are no potential drinking water sources within or contiguous to SWMU 70. Therefore, ingestion of surface water is not considered a exposure pathway for upper trophic level terrestrial receptors.

Certain potential exposure pathways and/or routes depicted on Figure 2-7 are considered insignificant relative to other pathways due to low potential for exposure and low levels of relevant contaminants. For example, dermal exposures are not considered significant relative to ingestion exposures for upper trophic level receptors. This is supported by evidence outlined in Suter II et al. (2000) and the USEPA (2003a), including the general fate properties of the majority of compounds detected in soil (e.g., low affinity for dermal uptake), the low potential exposure frequency and duration, and the protection offered by feathers, fur, and scales to avian, mammalian, and reptilian receptors. In addition, literature reviews indicate that dermal exposures to wildlife from classes of chemicals known or suspected to be of concern via dermal adsorption (e.g., VOCs, organophosphorous pesticides, and petroleum compounds) are often overestimated in laboratory studies (where feathers/fur are removed) and do not represent realistic exposure scenarios (USEPA, 2003a). Furthermore, though burrowing reptiles (which would be expected to experience the most significant exposure) may inhabit the upland vegetative units at and contiguous to SWMU 70, chemicals known or suspected to be of concern via dermal adsorption are not known to be associated with historical activities at the site (e.g., organophosphorous pesticides) or were detected at a low frequency and concentration (e.g., VOCs). Moreover, USEPA (2003a) calculated that the contribution of dermal exposures to the total dose received by terrestrial receptors to be 0.5 percent or less and therefore omitted the dermal pathway from consideration during ecological soil screening level (Eco-SSL) development. Incidental ingestion of surface soil during feeding and preening activities by upper trophic level receptors, as well as direct contact exposures by lower trophic level terrestrial receptors (i.e., invertebrates) are considered significant exposure routes (see Figure 2-7).

Inhalation of gaseous chemicals and chemicals adhered to particulate matter (e.g., soil) also is considered insignificant relative to ingestion pathways. As described above for dermal exposures, this approach is consistent with Suter II et al. (2000) and USEPA (1997 and 2003a), which recognize the relatively small contribution the inhalation pathway contributes to exposure estimates. For example, USEPA (2003a) estimates that the expected contribution to the total dose associated with the inhalation pathway is less than 0.01 percent for particulates and less than 1.0 percent for volatiles. Site conditions further reduce the importance of this exposure route relative to ingestion. The vegetative groundcover at SWMU 70 (grasses) will minimize the suspension of dust and the potential for exposure via inhalation of chemicals adhered to soil particles. Furthermore, inhalation of gaseous chemicals that have volatilized from surface soil is likely to be insignificant given that VOCs, apart from the acetone detected in open water and estuarine sediment samples, were generally detected at a low frequency and concentration during the Phase I RFI field investigation.

2.3.2 Preliminary Conceptual Model for Human Receptors

Development of a preliminary conceptual model of potential exposure is critical in evaluating exposures for the human receptors. The preliminary conceptual model considers all reasonable current and future potential exposures and media of concern under a no-action scenario. The following four elements are considered to determine whether a complete exposure pathway is present (USEPA, 1989):

- A source and potential mechanism of chemical release
- An environmental retention or transport medium
- A point of potential human contact with the contaminated medium; and
- A human exposure route (e.g., ingestion) at the contact point

SWMU 70 (Disposal Area Northwest of Landfill) encompasses 55 acres of land and is located in near-shore flat lands and consists of flat lying land with open areas and areas covered by secondary growth vegetation. The former disposal area is currently not utilized. The history of this site is presented in Section 1.2. Current site conditions are presented in Section 2.1.

The Phase II ECP indicated the following:

- No organic chemicals exceeded the USEPA Region III residential or industrial RBCs in surface or subsurface soil
- Only arsenic exceeded Base background concentrations and the USEPA Region III RBCs in surface and subsurface soil samples
- Indeno(1,2,3-cd)pyrene and dissolved vanadium exceeded corresponding USEPA Tap Water RBCs in groundwater
- Copper, silver, and tin exceeded corresponding Marine Sediment Screening Values

The Phase I RFI indicated the following:

- No organic chemicals detected in surface soil, subsurface soil, open water sediment, or estuarine sediment exceeded Regional Residential and/or Industrial SLs.
- Arsenic was detected in the surface soil at several sample locations at concentrations exceeding both residential and industrial soil Regional Screening Levels (SLs) and its NAPR background concentration.
- Dissolved arsenic and vanadium were detected in groundwater in the northern portion of the SWMU at concentrations exceeding Regional Tap Water SLs and NAPR background concentrations. Vinyl chloride was also detected in one of eight locations at a concentration exceeding the Regional tap water SL.
- Vanadium exceeded its residential soil Regional SL in the estuarine sediment at one location in the southern portion of the SWMU.
- Cobalt was also detected in the open water sediment in the southern portion of the SWMU at concentrations exceeding its residential soil Regional SL and NAPR background concentration.

Based on the available information on SWMU 70, potential migration, exposure pathways, and human receptors have been identified (Figure 2-8). Potential contaminant release mechanisms from affected media include storm water runoff, leaching to underlying groundwater, and advective transport in the direction of groundwater flow. Potentially affected media at SWMU 70 may include one or more of the following: surface soil, subsurface soil, groundwater, surface water, and sediment.

Current and potential future exposure scenarios for SWMU 70 are presented in Figure 2-8. Current exposure scenarios for SWMU 70 are trespassers (adult and youth [6 to 16 years]). Future exposures at this site may consist of adult and youth trespassers, adult industrial/commercial workers, and adult construction workers. Future residential land use is also conservatively assumed for SWMU 70, although it is not likely given expected future land use. A future residential exposure scenario (adult and young child [1 to 6 years] residents) is included for conservative comparison with other exposure scenarios and to estimate the worst-case exposure conditions. The preliminary conceptual model will be refined, as necessary, following data collection. This will serve as the basis for the exposure pathway evaluations in the baseline Human Health Risk Assessment (HHRA).

3.0 SCOPE OF INVESTIGATION

In choosing sample locations, consideration was given to site topography, site features, and reported operational features of the facility, as well as the analytical results of the Phase I RFI. The SWMU topography will be taken into consideration and the sampling locations may be adjusted in the field as necessary. Following the sampling activities, the final locations will be surveyed. Any deviations to this work plan will be noted in the field notebooks by the sampling team.

The sampling and analytical program for this investigation is summarized in Table 3-1. The sampling locations for SWMU 70 are shown on Figure 3-1. Sampling will consist of thirty-eight surface soil samples from thirty-eight soil borings, eighteen subsurface soil samples from eighteen borings, sixteen groundwater samples (twelve from new soil borings and four from existing wells), nineteen sediment samples, and three surface water samples.

3.1 Soil Sampling and Analysis Program

The rationale for the soil sampling locations and the analytical program is discussed below. During the Phase I RFI investigation, only one subsurface soil sample was collected from borings 70SB01, 70SB02, 70SB03, 70SB04, and 70SB05 due to the presence of groundwater at approximately three feet bgs. At each proposed location, it is anticipated that one surface soil sample (0 to 1 ft bgs) and one shallow subsurface soil (1 to 3 ft bgs) sample (depending on site topography and geology) will be collected, unless otherwise indicated in the discussion below.

- Eight soil borings (70SB09 through 70SB16) will be advanced in the northern portion of the SWMU surrounding Phase I RFI location 70SB01 to delineate arsenic that was detected above Base background and Residential and Industrial Regional SLs in surface soil during the Phase I RFI. One surface (0 to 1 feet bgs) will be collected from soil borings 70SB09 through 70SB14. One surface, one shallow subsurface (1 to 3 ft bgs) sample and a groundwater sample will be collected from soil borings 70SB15(south) and 70SB16(west) and analyzed for Appendix IX metals (total and dissolved for groundwater samples). Additional groundwater sampling to the north and east are not proposed due to southwest direction of groundwater flow. The monitoring wells are being installed to delineate dissolved arsenic detected in groundwater during the Phase I RFI from boring 70SB01 that was above Base Background, Regional Tap Water Screening Levels, the MCL and ecological screening values.

- Eight soil boring locations (70SB17 through 70SB24) will be advanced surrounding Phase I RFI sample location 70SB02 in the northern portion of the SWMU. One surface (0 to 1 ft bgs) and one shallow subsurface (1 to 3 ft bgs) sample will be collected per boring and analyzed for Appendix IX metals to delineate nickel detected above Base background, and ecological screening values in the Phase I RFI from subsurface soil collected at this location. Monitoring wells will also be installed at two locations (70SB23 and 70SB24) to delineate dissolved vanadium detected in groundwater during the Phase I RFI from boring 70SB02 that was above Base background, Regional Tap Water Screening Levels and ecological screening values. The Base background soil data sets are presented within the Revised Final II Summary Report for Environmental Background Concentrations of Inorganic Compounds, Naval Activity Puerto Rico, Ceiba, Puerto Rico (Baker, 2010). Dissolved arsenic was also detected in the duplicate groundwater sample from this well at a concentration that was above the Base background, Regional Tap Water Screening Level and the MCL. Groundwater samples will be collected from 70SB02, 70SB23 and 70SB24 and analyzed for total and dissolved metals.

- Eight soil borings (70SB25 through 70SB32) will be advanced surrounding Phase I RFI sample location 70SB04 in the northwestern portion of the SWMU. One surface soil sample will be collected from soil borings 70SB25 through 70SB30 and analyzed for Appendix IX metals. One surface soil sample (0 to 1 ft bgs), one shallow subsurface soil (1 to 3 ft bgs) sample, and a groundwater sample will be collected from soil borings 70SB31 and 70SB32 and analyzed for Appendix IX metals (total and dissolved metals for groundwater). These samples are proposed to delineate arsenic detected in the surface soil from this boring during the Phase I RFI that was above the Base Background and Residential and Industrial SLs. Dissolved arsenic was detected in groundwater during the Phase I RFI from boring 70SB04 above Base background, Regional Tap Water Screening Levels and the MCL. Vinyl chloride was also detected from the groundwater sample collected at this boring above the Regional Tap Water SL. Therefore, Appendix IX VOCs will be also be analyzed in the groundwater samples (70SB04, 70SB31, and 70SB32).

- Eight soil borings (70SB33 through 71SB40) will be advanced around Phase I RFI sample location 71SB05 to delineate arsenic detected above Base background, and Regional Residential and Industrial SLs during the Phase I RFI. Surface soil samples collected from these borings will be analyzed for Appendix IX Metals. Since there were not exccedances of screening criteria in subsurface soil, only surface soil samples will be collected from the proposed soil borings.

- Six soil borings (70SB41 through 70SB46) will be installed in the northern portion of the SWMU primarily for monitoring well installation to provide additional information for groundwater flow and quality evaluation. One surface soil sample (0 to 1 ft bgs), one shallow subsurface soil (1 to 3 ft bgs) sample, and a groundwater sample will be collected from each boring and analyzed for Appendix IX metals (total and dissolved metals for groundwater).

Sample matrices for this investigation are provided as Table 3-1 and Table 3-2. The proposed sample locations for the Full RFI at SWMU 70 (as well as the previous sample locations of the Phase II ECP and the Phase I RFI) are shown on Figure 3-1. All analyses at the laboratory will be performed using current methodologies as presented in Table 3-3.

The surface and shallow subsurface soil samples will be obtained using a direct push technology (DPT) drill rig capable of advancing hollow stem augers. DPT soil sampling will be performed using a 4-foot long Macro Core Sampler. As shallow groundwater is anticipated to be encountered (i.e., depths ranging between approximately three and five feet bgs) continuous DPT soil sampling will be performed from the ground surface to depths of ten to twelve feet bgs for well installation. One surface soil sample (0 to 1 foot bgs) and one shallow subsurface soil sample (1 to 3 feet bgs) will be collected for fixed-base laboratory analysis for the parameters shown on Table 3-1. During soil boring installation, care will be taken to achieve maximum recovery so that a good stratigraphic profile can be developed. A boring log will be maintained indicating lithology, water occurrence, photoionization detector (PID) measurements and other observations. All pertinent sampling information such as soil description (e.g., color and texture), sample number and location, presence or absence of soil discoloration, actual depth determined in field, and the time of sample collection shall also be recorded in the field logbook. Surface and subsurface soil samples will be collected following the procedures in Final RCRA Facility Investigation Management Plans (Baker, 1995). All pertinent sampling information such as soil description (e.g., color and texture), sample number and location, presence or absence of soil discoloration, and the time of sample collection will be recorded in the field logbook. Criteria for distinguishing between sediment and soil shall follow the guidelines within Final RCRA Facility Investigation Management Plans, Appendix B, SOP F101.

Soil borings will be labeled consecutively (beginning with 70SB09 and ending with 70SB46) in a manner consistent with previous sample designations at NAPR. Extensions to the sample identification will reflect the depth at which the sample was obtained. For the purposes of this work plan, two-foot discrete depths will be used. Sample identification extensions will follow the pattern shown below.

70SB09-00 - SMWU 70
70SB09-00 - Soil Boring
70SB09-00 - Soil boring location identifier
70SB09-00 –Depth designator - 0 to 12 inches bgs (surface soil) sampling interval

Subsurface soil samples will be designated as follows:

70SB09-01 - First subsurface sampling interval, 1 to 3 feet bgs
70SB09-02 - Second subsurface sampling interval, 3 to 5 feet, bgs and so on.

The actual sample depth will be determined in the field.

Samples will be packed in ice and shipped next day air to the fixed-base laboratory. Tracking numbers for each shipment will be forwarded to the data manager for assisting in verification of receipt of samples by the laboratory.

All analysis at the laboratory will be performed using current methods as presented in Table 3-3. All analytical work conducted on the mainland of the United States of America must be certified by a Puerto Rico licensed chemist. The specific laboratory and third party validator, as well as a certified licensed chemist from Puerto Rico, will be determined at a later date. The validation services to be provided will include 100 percent validation of the data in accordance with the most recent USEPA guidelines.

3.2 Monitoring Well Installation

A monitoring well will be installed and a groundwater sample will be collected from twelve soil boring locations (70SB15, 70SB16, 70SB23, 70SB24, 70SB31, 70SB32 and 70SB41 through 70SB46) as presented on Figure 3-1. In addition, four groundwater samples will be collected from Phase I RFI locations (70SB01, 70SB02, 70SB03 and 70SB04). Permanent monitoring wells are proposed, however if site conditions do not allow for the installation of a permanent monitoring well, temporary wells will be installed. During the Phase I RFI, soil boring location 70SB05 was found to be in a transitional area within an estuarine wetland (approximately 100 feet from designated upland habitat). Although determined in the field to be soil rather than sediment, shallow groundwater was evident. If temporary monitoring well installation is necessary, a hand auger will be used to bore a hole and a 2-inch PVC well screen will be inserted into the soil to serve as a temporary well. A sample will be collected immediately after the screen fills with water. It should be noted that field conditions such as saturated/inundated wetland areas to the south and west, various topographical changes, and mounding to the north and east limited the drilling rig from gaining access to 70SB05 and subsequently installing the proposed permanent well during the Phase I RFI. Listed below is a discussion of permanent well installation procedures. If temporary monitoring wells are installed, development procedures will be conducted following the procedures in Final RCRA Facility Investigation Management Plans (Baker, 1995).

Permanent monitoring wells will be installed using hollow-stem augers (HSAs). The wells will be constructed of 2-inch inside diameter (ID), Schedule 40 PVC, with flush joint threads. Well screens

will be 10-feet long and installed to straddle the water table. The permanent monitoring wells are anticipated to be 12 feet in total depth due to the shallow groundwater within the study area.

- Soil sampling will be conducted in order to classify the soil during well installation. Upon completion of soil sampling, the borehole will be reamed as necessary to the desired depth using HSAs. The well construction materials shall be installed through the HSAs.

- The well screen and bottom cap will be set at the bottom of the borehole. The screen will be connected to threaded, flush-joint, riser. An expandable, water tight locking cap or slip-cap with a vent hole will be placed at the top of the casing.

- The annular space around the well screen will be backfilled with a well-graded, fine to medium sand as the HSAs or casing are being withdrawn from the borehole. Typically the sand will extend to approximately 2 feet above the top of the screened interval. However, with the shallow groundwater within the study area, the thickness of the sand above the screened interval likely will be reduced to a minimum of 0.5 feet to allow for placement of adequate sealing material.

- An approximately 2-foot thick sodium bentonite seal (minimum of 6 inches for very shallow wells) will be placed above the sand pack. If bentonite pellets or chips are used, they will be sized appropriately given the well and borehole diameter and placed in a careful manner that will prevent bridging. The bentonite will be hydrated with potable water, as necessary.

- The annular space above the bentonite seal will be backfilled with cement/bentonite grout to prevent surface and near subsurface water from infiltrating into the screened groundwater monitoring zone. The grout will consist of five to ten percent (by dry weight) of bentonite powder and seven gallons of potable water per 94-pound bag of portland cement. For very shallow wells, which are anticipated for this investigation, the cement/bentonite grout may be omitted.

- The depth intervals of all backfilled materials will be measured with a weighted measuring tape to the nearest 0.1-foot and recorded in the field logbook.

- The entire site area is heavily vegetated; therefore the wells will be provided with 2 to 3 feet of "stickup" above ground surface. Steel protective casing will be placed over the riser and surrounded by a concrete pad. The pad will be a minimum of 2 feet by 2 feet (length x width) and 6 inches in thickness (with 2 inches set into the ground outside the casing), and extending 2 feet bgs inside the annular space around the well. If water table conditions prevent having a 24-inch thick bentonite seal, the concrete pad depth in the annular space around the well may be decreased. Steel bollards will be installed around the concrete pad in areas of high vehicular traffic as additional protection and painted a bright color to aid in visibility.

- All wells will have a locking cap installed on the PVC riser or protective steel casing.

Each new permanent monitor well will be developed using surge and bail methods after allowing suitable time for the cement/bentonite grout to cure (typically a minimum of 24 hours). The purpose of well development is to restore the permeability of the formation which may have been reduced by the drilling operations and to remove fine-grained materials that may have entered/accumulated in the well or filter pack. The wells will be developed until the water is relatively clear of fine-grained materials. It should be noted that the water in some wells does not clear with continued development.

Typical limits placed on well development may include any one or a combination of the following:

- Clarity of water based on visual determination
- A maximum time period (typically two hours for shallow wells)
- A maximum borehole volume (typically three to five borehole volumes plus the amount of any water added during the drilling or installation process)
- The well development process will be recorded in the field logbook.

A record of the well development will be completed to document the development process. Monitoring well installation and well development procedures will be conducted following the procedures in Final RCRA Facility Investigation Management Plans (Baker, 1995). New wells will have well construction reports prepared for them, or at a minimum, the well construction details should be added to the appropriate boring log.

The depth at which to set the pump shall be field determined, based on the depth at which groundwater is initially encountered. Criteria for the field selection of the pump intake depth shall be as follows:

- Lower pump, safety cable, tubing and electrical lines slowly and smoothly (to minimize disturbance) into the well to the midpoint of the zone to be sampled.
- Position the pump intake between 3 ft (~0.9 m) below static water surface and a minimum distance above the top of the open/screened interval of 10 times the well diameter (20 in. for a 2-in. well diameter), if the sample is to be integrated over the entire screened or open area.
- The water-level sensor should be a maximum of 1 ft (~0.3 m) below water surface.
- If possible keep the pump intake at least two feet above the bottom of the well, to minimize mobilization of particulates present in the bottom of the well.
- Allow well to recharge after purging, keeping the pump just above or at the screen mid section.

3.3 Groundwater Sampling and Analysis Program

Sixteen groundwater samples will be collected from the twelve monitoring installed during this investigation and from the four permanent wells installed during the Phase I RFI and submitted to the laboratory for analysis of Appendix IX metals (total and dissolved), as shown on Table 3-1. In addition, samples 70GW04, 70GW31, and 70GW32 will be analyzed for Appendix IX VOCs to delineate vinyl chloride detected above Regional Tap Water SLs during the Phase I RFI.

The groundwater will be sampled using a bladder pump low-flow sampling technique if the well exhibits sufficient yield, with the pump intake set at the lowest practicable point in the well, otherwise samples will be grabbed according to the procedures for low yield sampling provided as part of Appendix D. Low-flow sampling shall be achieved using a portable positive displacement bladder pump (such as QED Well Wizard T1200M or equivalent) with an adjustable low-flow rate pump controller, maximum diameter of 1.66 inches, and stainless steel with polytetrafluoroethylene (PTFE) or Teflon® construction. Appendix D also includes a detailed description of the USEPA Region II low flow sampling technique. Field parameters of pH, temperature, turbidity, conductivity,

dissolved oxygen, and oxidation-reduction potential will be obtained with appropriate instrumentation during sampling if enough volume of groundwater is present. The groundwater samples will be placed into appropriate laboratory supplied containers. Prior to sampling, a synoptic set of static water levels will be recorded in order to obtain data to more accurately interpret the groundwater flow direction at SWMU 70.

The groundwater sample designations will be from the soil boring locations proposed, as shown on Figure 3-1 and Table 3-1. Sample identification extensions will follow the pattern below.

70GW01 - SMWU 70 Sample
70GW01 - GW = Groundwater Sample
70GW01 - Monitoring well location identifier (corresponding to the associated soil boring)

Samples will be packed in ice and shipped next day air to the analytical laboratory. Tracking numbers for each shipment will be forwarded to the data manager for assisting in verification of receipt of samples by the laboratory.

All analysis at the laboratory will be performed using current methods as presented in Table 3-3. All analytical work conducted on the mainland of the United States of America must be certified by a Puerto Rico licensed chemist. The specific laboratory and third party validator, as well as a certified licensed chemist from Puerto Rico, will be determined at a later date. The validation services to be provided will include 100 percent validation of the data in accordance with the most recent USEPA guidelines.

3.4 Sediment Sampling and Analysis Program

A total of nineteen sediment samples will be collected. The exact locations of the sediment samples will be field-determined based on the preferential drainage pathway evaluation; Figure 3-1 will be used as a guide in locating the sediment samples. When surface water is present near a sampling location for sediment, surface water will also be collected, as described in Section 3.5.

The samples will be obtained using disposable stainless steel spoons, or acetate sediment liners. Sediment samples shall be collected from zero to six inches below ground surface. The samples will be placed in a disposable aluminum pan and placed in the sample container. The sample container should be filled completely to avoid head space and air pockets for the AVS/SEM analysis. After the AVS/SEM container is filled, the sediment sample will be homogenized with a stainless steel spoon, and then placed in the sample container. All pertinent sampling information such as sediment description (e.g., color and texture), sample number and location, presence or absence of aquatic invertebrates, and the time of sample collection will be recorded in the field logbook.

Sediment sample identification extensions will be as follows:

70SD01	SMWU 70
70SD01	Sediment sample
70SD01	Sediment sample location identifier

During the Phase I RFI, sample locations 70SB06, 70SB07, and 70SB08 were proposed in the southwestern part of the SWMU based upon disturbed areas identified in historical aerial photographs (near/in the mangrove swamp) to determine potential migration of contaminants toward the Ensenada Honda. However, these locations were found to be located in an estuarine wetland with saturated sediment and shallow groundwater and were therefore, reclassified as estuarine sediment.

Only one surface sediment sample was collected from each of these three locations. Therefore, samples proposed in this area (wetland area) in this Full RFI are classified as sediment samples. If field conditions indicate that the proposed samples should be classified as soil, the sampling program will be modified to reflect the change in media and surface and subsurface soil samples will be collected as discussed in Section 3.1. The criteria and procedures to distinguish between sediment and soil is located in the Final RCRA Facility Investigation Management Plans (Baker, 1995), located in Appendix B, SOP101.

Samples 70SD09 through 70SD12 will be collected surrounding Phase I sample location 70SB07 to delineate chromium and nickel detected above Base Background and ecological screening values; and vanadium detected above Base Background, Regional SLs and ecological screening values. Sediment samples 70SD13 through 70SD27 are proposed in the southern area of the SWMU within the 1976, 1977, 1985 and 1995 polygon features to fully characterize the wetlands at this SWMU.

The sediment samples will be submitted for the following analysis; as shown on Table 3-1.

- Appendix IX Metals
- Total Organic Carbon (TOC)
- Acid Volatile Sulfides (AVS)/Simultaneously Extracted Metals (SEM)

AVS/SEM data will not be used within this Full RFI. This data is being collected for future use in the ERA which will be part of the CMS. These parameters are used to access the bioavailability of certain metals (cadmium, copper, lead, nickel, silver, and zinc). Similar to AVS/SEM, TOC is a measure of bioavailability. Site-specific TOC data will be used in the ERA to adjust EqP-based screening values. However, in the full RFI, a default TOC of 1.0 percent will be used for development of EQP-based screening values.

Samples will be packed in ice and shipped next day air to the “fixed base” laboratory. Tracking numbers for each shipment will be forwarded to the data manager for assisting in verification of receipt of samples by the laboratory.

All analytical work conducted on the mainland of the United States of America must be certified by a Puerto Rico licensed chemist. The specific laboratory and third party validator, as well as a certified licensed chemist from Puerto Rico, will be determined at a later date. The validation services to be provided will include 100 percent validation of the data in accordance with the most recent USEPA guidelines.

3.5 Surface Water Sampling and Analysis Program

Up to nineteen surface water samples shall be collected. If surface water is present while sampling for sediment, a surface water sample will be collected. The purpose of the collecting surface water samples is to characterize the water accumulating within the wetlands. The samples will be obtained by filling sample bottles directly with surface water.

The surface water sample designations will be from the sediment locations proposed, however only the nomenclature “SW” will be used to clarify just surface water. Sample identification extensions will follow the pattern below.

70SW25 - SMWU 70 Sample
70SW25 - SW = Surface Water Sample

70SW25 - Surface Water location identifier (corresponding to the associated sediment sample)

The samples will be analyzed for the following parameters:

- Total Recoverable and Dissolved Appendix IX Metals
- Total Organic Carbon (TOC)

Surface water sampling techniques include:

- Care shall be taken to minimize sediment disturbance while collecting surface water samples. If necessary, sediment samples shall be collected after the corresponding surface water sample.
- Samples may be collected either by immersing the approved sample container or decontaminated glassware into the water.
- Care shall be taken to avoid excessive agitation of the water which may result in the loss of volatile constituents. Additionally, samples for volatile organic analyses shall be collected first, followed by the samples for other constituents.
- Measurements for temperature, pH, specific conductance, or other field parameters, as appropriate, shall be collected immediately following sample collection for laboratory analyses.
- For preserved sample containers, extreme care will be exercised to avoid overfilling or spilling the contents of the sample container and diluting the preservative.

Field filtration of surface water samples requires preparation and preservation of water samples for dissolved inorganics involving some form of filtration. The samples to be filtered will be collected in in an approved non-preserved container. An additional sample will be collected to account for possible losses during the filtration process. The recommended method is through the use of a dedicated peristaltic pump, disposable polyethylene tubing and in-line filtration module (0.45 micron filter) utilizing the pressure provided by the pumping device to transfer sample from one container, through the filter and discharged into a clean approved preserved sampling container.

Filtration and preservation are to occur in the field on the same day as collected with the sample aliquot passing through a dedicated disposable 0.45 micron filter and polyethylene tubing. Samples for organic analyses shall never be filtered.

Samples will be packed in ice and shipped next day air to the fixed-based laboratory. Tracking numbers for each shipment will be forwarded to the project manager for assisting in verification of receipt or samples by the laboratory.

Table 3-1 summarizes the samples that will be collected and the associated analyses. As discussed previously, all analyses at the laboratory will be performed using current methodologies as presented in Table 3-3. All analytical work conducted on the mainland of the United States of America must be certified by a chemist licensed in Puerto Rico. The specific laboratory and third party validator, as well as the certified licensed chemist, will be determined at a later date.

3.6 Quality Assurance/Quality Control Samples

QA/QC requirements for this investigation will consist of trip blanks, equipment rinsates, field blanks, field duplicates, and matrix spike/matrix spike duplicates (MS/MSDs). These samples are listed on Tables 3-1 and 3-2. The Data Quality Assurance Project plan presented in the Final RCRA

Facility Investigation Management Plans (Baker, 1995) will be used as guidance for the sampling and analysis plan.

3.6.1 Trip Blanks

Trip blank samples are required to accompany the samples submitted to the laboratory for VOC analysis. Two trip blank samples are proposed as part of this investigation, as shown on Table 3-2.

3.6.2 Equipment Rinsates

Equipment rinsate samples are collected from analyte-free water rinse of decontaminated equipment, which required decontamination. Equipment rinsate blanks will be collected on a daily basis and submitted to a fixed-base analytical laboratory for analysis. The total number of equipment rinsate samples to be collected will be dependent on the length of the field investigation. The results from the blanks will be used to determine if the sampling equipment was free of contamination. The equipment rinsate samples are analyzed for the same parameters as the related samples. These samples will be associated with the surface and subsurface soil, groundwater, and sediment sampling equipment. The samples may be obtained from a stainless steel spoon for collection of soil and macro core liner for collection of subsurface soil. Samples may also be obtained from, but not limited to, the hand auger, bladder pump, and Teflon-lined polyethylene tubing used during the collection of groundwater and from the stainless steel spoon or acetate sediment liner for the collection of sediment samples. These samples will be analyzed for the analytes presented in Table 3-2.

3.6.3 Field Blanks

Field blank samples consist of the source water used in equipment decontamination procedures. At a minimum, one field blank for each source of water must be collected and analyzed for the same parameters as the related samples. It is anticipated that two different sources of water (i.e., store-bought distilled water, and laboratory-grade de-ionized water) will be utilized for this investigation as shown in Table 3-2.

3.6.4 Field Duplicates

Field duplicate samples of the surface soil, subsurface soil, sediment and groundwater will be collected during the same time the corresponding environmental sample is collected. One duplicate sample will be collected at a frequency of 10 percent of environmental samples collected per media as shown on Table 3-1.

3.6.5 Matrix Spike/Matrix Spike Duplicates

MS/MSDs are laboratory derived and are collected to evaluate the matrix effect of the sample upon the analytical methodology. One MS/MSD will be collected for every 20 samples collected of a similar matrix as shown on Table 3-1.

3.7 Other Investigation Considerations

During the investigation, the following activities will be performed:

- Clearing and Grubbing
- Utility Clearance

- Groundwater Elevation Measurement
- Slug Tests
- Investigation Derived Waste (IDW) Management
- Decontamination
- Delineation of Wetland Boundary
- Surveying
- Health and Safety Procedures
- Chain of Custody

Each of these activities is discussed in the following sections.

3.7.1 Clearing and Grubbing

It may be necessary for site clearing to be performed so the Geoprobe 66DT rig can gain access to delineate the suspected contamination. Site clearing will be performed by the direct push subcontractor, as required.

3.7.2 Utility Clearance

The party conducting the implementation of this work plan will be responsible for clearing utilities for all proposed soil boring and well locations.

3.7.3 Groundwater Elevation Measurements

Depth to groundwater measurements will be collected from each newly installed monitoring well shortly after installation and prior to and after well development and sampling activities. All groundwater level measurements will be recorded in the field log books. Prior to sampling, a synoptic set of static water levels from monitoring wells across the site will be recorded in order to obtain data to more accurately interpret the groundwater flow direction at SWMU 70.

3.7.4 Slug Tests

Slug tests will be performed at the eleven newly installed monitoring wells following completion of well installation, development and groundwater sampling. The purpose of the slug tests is to estimate the hydraulic conductivity of the saturated zone in the immediate vicinity of the monitoring well by measuring the aquifer response to a change in static conditions induced by introduction or removal of a slug of known volume from the well. A 1.5-inch diameter slug (approximately 1.5-inches in diameter by 3 foot long) will be used. Each test will be initiated by measuring the static water level in the well. A pressure transducer attached to a computerized data logger will then be installed in the well and the water levels will be allowed to re-equilibrate. The slug will be introduced into the well and the change in the water level over time will be measured for the falling head portion of the slug test. Measurements will continue until water levels stabilize at which point the slug will be removed from the well and the change in water level will again be measured until the water level stabilizes for the rising head portion of the test.

3.7.5 Investigation Derived Waste Management

The generation of IDW associated with soil sampling and monitoring well installation, including soil cuttings, well development purge water, and decontamination fluids will be collected and stored temporarily in 55-gallon drums. The soil cuttings associated with subsurface soil sampling will be

placed back into the location where the cuttings were collected immediately after the subsurface soil samples are collected. As much as possible, soils last out of the hole will be returned first, thereby, approximating original stratigraphy. If contamination is indicated, as determined by the field manager, the soil cuttings associated with that soil boring will be stored temporarily in a 55-gallon drum. All the soil cuttings for soil borings that show evidence of contamination will be placed in the same drum with proper label on the drums exterior. Soil cuttings from multiple borings will be placed in one drum (there will not be one drum for each soil boring) and a composite sample will be collected and submitted for laboratory analysis.

Two IDW samples will be collected during this investigation. One composite aqueous sample will be collected from all drums containing decontamination fluid (from sampling equipment and drill rig) in accordance with surface water sampling procedures outlined in Section 3.5. One composite soil sample will be collected from all drums containing drill cuttings.

A composite soil sample will be compiled from individual discrete (grab) samples of equal volume collected from each of the 55-gallon drums of containerized IDW soil. Each individual discrete soil sample will be placed into a decontaminated stainless-steel bowl (or other appropriate container) and thoroughly homogenized prior to filling the appropriate laboratory provided sample containers. However, the IDW grab sample for VOC analysis will be collected directly from soil exhibiting the highest potential impact based on visual and olfactory observations and screening results obtained during the investigation. The soil samples will be analyzed for toxicity characteristic leaching procedure (TCLP) metals, TCLP VOCs and reactivity, corrosivity, and ignitibility (RCI) as shown in Table 3-2, using methods presented in Table 3-3.

The IDW composite water sample will be collected similar to the soil composite sample with the exception that the individual discrete (grab) samples of equal volume collected from each of the 55-gallon drums of containerized IDW water will be placed directly into the appropriate laboratory provided sample containers. The water sample will be analyzed for Appendix IX metals and total VOCs as shown in Table 3-2, using methods presented in Table 3-3.

These samples will provide the necessary data to be able to dispose of the generated IDW at an appropriate disposal facility. Upon completion of the field program, the drums will be moved and stored per the direction of Public Works Department personnel. The soil and water IDW will be removed and disposed of from the site by an approved vendor upon receipt and review of the IDW sample analytical data.

In summary, the soil cuttings associated with subsurface soil sampling will be placed back into the location where the cuttings were collected from immediately after the subsurface soil samples are collected if a monitoring well is not going to be installed at that soil boring. If a monitoring well is going to be installed at a soil boring location, the soil cuttings associated with that soil boring will be stored temporarily in a 55-gallon drum. All the soil cuttings for soil borings that have monitoring wells installed will be placed in the same drum (there will not be one drum for each soil boring) and a composite sample will be collected and submitted for laboratory analysis.

3.7.6 Decontamination

All reusable (non-dedicated and non-disposable) soil sampling and monitoring well installation equipment (i.e. augers, bits, etc.), will be decontaminated between each sampling location in accordance with RFI Management Plans (Baker, 1995). The drill rigs will be decontaminated before arriving at the site and before leaving the site. The remaining contaminant-free sampling equipment and materials utilized during this investigation will be disposable.

3.7.7 Delineation of Wetland Boundaries

The estuarine wetland (E2SS3 and E2US3/4/5) resource boundaries depicted on Figures 1-3, 1-4, and 3-1 was delineated by Geo-marine, Inc. in December 1999 from 1993 color infrared and 1998 true color photography. As such, the wetland boundaries do not represent a field delineated jurisdictional boundaries. As part of the Full RFI and prior to start of sampling activities, the estuarine wetland (E2SS3 and E2US3/4/5) boundaries within the borders of the SWMU will be field-delineated in accordance with the U.S. Army Corps of Engineers Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Caribbean Islands Region (Environmental Laboratory, 2009).

Soil and sediment sampling locations will be altered from those depicted on Figure 3-1 based on field delineated location of wetland where necessary. If significant sediments are present within the surface soil interval at the soil sampling location within the wetland it will be noted in the sampling log and TOC analysis will be added to the surface soil sample. Additionally, if significant sediments are not present within a proposed sediment sample, the surface soil will be sampled, and it will be noted in the sampling log and TOC analysis will be excluded from the laboratory sample.

3.7.8 Surveying

All sampling locations are pre-determined and presented on a figure prior to entering the field. This figure will be loaded into a field-grade global positioning system (GPS) unit for locating purposes in the field. After sample locations are determined in the field and flagged, a surveyor (subcontractor) will obtain and record the locations of each sample. The wetland boundary will also be surveyed after it is established. Traditional survey equipment or survey grade GPS unit will be utilized to obtain vertical (+/- 0.01 foot) and horizontal (+/- 0.1 foot) locations and top of PVC elevations of the monitoring well(s).

3.7.9 Health and Safety Procedures

The health and safety procedures previously presented in the Final RCRA Facility Investigation Management Plans (Baker, 1995) will be employed during this investigation.

3.7.10 Chain-of-Custody

Chain-of-Custody procedures will be followed to ensure a documented, traceable link between measurement results and the sample/parameter that they represent. These procedures are intended to provide a legally acceptable record of sample preparation, storage, and analysis.

A chain-of-custody form will be completed for and accompany each shipment of samples in accordance with RFI Management Plans (Baker, 1995). After the samples are properly packaged, the shipping container will be sealed and prepared for shipment to the analytical laboratory.

The Navy plans to implement this investigation at NAPR in accordance with the EPA approved Master Project Management Plan (PMP), Master Data Collection Quality Assurance Plan (DCQAP), Data Management Plan (DMP), and Master Health and Safety Plan (HASP) for NAPR (Baker, 1995. Final RCRA Facility Investigation Management Plans, Naval Station Roosevelt Roads, Ceiba, Puerto Rico. September 14, 1995. Coraopolis, Pennsylvania.) The EPA approved the Work Plan on September 29, 1995.

4.0 REPORTING

This section outlines the reporting activities that are associated with the field investigation. The Full RFI report will include the following:

- Introduction
- Background
- Physical Characteristics of Study Area
- Full RFI Activities
- Physical Results
- Analytical Results
- Conclusions and Recommendations
- References

The Full RFI report sections that will address these requirements are discussed in the following subsections.

4.1 Introduction

The introduction will consist of a discussion of the historical background of any investigations conducted at the SWMU. The introduction will also provide a regulatory framework for NAPR and the SWMU, as well as a discussion of current conditions.

4.2 Background

This section will include a summary of the history and description of NAPR and SWMU 70. This section will also include a summary of the results of previous investigations conducted at SWMU 70.

4.3 Physical Characteristics of Study Area

This section will provide the environmental setting, including the regional and site-specific geology and hydrogeology. Regional and local climatic conditions that may be relevant to the environmental impacts of the contaminated media at the site will also be discussed, as relevant.

4.4 Full RFI Activities

This section will describe the basis for the most recent investigation and will include a description of the sample locations, sample collection and handling procedures, QA/QC procedures, and analytical methods used. This section will also discuss any problems encountered including any deviations from the Work Plan and problem resolution.

4.5 Physical Results

This section will present the current site conditions at SWMU 70 at the time of the Full RFI Investigation. The site geology and hydrogeology, as ascertained from the soil boring program and other field observations will also be discussed.

4.6 Analytical Results

This section will present analytical results of the environmental media and interpretation of the data, to characterize the contaminants present in the soil, groundwater, sediment, and surface water.

4.6.1 Media-Specific Ecological Screening Values

The sections that follow describe the various criteria and toxicological benchmarks that will be used as ecological-based media-specific screening values for chemicals in soil (surface and subsurface soil) groundwater, and sediment. The media-specific screening values, listed in Table 4-1 (soil), Table 4-2 (groundwater) and Table 4-3 (sediment) represent conservative exposure thresholds above which adverse ecological effects may occur.

4.6.1.1 Soil Screening Values

The literature-based toxicological benchmarks selected as screening values for chemicals in surface soil (0.0 to 1.0-foot depth interval) and subsurface soil (1.0 to 3.0-foot depth interval) are summarized in Table 4-1. USEPA ecological soil screening levels (Eco-SSLs) (documentation available at http://www.epa.gov/ecotox/ecossl/) were preferentially used as soil screening values.

Eco-SSLs have been developed for eight receptor groups: plants, soil invertebrates, avian herbivores, avian ground insectivores, avian carnivores, mammalian herbivores, mammalian ground insectivores, and mammalian carnivores. For a given chemical, the lowest Eco-SSL value for plants, soil invertebrates, avian herbivores, avian ground insectivores, avian carnivores, mammalian herbivores was selected as the soil screening value. Eco-SSLs for mammalian ground insectivores were not considered for soil screening value development because there are no mammalian ground insectivores in Puerto Rico (mammalian insectivores are limited to aerial insectivores [i.e., bats]). As discussed in Guidelines for Developing Ecological Soil Screening Levels (USEPA, 2005), aerial and arboreal insectivorous birds and mammals were excluded from Eco-SSL development because they are considered inappropriate (i.e., they do not have a clear or indirect exposure pathway link to soil [indirect exposure pathways involve ingestion of prey that have direct contact with soil]). Eco-SSLs for mammalian carnivores also were not considered for soil screening value development because there are no carnivorous mammals on Puerto Rico. With the exception of bats, the terrestrial mammals represented by potentially complete exposure pathways are limited to nonindigenous, nuisance species (i.e., Norway rat, black rat, and mongoose) that have been implicated in the decline of native reptilian and bird populations (Mac et al., 1998 and United States Fish and Wildlife Service [USFWS], 1996). Eco-SSLs for mammalian herbivores are considered appropriate for soil screening value development based on the presence of fruit-eating and nectivorous bats in Puerto Rico.

For those chemicals lacking plant, soil invertebrate, avian herbivore, avian ground insectivore, avian carnivore, or mammalian herbivore Eco-SSLs, the literature-based toxicological benchmarks listed below were used as soil screening values.

- Toxicological thresholds for earthworms and microorganisms (Efroymson et al., 1997a)
- Toxicological thresholds for plants (Efroymson et al., 1997b)

Identical to the Eco-SSLs, when more than one screening value was available for a given chemical from Efroymson et al. (1997a and 1997b), the lowest value was selected as the soil screening value. For those chemicals lacking plant, soil invertebrate, avian herbivore, avian ground insectivore, avian carnivore, or mammalian herbivore Eco-SSL and a toxicological threshold from Efroymson et al.

(1997a and 1997b), the following literature-based values, listed in their order of decreasing preference, were used as soil screening values:

- Toxicity reference values for plants and invertebrates listed in USEPA (1999)
- Soil standards developed by the Ministry of Housing, Spatial Planning and Environment (MHSPE, 2000)
- Canadian soil quality guidelines (agricultural land use) developed by the Canadian Council of Ministers of the Environment (CCME, 2007)

Soil screening values based on MHSPE soil standards represent an average of the target and intervention soil standards. Values are based on a default organic carbon content of 2.0 percent, which represents the minimum adjustment range (2.0 to 30.0 percent). Soil screening values developed by CCME soil quality guidelines were given the lowest preference since many are background-based interim guidelines that do not represent effect-based concentrations.

4.6.1.2 Groundwater Screening Values

Groundwater flow direction at SWMU 70 is southeast, toward an estuarine wetland system (comprised primarily of E2SS3 wetland units) and the Ensenada Honda (Baker, 2009). Because the estuarine wetland system and/or Ensenada Honda represent potential discharge points for SWMU 70 groundwater, the groundwater analytical data for samples collected during the Full RFI field investigation will be compared to the marine toxicological thresholds listed in Table 4-2. Data for surface water samples collected from the estuarine wetland system adjacent to SWMU 70 also will be screened against these marine-based toxicological thresholds.

Puerto Rico Water Quality Standards (PRWQS) for Class SB coastal and estuarine waters listed in the Puerto Rico Water Quality Standards Regulation (PRWQSR) dated March 31, 2010 (PREQB, 2010) were preferentially used as groundwater screening values. PRWQS for Class SB coastal and estuarine waters were selected based on the classifications contained within Rule 1302.1 of the PRWQSR. For those chemicals lacking PRWQS for Class SB coastal and estuarine waters, groundwater screening values were identified from the following information listed in their order of decreasing preference:

- Chronic saltwater National Ambient Water Quality Criteria (NAWQC) (USEPA, 2009a)
- Final Chronic Values (FCVs) for saltwater contained in ECO Update Volume 3, Number 2 (USEPA, 1996)
- USEPA Region 4 chronic screening values for saltwater contained in Ecological Risk Assessment Bulletins – Supplement to Risk Assessment Guidance for Superfund (RAGS) (USEPA, 2001)
- Minimum chronic toxicity test endpoints (No Observed Effect Concentration [NOEC], No Observed Effect Level [NOEL], and Maximum Acceptable Toxicant Concentration [MATC] values) for marine species reported in the ECOTOX Database System (USEPA, 2007b)
- Chronic Lowest Observable Effect Levels (LOELs) for saltwater contained in National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference Tables (SQUIRTs) (Buchman, 2008) with a safety factor of 10 (Wentsel et al., 1996)

The order of preference was selected based on their level of protection. For example, FCVs would be expected to offer a greater degree of protection than a single species NOEC, MATC, or LOEL since their derivation considers a larger toxicological database. In the absence of the above-mentioned FCVs, USEPA Region 4 chronic screening values, chronic test endpoints, and chronic LOELs, screening values were derived from the acute literature values listed below:

- Acute LOELs for saltwater contained in NOAA SQUIRTs (Buchman, 2008)

- Acute toxicity test endpoints (NOEC, NOEL, LOEL, Lowest Observed Effect Concentration [LOEC], median lethal concentration [LC_{50}], and median effective concentration [EC_{50}] values) for marine species contained in the ECOTOX Database System (USEPA, 2007b)

- LC_{50} values for marine species contained in Superfund Chemical Matrix (USEPA, 2004)

Chronic-based screening values were extrapolated from acute NOEC, NOEL, LOEC, LOEL, LC_{50}, and EC_{50} values as follows:

- An uncertainty factor of 30 was used to convert an acute NOEC or NOEL a chronic-based screening value (Wentsel et al., 1996)

- An uncertainty factor of 50 was used to convert an Acute LOEC or LOEL to a chronic-based screening value (Wentsel et al., 1996)

- An uncertainty factor of 100 was used to convert an EC_{50} or LC_{50} to a chronic-based screening value (Wentsel et al., 1996)

When acute toxicity data were used to extrapolate a chronic screening value, NOECs/NOELs were given preference over LOECs/LOELs, LOECs/LOELs were given preference over LC_{50} and EC_{50} values, and EC_{50} values were given preference over LC_{50} values. When more than one value was available from the literature for a given test endpoint (e.g., NOEC), the minimum value was conservatively used to extrapolate a chronic screening value.

As evidenced by Table 4-2, the total recoverable screening values selected for arsenic, cadmium, chromium, copper, lead, nickel, selenium, and zinc are PRWQS for Class SD surface waters, while the total recoverable screening value selected for mercury is a USEPA saltwater NAWQC (CCC value). PRWQSR has adopted USEPA total recoverable NAWQC as PRWQS for arsenic, cadmium, chromium, copper, lead, nickel, selenium, and zinc (the PRWQSR for these eight metals are identical to the total recoverable CCC values listed in National Recommended Water Quality Criteria [USEPA, 2009a]). Because groundwater and surface water samples collected at SWMU 70 will be analyzed for total recoverable and dissolved metals, dissolved screening values also were identified from the literature. PRWQS expressed in terms of the dissolved metal in the water column are not available from the PRWQSR. However, USEPA saltwater CCC values for arsenic, cadmium, chromium, copper, lead, nickel, selenium, and zinc, as well as mercury, can be expressed as dissolved or total recoverable concentrations (USEPA, 2009a). Therefore, screening values for these nine metals, expressed in terms of the dissolved metal in the water column, were derived by multiplying total recoverable PRWQS/USEPA CCC values by the saltwater conversion factors listed below (USEPA, 2009a):

- Arsenic: 1.000
- Cadmium: 0.994

- Chromium: 0.993
- Copper: 0.830
- Lead: 0.951
- Mercury: 0.850
- Nickel: 0.990
- Selenium: 0.998
- Zinc: 0.946

Total recoverable screening values were conservatively used to screen dissolved analytical data for those metals lacking screening values expressed as dissolved concentrations (i.e., antimony, barium, beryllium, cobalt, silver, thallium, tin, and vanadium).

For those chemicals lacking saltwater toxicological thresholds and literature values, surface water screening values were identified or developed from the literature-based freshwater values listed below in their order of decreasing preference.

- PRWQS for Class SD surface waters listed in the PRWQSR (PREQB, 2010).

- Chronic freshwater NAWQC (USEPA, 2009b)

- FCVs for freshwater contained in ECO Update Volume 3, Number 2 (USEPA, 1996)

- USEPA Region 4 chronic screening values for freshwater contained in Ecological Risk Assessment Bulletins – Supplement to RAGs (USEPA 2001) and USEPA Region 5 ecological screening levels (ESLs) (http://www.epa.gov/reg5rcra/ca/ESL.pdf) (USEPA, 2003)

- Minimum chronic toxicity test endpoints (NOEC, NOEL, and MATC values) for freshwater species reported in the ECOTOX Database System (USEPA, 2007b)

- Great Lakes basin Tier II Secondary Chronic Values (SCVs) listed in the Great Lakes Initiative Toxicity Data Clearinghouse (http://www.epa.gov/gliclearinghouse/) (USEPA, 2007c)

- Chronic LOELs for freshwater contained in NOAA SQUIRTs (Buchman, 2008) with a safety factor of 10 (Wentsel et al., 1996)

Identical to saltwater-based values, the order of preference was selected based on their level of protection. It is noted that USEPA Region 4 and Region 5 screening values were given equal preference. When a value was available from both sources, the minimum value was selected as the surface water screening value. In the absence of the above-mentioned freshwater FCVs, freshwater USEPA Region 4 and Region 5 screening values, freshwater chronic test endpoints, and freshwater chronic LOELs, screening values were derived from the acute literature values listed below:

- Acute LOELs for freshwater contained in NOAA SQUIRTs (Buchman, 2008)

- Acute toxicity test endpoints (NOEC, NOEL, LOEL, LOEC, LC_{50}, EC_{50} values) for freshwater species contained in the ECOTOX Database System (USEPA, 2007a)

- LC_{50} values for freshwater species contained in Superfund Chemical Matrix (USEPA, 2004)

Chronic-based screening values were extrapolated from acute NOEC, NOEL, LOEC, LOEL, LC_{50}, and EC_{50} values using the safety factors from Wentsel et al. (1996) identified above.

In some cases, acute and/or chronic saltwater LOELs for chemical classes [e.g., Polynuclear Aromatic Hydrocarbons [PAHs]) were available from the literature (Buchman, 2008). A saltwater LOEL based on a chemical class was used as the groundwater screening value only if that chemical lacked freshwater and saltwater literature-based benchmarks and/or toxicity test endpoints.

4.6.1.3 Sediment Screening Values

The marine and estuarine bulk sediment toxicological benchmarks listed below were preferentially used as sediment screening values:

- Effects-Range low (ER-L) marine and estuarine sediment quality guidelines (SQGs) (Long and Morgan, 1991 and Long et al., 1995)

- Threshold Effects Level (TEL) marine sediment quality assessment guidelines (SQAGs) (MacDonald, 1994)

- Apparent Effects Threshold (AET) marine SQGs (Buchman, 2008)

AVS/SEM data will not be used in the Full RFI, as discussed in Section 3.4. The data will be used in the future ecological risk assessment (ERA) as a means of evaluating the bioavailability of SEM metals (cadmium, copper, lead, nickel, selenium, and silver). The ERA will be included as part of a future CMS.

A description of ER-L, TEL, and AET values and the methods used in their derivation are provided in the paragraphs that follow.

ER-L marine and estuarine SQGs. Long and Morgan (1991) developed effects-based SQGs using literature-based data from EqP modeling, spiked-sediment toxicity tests, and matched sediment chemistry and biological effects measures. For a given chemical, the data were arranged in ascending order of concentration with each data entry assigned an "effects" or "no effects" descriptor, and the 10th percentile and 50th percentile concentrations of the “effects” data were calculated. The 10th and 50th percentiles of the “effects” data represent the ER-L and Effects Range-Median (ER-M), respectively. The ER-L and the ER-M delineate three concentration ranges for a given chemical. The concentration range below the ER-L value represents a minimal effects range (i.e., the concentration range in which effects would be rarely observed). Concentrations equal to or greater than the ER-L but less than the ER-M represent a possible effects range within which effects would occasionally occur, while concentrations greater than the ER-M represent a probable-effects range within which effects would frequently occur. The ER-L and ER-M values were recalculated by Long et al. (1995) after omitting a small amount of freshwater data included in the original calculations (Long and Morgan 1991) and incorporating more recent marine and estuarine data from the literature. Only ER-Ls were considered for use as sediment screening values.

TEL marine SQAGs for Florida coastal waters. The updated and revised data set used by Long et al. (1995) also was used by MacDonald (1994) to calculate SQAGs for Florida coastal waters (TELs and Probable Effect Levels [PELs]). Unlike the methodology used by Long et al. (1991) to derive ER-L and ER-M values, the derivation of TELs and PELs took into consideration the "no effects" data set. Specifically, TELs were derived by calculating the geometric mean of the 15th percentile in the "effects" data set and the 50th percentile in the "no effects" data set, while PELs were derived by

calculating the geometric mean of the 50th percentile in the “effects” data set and the 85th percentile in the “no effects” data set.

Identical to ER-Ls and ER-Ms, TELs and PELs delineate three concentration ranges for a given chemical. The TEL represents the upper limit of the range of sediment concentrations dominated by "no effects" data. Within this range, concentrations are not considered to represent significant hazards to sediment-associated biota. The PEL represents the lower limit of the range of sediment concentrations that are usually or always associated with adverse biological effects. The range of concentrations that could be associated with biological effects is delineated by the TEL and PEL. Within this range of concentrations, adverse biological effects are possible. Only TELs were considered for use as sediment screening values

AET marine SQGs. The AET method, developed by Tetra Tech, Inc (1986), associates chemical concentrations in sediments with adverse biological effects (lethal and sub-lethal toxicity as measured using sediment toxicity tests or changes in benthic macroinvertebrate abundance and community structure as measured by *in situ* biological surveys). For a given chemical and measurement of biological effect (biological indicator), the AET value represents the sediment concentration above which statistically significant biological effects are always observed. The AET values shown in Table 4-3 represent minimum AET value from a suite of seven biological indicators (amphipod mortality, oyster larval abnormality, Microtox luminescence, benthic macroinvertebrate abundance, bivalve larvae mortality/abnormality, Echinoderm larvae mortality/abnormality, and juvenile polychaete growth). It is noted that the AET values developed by Buchman (2008) are interim values subject to change.

Minimum, chemical-specific AET values are used by the Washington Department of Ecology (1995) as sediment management standards for Puget Sound. Minimum AET values also are used by the United States Army Corps of Engineers (USEPA/USACE, 1998) as “reason to believe” guidance for screening levels for the Dredged Material Management Program (DMMP). The DMMP screening levels are implemented for use in Puget Sound and Grays Harbor/Willapa Bay in the State of Washington. Current Washington State Department of Ecology sediment management standards and USACE DMMP screening levels do not reflect the interim AET values reported by Buchman (2008).

For a given chemical, when more than one toxicological threshold was available from the sources listed above (i.e., Long et al., 1995, MacDonald, 1994, and Buchman, 2008), the minimum value was conservatively selected as the sediment screening value. For those organic chemicals lacking literature-based marine and estuarine toxicological benchmarks, equilibrium partitioning (EqP)-based screening values were either developed using USEPA methodology (USEPA, 1993 and 1996 [see Appendix E] or identified from the literature (Di Toro and McGrath, 2000). For a given chemical, when an EqP-based value was derived in accordance with USEPA (1993 and 1996) methodology and a value also was available from Di Toro and McGrath (2000), the minimum value was selected as the sediment screening value. It is noted that consideration was given to the following literature-based freshwater toxicological thresholds for chemicals lacking marine and estuarine values: (1) consensus-based SQGs for freshwater (MacDonald et al., 2000), (2) SQAGs for Florida inland waters (MacDonald et al., 2003), (3) Ontario Ministry of the Environment Lowest Effect Level (LEL) Provincial sediment quality guidelines (PSQGs) (Persaud et al., 1993), and (4) Canadian interim freshwater sediment quality guidelines (ISQGs) (CCME, 2002]. However, no values were available from these sources.

4.6.2 Human Health Screening Values

Applicable human health criteria for soils include USEPA Regional Industrial SLs and USEPA Regional Residential SLs (USEPA, 2010), and the upper limit of means background levels (inorganics only) (Baker, 2010). The USEPA Regional Industrial and Residential SLs selected as screening values for chemicals in surface soil (0 to 1-foot depth interval) and subsurface soil (1 to 10-foot depth interval) are summarized in Table 4-4. In the absence of human health screening criteria specific to sediment, USEPA Regional Residential and Industrial Soil SLs (USEPA, 2010) are conservatively used along with appropriate NAPR sediment background levels (Baker, 2010). Applicable human health criteria for groundwater are USEPA Regional Tap Water SLs, Federal Drinking Water MCLs (USEPA, 2010), Puerto Rico Water Quality Standards, and any inorganic background levels present in the groundwater at NAPR (Baker, 2010). The USEPA Regional Tap Water SLs and Federal MCLs selected as screening values for chemicals in groundwater are summarized in Table 4-4. In the absence of human health screening criteria specific to surface water, USEPA Regional Tap Water SLs (USEPA, 2010b) are conservatively used.

4.6.2.1 Regional Screening Levels

The Regional SLs were developed by the USEPA to support the risk assessment screening process, while improving consistency across USEPA Regions and incorporating updated guidance in a timely manner. The Regional SL Table was developed with the Department of Energy's Oak Ridge National Laboratory under an Interagency Agreement as an update of the individual screening tables that had previously been maintained by Regions 3, 4, and 9. As recommended by the USEPA, these Regional SLs are to replace all other screening values.

The Regional SL Table contains risk-based screening levels derived from standardized equations (representing ingestion, dermal contact, and inhalation exposure pathways), calculated using the latest toxicity values, default exposure assumptions and physical and chemical properties. The SLs contained in the Regional SL Table are generic; they are calculated without site-specific information. Regional SLs should be viewed as Agency guidelines, not legally enforceable standards. The SLs for potentially carcinogenic chemicals are based on a target Incremental Lifetime Cancer Risk (ILCR) of $1x10^{-06}$. The SLs for noncarcinogens are based on a target hazard quotient (HQ) of 1.0. However, in order to account for cumulative risk from multiple chemicals in a medium, the noncarcinogenic SLs will be divided by a factor of ten, yielding a target HQ of 0.1. For potential carcinogens, the toxicity criteria applicable to the derivation of SL values are oral Cancer Slope Factors (CSFs) and inhalation unit risk (IUR) factors; for noncarcinogens, they are chronic oral reference doses (RfDs) and inhalation reference concentrations (RfCs). These toxicity criteria are subject to change as more updated information and results from the most recent toxicological/epidemiological studies become available. The Regional SL Table is updated periodically to reflect such changes. It should be noted that the most recent Regional SL Table update available at this time is from May 2010 (USEPA, 2010). However, the most current version available at the time the Full RFI is completed will be used for screening purposes.

4.6.2.2 Federal Drinking Water MCLs

Federal Drinking Water MCLs are enforceable standards for public water supplies promulgated under the Safe Drinking Water Act and are designed for the protection of human health. MCL Goals are calculated based on laboratory or epidemiological studies and apply to drinking water supplies consumed by a minimum of 25 persons. They are designed for prevention of human health effects associated with a lifetime exposure (70-year lifetime) of an average adult (70 kilograms [kg]) consuming 2 liters of water per day. MCLs consider both the MCL Goal and the technical feasibility of removing the contaminant from the public water supply. Accordingly, MCLs are established as

close to the MCL Goal as technically feasible (USEPA, 2010).

4.6.2.3 Puerto Rico's Water Quality Standards Regulations

Puerto Rico's water quality standards regulation (PRWQSR) establishes regulations designed to enhance maintain and preserve the quality of the waters of Puerto Rico compatible with the social and economic needs of Puerto Rico. Rule 1303 establishes water quality standards and use classifications promulgated for the protection of the uses assigned to the classifications of the coastal, surface, estuarine, wetlands, and ground waters of the Commonwealth. In Rules 1303.1 (I) (1), 1303.1 (I) (2), 1303.1 (I) (3), 1303.1 (I) (4), and1303.1 (I) (5) are identified specific substances for which numeric water quality standards have been established (PREQB, 2010).

Puerto Rico Water Quality Standards for Class SG (groundwater intended for use as a source of drinking water supply and agricultural uses including irrigation) listed in the Puerto Rico Water Quality Standards Regulation amended March 31, 2010 (PREQB, 2010) are also included as groundwater screening values. Puerto Rico's Water Quality Standard Regulations will be used in place of the Federal Drinking Water Quality Standards when more stringent.

4.6.3 Background Screening Values

For a given medium (i.e., soil, sediment, and groundwater), analytical data for inorganic chemicals exceeding one or more of the screening values (human health or ecological) will be compared to NAPR background screening values (i.e., ULM background concentrations), as presented in Table 4-5. The ULM background concentrations used in the evaluations are those derived from the inorganic data sets contained in the Revised Final II Summary Report for Environmental Background Concentrations of Inorganic Compounds (Baker, 2010). The ULM background concentrations, as well as the ecological and human health screening values, will be compared to the Full RFI analytical data to determine if the proposed sampling effort delineated the extent of soil contamination detected during the Phase I RFI.

4.7 Conclusions and Recommendations

Information from the physical and analytical results (nature and extent of contamination) will be synthesized into conclusions regarding site conditions. Recommendations will be made from these conclusions as to whether a CMS is needed or the SWMU can proceed toward corrective action complete. If the conclusions from the Full RFI indicate exceedances of human health and/or ecological screening values and background screening values, then the Full RFI Report will recommend moving the SWMU to a CMS with the preparation of a Draft CMS Work Plan. A HHRA and ERA will be conducted as part of the CMS and the CMS Work Plan will present the specific methodology that will be employed for conducting these assessments, if required.

All data discussed within this section from the laboratory will be certified by a Puerto Rican Chemist and laboratory data will be validated to ensure data usability. Only usable data will be included in the evaluation and the conclusions and recommendations sections of the report. Data validation reports will be included as an appendix to this report and will discuss:

- Overall Evaluation of the Data
- Potential Usability Issues
- Data Completeness
- Technical Holding Times
- Initial and Continuing Calibrations

- Method and QC Blanks
- Laboratory Control Samples
- Matrix Spikes
- Quantitation and Data Qualifications

Documentation generated during the reporting task will be posted to the NAPR web site under the document library. Additionally, all data obtained during the field effort will be incorporated into the web based Geographic Information System (GIS) system currently residing on the NAPR project team website. The data that is loaded onto the NAPR website is validated, and validation qualifiers are included on the website. Before the data files are uploaded to the website, the hard copy of the validation reports are checked against the validated electronic data files. Baker will also provide updates of current activities associated with this project in the RCRA Quarterly Progress Report for NAPR.

4.8 References

Source material used in the development of the Full RFI Report will be documented in the References section of the report.

5.0 SCHEDULE

A schedule for the implementation of this Work Plan, and follow-up reports for the Full RFI for SWMU 70, is provided as Figure 5-1. It should be noted that this schedule is dependent upon EPA review time. Many other factors can also extend the schedule such as if further re-characterization is required, weather delays in the field, funding is delayed by the Navy, or consensus cannot be reached on how the EPA's comments are to be incorporated.

6.0 SITE MANAGEMENT

An organization chart presenting the proposed staffing for this project is provided on Figure 6-1. This section also outlines the responsibilities and reporting requirements of field personnel and staff.

6.1 Project Team Responsibilities

Mr. Mark Kimes, P.E, Activity Manager for all work in Puerto Rico, will manage the Baker Project Team. His responsibilities will be to direct the technical performance of the project staff, costs and schedule, ensuring that QA/QC procedures are followed during the course of the project. He will maintain communication with the Navy BRAC PMO SE, Navy Technical Representative (NTR), Mr. Mark Davidson. Mr. John Mentz will administer overall QA/QC for this project.

The field activities of this project will consist of one field team managed by the Site Manager (to be determined). The Site Manager's responsibilities include directing the field team and subcontractors. Mr. Rick Aschenbrenner, P.G. will direct the reporting effort associated with the field investigation, ensuring that all necessary staffing is utilized to assist in developing the Full RFI Report for SWMU 70 – Disposal Area Northwest of Landfill.

6.2 Field Reporting Requirements

The Site Manager will maintain a daily summary of each day's field activities. The following information will be included in this summary:

- Baker and subcontractor personnel on site
- Major activities of the day
- Samples collected
- Problems encountered
- Other pertinent site information

The Site Manager will receive direction from the Project Manager regarding any changes in scope of the investigation.

7.0 REFERENCES

Michael Baker Jr., Inc. (Baker), 2009. Final Phase I RCRA Facility Investigation Report for SWMU 70. Naval Activity Puerto Rico, Ceiba, Puerto Rico. November 19, 2009.

Baker, 2010. Revised Final II Summary Report for Environmental Background Concentrations of Inorganic Compounds, Naval Activity Puerto Rico, Ceiba, Puerto Rico. July 30, 2010.

Baker, 2007. Final Phase I RCRA Facility Investigation Work Plan for SWMU 70. Naval Activity Puerto Rico, Ceiba, Puerto Rico. December 20, 2007.

Baker, 1995. Final RCRA Facility Investigation Management Plans, Naval Station Roosevelt Roads, Ceiba, Puerto Rico. September 14, 1995. Coraopolis, Pennsylvania.

Buchman, M.F. 2008. NOAA Screening Quick Reference Tables. NOAA OR&R Report 08-1. Office of Response and Restoration, Seattle, WA. 34 pp.

Canadian Council of Ministers of the Environment (CCME), 2007. Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health: Summary Tables. Updated September 2007. In: Canadian Environmental Quality Guidelines, 1999, CCME, Winnipeg. http://www.ccme.ca/assets/pdf/rev_soil_summary_tbl_7.0_e.pdf.

CCME, 2002. Canadian Sediment Quality Guidelines for the Protection of Aquatic Life: Summary Tables. Updated 2002. In: Canadian Environmental Quality Guidelines, 1999, CCME, Winnipeg. http://www.ccme.ca/publications/ceqg_rcqe.html?category_id=124.

Di Toro, D.M. and J.A. McGrath, 2000. Technical Basis for Narcotic Chemicals and Polycyclic Aromatic Hydrocarbon Criteria. II. Mixtures and Sediments. Environ. Toxicol. and Chem. 19:1971-1982.

Efroymson, R.A., Will, M.E., and Suter II, G.W., 1997a. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. (ES/ER/TM-126/R2).

Efroymson, R.A., Will, M.E., Suter II, G.W., and Wooten, A.C., 1997b. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory. Oak Ridge, TN. (ES/ER/TM-85/R3).

Environmental Laboratory, 2009. *Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Caribbean Islands Region*. ERDC/EL TR-09-8, U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

Long, E.R. and L.G. Morgan, 1991. The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program. National Oceanic and Atmospheric Administration, Seattle, WA. NOAA Technical Memorandum NOS OMA 52.

Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder, 1995. Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. Environ. Manage. 19(1):81-97.

Mac, M.J., P.A. Opler, C.E. Puckett Haecker, and P.D. Doran, 1998. Status and Trends of the Nation's Biological Resources. 2 Vols. U.S. Department of the Interior, U.S. Geological Survey,

Reston, Va. http://www.nwrc.usgs.gov/sandt/index.html.

MacDonald, D.D., 1994. Approach to the Assessment of Sediment Quality in Florida Waters: Volume 1 - Development and Evaluation of Sediment Quality Assessment Guidelines. Prepared for Florida Department of Environmental Protection, Tallahassee, Fl. November 1994.

MacDonald, D.D, C.G. Ingersoll, D.E. Smorong, R.A. Lindskoog, G. Sloane, and T. Biernacki, 2003. Development and Evaluation of Numerical Sediment Quality Assessment Guidelines for Florida Inland Waters. Prepared for Florida Department of Environmental Protection, Tallahassee, Florida. January 2003.

MacDonald, D.D., C.G. Ingersoll, T.A. Berger, 2000. Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems. Arch. Environ. Contam. Toxicol. 39:20-31.

Ministry of Housing, Spatial Planning and Environment (MHSPE), 2000. Intervention Values. Directorate-General for Environmental Protection, Department of Soil Protection, The Hague, Netherlands.

NAVFAC Atlantic, 2005. Final Phase I/II Environmental Condition of Property, Former U.S. Naval Station Roosevelt Roads, Ceiba, Puerto Rico. Norfolk, Virginia.

Naval Facilities Engineering Command, Atlantic Division (LANTDIV), 2004. Draft Phase I Environmental Condition of Property, Naval Station Roosevelt Roads, Ceiba, Puerto Rico. March 31, 2004. Norfolk, Virginia.

Persaud, D.R., R. Jaagumagi, and A. Hayton, 1993. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. Ontario Ministry of the Environment (OMOE).

PREQB, 2010, Puerto Rico Water Quality Standards Regulation. Puerto Rico Environmental Quality Board. http://www.gobierno.pr/NR/rdonlyres/B1978466-1AA0-4E48-899A-48D50311D7DF/0/Water_Quality_Standards_Reg_2010.pdf.

Tetra Tech Inc., 1986. *Development of Sediment Quality Values for Puget Sound. Vol. 1*. Bellevue, WA, 128 pp.

United States Environmental Protection Agency (USEPA), 2010. Regional Screening Levels Table. May 2010. http://epa-rgs.ornl.gov/chemicals/index.shtml

USEPA, 2009a. National Recommended Water Quality Criteria. Office of Water and Office of Science and Technology, Washington, D.C. http://www.epa.gov/waterscience/criteria/wqctable/.

USEPA, 2009b. Drinking Water Regulations and Health Advisories. Office of Water. Washington, D.C. September 2009. http://www.epa.gov/safewater/contaminants/index.html#mcls

USEPA, 2007a. RCRA § 7003 Administrative Order on Consent. In the Matter of: United States the Department of the Navy, Naval Activity Puerto Rico formerly Naval Station Roosevelt Roads, Puerto Rico. Environmental Protection Agency, EPA Docket No. RCRA-02-2007-7301. January 29, 2007.

USEPA, 2007b. ECOTOX User Guide: Ecotoxicology Database System. Version 4.0. http://www.epa.gov/ecotox/. Accessed April 7, 2008.

USEPA, 2007c. Great Lakes Initiative Toxicity Data Clearinghouse. http://www.epa.gov/gliclearinghouse/.

USEPA, 2005. Guidance for Developing Ecological Soil Screening Levels. Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-55.

USEPA, 2004. Superfund Chemical Data Matrix. http://www.epa.gov/superfund/sites/npl/hrsres/tools/scdm.htm.

USEPA, 2003. USEPA Region 5 Ecological Screening Levels Table. http://www.epa.gov/reg5rcra/ca/ESL.pdf.

USEPA, 2001. Region 4 Ecological Risk Assessment Bulletins - Supplement to RQGS. Waste Management Division, Atlanta, GA. http://www.epa.gov/region04/waste/ots/ecolbul.htm.

USEPA, 1999. Screening-Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities. EPA/530/D-99/001A.

USEPA/USACE, 1998. Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. - Testing Manual (Inland Testing Manual; ITM). Washington, D.C. EPA-823-B-98-004. February 1998.

USEPA, 1996. Ecotox Thresholds. ECO Update, Volume 3, Number 2. Office of Solid Waste and Emergency Response, Washington, D.C. EPA 540/F-95/038.

USEPA, 1993. Technical Basis for Deriving Sediment Quality Criteria for Nonionic Organic Contaminants for the Protection of Benthic Organisms by Using Equilibrium Partitioning. Office of Water, Washington, D.C. EPA-822-R-93-011.

United States Fish and Wildlife Service (USFWS), 1996. Recovery Plan for the Yellow-Shouldered Blackbird (*Agelaius xanthomus*). USFWS, Southeast Region, Atlanta, GA.

Washington State Department of Ecology, 1995. Sediment Management Standards. Chapter 173-204 WAC. Olympia, Washington.

Wentsel, R.S, T.W. Pa Point, M. Simini, R.T. Checkai, and D. Ludwig, 1996. Tri-Service Procedural Guidelines for Ecological Risk Assessments. Edgewood Research Development and Engineering Center, Aberdeen Proving Ground, MD. ADA297968.

TABLES

TABLE 2-1
LIST OF BIRDS REPORTED FROM OR HAVING THE POTENTIAL TO OCCUR AT NAVAL ACTIVITY PUERTO RICO
SWMU 70 –DISPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Common Name [(1)]		
Pied-billed grebe	Red-billed tropicbird	Brown pelican [(2)]
Brown booby	Magnificent frigatebird	Great blue heron
Louisiana heron	Snowy egret	Great egret
Striated heron	Little blue heron	Cattle egret
Least bittern	Yellow-crowned night heron	Black-crowned night heron
White-cheeked pintail	Blue-winged teal	American widgeon
Red-tailed hawk	Osprey	Merlin
Clapper rail	American coot	Caribbean coot
Common gallinule	Piping plover [(3)(4)]	Semipalmated plover
Black-bellied plover	Wilson's plover	Killdeer
Ruddy turnstone	Black-necked stilt	Whimbrel
Spotted sandpiper	Semipalmated sandpiper	Short-billed dowitcher
Greater yellowlegs	Lesser yellowlegs	Willet
Stilt sandpiper	Pectoral sandpiper	Laughing gull
Royal tern	Sandwich tern	Bridled tern
Least tern	Brown noddy	White-winged dove
Zenaida dove	White-crowned pigeon	Mourning dove
Red-necked pigeon	Common ground dove	Bridled quail dove
Ruddy quail dove	Caribbean parakeet	Smooth-billed ani
Yellow-billed cuckoo	Mangrove cuckoo	Short-eared owl
Chuck-will's-widow	Common nighthawk	Antillean crested hummingbird
Green-throated carib	Antillean mango	Belted kingfisher

TABLE 2-1
LIST OF BIRDS REPORTED FROM OR HAVING THE POTENTIAL TO OCCUR AT NAVAL ACTIVITY PUERTO RICO
SWMU 62 – FORMER BUNDY DISPOSAL AREA
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Common Name [1]		
Gray kingbird	Loggerhead kingbird	Stolid flycatcher
Caribbean elaenia	Purple martin	Cave swallow
Barn swallow	Northern mockingbird	Pearly-eyed thrasher
Red-legged thrush	Black-whiskered vireo	American redstart
Parula warbler	Prairie warbler	Yellow warbler
Magnolia warbler	Cape May warbler	Black-throated blue warbler
Adelaide's warbler	Palm warbler	Black and white warbler
Ovenbird	Northern water thrush	Bananaquit
Striped-headed tanager	Shiny cowbird	Black-cowled oriole
Greater Antillean grackle	Yellow-shouldered blackbird [2]	Hooded manakin
Yellow-faced grassquit	Black-faced grassquit	Least sandpiper
Western sandpiper	Puerto Rican woodpecker	Rock dove
Puerto Rican emerald	Puerto Rican flycatcher	Pin-tailed whydah
Spice finch	Ruddy duck	Peregrine falcon
Marbled godwit	Puerto Rican lizard cuckoo	Prothonotary warbler
Green-winged teal	Orange-cheeked waxbill	Roseate tern [3][4]
Least grebe	West Indian whistling duck	Puerto Rican screech owl
Puerto Rican tody	Green heron	

Notes:

[1] List of birds taken from Geo-Marine, Inc. (1998).
[2] Federally-designated endangered species.
[3] Federally-designated threatened species.
[4] Species has the potential to occur at Naval Activity Puerto Rico.

TABLE 3-1

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ENVIRONMENTAL SAMPLES
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO

		Analysis Requested					
Media	**Sample Depth (ft bgs)**	App IX VOCs	App IX Metals (Total)	App IX Metals (Dissolved)	AVS/SEM	TOC	**Comment**
Surface Soil Samples							
70SB09-00	0.0 - 1.0		X				
70SB10-00	0.0 - 1.0		X				
70SB11-00	0.0 - 1.0		X				
70SB12-00	0.0 - 1.0		X				
70SB12-00D	0.0 - 1.0		X				Duplicate
70SB12-00MS/MSD	0.0 - 1.0		X				Matrix Spike/Matrix Spike Duplicate
70SB13-00	0.0 - 1.0		X				
70SB14-00	0.0 - 1.0		X				
70SB15-00	0.0 - 1.0		X				
70SB16-00	0.0 - 1.0		X				
70SB17-00	0.0 - 1.0		X				
70SB18-00	0.0 - 1.0		X				
70SB19-00	0.0 - 1.0		X				
70SB20-00	0.0 - 1.0		X				
70SB21-00	0.0 - 1.0		X				
70SB22-00	0.0 - 1.0		X				
70SB23-00	0.0 - 1.0		X				
70SB24-00	0.0 - 1.0		X				
70SB24-00D	0.0 - 1.0		X				Duplicate
70SB25-00	0.0 - 1.0		X				
70SB26-00	0.0 - 1.0		X				
70SB27-00	0.0 - 1.0		X				
70SB28-00	0.0 - 1.0		X				
70SB29-00	0.0 - 1.0		X				
70SB30-00	0.0 - 1.0		X				
70SB31-00	0.0 - 1.0		X				
70SB32-00	0.0 - 1.0		X				
70SB33-00	0.0 - 1.0		X				
70SB34-00	0.0 - 1.0		X				
70SB34-00D	0.0 - 1.0		X				Duplicate
70SB34-00MS/MSD	0.0 - 1.0		X				Matrix Spike/Matrix Spike Duplicate
70SB35-00	0.0 - 1.0		X				
70SB36-00	0.0 - 1.0		X				
70SB37-00	0.0 - 1.0		X				
70SB38-00	0.0 - 1.0		X				
70SB39-00	0.0 - 1.0		X				
70SB40-00	0.0 - 1.0		X				
70SB41-00	0.0 - 1.0		X				
70SB42-00	0.0 - 1.0		X				
70SB43-00	0.0 - 1.0		X				

TABLE 3-1

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ENVIRONMENTAL SAMPLES
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO

		Analysis Requested					
Media	**Sample Depth (ft bgs)**	App IX VOCs	App IX Metals (Total)	App IX Metals (Dissolved)	AVS/SEM	TOC	**Comment**
Surface Soil Samples							
70SB44-00	0.0 - 1.0		X				
70SB44-00D	0.0 - 1.0		X				Duplicate
70SB45-00	0.0 - 1.0		X				
70SB46-00	0.0 - 1.0		X				
Subsurface Soil Samples							
70SB15-01(1)	1.0-3.0		X				
70SB16-01(1)	1.0-3.0		X				
70SB17-01(1)	1.0-3.0		X				
70SB18-01(1)	1.0-3.0		X				
70SB19-01(1)	1.0-3.0		X				
70SB20-01(1)	1.0-3.0		X				
70SB21-01(1)	1.0-3.0		X				
70SB22-01(1)	1.0-3.0		X				
70SB22-01D(1)	1.0-3.0		X				Duplicate
70SB22-01MS/MSD(1)	1.0-3.0		X				Matrix Spike/Matrix Spike Duplicate
70SB23-01(1)	1.0-3.0		X				
70SB24-01(1)	1.0-3.0		X				
70SB31-01(1)	1.0-3.0		X				
70SB32-01(1)	1.0-3.0		X				
70SB41-01(1)	1.0-3.0		X				
70SB42-01(1)	1.0-3.0		X				
70SB42-01D(1)	1.0-3.0		X				Duplicate
70SB43-01(1)	1.0-3.0		X				
70SB44-01(1)	1.0-3.0		X				
70SB45-01(1)	1.0-3.0		X				
70SB46-01(1)	1.0-3.0		X				
Groundwater Samples							
70GW01	(2)		X	X			
70GW02	(2)		X	X			
70GW03	(2)		X	X			
70GW03D	(2)		X	X			Duplicate
70GW04	(2)	X	X	X			
70GW15	(2)		X	X			
70GW16	(2)		X	X			
70GW23	(2)		X	X			
70GW24	(2)		X	X			

TABLE 3-1

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ENVIRONMENTAL SAMPLES
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO

		Analysis Requested					
Media	**Sample Depth (ft bgs)**	App IX VOCs	App IX Metals (Total)	App IX Metals (Dissolved)	AVS/SEM	TOC	**Comment**
Groundwater Samples							
70GW31	(2)	X	X	X			
70GW32	(2)	X	X	X			
70GW32D	(2)	X	X	X			Duplicate
70GW32MS/MSD	(2)	X	X	X			Matrix Spike/Matrix Spike Duplicate
70GW41	(2)		X	X			
70GW42	(2)		X	X			
70GW43	(2)		X	X			
70GW44	(2)		X	X			
70GW45	(2)		X	X			
70GW46	(2)		X	X			
Sediment Samples							
70SD09	0-0.5		X		X	X	
70SD10	0-0.5		X		X	X	
70SD11	0-0.5		X		X	X	
70SD11D	0-0.5		X		X		Duplicate
70SD11MS/MSD	0-0.5		X		X		Matrix Spike/Matrix Spike Duplicate
70SD12	0-0.5		X		X	X	
70SD13	0-0.5		X		X	X	
70SD14	0-0.5		X		X	X	
70SD15	0-0.5		X		X	X	
70SD16	0-0.5		X		X	X	
70SD17	0-0.5		X		X	X	
70SD18	0-0.5		X		X	X	
70SD19	0-0.5		X		X	X	
70SD20	0-0.5		X		X	X	
70SD21	0-0.5		X		X	X	
70SD21D	0-0.5		X		X		Duplicate
70SD22	0-0.5		X		X	X	
70SD23	0-0.5		X		X	X	
70SD24	0-0.5		X		X	X	
70SD25	0-0.5		X		X	X	
70SD26	0-0.5		X		X	X	
70SD27	0-0.5		X		X	X	

TABLE 3-1

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ENVIRONMENTAL SAMPLES
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO

		Analysis Requested					
Media	**Sample Depth (ft bgs)**	App IX VOCs	App IX Metals (Total)	App IX Metals (Dissolved)	AVS/SEM	TOC	**Comment**
Surface Water Samples							
70SW09	NA	X	X				
70SW10	NA	X	X				
70SW11	NA	X	X				
70SW11D	NA	X	X				Duplicate
70SW11MS/MSD	NA	X	X				Matrix Spike/Matrix Spike Duplicate
70SW12	NA	X	X				
70SW13	NA	X	X				
70SW14	NA	X	X				
70SW15	NA	X	X				
70SW16	NA	X	X				
70SW17	NA	X	X				
70SW18	NA	X	X				
70SW19	NA	X	X				
70SW20	NA	X	X				
70SW21	NA	X	X				
70SW21D	NA	X	X				
70SW22	NA	X	X				
Surface Water Samples							
70SW23	NA	X	X				
70SW24	NA	X	X				
70SW25	NA	X	X				
70SW26	NA	X	X				
70SW27	NA	X	X				
70SW27D	NA	X	X				Duplicate
70SW27MS/MSD	NA	X	X				Matrix Spike/Matrix Spike Duplicate

Notes:

(1) 01 - This indicates the designation for the depth interval from which the sample will be collected (i.e., 01 = 1-3 ft bgs). It is expected that only one suburface soil sample will be collected from the 1-3 ft. bgs depth. If site conditions indicate differently, the sampling program will be adjusted as well as the QA/QC outlined in Section 3.5.
(2) The depth at which to set the pump shall be determined in the field, based off the depth at which groundwater is initially encountered. Criteria for the selection of intake depth is in Section 3.2 of the Work Plan.
ft bgs - feet below ground surface.
App IX - Appendix IX
AVS - Acid Volatile Sulfides
SEM - Simultaneously Extracted Metals
NA - Not Applicable.
VOCs - Volatile Organic Compounds

TABLE 3-2

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - QA/QC SAMPLES
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

		Analysis Requested				
Sample Media	**Media**	App IX VOCs	App IX Metals	Reactivity, Corrosivity and Ignitability	TCLP Metals, TCLP VOCs	**Comment**
Trip Blank	70TB01	X				
	70TB02	X				
Equipment Rinsates	70ER01		X			Stainless Steel Spoon
	70ER02		X			Stainless Steel Spoon
	70ER03		X			Acetate Sediment Liner
	70ER04		X			Macro Core Acetate Liner
	70ER05		X			Macro Core Acetate Liner
	70ER06	X	X			Teflon-lined Polyethylene Tubing
	70ER07	X	X			Groundwater Sampling Equipment
	70ER08		X			Macro Core Acetate Liner
	70ER09		X			Aluminum Pie Pan
	70ER10		X			Macro Core Acetate Liner
Field Blanks	70FB01		X			Store Bought Distilled Water
	70FB02		X			Lab Grade Deionized Water
IDW	70IDW01			X	X	Solid
	70IDW02	X	X	X		Aqueous

Notes:
App IX - Appendix IX
TCLP - Toxicity Characteristic Leaching Procedure
IDW - Investigation Derived Waste
VOC - Volatile Organic Compounds

TABLE 3-3

METHOD PERFORMANCE LIMITS
APPENDIX IX COMPOUND LIST AND CONTRACT
REQUIRED QUANTITATION LIMITS (CRQL)
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

	Quantitation Limits*				Preparation Methods	
Volatiles	**Water (µg/L)**	**Low Soil (µg/kg)**	**Method Description**	**Method Number**	**Water**	**Soil**
Acetone	25	50	Gas Chromotography/Mass Spectrometry (GC/MS)	8260B (5030B)(low level)	5030 B	5035
Acetonitrile	40	200	GC/MS	8260B (5030B)(low level)	5030 B	5035
Acrolein	20	100	GC/MS	8260B (5030B)(low level)	5030 B	5035
Acrylonitrile	20	100	GC/MS	8260B (5030B)(low level)	5030 B	5035
Benzene	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
Bromodichloromethane	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
Bromoform	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
Bromomethane	1.0	10	GC/MS	8260B (5030B)(low level)	5030 B	5035
Carbon Disulfide	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
Carbon Tetrachloride	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
Chlorobenzene	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
Chloroethane	1.0	10	GC/MS	8260B (5030B)(low level)	5030 B	5035
Chloroform	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
Chloromethane	1.0	10	GC/MS	8260B (5030B)(low level)	5030 B	5035
Chloroprene	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
3-Chloro-1-propene	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
1,2-Dibromo-3-chloroprop	1.0	10	GC/MS	8260B (5030B)(low level)	5030 B	5035
Dibromochloromethane	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
1,2-Dibromoethane	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
Dibromomethane	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
trans-1,4-Dichloro-2-buten	2.0	10	GC/MS	8260B (5030B)(low level)	5030 B	5035
Dichlorodifluoromethane	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
1,1-Dichloroethane	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
1,2-Dichloroethane	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
trans-1,2-dichloroethene	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
1,1-Dichloroethene	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
Methylene Chloride	5.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
1,2-Dichloropropane	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
cis-1,3-Dichloropropene	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
trans-1,3-Dichloropropene	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
Ethyl benzene	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
Ethyl methacrylate	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
2-Hexanone	10	25	GC/MS	8260B (5030B)(low level)	5030 B	5035
Iodomethane	5.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
Isobutanol	40	200	GC/MS	8260B (5030B)(low level)	5030 B	5035
Methacrylonitrile	20	100	GC/MS	8260B (5030B)(low level)	5030 B	5035
2-Butanone	10	25	GC/MS	8260B (5030B)(low level)	5030 B	5035
Methyl methacrylate	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
4-Methyl-2-pentanone	10	25	GC/MS	8260B (5030B)(low level)	5030 B	5035
Pentachloroethane	5.0	25	GC/MS	8260B (5030B)(low level)	5030 B	5035
Propionitrile	20	100	GC/MS	8260B (5030B)(low level)	5030 B	5035
Stryene	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
1,1,1,2-Tetrachloroethane	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035

TABLE 3-3

METHOD PERFORMANCE LIMITS
APPENDIX IX COMPOUND LIST AND CONTRACT
REQUIRED QUANTITATION LIMITS (CRQL)
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

	Quantitation Limits*				Preparation Methods	
Volatiles (Cont.)	**Water (µg/L)**	**Low Soil (µg/kg)**	**Method Description**	**Method Number**	**Water**	**Soil**
1,1,2,2-Tetrachloroethane	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
Tetrachloroethene	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
Toluene	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
1,1,1-Trichloroethane	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
1,1,2-Trichloroethane	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
Trichloroethene	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
Trichlorofluoromethane	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
1,2,3-Trichloropropane	1.0	5.0	GC/MS	8260B (5030B)(low level)	5030 B	5035
Vinyl Acetate	2.0	10	GC/MS	8260B (5030B)(low level)	5030 B	5035
Vinyl Chloride	2.0	10	GC/MS	8260B (5030B)(low level)	5030 B	5035
Xylene	2.0	10	GC/MS	8260B (5030B)(low level)	5030 B	5035
	Quantitation Limits*				**Preparation Methods**	
Inorganics	**Water (µg/L)**	**Low Soil (mg/kg)**	**Method Description**	**Method Number**	**Water**	**Soil**
Antimony	20	2.0	Inductively Coupled Plasma	6020A	3010A	3050B
Arsenic	10	1.0	Inductively Coupled Plasma	6020A	3010A	3050B
Barium	10	1.0	Inductively Coupled Plasma	6020A	3010A	3050B
Beryllium	4.0	0.4	Inductively Coupled Plasma	6020A	3010A	3050B
Cadmium	5.0	0.5	Inductively Coupled Plasma	6020A	3010A	3050B
Chromium	10	1.0	Inductively Coupled Plasma	6020A	3010A	3050B
Cobalt	10	1.0	Inductively Coupled Plasma	6020A	3010A	3050B
Copper	20	2.0	Inductively Coupled Plasma	6020A	3010A	3050B
Lead	5.0	0.5	Inductively Coupled Plasma	6020A	3010A	3050B
Mercury	0.2	0.02	Cold Vapor AA	7470A/7471A	3010A	7471A
Nickel	40	4.0	Inductively Coupled Plasma	6020A	3010A	3050B
Selenium	10	1.0	Inductively Coupled Plasma	6020A	3010A	3050B
Silver	10	1.0	Inductively Coupled Plasma	6020A	3010A	3050B
Thallium	10	1.0	Inductively Coupled Plasma	6020A	3010A	3050B
Tin	10	5.0	Inductively Coupled Plasma	6020A	3010A	3050B
Vanadium	10	1.0	Inductively Coupled Plasma	6020A	3010A	3050B
Zinc	20	2.0	Inductively Coupled Plasma	6020A	3010A	3050B
	Quantitation Limits*				**Preparation Methods**	
AVS/SEM Metals	**Water**	**Soil (umol/g)**	**Method Description**	**Method Number**	**Water**	**Soil**
Cadmium	N/A	0.00089	SEM/ICP	6010C	N/A	821/R-91-100
Chromium	N/A	0.024	SEM/ICP	6010C	N/A	821/R-91-100
Copper	N/A	0.0079	SEM/ICP	6010C	N/A	821/R-91-100
Lead	N/A	0.0012	SEM/ICP	6010C	N/A	821/R-91-100
Nickel	N/A	0.0085	SEM/ICP	6010C	N/A	821/R-91-100
Silver	N/A	0.0023	SEM/ICP	6010C	N/A	821/R-91-100
Zinc	N/A	0.019	SEM/ICP	6010C	N/A	821/R-91-100

TABLE 3-3

METHOD PERFORMANCE LIMITS
APPENDIX IX COMPOUND LIST AND CONTRACT
REQUIRED QUANTITATION LIMITS (CRQL)
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

	Quantitation Limits*				Preparation Methods	
Reactivity, Corrosivity, Ignitibility	**Water (µg/L)**	**Soil (µg/kg)**	**Method Description**	**Method Number**	**Water**	**Soil**
Cyanide	0.01	0.62	Titrimetric	9012A	9012A	9012A
Flashpoint	NA	NA	Pensky-Martens Closed Cup Tester	1010A/1030	NA	NA
pH	NA	NA	Electrometric	9040C/9045D	NA	NA
Sulfide	1.0	1.0	Titrimetric	9034	NA	9030B
	Quantitation Limits*				**Preparation Methods**	
Toxicity Characteristic Leaching Procedure	**Water (ug/L)**	**Soil (ug/kg)**	**Method Description**	**Method Number**	**Water**	**Soil**
TCLP Volatiles	NA	20	NA	1311	NA	1311/3010A
Total Organic Carbon	**Water (mg/L)**	**Soil (mg/kg)**	**Method Description**	**Method Number**	**Water**	**Soil**
TOC	NA	1	NA	9060	NA	NA
	Quantitation Limits*				**Preparation Methods**	
TCLP Metals	**Water (ug/L)**	**Soil (ug/kg)**	**Method Description**	**Method Number**	**Water**	**Soil**
Arsenic	10	1.0	TCLP/ICP	6010C(3050/3010)	NA	1311/3010A
Barium	10	1.0	TCLP/ICP	6010C(3050/3010)	NA	1311/3010A
Cadmium	5	0.50	TCLP/ICP	6010C(3050/3010)	NA	1311/3010A
Chromium	10	1.0	TCLP/ICP	6010C(3050/3010)	NA	1311/3010A
Lead	5	0.50	TCLP/ICP	6010C(3050/3010)	NA	1311/3010A
Mercury	0.2	0.020	Cold Vapor AA	7471A/7470A	NA	1311/7470A
Selenium	10	1.0	TCLP/ICP	6010C(3050/3010)	NA	1311/3010A
Silver	10	1.0	TCLP/ICP	6010C(3050/3010)	NA	1311/3010A

Notes:

* Quantitation limits listed for soil are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis, will be higher.

µg/L - micrograms per liter.
µg/kg - micrograms per kilogram.
mg/L - micorgrams per liter
mg/kg - milligrams per kilogram.
umole/g - micormoles per gram
AVS - Acid Volatile Sulfides
SEM - Simultaneously Extracted Metals
TCLP - Toxicity Characteristic Leaching Procedure

TABLE 4-1
ECOLOGICAL SOIL SCREENING VALUES
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Surface Soil Screening Value	Reference	Comment
Metals (mg/kg):			
Antimony	10.0	USEPA 2005a	Ecological soil screening level for mammalian herbivores
Arsenic	18.0	USEPA 2005b	Ecological soil screening level for plants
Barium	330	USEPA 2005c	Ecological soil screening level for soil invertebrates
Beryllium	21.0	USEPA 2005d	Ecological soil screening level for mammalian herbivores
Cadmium	0.77	USEPA 2005e	Ecological soil screening level for avian ground insectivores
Chromium	26.0	USEPA 2008	Ecological soil screening level for avian ground insectivores
Cobalt	13.0	USEPA 2005f	Ecological soil screening level for plants
Copper	28.0	USEPA 2007b	Ecological soil screening level for avian ground insectivores
Lead	11.0	USEPA 2005g	Ecological soil screening level for avian ground insectivores
Mercury	0.10	Efroymson et al. 1997a	Toxicological threshold for earthworms
Nickel	38.0	USEPA 2007c	Ecological soil screening level for plants
Selenium	0.52	USEPA 2007d	Ecological soil screening level for plants
Silver	4.2	USEPA 2006	Ecological soil screening level for avian ground insectivores
Thallium	1.00	Efroymson et al. 1997b	Toxicological threshold for plants
Tin	50.0	Efroymson et al. 1997b	Toxicological threshold for plants
Vanadium	7.8	USEPA 2005h	Ecological soil screening level for avian ground insectivores
Zinc	46.0	USEPA 2007e	Ecological soil screening level for avian ground insectivores

Notes:
USEPA = United States Environmental Protection Agency
PAH = Polynuclear Aromatic Hydrocarbon
ug/kg = microgram per kilogram
mg/kg = milligram per kilogram

TABLE 4-1
ECOLOGICAL SOIL SCREENING VALUES
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Table References:

Efroymson, R.A., M.E. Will, and G.W. Suter II. 1997a. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revisions. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-126/R2.

Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. 1997b. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revisions. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-85/R3

United States Environmental Protection Agency (USEPA). 2008. Ecological Soil Screening Levels for Chromium (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-66.

USEPA. 2007a. Ecological Soil Screening Levels for Polycyclic Aromatic Hydrocarbons (PAHs) (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-78.

USEPA. 2007b. Ecological Soil Screening Levels for Copper (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-68.

USEPA 2007c. Ecological Soil Screening Levels for Nickel (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-76.

USEPA. 2007d. Ecological Soil Screening Levels for Selenium (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-72.

USEPA. 2007e. Ecological Soil Screening Levels for Zinc (Interim Final). Office of Solid Waste and Emergecny Response, Washington, D.C. OSWER Directive 9285.7-73.

USEPA. 2006. Ecological Soil Screening Levels for Silver (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWEER Directive 9285.7-77.

USEPA. 2005a. Ecological Soil Screening Levels for Antimony (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-61.

USEPA. 2005b. Ecological Soil Screening Levels for Arsenic (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-62.

USEPA. 2005c. Ecological Soil Screening Levels for Barium (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-63.

USEPA. 2005d. Ecological Soil Screening Levels for Beryllium (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-64.

USEPA. 2005e. Ecological Soil Screening Levels for Cadmium (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-65.

USEPA. 2005f. Ecological Soil Screening Levels for Cobalt (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-67

USEPA. 2005g. Ecological Soil Screening Levels for Lead (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-70.

USEPA. 2005h. Ecological Soil Screening Levels for Vanadium (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-75.

TABLE 4-2
ECOLOGICAL GROUNDWATER SCREENING VALUES
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Surface Water Screening Value [1]	Reference	Comment [2]
Metals - Toal Recoverable Fraction (ug/L):			
Antimony	500	Buchman 2008	Proposed CCC
Arsenic	36.0	PREQB 2010/USEPA 2009	Total recoverable Puerto Rico Water Quality Standard/Total recoverable Critria Continuous Concentration
Barium	16,667	USEPA 2007	Minimum acute value (96-hr NOEC for *Cyprinodon variegatus* [sheepshead minnow]) with a safety factor of 30
Beryllium	310	USEPA 2007	Minimum acute value (96-hr LC_{50} for *Fundulus heteroclitus* [mummichog]) with a safety factor of 100
Cadmium	8.85	PREQB 2010/USEPA 2009	Total recoverable Puerto Rico Water Quality Standard/Total recoverable Critria Continuous Concentration
Chromium	50.4	PREQB 2010/USEPA 2009	Total recoverable Puerto Rico Water Quality Standard/Criteria Continuous Concentration for hexavalent chromium
Cobalt	45.0	USEPA 2007	Minimum acute value (96-hr LC_{50} for *Nitocra spinipes* [Harpacticoid copepod]) with a safety factor of 100
Copper	3.73	PREQB 2010/USEPA 2009	Total recoverable Puerto Rico Water Quality Standard/Total recoverable Critria Continuous Concentration
Lead	8.52	PREQB 2010/USEPA 2009	Total recoverable Puerto Rico Water Quality Standard/Total recoverable Critria Continuous Concentration
Mercury	1.11	USEPA 2009	Total recoverable Criteria Continuous Concentration
Nickel	8.28	PREQB 2010/USEPA 2009	Total recoverable Puerto Rico Water Quality Standard/Total recoverable Critria Continuous Concentration
Selenium	71.1	PREQB 2010/USEPA 2009	Total recoverable Puerto Rico Water Quality Standard/Total recoverable Critria Continuous Concentration
Silver	2.24	PREQB 2010	Total recoverable Puerto Rico Water Quality Standard
Thallium	21.3	USEPA 2001	USEPA Region 4 chronic screening value
Tin	180 [3]	USEPA 2003	USEPA Region 5 ecological screening level
Vanadium	12.0 [3]	USEPA 2003	USEPA Region 5 ecological screening level
Zinc	85.6	PREQB 2010/USEPA 2009	Total recoverable Puerto Rico Water Quality Standard/Total recoverable Critria Continuous Concentration
Metals - Dissolved Fraction (ug/L):			
Antimony	500 [4]	Buchman 2008	Proposed Criteria Continuous Concentration
Arsenic	36.0	USEPA 2009	Dissolved Criteria Continuous Concentration for trivalent arsenic
Barium	16,667 [4]	USEPA 2007	Minimum acute value (96-hr NOEC for *Cyprinodon variegatus* [sheepshead minnow]) with a safety factor of 30
Beryllium	310 [4]	USEPA 2007	Minimum acute value (96-hr LC_{50} for *Fundulus heteroclitus* [mummichog]) with a safety factor of 100
Cadmium	8.8	USEPA 2009	Dissolved Criteria Continuous Concentration
Chromium	50.0	USEPA 2009	Dissolved Criteria Continuous Concentration for hexavalent chromium
Cobalt	45.0 [4]	USEPA 2007	Minimum acute value (96-hr LC_{50} for *Nitocra spinipes* [Harpacticoid copepod]) with a safety factor of 100
Copper	3.1	USEPA 2009	Dissolved Criteria Continuous Concentration
Lead	8.1	USEPA 2009	Dissolved Criteria Continuous Concentration
Mercury	0.94	USEPA 2009	Dissolved Criteria Continuous Concentration

TABLE 4-2
ECOLOGICAL GROUNDWATER SCREENING VALUES
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Surface Water Screening Value [1]	Reference	Comment [2]
Metals - Dissolved Fraction (ug/L) continued:			
Nickel	8.2	USEPA 2009	Dissolved Criteria Continuous Concentration
Selenium	71.0	USEPA 2009	Dissolved Criteria Continuous Concentration
Silver	2.24 [4]	PREQB 2010	Total recoverable Puerto Rico Water Quality Standard
Thallium	21.3 [4]	USEPA 2001	USEPA Region 4 chronic screening value
Tin	180 [3][4]	USEPA 2003	USEPA Region 5 ecological screening level
Vanadium	12.0 [3][4]	USEPA 2003	USEPA Region 5 ecological screening level
Zinc	81.0	USEPA 2009	Dissolved Criteria Continuous Concentration

Notes:

NA = Not Available
USEPA = United States Environmental Protection Agency
µg/L = microgram per liter

[1] The values shown are marine/estuarine screening values unless otherwise noted.

[2] The safety factors applied to acute endpoints (i.e., LC_{50}, EC_{50}, NOEC, and LOEL values) and chronic endpoints (i.e., LOELs) are those recommended by Wentsel et al. (1996).

[3] The chemical lacks a marine/estuarine surface water screening value/literature-based toxicity value. The value shown is a freshwater screening value/toxicity value.

[4] The chemical lacks a screening value expressed as a dissolved concentration. The value shown is expressed as a total recoverable concentration.

Table References:

Buchman, M.F. 2008. NOAA Screening Quick Reference Tables. NOAA OR&R Report 08-1. National Oceanic and Atmospheric Administration, Office of Response

Puerto Rico Environmental Quality Board (PREQB). 2010. Puerto Rico Water Quality Standards Regulation. March 31, 2010.

Wentsel, R.S., T.W. Pa Point, M. Simini, R.T. Checkai, and D. Ludwig. 1996. Tri-Service Procedural Guidelines for Ecological Risk Assessments. Edgewood Research Aberdeen Proving Ground, MD. ADA297968.

USEPA. 2009. National Recommended Water Quality Criteria. Office of Water and Office of Science and Technology, Washington, D.C. http://www.epa.gov/waterscience/criteria/wqctable/.

TABLE 4-2
ECOLOGICAL GROUNDWATER SCREENING VALUES
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Table References (continued) :

USEPA. 2007. ECOTOX User Guide: Ecotoxicology Database System. Version 4.0. http:/www.epa.gov/ecotox/. Accessed May 14, 2003, July 2, 2008, January 8, 2009, April 1, 2009, and August 28, 2009.

USEPA. 2003. USEPA Region 5 Ecological Screening Levels Table. http://www.epa.gov/reg5rcra/ca/ESL.pdf.

USEPA. 2001. Region 4 Ecological Risk Assessment Bulletins - Supplement to RQGS. Waste Management Division, Atlanta, GA. http://www.epa.gov/region04/waste/ots/ecolbul.htm.

TABLE 4-3
ECOLOGICAL SEDIMENT SCREENING VALUES
SWMU 70 - DIPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value [1]	Reference	Comment [2][3]
Metals (mg/kg):			
Antimony	2.00	Long and Morgan 1991	Effects Range-Low
Arsenic	7.24	MacDonald 1994	Threshold Effect Level
Barium	48.0	Buchman 2008	Minimum Apparent Effects Threshold (amphipod)
Beryllium	NA	---	---
Cadmium	0.676	MacDonald 1994	Threshold Effect Level
Chromium, total	52.3	MacDonald 1994	Threshold Effect Level
Cobalt	10.0	Buchman 2008	Minimum Apparent Effects Threshold (Neanthes bioassays)
Copper	18.7	MacDonald 1994	Threshold Effect Level
Lead	30.2	MacDonald 1994	Threshold Effect Level
Mercury	0.13	MacDonald 1994	Threshold Effect Level
Nickel	15.9	MacDonald 1994	Threshold Effect Level
Selenium	1.00	Buchman 2008	Minimum Apparent Effects Threshold (amphipod)
Silver	0.733	MacDonald 1994	Threshold Effect Level
Thallium	NA	---	---
Tin	3.40	Buchman 2008	Minimum Apparent Effects Threshold (Neanthes bioassays)
Vanadium	57.0	Buchman 2008	Minimum Apparent Effects Threshold (Neanthes bioassays)
Zinc	124	MacDonald 1994	Threshold Effect Level

Notes:
ug/kg = microgram per kilogram
mg/kg = milligram per kilogram

(1) The values shown are marine and estuarine screening values unless otherwise noted.

(2) EqP-based sediment screening values calculated using USEPA (1993 and 1996) methodology: $SV_{sed} = (K_{oc})(f_{oc})(SV_{sw})$ where K_{oc} is the organic carbon partition coefficient (L/kg), f_{oc} is the fraction of organic carbon (unitless), and SV_{sw} is the surface water screening value (ug/L). An f_{oc} of 0.01 was assumed.

(3) EqP-based sediment screening values from Di Toro and McGrath (2000) are based on an assumed f_{oc} of 0.01.

TABLE 4-3
ECOLOGICAL SEDIMENT SCREENING VALUES
SWMU 70 - DIPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Table References:

Buchman, M.F. 2008. NOAA Screening Quick Reference Tables. NOAA OR&R Report 08-1. National Oceanic and Atmospheric Administration, Office of Response and Restoration Division, Seattle, WA.

Di Toro, D.M. and J.A. McGrath. 2000. Technical Basis for Narcotic Chemicals and Polycyclic Aromatic Hydrocarbon Criteria. II. Mixtures and Sediments. Environ. Toxicol. and Chem. 19:1971-1982.

Long, E.R. and L.G. Morgan. 1991. The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program. National Oceanic and Atmospheric Administration, Seattle, WA. NOAA Technical Memorandum NOS OMA 52.

MacDonald, D.D. 1994. Approach to the Assessment of Sediment Quality in Florida Waters: Volume 1 - Development and Evaluation of Sediment Quality Assessment Guidelines. Prepared for Florida Department of Environmental Protection, Tallahassee, Fl. November 1994.

USEPA. 1996. Ecotox Thresholds. Eco Update, Volume 3, Number 2. Office of Solid Waste and Emergency Response, Washington, D.C. EPA/F-95/038.

USEPA. 1993. Technical Basis for Deriving Sediment Quality Criteria for Nonionic Organic Contaminants for the Protection of Benthic Organisms by Using Equilibrium Partitioning. Office of Water, Washington, D.C. EPA-822-R-93-011.

TABLE 4-4

HUMAN HEALTH SCREENING VALUES
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Regional Screening Levels Residential Soil [(1)(2)]	(units)	Regional Screening Levels Industrial Soil [(1)(2)]	(units)	Regional Screening Levels Tap Water [(1)(3)]	(units)	USEPA MCLs/ PR WQS [(4)]	(units)
Volatile Organics								
Acetone	NA		NA		2,200 [(5)]	ug/L	NE	
Acetonitrile	NA		NA		13 [(5)]	ug/L	NE	
Acrolein	NA		NA		0.0042 [(5)]	ug/L	NE	
Acrylonitrile	NA		NA		0.045	ug/L	NE	
Benzene	NA		NA		0.41	ug/L	5	ug/L
Bromodichloromethane	NA		NA		0.12	ug/L	80	ug/L
Bromoform	NA		NA		9	ug/L	80	ug/L
Bromomethane	NA		NA		1 [(5)]	ug/L	NE	
Carbon Disulfide	NA		NA		100 [(5)]	ug/L	NE	
Carbon Tetrachloride	NA		NA		0.44	ug/L	5	ug/L
Chlorobenzene	NA		NA		9 [(5)]	ug/L	100	ug/L
Chloroethane	NA		NA		2,100 [(5)]	ug/L	NE	
Chloroform	NA		NA		0.19	ug/L	80	ug/L
Chloromethane	NA		NA		19 [(5)]	ug/L	NE	
Chloroprene	NA		NA		1 [(5)]	ug/L	NE	
3-Chloro-1-propene	NA		NA		0.21 [(5)]	ug/L	NE	
1,2-Dibromo-3-chloropropane	NA		NA		0.00032	ug/L	0.2	ug/L
Dibromochloromethane	NA		NA		0.15	ug/L	80	ug/L
1,2-Dibromoethane	NA		NA		0.01	ug/L	0.05	ug/L
Dibromomethane	NA		NA		1 [(5)]	ug/L	NE	
trans-1,4-Dichloro-2-butene	NA		NA		0.0012	ug/L	NE	
Dichlorodifluoromethane	NA		NA		39 [(5)]	ug/L	NE	
1,1-Dichloroethane	NA		NA		2	ug/L	NE	
1,2-Dichloroethane	NA		NA		0.15	ug/L	5	ug/L
trans-1,2-dichloroethene	NA		NA		11 [(5)]	ug/L	100	ug/L
1,1-Dichloroethene	NA		NA		34 [(5)]	ug/L	7	ug/L
Methylene Chloride	NA		NA		5	ug/L	5	ug/L
1,2-Dichloropropane	NA		NA		0.39	ug/L	5	ug/L
cis-1,3-Dichloropropene	NA		NA		0.43 [(6)]	ug/L	NE	
trans-1,3-Dichloropropene	NA		NA		0.43 [(6)]	ug/L	NE	

TABLE 4-4

HUMAN HEALTH SCREENING VALUES
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Regional Screening Levels Residential Soil (1)(2)	(units)	Regional Screening Levels Industrial Soil (1)(2)	(units)	Regional Screening Levels Tap Water (1)(3)	(units)	USEPA MCLs/ PR WQS (4)	(units)
Volatile Organics (continued)								
Ethyl benzene	NA		NA		2	ug/L	700	ug/L
Ethyl methacrylate	NA		NA		330 (5)	ug/L	NE	
2-Hexanone	NA		NA		5 (5)	ug/L	NE	
Iodomethane	NA		NA		NE		NE	
Isobutanol	NA		NA		1,100 (5)	ug/L	NE	
Methacrylonitrile	NA		NA		0.1 (5)	ug/L	NE	
2-Butanone	NA		NA		710 (5)	ug/L	NE	
Methyl methacrylate	NA		NA		140 (5)	ug/L	NE	
4-Methyl-2-pentanone	NA		NA		200 (5)	ug/L	NE	
Pentachloroethane	NA		NA		1	ug/L	NE	
Propionitrile	NA		NA		NE		NE	
Styrene	NA		NA		160 (5)	ug/L	100	ug/L
1,1,1,2-Tetrachloroethane	NA		NA		1	ug/L	NE	
1,1,2,2-Tetrachloroethane	NA		NA		0.067	ug/L	NE	
Tetrachloroethene	NA		NA		0.11	ug/L	5	ug/L
Tetrachloroethene	NA		NA		0.11	ug/L	5	ug/L
Toluene	NA		NA		230 (5)	ug/L	1,000	ug/L
1,1,1-Trichloroethane	NA		NA		910 (5)	ug/L	200	ug/L
1,1,2-Trichloroethane	NA		NA		0.24	ug/L	5	ug/L
Trichloroethene	NA		NA		2	ug/L	5	ug/L
Trichlorofluoromethane	NA		NA		130 (5)	ug/L	NE	
1,2,3-Trichloropropane	NA		NA		0.001	ug/L	NE	
Vinyl Acetate	NA		NA		41 (5)	ug/L	NE	
Vinyl Chloride	NA		NA		0.016	ug/L	2	ug/L
Xylene	NA		NA		20 (5)	ug/L	10,000	ug/L
Metals								
Antimony	3 (5)	mg/kg	41 (5)	mg/kg	2 (5)	ug/L	5.6 (10)	ug/L
Arsenic	0.39	mg/kg	2	mg/kg	0.045	ug/L	10	ug/L
Barium	1,500 (5)	mg/kg	19,000 (5)	mg/kg	730 (5)	ug/L	2,000	ug/L

TABLE 4-4

HUMAN HEALTH SCREENING VALUES
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Regional Screening Levels Residential Soil [1][2]	(units)	Regional Screening Levels Industrial Soil [1][2]	(units)	Regional Screening Levels Tap Water [1][3]	(units)	USEPA MCLs/ PR WQS [4]	(units)
Metals (continued)								
Beryllium	16 [5]	mg/kg	200 [5]	mg/kg	7 [5]	ug/L	4	ug/L
Cadmium	7 [5]	mg/kg	80 [5]	mg/kg	2 [5]	ug/L	5	ug/L
Chromium	12,000 [5][7]	mg/kg	150,000 [5][7]	mg/kg	5,500 [5][7]	ug/L	100	ug/L
Cobalt	2 [5]	mg/kg	30 [5]	mg/kg	1 [5]	ug/L	NE	
Copper	310 [5]	mg/kg	4,100 [5]	mg/kg	150 [5]	ug/L	1,300	ug/L
Lead	400 [8]	mg/kg	800 [8]	mg/kg	15 [9]	ug/L	15	ug/L
Mercury	1 [5]	mg/kg	3 [5]	mg/kg	0.057 [5]	ug/L	0.05 [10]	ug/L
Nickel	150 [5]	mg/kg	2,000 [5]	mg/kg	73 [5]	ug/L	610 [10]	
Selenium	39 [5]	mg/kg	510 [5]	mg/kg	18 [5]	ug/L	50	ug/L
Silver	39 [5]	mg/kg	510 [5]	mg/kg	18 [5]	ug/L	NE	
Thallium	NE		NE		2 [9]	ug/L	0.24 [10]	ug/L
Tin	4,700 [5]	mg/kg	61,000 [5]	mg/kg	2,200 [5]	ug/L	NE	
Vanadium	1 [5]	mg/kg	7 [5]	mg/kg	0.26 [5]	ug/L	NE	
Zinc	2,300 [5]	mg/kg	31,000 [5]	mg/kg	1,100 [5]	ug/L	NE	

Notes:

ug/L - microgram per liter
ug/kg - microgram per kilogram
mg/kg - milligram per kilogram
USEPA - United States Environmental Protection Agency
NA - Not applicable
MCL - Maximum Contaminant Level
NE - Not established
PR - Puerto Rico
WQS - Water Quality Standards

[1] USEPA Regional Screening Levels (May 2010)

[2] USEPA Regional Screening Levels for Soil also used for sediment in absence of sediment-specific screening values.

[3] USEPA Regional Screening Levels for Tap Water also used for surface water in absence of surface water-specific screening values.

[4] The more stringent of the USEPA MCL or PR WQS is listed.

[5] Noncarcinogenic Regional Screening Levels based on a target hazard quotient of 0.1 for conservative screening purposes.

[6] Value for total 1,3-dichloropropene used as a surrogate.

[7] Value for chromium III used as a surrogate.

[8] USEPA Action Level for lead in soil.

[9] Value for MCL used as surrogate.

[10] Value designated by PREQB WQS for protection of water body for reasons of human health.

TABLE 4-5
NAPR BACKGROUND SCREENING VALUES
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

	Surface Soil (mg/kg)	Subsurface Soil Fine Sand/Silt (mg/kg)	Sediment (mg/kg)
Metals	**Upper Limit of Means (x+2s)**	**Upper Limit of Means (x+2s)**	**Upper Limit of Means (x+2s)**
Antimony	3.17	7.44	3.25
Arsenic	2.65	6.66	7.0
Barium	199	207	24.9
Beryllium	0.590	0.933	0.550
Cadmium	1.02	0.57	1.23
Chromium	49.8	47.9	50.1
Cobalt	46.2	63.1	22.3
Copper	168	120	132
Lead	22.0	6.2	25.4
Mercury	0.109	0.067	0.168
Nickel	20.7	26.5	17.3
Selenium	1.48	1.19	1.51
Silver	--	--	2.41
Thallium	--	--	--
Tin	3.76	3.47	10.44
Vanadium	259	256	230
Zinc	115	92	96.9

Notes:
(--) - Could not be calculated (insufficient number of detections)

Reference: Baker, 2010. *Revised Final II Summary Report for Environmental* Background Concentrations of Inorganic Compounds, Naval Station Roosevelt Roads, Ceiba, Puerto Rico. February 29, 2008.

FIGURES

K:_SOUTHNAVFAC\AA9A97 JM01\SWMU 70\CADD\111626_RFI_70_01.DWG

4 0 2 4 8

1 inch = 4 miles

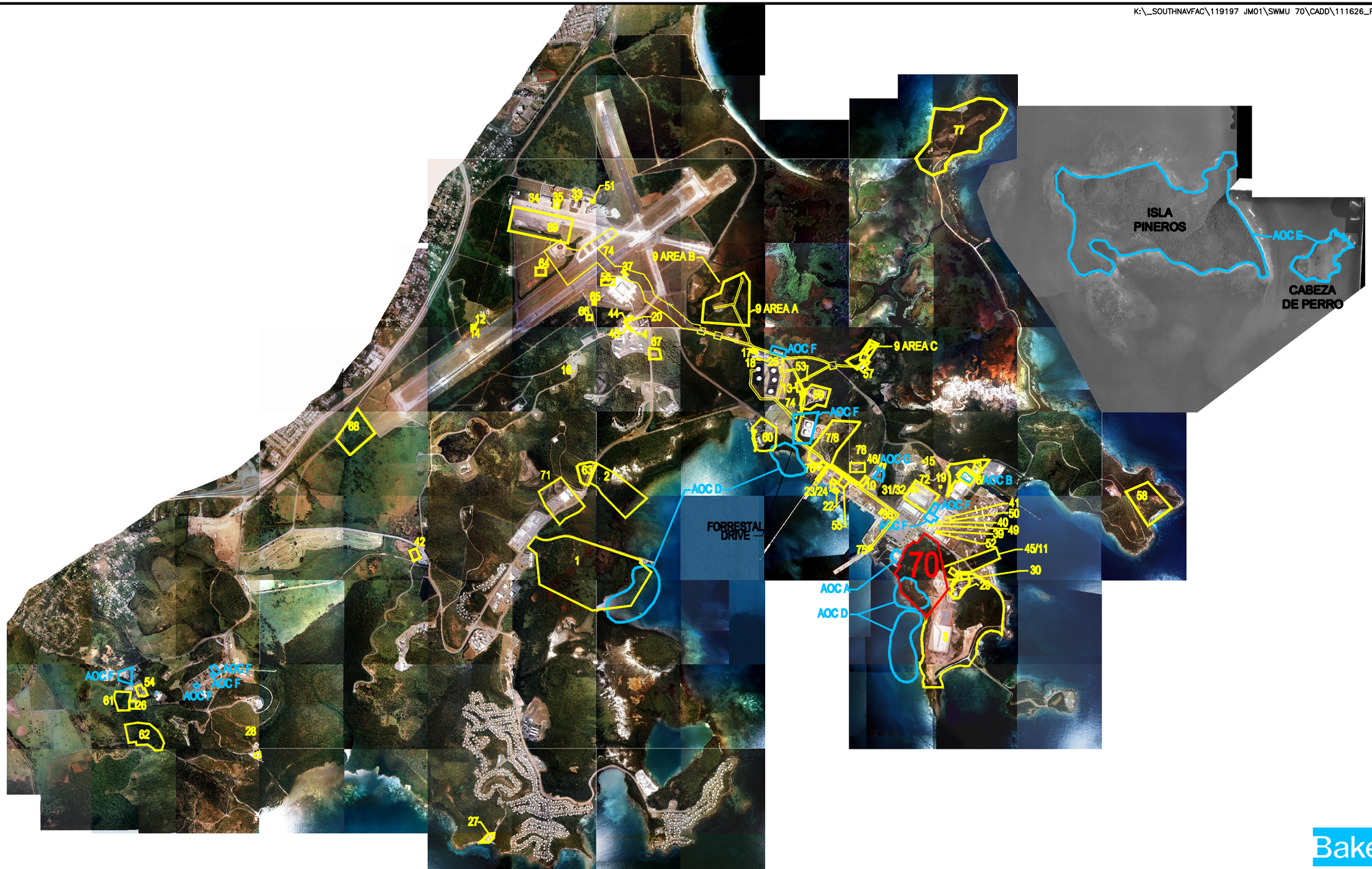
Baker

FIGURE 1-1
REGIONAL LOCATION MAP
SWMU 70-DISPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN

SOURCE: METRODATA, INC., 1999.

NAVAL ACTIVITY PUERTO RICO

K:_SOUTHNAVFAC\119197 JM01\SWMU 70\CADD\111626_RFI_70_02.DWG



Baker

LEGEND

1 – SWMUs

70 – AREA TO WHICH THIS INVESTIGATION PERTAINS

AOC D – AOCs

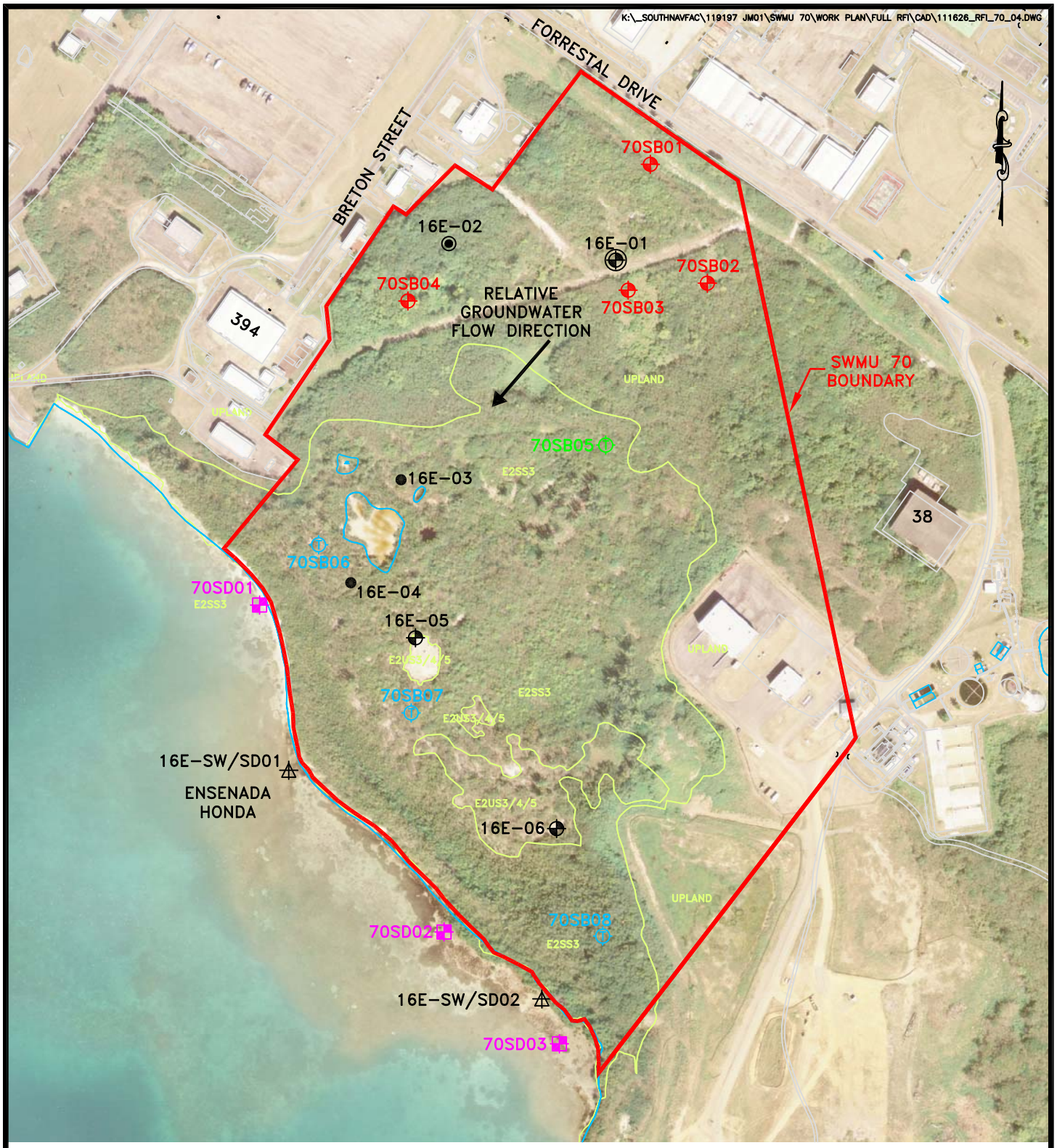
SOURCE: GEO-MARINE, INC., SEPTEMBER 6, 2000.

3000 0 1500 3000

1 inch = 3000 ft.

FIGURE 1-2
SWMU/AOC LOCATION MAP
SWMU 70-DISPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN

NAVAL ACTIVITY PUERTO RICO



350 0 175 350

1 inch = 350 ft.

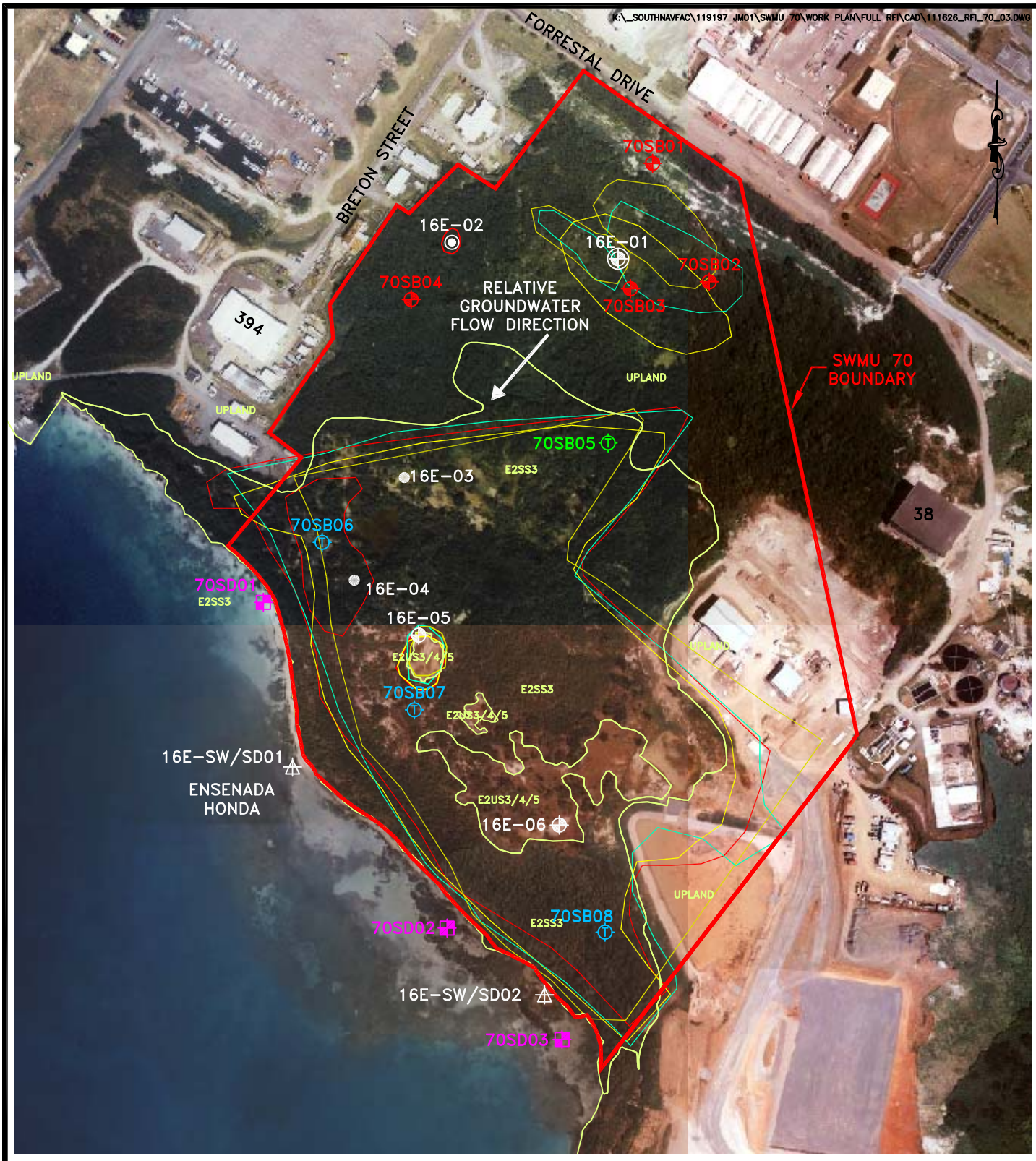
SOURCE: USGS, NOV, 2006.

Baker

LEGEND

- —WATER BOUNDARY
- —SWMU BOUNDARY
- —ESTUARINE WETLAND BOUNDARY
- E2SS3 —ESTUARINE WETLAND IDENTIFICATION
- —SURFACE SOIL SAMPLE LOCATION (PHASE II ECP 2004)
- —SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION (PHASE II ECP 2004)
- —SURFACE WATER AND SEDIMENT SAMPLE LOCATION (PHASE II ECP 2004)
- —SURFACE SOIL AND GROUNDWATER SAMPLE LOCATION (PHASE II ECP 2004)
- —SURFACE SOIL, SUBSURFACE SOIL, AND GROUNDWATER SAMPLE LOCATION (PHASE II ECP 2004)
- —SURFACE SOIL, SUBSURFACE SOIL AND GROUNDWATER SAMPLE LOCATION
- —SURFACE SOIL, SUBSURFACE SOIL AND GROUNDWATER (TEMPORARY) SAMPLE LOCATION
- —ESTUARINE SEDIMENT AND GROUNDWATER (TEMPORARY) SAMPLE LOCATION
- —OPEN WATER SEDIMENT SAMPLE LOCATION

FIGURE 1-3
SITE LAYOUT AND ECP/PHASE I RFI SAMPLE LOCATION MAP – 2006 AERIAL PHOTOGRAPH
SWMU 70-DISPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO



350 0 175 350

1 inch = 350 ft.

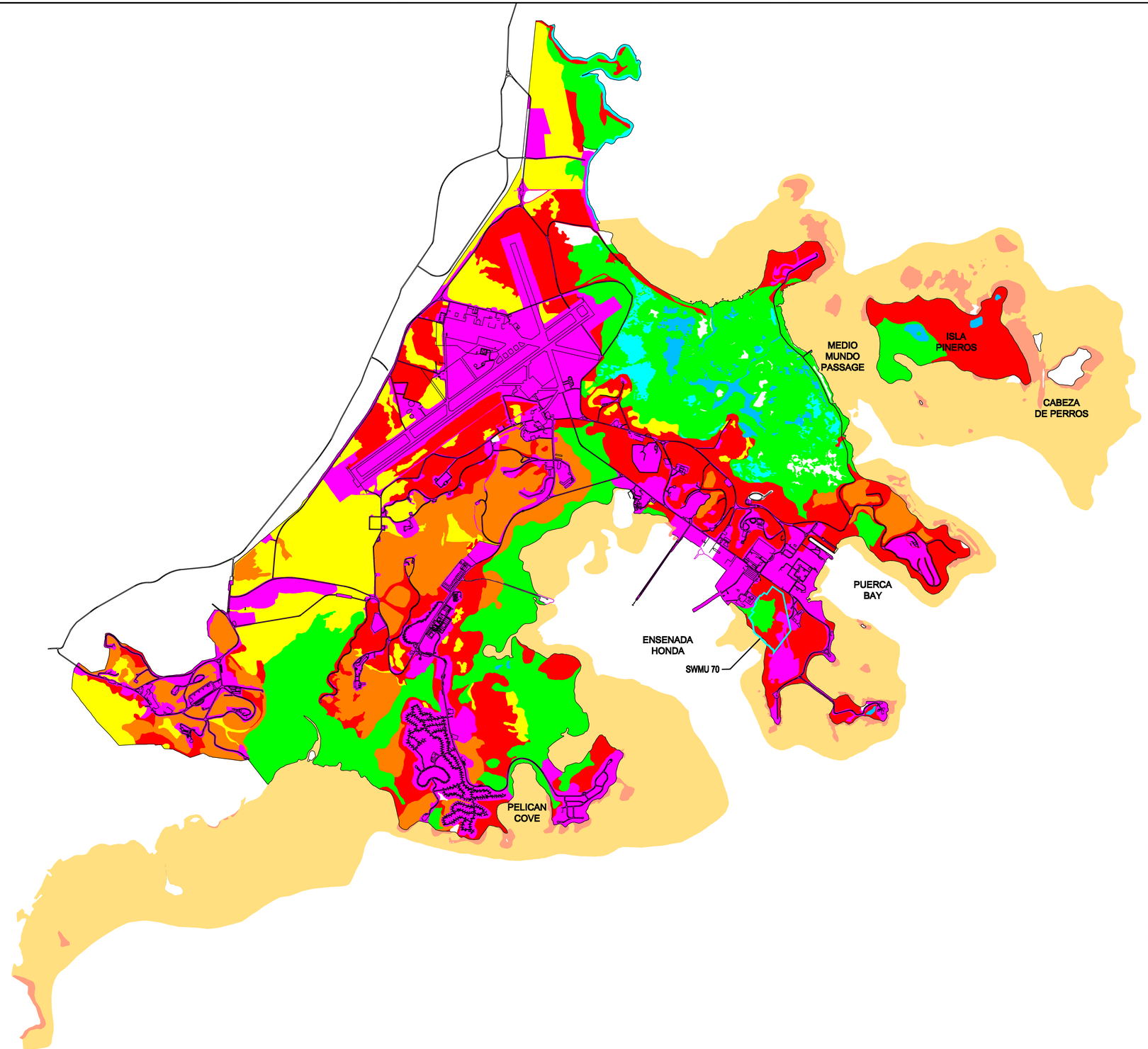
SOURCE: GEO-MARINE, INC., SEPTEMBER 6, 2000.

Baker

- -1976 POLYGON FEATURE
- -1977 POLYGON FEATURE
- -ESTUARINE WETLAND BOUNDARY
- -SWMU BOUNDARY
- -SURFACE SOIL SAMPLE LOCATION (PHASE II ECP 2004)
- -SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION (PHASE II ECP 2004)
- -SURFACE WATER AND SEDIMENT SAMPLE LOCATION (PHASE II ECP 2004)
- -SURFACE SOIL AND GROUNDWATER SAMPLE LOCATION (PHASE II ECP 2004)
- -SURFACE SOIL, SUBSURFACE SOIL, AND GROUNDWATER SAMPLE LOCATION (PHASE II ECP 2004)
- -SURFACE SOIL, SUBSURFACE SOIL AND GROUNDWATER SAMPLE LOCATION
- -SURFACE SOIL, SUBSURFACE SOIL AND GROUNDWATER (TEMPORARY) SAMPLE LOCATION
- -ESTUARINE SEDIMENT AND GROUNDWATER (TEMPORARY) SAMPLE LOCATION
- -OPEN WATER SEDIMENT SAMPLE LOCATION
- -1985 POLYGON FEATURE
- -1995 POLYGON FEATURE
- E2SS3 -ESTUARINE WETLAND IDENTIFICATION

FIGURE 1-4
SAMPLE LOCATION MAP
WITH 2000 AERIAL PHOTOGRAPH
SWMU 70-DISPOSAL AREA
NORTHWEST OF LANDFILL
FULL RFI WORK PLAN

NAVAL ACTIVITY PUERTO RICO



LEGEND
- COASTAL SCRUB FOREST
- CORAL
- GRASSLAND/WET MEADOW
- MANGROVE
- SEAGRASS
- SHALLOW FLAT
- UPLAND COASTAL FOREST
- URBAN
- WATER

SOURCE: GEO-MARINE, INC.

REVISIONS		NORTH				
	DRAWN /RRR REVIEWED MEK S.O.# 119197 CADD# 119197_70_01.DWG			SWMU 70-DISPOSAL AREA NORTHWEST OF LANDFILL NAVAL ACTIVITY PUERTO RICO Michael Baker Jr., Inc. Moon Township, Pennsylvania	Baker	TERRESTRIAL AND AQUATIC HABITAT OCCURRING AT NAVAL ACTIVITY PUERTO RICO FULL RFI WORK PLAN SCALE 1" = 2000' DATE OCTOBER 2010

FIGURE
2-1

500 0 250 500

1 inch = 500 ft.

SOURCE: GEO-MARINE, INC., SEPTEMBER 6, 2000.

Baker

LEGEND

—SWMU BOUNDARY

E2SS3 —ESTUARINE WETLAND IDENTIFICATION

—ESTUARINE WETLAND BOUNDARY

FIGURE 2-2
WETLAND LOCATION MAP
SWMU 70-DISPOSAL AREA
NORTHWEST OF LANDFILL
FULL RFI WORK PLAN

NAVAL ACTIVITY PUERTO RICO

119197_70_02.DWG

M - MARINE

SYSTEM	M - MARINE								
SUBSYSTEM	1 - SUBTIDAL					2 - INTERTIDAL			
CLASS	RB - Rock Bottom	UB - Unconsolidated Bottom	AB - Aquatic Bed	RF - Reef	OW - Open Water (unknown bottom)	AB - Aquatic Bed	RF - Reef	RS - Rocky Shore	US - Unconsolidated Shore
Subclass	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic	1 Algal 3 Rooted Vasc 5 Unknown	1 Coral 3 Worm		1 Algal 3 Rooted Vasc 5 Unknown	1 Coral 3 Worm	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic

E - ESTUARINE

SYSTEM	E - ESTUARINE											
SUBSYSTEM	1 - SUBTIDAL				2 - INTERTIDAL							
CLASS	RB - Rock Bottom	UB - Unconsolidated Bottom	AB - Aquatic Bed	RF - Reef	OW - Open Water (unknown bottom)	AB - Aquatic Bed	RF - Reef	SB - Streambed	RS - Rocky Shore	US - Unconsolidated Shore	EM - Emergent	SS - Scrub-Shrub	FO - Forested
Subclass	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic	1 Algal 3 Rooted Vasc 4 Floating Vasc 5 *Unknown Submerg.* 6 *Unknown Surface*	2 Mollusk 3 Worm		1 Algal 3 Rooted Vasc 4 Floating Vasc 5 *Unknown Submerg.* 6 *Unknown Surface*	2 Mollusk 3 Worm	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic 5 Dead	1 Persistent 2 Nonpersistent	1 Broad-leaved Decid. 2 Needle-leaved Decid. 3 Broad-leaved Everg. 4 Needle-leaved Everg. 5 Dead 6 *Deciduous* 7 *Evergreen*	1 Broad-leaved Decid. 2 Needle-leaved Decid. 3 Broad-leaved Everg. 4 Needle-leaved Everg. 5 Dead 6 *Deciduous* 7 *Evergreen*

R - RIVERINE

SYSTEM	R - RIVERINE							
SUBSYSTEM	1 - TIDAL	2 - LOWER PERENNIAL		3 - UPPER PERENNIAL		4 INTERMITTENT		5 - UNKNOWN PERENNIAL
CLASS	RB - Rock	UB - Unconsolidated Bottom	SB - Streambed	AB - Aquatic Bed	RS - Rocky Shore	US - Unconsolidated Shore	OW - Open Water (unknown bottom)	**EM - Emergent
Subclass	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic	1 Bedrock 2 Rubble 3 Cobble - Gravel 4 Sand 5 Mud 6 Organic 7 Vegetated	1 Algal 2 Aquatic Moss 3 Rooted Vasc 4 Floating Vasc 5 *Unknown Submerg.* 6 *Unknown Surface*	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic		2 Nonpersistent

L - LACUSTRINE

SYSTEM	L - LACUSTRINE											
SUBSYSTEM	1 - LIMNETIC				2 - LITTORAL							
CLASS	RB - Rock Bottom	UB - Unconsolidated Bottom	AB - Aquatic Bed	OW - Open Water (unknown bottom)	RB - Rock Bottom	RS - Rocky Shore	UB - Unconsolidated Bottom	AB - Aquatic Bed	US - Unconsolidated Shore	EM - Emergent	OW - Open Water (unknown bottom)
Subclass	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic	1 Algal 2 Aquatic Moss 3 Rooted Vasc 4 Floating Vasc 5 *Unknown Submerg.* 6 *Unknown Surface*		1 Bedrock 2 Rubble	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic	1 Algal 2 Aquatic Moss 3 Rooted Vasc 4 Floating Vasc 5 *Unknown Submerg.* 6 *Unknown Surface*	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated	2 Nonpersistent	

P - PALUSTRINE

SYSTEM	P - PALUSTRINE								
CLASS	RB - Rock Bottom	UB - Unconsolidated Bottom	AB - Aquatic Bed	US - Unconsolidated Shore	ML - Moss-Lichen	EM - Emergent	SS - Scrub-Shrub	FO - Forested	OW - Open Water (unknown bottom)
Subclass	1 Bedrock 2 Rubble	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic	1 Algal 2 Aquatic Moss 3 Rooted Vasc 4 Floating Vasc 5 *Unknown Submerg.* 6 *Unknown Surface*	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated	1 Moss 2 Lichen	1 Persistent 2 Nonpersistent	1 Broad-leaved Decid. 2 Needle-leaved Decid. 3 Broad-leaved Everg. 4 Needle-leaved Everg. 5 Dead 6 *Deciduous* 7 *Evergreen*	1 Broad-leaved Decid. 2 Needle-leaved Decid. 3 Broad-leaved Everg. 4 Needle-leaved Everg. 5 Dead 6 *Deciduous* 7 *Evergreen*	

MODIFIERS

WATER REGIME

Non-Tidal

- A Temp. Flooded
- B Saturated
- C Seasonally Flooded
- D Seasonally Flooded/ Well Drained
- E Seasonally Flooded/ Saturated
- F Semipermanently Flooded
- G Intermittently Exposed
- H Permanently Flooded
- J Intermittently Flooded
- K Artificially Flooded
- W Intermittently Flooded/ Temporary
- Y Saturated/Semipermanent/ Seasonal
- Z Intermittently Exposed/ Permanent
- U Unknown

Tidal

- K Artificially Flooded
- L Subtidal
- M Irregularly Flooded
- N Regularly Flooded
- P Irregularly Flooded
- *S Temporary-Tidal
- *R Seasonal-Tidal
- *T Semipermanent- Tidal
- *V Permanent-Tidal
- U Unknown

* These water regimes are only used in tidally influenced, freshwater systems.

WATER CHEMISTRY

Coastal Halinity

- 1 Hyperhaline
- 2 Euhaline
- 3 Mixohaline
- 4 Polyhaline
- 5 Mesohaline
- 6 Oligohaline
- 0 Fresh

Inland Salinity

- 7 Hypersaline
- 8 Eusaline
- 9 Mixosaline
- 0 Fresh

pH (fresh water)

- a Acid
- t Circumneutral
- i Alkaline

SOIL

- g Organic
- n Mineral

SPECIAL

- b Beaver
- d partially drained/ditched
- f Farmed
- h Diked/Impounded
- r Artificial Substrate
- s Spoil
- x Excavated

SOURCE: UNITED STATES, FISH AND WILDLIFE SERVICE. CLASSIFICATION OF WETLANDS AND DEEPWATER HABITATS OF THE UNITED STATES, 1985

Baker

FIGURE 2–3
THE COWARDIN WETLAND CLASSIFICATION SYSTEM
SWMU 70–DISPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO

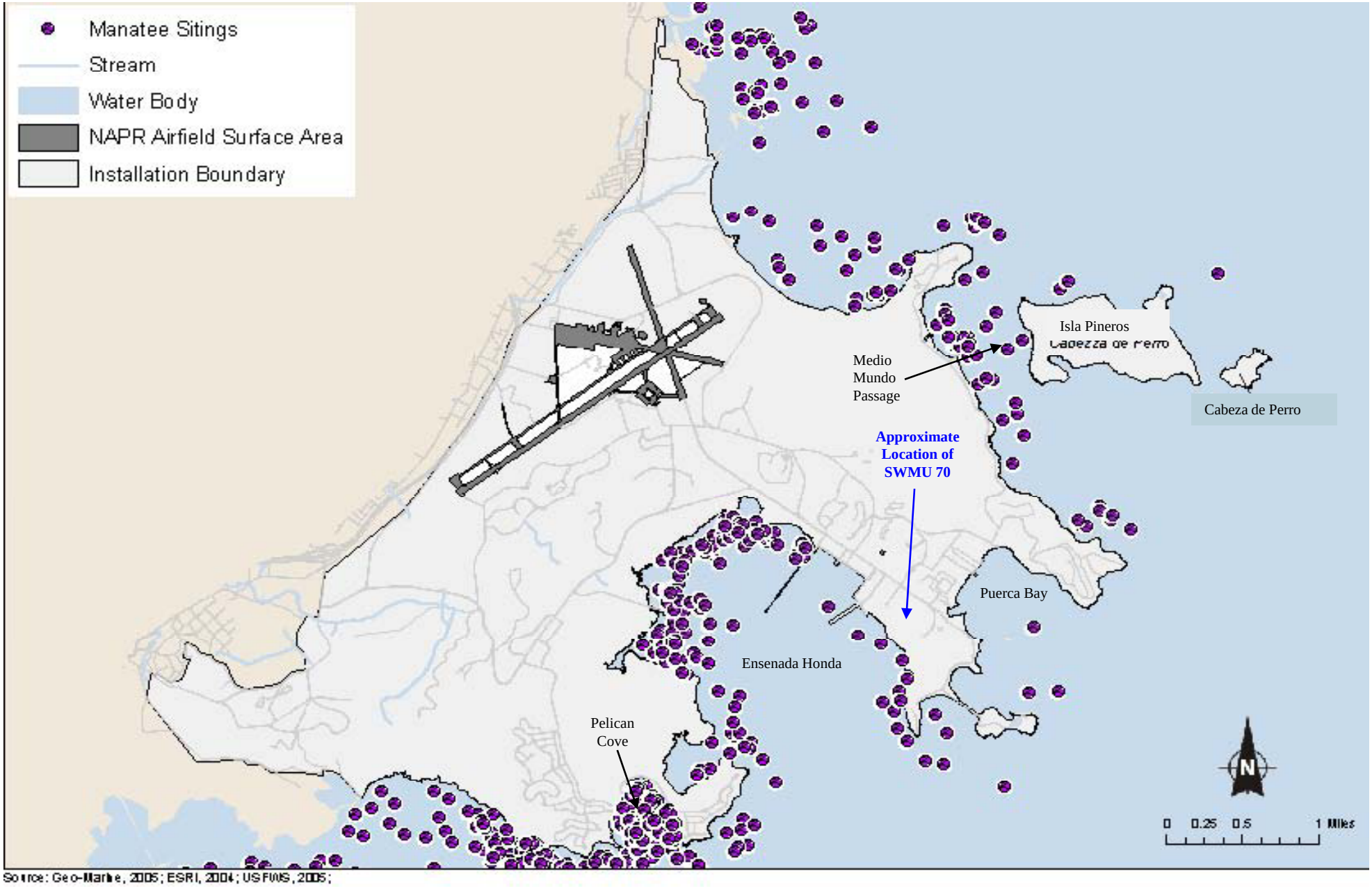
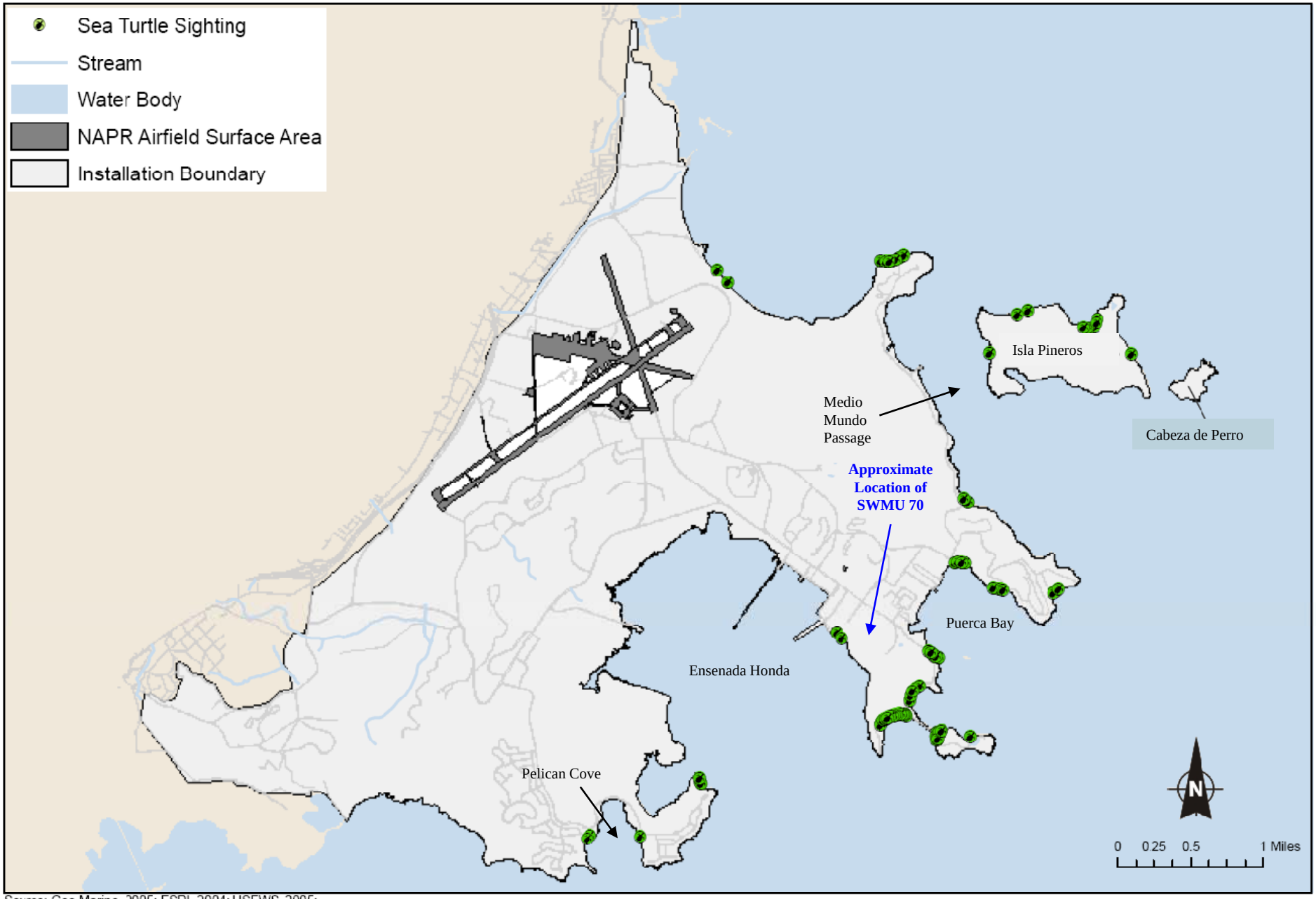


Figure from: Department of the Navy (DoN). 2007. *Environmental Assessment for the Disposal of Naval Activity Puerto Rico (formerly Naval Station Roosevelt Roads).* April 2007.

FIGURE 2-4
HISTORICAL MANATEE SIGHTINGS IN EASTERN PUERTO RICO
SWMU 70 – DISPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO

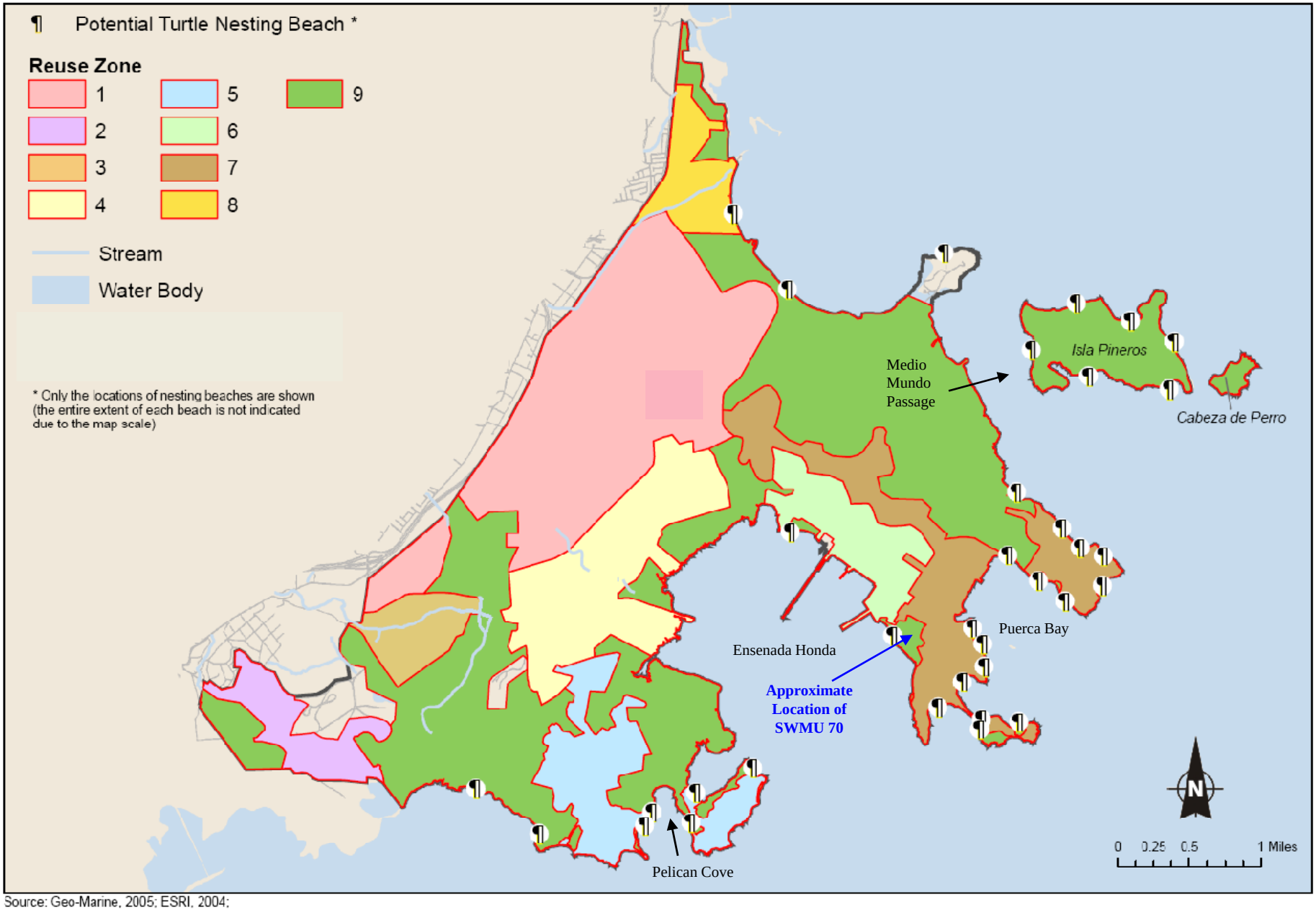


Source: Geo-Marine, 2005; ESRI, 2004; USFWS, 2005;

Cumulative sea turtle sightings from March 1984 through March 1995 obtained from weekly aerial surveys of the Former Naval station Roosevelt Roads.

Figure from: Department of the Navy (DoN). 2007. *Environmental Assessment for the Disposal of Naval Activity Puerto Rico (formerly Naval Station Roosevelt Roads).* April 2007.

FIGURE 2-5
SEA TURTLE SIGHTINGS AT NAVAL ACTIVITY PUERTO RICO
SWMU 70 – DISPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO



Source: Geo-Marine, 2005; ESRI, 2004;

Figure from: Department of Navy (DoN). 2007. *Environmental Assessment for the Disposal of Naval Activity Puerto Rico (formerly Naval Station Roosevelt Roads).* April 2007

FIGURE 2-6
POTENTIAL TURTLE NESTING SITES
SWMU 70 – DISPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO

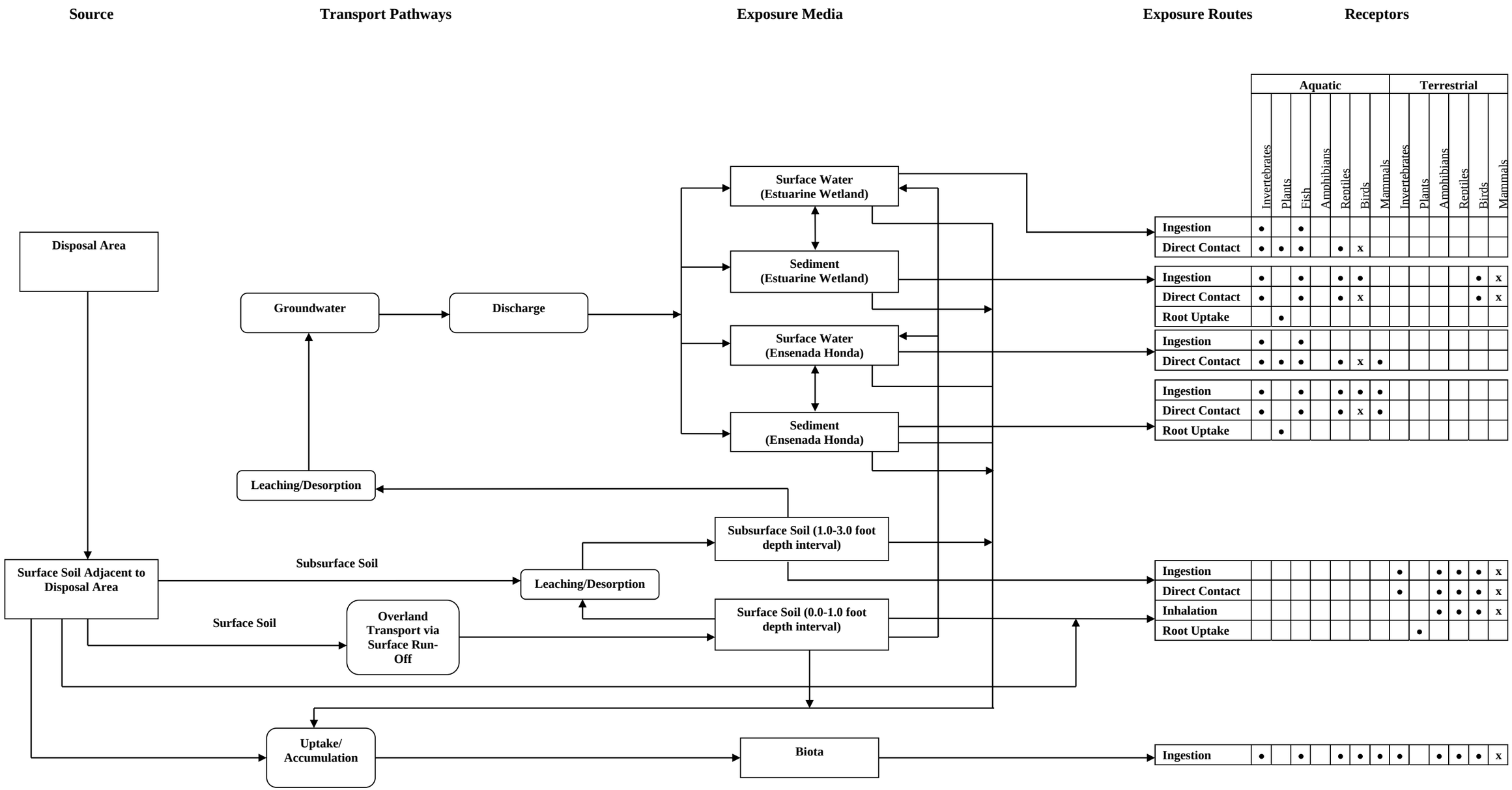


FIGURE 2-7
PRELIMINARY CONCEPTUAL MODEL FOR ECOLOGICAL RECEPTORS
SWMU 70 – DISPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

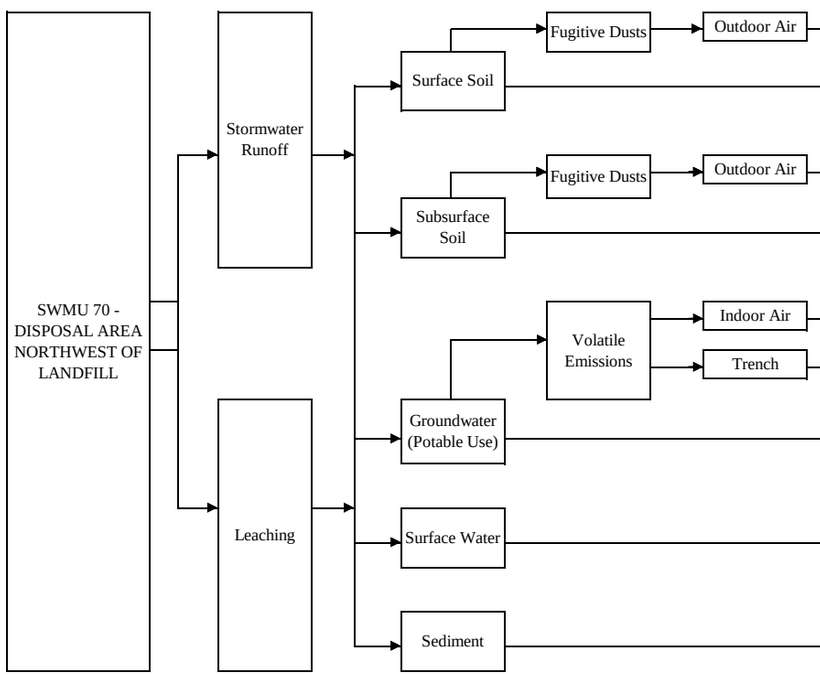
→ Potentially complete and significant pathway
- - - → Potentially complete and insignificant pathway

● - Receptor/represented by a potentially complete exposure pathway
x - Receptor/represented by a potentially complete and insignificant exposure pathway

K:_SOUTHNAVFAC\111626 DO2\Task 15 - CMS Inv 56 61 69\69 CMS Report\Draft\ERA\Figures

FIGURE 2-8

PRELIMINARY CONCEPTUAL MODEL FOR HUMAN RECEPTORS
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

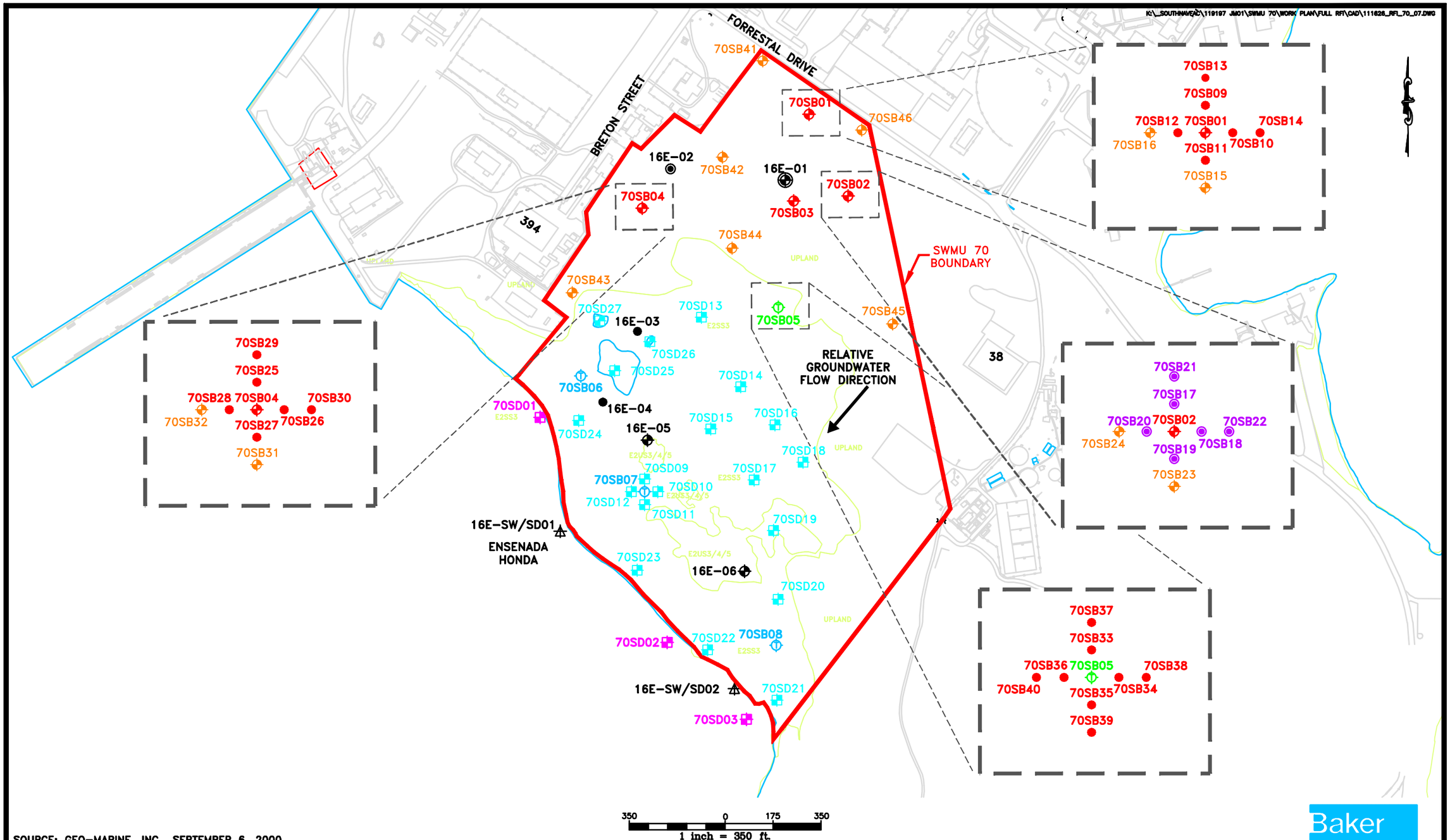


Primary Source	Primary Release Mechanism	Secondary Source	Secondary Release Mechanism	Tertiary Source	Exposure Route	Potential Human Receptors: Current and Future Adult Trespassers	Current and Future Youth Trespassers	Future Adult Industrial / Commercial Workers	Future Adult Residents	Future Young Child Residents	Future Adult Construction Workers
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL	Stormwater Runoff	Surface Soil	Fugitive Dusts	Outdoor Air	Inhalation	*CF*	*CF*	F	F	F	F
					Ingestion	*CF*	*CF*	F	F	F	F
					Dermal Contact	*CF*	*CF*	F	F	F	F
		Subsurface Soil	Fugitive Dusts	Outdoor Air	Inhalation			F	F	F	F
					Ingestion			F	F	F	F
					Dermal Contact			F	F	F	F
	Leaching	Groundwater (Potable Use)	Volatile Emissions	Indoor Air	Inhalation			F	F		
				Trench	Inhalation						F
					Ingestion				F	F	F
					Dermal Contact				F	F	F
		Surface Water			Ingestion	*CF*	*CF*		F	F	
					Dermal Contact	*CF*	*CF*		F	F	
		Sediment			Ingestion	*CF*	*CF*		F	F	
					Dermal Contact	*CF*	*CF*		F	F	

Legend

F	Future Exposure Pathway	⟶	Complete Exposure Pathway
CF	Current and Future Exposure Pathway	- · - · -▸	Incomplete Exposure Pathway

K:_SOUTHNAVFAC\119197 JM01\SWMU 70\WORK PLAN\FULL RFI\CAD\111626_RFI_70_07.DWG



SOURCE: GEO-MARINE, INC., SEPTEMBER 6, 2000.

Baker

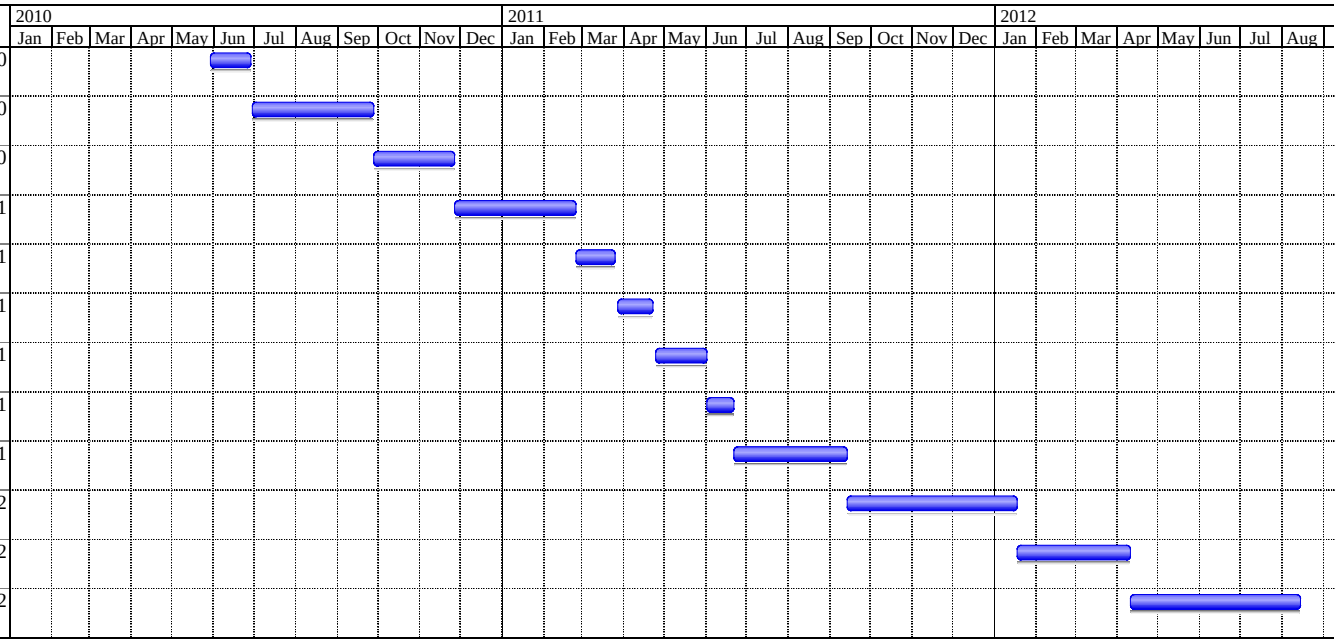
LEGEND

- -WATER BOUNDARY
- -ESTUARINE WETLAND BOUNDARY
- -SWMU BOUNDARY
- -ESTUARINE WETLAND IDENTIFICATION
- -SURFACE SOIL SAMPLE LOCATION (PHASE II ECP 2004)
- -SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION (PHASE II ECP 2004)
- -SURFACE WATER AND SEDIMENT SAMPLE LOCATION (PHASE II ECP 2004)
- -SURFACE SOIL AND GROUNDWATER SAMPLE LOCATION (PHASE II ECP 2004)
- -SURFACE SOIL, SUBSURFACE SOIL, AND GROUNDWATER SAMPLE LOCATION (PHASE II ECP 2004)
- -PHASE 1 SURFACE SOIL, SUBSURFACE SOIL AND GROUNDWATER SAMPLE LOCATION
- -PHASE 1 SURFACE SOIL, SUBSURFACE SOIL AND GROUNDWATER (TEMPORARY) SAMPLE LOCATION
- -PHASE 1 ESTUARINE SEDIMENT AND GROUNDWATER (TEMPORARY) SAMPLE LOCATION
- -PHASE 1 OPEN WATER SEDIMENT SAMPLE LOCATION
- -PROPOSED FULL RFI SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION
- -PROPOSED FULL RFI SURFACE, SUBSURFACE, AND GROUNDWATER SAMPLE LOCATION
- -PROPOSED FULL RFI SURFACE SOIL SAMPLE LOCATION
- -PROPOSED FULL RFI SURFACE WATER AND SEDIMENT SAMPLE LOCATION

FIGURE 3-1
PROPOSED FULL RFI
SAMPLE LOCATION MAP
SWMU 70-DISPOSAL AREA
NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO

FIGURE 5-1
PROPOSED PROJECT SCHEDULE
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

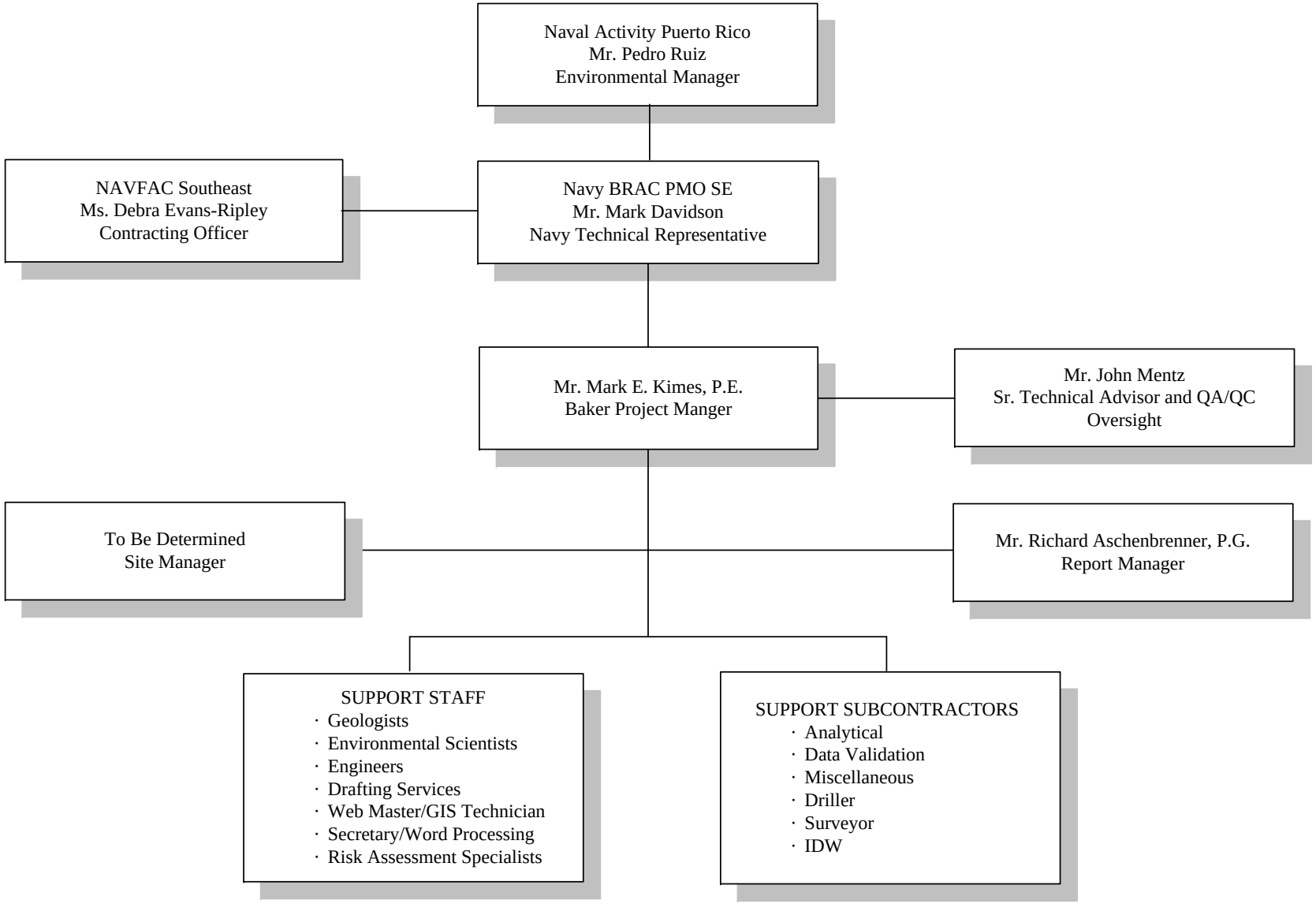
Task Name	Duration	Start	Finish
Draft Full RFI Work Plan to the EPA	30 edays	5/30/10	6/29/10
EPA Review	90 edays	6/30/10	9/28/10
Final Full RFI Work Plan to the EPA	60 edays	9/28/10	11/27/10
EPA Review & Approval	90 edays	11/27/10	2/25/11
Sub Procurement and Field Work Planning	21 days	2/25/11	3/25/11
Field Investigation	20 days	3/28/11	4/22/11
Laboratory Analysis	28 days	4/25/11	6/1/11
Data Validation	14 days	6/2/11	6/21/11
Draft Full RFI Report for SWMU 70 to EPA	60 days	6/22/11	9/13/11
EPA Review	90 days	9/14/11	1/17/12
Final Full RFI Report for SWMU 70 to EPA	60 days	1/18/12	4/10/12
EPA Review & Approval	90 days	4/11/12	8/14/12



Project: Full RFI Work Plan
Date: 6/7/10

Task

FIGURE 6-1
PROJECT ORGANIZATION
SWMU 70 – DISPOSAL AREA NORTHWEST OF LANDFILL
FULL RFI WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO



APPENDIX A
SITE PHOTOGRAPHS

Photo 1. Debris piles in the southernmost portion of SWMU 70 (January 2009).

Photo 2. Southwestern limits of SWMU 70 and Ensenada Honda looking northwest (January, 2009).

Photo 3. Typical thick secondary growth vegetation (January, 2009).

APPENDIX B
SUMMARY OF POSITIVE DETECTS - PHASE II ECP

APPENDIX B

SUMMARY OF ORGANIC DETECTIONS IN SURFACE SOIL
SWMU 70- DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE II ECP INVESTIGATION
NAVAL ACTIVITY PUERTO RICO

Site ID Sample ID Sample Date Sample Depth (ft bgs)	EPA Region III Industrial RBCs (ug/kg)	**EPA Region III Residential RBCs** (ug/kg)	16E-01 16E-SS01 05/13/04 0.00 - 1.00	16E-01 16E-SS01D 05/13/04 0.00 - 1.00	16E-02 16E-SS02 05/13/04 0.00 - 1.00	16E-03 16E-SS03 05/13/04 0.00 - 0.30	16E-04 16E-SS04 05/13/04 0.00 - 1.00	16E-05 16E-SS05 05/13/04 0.00 - 1.00	16E-06 16E-SS06 05/13/04 0.00 - 1.00
Volatile Organic Compounds (ug/kg)									
Chlorobenzene	2,000,000	160,000	6.1 U	2.4 J	6.3 U	2.2 J	5.4 U	2.2 J	5.2 U
Tetrachloroethene	5,300	1,200	2.4 J	5.5 J	2.1 J	2.3 J	5.4 U	2.3 J	5.2 U
Semivolatile Organic Compounds (ug/kg)									
Benzo(g,h,i)perylene	NE	NE	440 U	450 U	420 U	480 U	390 U	42 J	390 U
Indeno(1,2,3-cd)pyrene	3,900	870	440 U	450 U	420 U	480 U	390 U	46 J	390 U
Pesticides/PCBs (ug/kg)									
Not Detected									
OP-Pesticides (ug/kg)									
Not Detected									
Chlorinated Herbicides (ug/kg)									
Not Detected									

Notes:

J - The reported result is an estimated concentration that is less than the PQL, but greater than or equal to the MDL.
U - The compound was analyzed for, but was not detected at or above the MDL/PQL.
NE - Not Established.
ft bgs - feet below ground surface.
ug/kg - micrograms per kilogram.

APPENDIX B

SUMMARY OF ORGANIC DETECTIONS IN SURFACE SOIL
SWMU 70- DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE II ECP INVESTIGATION
NAVAL ACTIVITY PUERTO RICO

Site ID Sample ID Sample Date Sample Depth (ft bgs)	EPA Region III Industrial RBCs (ug/kg)	**EPA Region III Residential RBCs** (ug/kg)	Number Exceeding EPA Region III Industrial RBCs	Range Exceeding EPA Region III Industrial RBCs	**Number Exceeding EPA Region III Residential RBCs**	**Range Exceeding EPA Region III Residential RBCs**	Location of Maximum Detection
Volatile Organic Compounds (ug/kg)							
Chlorobenzene	2,000,000	160,000	0/7		0/7		16E-SS01D
Tetrachloroethene	5,300	1,200	0/7		0/7		16E-SS01D
Semivolatile Organic Compounds (ug/kg)							
Benzo(g,h,i)perylene	NE	NE	NE		NE		16E-SS05
Indeno(1,2,3-cd)pyrene	3,900	870	0/7		0/7		16E-SS05
Pesticides/PCBs (ug/kg) Not Detected							
OP-Pesticides (ug/kg) Not Detected							
Chlorinated Herbicides (ug/kg) Not Detected							

Notes:

J - The reported result is an estimated concentration that is less than the PQ
U - The compound was analyzed for, but was not detected at or above the I
NE - Not Established.
ft bgs - feet below ground surface.
ug/kg - micrograms per kilogram.

APPENDIX B

SUMMARY OF INORGANIC DETECTIONS IN SURFACE SOIL
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE II ECP INVESTIGATION
NAVAL ACTIVITY PUERTO RICO

Site ID Sample ID Sample Date Sample Depth (ft bgs)	EPA Region III Industrial RBCs (ug/kg)	**EPA Region III Residential RBCs** (ug/kg)	2x Average Detected Background (mg/kg)	16E-01 16E-SS01 05/13/04 0.00 - 1.00	16E-01 16E-SS01D 05/13/04 0.00 - 1.00	16E-02 16E-SS02 05/13/04 0.00 - 1.00	16E-03 16E-SS03 05/13/04 0.00 - 0.30	16E-04 16E-SS04 05/13/04 0.00 - 1.00	16E-05 16E-SS05 05/13/04 0.00 - 1.00	16E-06 16E-SS06 05/13/04 0.00 - 1.00
Appendix IX Inorganics (mg/kg)										
Arsenic	1.9	0.43	2.4	**1.9**	**2.2**	**2**	**2.9**	**3.7**	**3.2**	**1.9**
Barium	7,200	550	181	11	16	120	11	7.8	12	16
Beryllium	200	16	0.45	0.51 U	0.051 B	0.43 B	0.06 B	0.047 B	0.057 B	0.085 B
Cadmium	100	7.8	0.27	0.64 U	0.63 U	0.26 B	0.64 U	0.57 U	0.64 U	0.19 B
Chromium	310	23	59.3	5.8	5.8	19	7.2	4.3	7.8	**47**
Cobalt	2,000	160	44.0	1.4	1.4	27	2.5	0.76 B	2.4	13
Copper	4,100	310	234	11	14	150	11	3	8.4	43
Lead	400(1)	400(1)	125	2.8	2.3	7.9	1.9	0.77	1.4	3.3
Mercury	31(2)	2.3(2)	0.11	0.0079 B	0.0096 B	0.02 B	0.018 B	0.0086 B	0.0063 B	0.012 B
Nickel	2,000	160	16.6	2.3 B	2.6 B	14	2.7 B	1.4 B	3.3 B	19
Sulfide	NE	NE	28.48	34 U	34 U	32 U	36 U	29 U	37 U	30 B
Tin	61,000	4,700	2.43	2 B	2.6 B	2.7 B	3.3 B	2.9 B	2.1 B	2.9 B
Vanadium	100	7.8	355	**14** N*	**18** N*	**96** N*	**20** N*	6 N*	**23** N*	**74** N*
Zinc	31,000	2,300	125	7	9.2	130	11	3.4	7	34

Notes:

B - The reported result is an estimated concentration that is less than the PQL, but greater than or equal to the MDL.
N - The matrix spike recovery is not within control limtis.
U - The compound was analyzed for, but was not detected at or above the MDL/PQL.
* - Duplicate analysis is not within control limits.
(1) - 1996 Soil Screening Guidance.
(2) - Value based on the RBC for Mercuric Chloride.
NE - Not Established.
ft bgs - feet below ground surface.
ug/kg - micrograms per kilogram.
mg/kg - milligrams per kilogram.

APPENDIX B

SUMMARY OF INORGANIC DETECTIONS IN SURFACE SOIL
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE II ECP INVESTIGATION
NAVAL ACTIVITY PUERTO RICO

Site ID Sample ID Sample Date Sample Depth (ft bgs)	EPA Region III Industrial RBCs (ug/kg)	**EPA Region III Residential RBCs** (ug/kg)	2x Average Detected Background (mg/kg)	Number Exceeding EPA Region III Industrial RBCs	Range Exceeding EPA Region III Industrial RBCs	**Number Exceeding EPA Region III Residential RBCs**	**Range Exceeding EPA Region III Residential RBCs**	Number Exceeding 2x Average Detected Background	Range Exceeding 2x Average Detected Background	Location of Maximum Detection
Appendix IX Inorganics (mg/kg)										
Arsenic	1.9	0.43	2.4	5/7	2 - 3.7	7/7	1.9 - 3.7	3/7	2.9 - 3.7	16E-SS04
Barium	7,200	550	181	0/7		0/7		0/7		16E-SS02
Beryllium	200	16	0.45	0/7		0/7		0/7		16E-SS02
Cadmium	100	7.8	0.27	0/7		0/7		0/7		16E-SS02
Chromium	310	23	59.3	0/7		1/7	47	0/7		16E-SS06
Cobalt	2,000	160	44.0	0/7		0/7		0/7		16E-SS02
Copper	4,100	310	234	0/7		0/7		0/7		16E-SS02
Lead	400[(1)]	400[(1)]	125	0/7		0/7		0/7		16E-SS02
Mercury	31[(2)]	2.3[(2)]	0.11	0/7		0/7		0/7		16E-SS02
Nickel	2,000	160	16.6	0/7		0/7		1/7	19	16E-SS06
Sulfide	NE	NE	28.48	NE		NE		1/7	30B	16E-SS06
Tin	61,000	4,700	2.43	0/7		0/7		5/7	2.6B - 3.3B	16E-SS03
Vanadium	100	7.8	355	0/7		6/7	14N* - 96N*	0/7		16E-SS02
Zinc	31,000	2,300	125	0/7		0/7		1/7	130	16E-SS02

Notes:

B - The reported result is an estimated concentration that is less than the PQL, but greater than or equal to the MDL.
N - The matrix spike recovery is not within control limtis.
U - The compound was analyzed for, but was not detected at or above the MDL/PQL.
* - Duplicate analysis is not within control limits.
(1) - 1996 Soil Screening Guidance.
(2) - Value based on the RBC for Mercuric Chloride.
NE - Not Established.
ft bgs - feet below ground surface.
ug/kg - micrograms per kilogram.
mg/kg - milligrams per kilogram.

APPENDIX B

SUMMARY OF ORGANIC DETECTIONS IN SUBSURFACE SOIL
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE II ECP INVESTIGATION
NAVAL ACTIVITY PUERTO RICO

Site ID Sample ID Sample Date Sample Depth (ft bgs)	EPA Region III Industrial RBCs (ug/kg)	**EPA Region III Residential RBCs** (ug/kg)	16E-01 16E-SB01-02 05/13/04 3.00 - 5.00	16E-02 16E-SB02-02 05/13/04 3.00 - 5.00	Number Exceeding EPA Region III Industrial RBCs	Range Exceeding EPA Region III Industrial RBCs	**Number Exceeding EPA Region III Residential RBCs**	**Range Exceeding EPA Region III Residential RBCs**	Location of Maximum Detection
Volatile Organic Compounds (ug/kg)									
Acetone	92,000,000	7,000,000	17 J	47 U	0/2		0/2		16E-SB01-02
Semivolatile Organic Compounds (ug/kg)									
Not Detected									
Pesticides/PCBs (ug/kg)									
Not Detected									
OP-Pesticides (ug/kg)									
Not Detected									
Chlorinated Herbicides (ug/kg)									
Not Detected									

Notes:

J - The reported result is an estimated concentration that is less than the PQL, but greater than or equal to the MDL.
U - The compound was analyzed for, but was not detected at or above the MDL/PQL.
ft bgs - feet below ground surface.
ug/kg - micrograms per kilogram.

APPENDIX B

SUMMARY OF INORGANIC DETECTIONS IN SUBSURFACE SOIL
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE II ECP INVESTIGATION
NAVAL ACTIVITY PUERTO RICO

Site ID Sample ID Sample Date Sample Depth (ft bgs)	EPA Region III Industrial RBCs (mg/kg)	**EPA Region III Residential RBCs** (mg/kg)	2x Average Detected Background (mg/kg)	16E-01 16E-SB01-02 05/13/04 3.00 - 5.00	16E-02 16E-SB02-02 05/13/04 3.00 - 5.00	Number Exceeding EPA Region III Industrial RBCs	Range Exceeding EPA Region III Industrial RBCs	**Number Exceeding EPA Region III Residential RBCs**	**Range Exceeding EPA Region III Residential RBCs**	Number Exceeding 2x Average Detected Background	Range Exceeding 2x Average Detected Background	Location of Maximum Detection
Appendix IX Inorganics (mg/kg)												
Arsenic	1.9	0.43	2.05	**6.1**	**6.4**	2/2	6.1 - 6.4	2/2	6.1 - 6.4	2/2	6.1 - 6.4	16E-SB02-02
Barium	7,200	550	222	10	13	0/2		0/2		0/2		16E-SB02-02
Beryllium	200	16	0.74	0.072 B	0.43 U	0/2		0/2		0/2		16E-SB01-02
Chromium	310	23	133	13	2.9	0/2		0/2		0/2		16E-SB01-02
Cobalt	2,000	160	30.0	1 B	1.1 U	0/2		0/2		0/2		16E-SB01-02
Copper	4,100	310	193	9.6	1.4 B	0/2		0/2		0/2		16E-SB01-02
Lead	400[(1)]	400[(1)]	8.68	0.95	0.54 U	0/2		0/2		0/2		16E-SB01-02
Nickel	2,000	160	31.9	4.5 B	0.88 B	0/2		0/2		0/2		16E-SB01-02
Tin	61,000	4,700	2.96	3.3 B	2.7 B	0/2		0/2		1/2	3.3B	16E-SB01-02
Vanadium	100	7.8	462	**17** N*	3 N*	0/2		1/2	17N*	0/2		16E-SB01-02
Zinc	31,000	2,300	88.6	8	1.4 B	0/2		0/2		0/2		16E-SB01-02

Notes:

B - The reported result is an estimated concentration that is less than the PQL, but greater than or equal to the MDL.
N - The matrix spike recovery is not within control limtis.
U - The compound was analyzed for, but was not detected at or above the MDL/PQL.
* - Duplicate analysis is not within control limits.
(1) - 1996 Soil Screening Guidance.
ft bgs - feet below ground surface.
mg/kg - milligrams per kilogram.

APPENDIX B

SUMMARY OF ORGANIC DETECTIONS IN GROUNDWATER
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE II ECP INVESTIGATION
NAVAL ACTIVITY PUERTO RICO

Site ID Sample ID Sample Date	Federal MCLs (ug/L)	**EPA Region III Tap Water RBCs** (ug/L)	PR Water Quality Standards (ug/L)	16E-01 16E-GW01 05/15/04	16E-01 16E-GW01D 05/15/04	16E-05 16E-GW05 05/12/04	16E-06 16E-GW06 05/12/04
Volatile Organic Compounds (ug/L)							
Acetone	NE	550	NE	6 J	25 U	25 U	25 U
2-Butanone	NE	700	NE	1.3 J	1.3 J	10 U	10 U
Semivolatile Organic Compounds (ug/L)							
Benzo(g,h,i)perylene	NE	NE	NE	10 U	10 U	1 J	10 U
Indeno(1,2,3-cd)pyrene	NE	0.092	NE	10 U	10 U	**0.85** J	10 U
Pesticides/PCBs (ug/L) Not Detected							
OP-Pesticides (ug/L) Not Detected							
Chlorinated Herbicides (ug/L) Not Detected							

Notes:

J - The reported result is an estimated concentration that is less than the PQL, but greater than or equal to the MDL.

U - The compound was analyzed for, but was not detected at or above the MDL/PQL.

ug/L - micrograms per liter.

NE - Not Established.

APPENDIX B

SUMMARY OF ORGANIC DETECTIONS IN GROUNDWATER
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE II ECP INVESTIGATION
NAVAL ACTIVITY PUERTO RICO

Site ID Sample ID Sample Date	Federal MCLs (ug/L)	**EPA Region III Tap Water RBCs** (ug/L)	PR Water Quality Standards (ug/L)	Number Exceeding Federal MCLs	Range Exceeding Federal MCLs	**Number Exceeding EPA Region III Tap Water RBCs**	**Range Exceeding EPA Region III Tap Water RBCs**	Number Exceeding PR Water Quality Standards	Range Exceeding PR Water Quality Standards	Location of Maximum Detection
Volatile Organic Compounds (ug/L)										
Acetone	NE	550	NE	NE		0/4		NE		16E-GW01
2-Butanone	NE	700	NE	NE		0/4		NE		16E-GW01, 16E-GW01D
Semivolatile Organic Compounds (ug/L)										
Benzo(g,h,i)perylene	NE	NE	NE	NE		NE		NE		16E-GW05
Indeno(1,2,3-cd)pyrene	NE	0.092	NE	NE		1/4	0.85J	NE		16E-GW05
Pesticides/PCBs (ug/L) Not Detected										
OP-Pesticides (ug/L) Not Detected										
Chlorinated Herbicides (ug/L) Not Detected										

Notes:

J - The reported result is an estimated concentration that is less than the PQL, but greater than or equal to the MDL.

U - The compound was analyzed for, but was not detected at or above the MDL/PQL.

ug/L - micrograms per liter.

NE - Not Established.

APPENDIX B

SUMMARY OF INORGANIC DETECTIONS IN GROUNDWATER
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE II ECP INVESTIGATION
NAVAL ACTIVITY PUERTO RICO

Site ID Sample ID Sample Date	Federal MCLs (mg/L)	**EPA Region III Tap Water RBCs** (mg/L)	PR Water Quality Standards (mg/L)	16E-01 16E-GW01 05/15/04	16E-01 16E-GW01D 05/15/04	16E-05 16E-GW05 05/12/04	16E-06 16E-GW06 05/12/04
Appendix IX (Dissolved) Inorganics (mg/L)							
Barium	2	0.26	NE	0.062	0.062	0.031	0.055
Chromium	0.1	0.011	NE	0.0018 B	0.0015 B	0.01 U	0.0017 B
Cobalt	NE	0.073	NE	0.01 U	0.01 U	0.0021 B	0.01 U
Nickel	NE	0.073	NE	0.04 U	0.04 U	0.0041 B	0.0042 B
Vanadium	NE	0.0037	NE	**0.015** B	**0.019** B	0.05 U	**0.013**
Total Cyanide and Sulfide (mg/L) Not Detected							

Notes:

B - The reported result is an estimated concentration that is less than the PQL, but greater than or equal to the MDL.

U - The compound was analyzed for, but was not detected at or above the MDL/PQL.

NE - Not Established.

mg/L - milligrams per liter.

APPENDIX B

SUMMARY OF INORGANIC DETECTIONS IN GROUNDWATER
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE II ECP INVESTIGATION
NAVAL ACTIVITY PUERTO RICO

Site ID Sample ID Sample Date	Federal MCLs (mg/L)	**EPA Region III Tap Water RBCs** (mg/L)	PR Water Quality Standards (mg/L)	Number Exceeding Federal MCLs	Range Exceeding Federal MCLs	**Number Exceeding EPA Region III Tap Water RBCs**	**Range Exceeding EPA Region III Tap Water RBCs**	Number Exceeding PR Water Quality Standards	Range Exceeding PR Water Quality Standards	Location Maximum Detection
Appendix IX (Dissolved) Inorganics (mg/L)										
Barium	2	0.26	NE	0/4		0/4		NE		16E-GW01, 16E-GW01D
Chromium	0.1	0.011	NE	0/4		0/4		NE		16E-GW01
Cobalt	NE	0.073	NE	NE		0/4		NE		16E-GW05
Nickel	NE	0.073	NE	NE		0/4		NE		16E-GW06
Vanadium	NE	0.0037	NE	NE		3/4	0.013 - 0.019B	NE		16E-GW01D
Total Cyanide and Sulfide (mg/L) Not Detected										

Notes:

B - The reported result is an estimated concentration that is less than the PQL, but greater than or equal to the MDL.

U - The compound was analyzed for, but was not detected at or above the MDL/PQL.

NE - Not Established.

mg/L - milligrams per liter.

APPENDIX B

SUMMARY OF INORGANIC DETECTIONS IN SEDIMENT
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE II ECP INVESTIGATION
NAVAL ACTIVITY PUERTO RICO

Site ID Sample ID Sample Date Sample Depth (ft bgs)	Marine Sediment Screening Values (mg/kg)	16E-SW/SD01 16E-SD01 05/14/04 0.00 - 0.50	16E-SW/SD02 16E-SD02 05/14/04 0.00 - 0.50	Number Exceeding Marine Sediment Screening Values	Range Exceeding Marine Sediment Screening Values	Location of Maximum Detection
Appendix IX Inorganics (mg/kg)						
Arsenic	7.24	3.1	3 B	0/2		16E-SD01
Barium	48.0	8.3	11	0/2		16E-SD02
Chromium	52.3	13	23	0/2		16E-SD02
Cobalt	10.0	3.3	6.4	0/2		16E-SD02
Copper	18.7	21	41	2/2	21 - 41	16E-SD02
Lead	30.2	2	4.8	0/2		16E-SD02
Mercury	0.13	0.018 B	0.036 B	0/2		16E-SD02
Nickel	15.9	5 B	9 B	0/2		16E-SD02
Silver	0.73	1.9 U	0.86 B	1/2	0.86B	16E-SD02
Tin	3.40	3.5 B	6.1 B	2/2	3.5B - 6.1B	16E-SD02
Vanadium	57.0	21 N*	36 N*	0/2		16E-SD02
Zinc	124	24	35	0/2		16E-SD02
Sulfide	NA	160	680	NA		16E-SD02

Notes:

B - The reported result is an estimated concentration that is less than the PQL, but greater than or equal to the MDL.
N - The matrix spike recovery is not within control limtis.
U - The compound was analyzed for, but was not detected at or above the MDL/PQL.
* - Duplicate analysis is not within control limits.
NA - Not Available.
ft bgs - feet below ground surface.
mg/kg - milligrams per kilogram.

APPENDIX B

SUMMARY OF ORGANIC DETECTIONS IN SURFACE WATER
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE II ECP INVESTIGATION
NAVAL ACTIVITY PUERTO RICO

Site ID Sample ID Sample Date	PR Water Quality Standards (ug/L)	**Surface Water Screening Values** (ug/L)	16E-SW/SD01 16E-SW01 05/14/04	16E-SW/SD02 16E-SW02 05/14/04	Number Exceeding PR Water Quality Standards	Range Exceeding PR Water Quality Standards	**Number Exceeding Surface Water Screening Values**	**Range Exceeding Surface Water Screening Values**	Location Maximum Detection
Volatile Organic Compounds (ug/L)									
Bromoform	NE	640	1 U	1	NE		0/2		16E-SW02
Semivolatile Organic Compounds (ug/L)									
Not Detected									
Pesticides/PCBs (ug/L)									
Not Detected									
OP-Pesticides (ug/L)									
Not Detected									
Chlorinated Herbicides (ug/L)									
Not Detected									

Notes:

U - The compound was analyzed for, but was not detected at or above the MDL/PQL.
ug/L - micrograms per liter.
NE - Not Established.

APPENDIX B

SUMMARY OF INORGANIC DETECTIONS IN SURFACEWATER
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE II ECP INVESTIGATION
NAVAL ACTIVITY PUERTO RICO

Site ID Sample ID Sample Date	PR Water Quality Standards (mg/L)	**Surface Water Screening Values** (mg/L)	16E-SW/SD01 16E-SW01 05/14/04	16E-SW/SD02 16E-SW02 05/14/04	Number Exceeding PR Water Quality Standards	Range Exceeding PR Water Quality Standards	**Number Exceeding Surface Water Screening Values**	**Range Exceeding Surface Water Screening Values**	Location Maximum Detection
Appendix IX (Total) Inorganics (mg/L)									
Barium	NE	50	0.0068 B	0.026	NE		0/2		16E-SW02
Chromium	0.011	0.0504	0.01 U	0.0015 B	0/2		0/2		16E-SW02
Vanadium	NE	0.120[(1)]	0.1 U	0.018	NE		0/2		16E-SW02
Zinc	0.081	0.086	0.025	0.012 B	0/2		0/2		16E-SW01

Notes:

B - The reported result is an estimated concentration that is less than the PQL, but greater than or equal to the MDL.
U - The compound was analyzed for, but was not detected at or above the MDL/PQL.
[(1)] - This chemical lacks a marine/estuarine surface water screening value. The value shown is a freshwater screening value.
NE - Not Established.
mg/L - milligrams per liter.

APPENDIX C
SUMMARY OF PHASE I RFI ANALYTICAL RESULTS

APPENDIX C

SUMMARY OF DETECTED LABORATORY RESULTS - SURFACE SOIL
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE I RFI REPORT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Site ID Sample ID Date Depth Range (ft bgs)	**Regional Screening Levels Residential**	*Regional Screening Levels Industrial*	Selected Ecological Soil Screening Values	NAPR Basewide Background [1]	70SB01 70SB01-00 1/14/2009 0.0-1.0	70SB02 70SB02-00 1/14/2009 0.0-1.0	70SB03 70SB03-00 1/14/2009 0.0-1.0	70SB04 70SB04-00 1/15/2009 0.0-1.0	70SB04 70SB04-00D 1/15/2009 0.0-1.0	70SB05 70SB05-00 1/20/2009 0.0-1.0
Volatile Organic Compounds (ug/kg)										
Benzene	1,100	5,600	101 [7]	NE	0.81 U	1.1 U	0.93 U	1.1 U	1 U	1.6 J
Carbon disulfide	67,000 [2]	300,000 [2]	NE	NE	1.2 U	2.4 J	1.4 U	1.6 U	1.6 U	1.7 U
Semivolatile Organic Compounds (ug/kg)										
2-Methylnaphthalene	31,000 [2]	410,000 [2]	NE	NE	6.6 J	7.2 J	38	84 J	4.6 J	2 U
Benzo[a]anthracene	150	2,100	NE	NE	1.8 U	2.6 U	2.4 U	2.1 U	2.2 U	6.2 J
Benzo[a]pyrene	15	210	NE	NE	1.8 U	2.6 U	2.4 U	2.1 U	2.2 U	8.7
Benzo[b]fluoranthene	150	2,100	NE	NE	1.8 U	2.6 UJ	2.4 UJ	2.1 U	2.2 U	9.1
Benzo[g,h,i]perylene	170,000 [2] [3]	1,700,000 [2] [3]	NE	NE	1.8 UJ	2.6 U	2.4 U	2.1 UJ	2.2 UJ	6.7 J
Benzo[k]fluoranthene	1,500	21,000	NE	NE	1.8 U	2.6 U	2.4 U	2.1 U	2.2 U	9.3
Chrysene	15,000	210,000	NE	NE	1.8 U	2.6 U	2.4 U	2.1 U	2.2 U	7.3 J
Dibenz(a,h)anthracene	15	210	NE	NE	0.6 UJ	0.86 U	0.8 U	0.71 UJ	0.75 UJ	2.7 J
Fluoranthene	230,000 [2]	2,200,000 [2]	NE	NE	0.4 U	0.57 U	0.86 J	0.77 J	0.5 U	4.1 J
Indeno[1,2,3-cd]pyrene	150	2,100	NE	NE	3.5 UJ	5 U	4.6 U	4.1 UJ	4.3 UJ	4 J
Naphthalene	3,900	20,000	NE	NE	1.8 U	2.6 U	2.7 J	4.2 J	2.2 U	2 U
Pyrene	170,000 [2]	1,700,000 [2]	NE	NE	1.8 U	2.6 U	2.4 U	2.1 U	2.2 U	4.8 J
PAHs (ug/kg)										
Low molecular weight PAHs	NE	NE	29,000 [5]	NE	17.8	23.37	53.56	99.47	18.3	18.1
High molecular weight PAHs	NE	NE	18,000 [6]	NE	16.7	24.06	22.2	19.51	20.45	58.8
PCBs (ug/kg)										
None Detected										
Metals (mg/kg)										
Arsenic	0.39	1.6	18 [8]	2.65	***4.2***	1.9 U	***2.2*** J	***4.4***	***6***	***7***
Barium	1,500 [2]	19,000 [2]	330 [9]	199	7.9 J	8.2 J	9.4 J	11 J	12 J	30
Beryllium	16 [2]	200 [2]	40 [9]	0.59	0.08 U	0.13 U	0.12 U	0.11 U	0.11 U	0.041 J

APPENDIX C

SUMMARY OF DETECTED LABORATORY RESULTS - SURFACE SOIL
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE I RFI REPORT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Site ID	**Regional**	*Regional*	Selected	NAPR	70SB01	70SB02	70SB03	70SB04	70SB04	70SB05
Sample ID	**Screening**	*Screening*	Ecological	Basewide	70SB01-00	70SB02-00	70SB03-00	70SB04-00	70SB04-00D	70SB05-00
Date	**Levels**	*Levels*	Soil	Background [1]	1/14/2009	1/14/2009	1/14/2009	1/15/2009	1/15/2009	1/20/2009
Depth Range (ft bgs)	**Residential**	*Industrial*	Screening		0.0-1.0	0.0-1.0	0.0-1.0	0.0-1.0	0.0-1.0	0.0-1.0
Metals (mg/kg)										
Cadmium	7 [2]	81 [2]	32 [8]	1.02	0.14 U	0.22 U	0.21 U	0.19 U	0.19 U	0.043 J
Chromium	280	1,400	57 [10]	49.8	5.7 J	7.8 J	6.4 U	4.4 U	3.8 U	13
Cobalt	2.3 [2]	30 [2]	13 [8]	46.2	1.1 J	0.94 J	1.1 J	0.73 J	0.67 J	**3.4**
Copper	310 [2]	4,100 [2]	70 [8]	168	4.4 J	5.3 J	5.1 J	3 UJ	3.1 UJ	12
Lead	400 [4]	800 [4]	120 [8]	22	0.43 J	0.63 UJ	0.61 UJ	0.53 UJ	0.55 UJ	0.58
Mercury	2.3 [2]	31 [2]	0.1 [11]	0.109	0.004 U	0.005 U	0.0048 U	0.0048 U	0.0048 U	0.0066 J
Nickel	160 [2]	2,000 [2]	38 [8]	20.7	2.6 J	3.2 J	2.4 J	1.9 J	1.6 J	4.4
Vanadium	55 [2]	720 [2]	10 [12]	259	11 J	8.5 J	8 J	7.5 J	4.4 UJ	27
Zinc	2,300 [2]	31,000 [2]	120 [9]	115	4.2 UJ	6.2 UJ	6.7 UJ	3.9 UJ	4 UJ	5.5
TPH DRO and GRO (mg/kg)										
Diesel Range Organics	NE	NE	NE	NE	0.81 U	1.9 U	12	2.6 U	1.9 U	30
Gasoline Range Organics	NE	NE	NE	NE	0.067 U	0.079 U	0.19 U	0.087 U	0.086 U	0.098 J
Total TPH	100 [13]	NE	NE	NE	0.88	1.98	12	2.69	1.99	30.1

APPENDIX C

SUMMARY OF DETECTED LABORATORY RESULTS - SURFACE SOIL
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE I RFI REPORT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Table References:

Baker Environmental, Inc, (2008). Revised Final II Summary Report for Environmental Background Concentrations of Inorganic Compounds, Naval Activity Puerto Rico, Ceiba, Puerto Rico. February 29, 2008.

Efroymson, R.A., M.E. Will, and G.W. Suter II. 1997a. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revisions. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-126/R2.

Ministry of Housing, Spatial Planning and Environment (MHSPE). 2000. Circular on Target Values and Intervention Values for Soil Remediation. Directorate-General for Environmental Protection, Department of Soil Protection, The Hague, Netherlands. February 4, 2000.

United States Environmental Protection Agency (USEPA). 2008. Ecological Soil Screening Levels for Chromium (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-66.

USEPA. 2007a. Ecological Soil Screening Levels for Polycyclic Aromatic Hydrocarbons (PAHs) (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-78.

USEPA. 2007b. Ecological Soil Screening Levels for Copper (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-68.

USEPA. 2007c. Ecological Soil Screening Levels for Nickel (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-76.

USEPA. 2007d. Ecological Soil Screening Levels for Zinc (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-72.

USEPA. 2005a. Ecological Soil Screening Levels for Arsenic (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C.

USEPA. 2005b. Ecological Soil Screening Levels for Cadmium (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-62.

USEPA. 2005c. Ecological Soil Screening Levels for Cobalt (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-67

USEPA. 2005d. Ecological Soil Screening Levels for Lead (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-70.

USEPA. 2005e. Ecological Soil Screening Levels for Barium (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-63.

USEPA. 2005f. Ecological Soil Screening Levels for Beryllium (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-63.

USEPA. 2005g. Ecological Soil Screening Levels for Vanadium (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-75.

APPENDIX C

SUMMARY OF DETECTED LABORATORY RESULTS - SURFACE SOIL
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE I RFI REPORT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Notes/Qualifiers:

J - Estimated: The analyte was positively identified; the quantitation is an estimation
U - Undetected at the Method Detection Limit
UJ - Reported quantitation limit is qualified as estimated
ft bgs - feet below ground surface
ug/kg - micrograms per kilogram
mg/kg - miligrams per kilogram
NE - Not Established
NAPR - Naval Activity Puerto Rico
USEPA - United States Environmental Protection Agency

(1) NAPR basewide background surface soil screening value (upper limit of the means concentration [mean plus two standard deviations]) (Baker, 2008)

(2) Noncarcinogenic Regional Screening Levels based on a target hazard quotient of 0.1 for conservative screening purposes

(3) Pyrene used as a surrogate for screening purposes for benzo[g,h,i] perylene

(4) USEPA Action Level for lead in soils

(5) Low molecular weight PAHs are defined by the USEPA (2007a) as PAH compounds composed of fewer than four rings. The low molecular weight PAH compounds analyzed for in SWMU 70 soil were 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, fluoranthene, fluorene, naphthalene, and phenanthrene. Maximum method detection limit was used if there were no detections.

(6) High molecular weight PAHs are defined by the USEPA (2007a) as PAH compounds composed of four or more rings. The high molecular weight PAH compounds analyzed for in SWMU 70 soil were benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, and pyrene. Maximum method detection limits were used for non-detected PAHs.

(7) The screening value shown is an average of the target and intervention soil standards. The value is based on a default organic carbon content of 0.02 (2 percent), which represents a minimum value (adjustment range is 2 to 30 percent).

(8) Plant-based ecological soil screening level (USEPA, 2005a [arsenic]; USEPA, 2005b [cadmium]; USEPA, 2005c [cobalt]; USEPA, 2005d [lead]; USEPA, 2007b [copper]; USEPA, 2007c [nickel]

(9) Invertebrate-based ecological soil screening level (USEPA, 2005e[barium]; USEPA, 2005f [beryllium]; USEPA, 2007d [zinc])

(10) Reproduction-based MATC for *Eisenia andrei* (earthworm)

(11) Toxicological threshold for earthworms (Efroymson et al., 1997a)

(12) Growth-based LOAEC for *Brassica oleracea* (broccoli) with a safety factor of 10 (USEPA, 2005g)

(13) Total TPH value represents the Puerto Rico Environmental Quality Board recommended screening value for soils

APPENDIX C

SUMMARY OF DETECTED LABORATORY RESULTS - SUBSURFACE SOIL
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE I RFI REPORT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Site ID Sample ID Date Depth Range (ft bgs)	**Regional Screening Levels Residential**	*Regional Screening Levels Industrial*	Selected Ecological Soil Screening Values	NAPR Basewide Background [1]	70SB01 70SB01-01 1/14/2009 1.0-3.0	70SB02 70SB02-01 1/14/2009 1.0-3.0	70SB03 70SB03-01 1/14/2009 1.0-3.0	70SB04 70SB04-01 1/15/2009 1.0-3.0	70SB04 70SB04-01D 1/15/2009 1.0-3.0	70SB05 70SB05-01 1/20/2009 1.0-3.0	70SB05 70SB05-01D 1/20/2009 1.0-3.0
Volatile Organic Compounds (ug/kg)											
Benzene	1,100	5,600	101 [3]	NE	1 U	1.3 U	1 U	1.1 U	1.1 U	1.5 J	1.2 U
Carbon disulfide	67,000 [2]	300,000 [2]	NE	NE	1.5 U	2 U	1.6 U	1.7 U	1.7 U	2 J	2.3 J
Semivolatile Organic Compounds (ug/kg)											
2-Methylnaphthalene	31,000 [2]	410,000 [2]	NE	NE	2.2 U	12	3 J	2.5 U	2.4 U	2.4 U	2.4 U
PAHs (ug/kg)											
Low molecular weight PAHs	NE	NE	29,000 [4]	NE	13.7	27.7	15.5	15.6	15.0	17.3	17.3
High molecular weight PAHs	NE	NE	18,000 [5]	NE	20.4	27.8	22.3	23.2	22.3	22.2	22.2
PCBs (ug/kg)											
None Detected											
Metals (mg/kg)											
Arsenic	0.39	1.6	18 [6]	6.66	***3.8***	***6.1***	***3.9***	***5.6***	***4.8***	***4.8***	***4.7***
Barium	1,500 [2]	19,000 [2]	330 [7]	207	8.8 J	12 J	10 J	8.6 J	9 J	10	11
Beryllium	16 [2]	200 [2]	40 [7]	0.933	0.11 U	0.13 U	0.11 U	0.11 U	0.11 U	0.021 U	0.025 J
Chromium	280	1,400	57 [8]	47.9	3.6 UJ	21 J	8.8 J	3 U	2.6 U	7.3	9
Cobalt	2.3 [2]	30 [2]	13 [6]	63.1	0.74 J	**4.3** J	1.1 J	0.66 J	0.71 J	1.7 J	**3.7** J
Copper	310 [2]	4,100 [2]	70 [6]	120	3 UJ	23 J	5.7 U	3.1 UJ	3.2 UJ	5.5 R	14 R
Mercury	2.3 [2]	31 [2]	0.1 [9]	0.067	0.0051 U	0.0065 U	0.049	0.0056 U	0.0053 U	0.005 U	0.005 U
Nickel	160 [2]	2,000 [2]	38 [6]	26.5	1.9 J	64 J	3 J	1.6 J	1.7 J	2.3 J	4 J
Vanadium	55 [2]	720 [2]	10 [10]	256	5.9 UJ	25 J	11 J	4.5 UJ	4 UJ	21 J	35 J
TPH DRO and GRO (mg/kg)											
Gasoline Range Organics	NE	NE	NE	NE	0.084 U	0.092 U	0.083 U	0.084 U	0.076 U	0.085 R	0.16 J
Diesel Range Organics	NE	NE	NE	NE	1.4 U	1.9 U	1.5 U	1.3 U	0.94 U	1.2 U	2.3 U
Total TPH	100 [11]	NE	NE	NE	1.48	1.99	1.58	1.38	1.02	1.29	0.16 J

APPENDIX C

SUMMARY OF DETECTED LABORATORY RESULTS - SUBSURFACE SOIL
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE I RFI REPORT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Notes/Qualifiers:

J - Estimated: The analyte was positively identified; the quantitation is an estimation
U - Undetected at the Method Detection Limit
UJ - Reported quantitation limit is qualified as estimated
R - Data is rejected and not usable
ft bgs - feet below ground surface
ug/kg - micrograms per kilogram
mg/kg - miligrams per kilogram
NE - Not Established
NAPR - Naval Activity Puerto Rico
USEPA - United States Environmental Protection Agency

(1) NAPR basewide background soil screening value (upper limit of the means concentration [mean plus two standard deviations]) for Subsurface Soil Background Fine Sand/Silt Table 3-7 (Baker, 2008)

(2) Noncarcinogenic RSLs based on a target hazard quotient of 0.1 for conservative screening purposes

(3) The screening value shown is an average of the target and intervention soil standards. The value is based on a default organic carbon content of 0.02 (2 percent), which represents a minimum value (adjustment range is 2 to 30 percent).

(4) Low molecular weight PAHs are defined by the USEPA (2007a) as PAH compounds composed of fewer than four rings. The low molecular weight PAH compounds analyzed for in SWMU 70 soil were 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, fluoranthene, fluorene, naphthalene, and phenanthrene. Maximum method detection limit was used if there were no detections. Rejected data was not used. Acenaphthylene was rejected in all the subsurface samples except 70SB05-01 and its duplicate sample.

(5) High molecular weight PAHs are defined by the USEPA (2007a) as PAH compounds composed of four or more rings. The high molecular weight PAH compounds analyzed for in SWMU 70 soil were benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, and pyrene. Maximum method detection limits were used for non-detected PAHs.

(6) Plant-based ecological soil screening level (USEPA, 2005a [arsenic]; USEPA, 2008 [cadmium]; USEPA, 2005b [cobalt]; USEPA, 2007b [copper]; USEPA, 2007c [nickel]

(7) Invertebrate-based ecological soil screening level (USEPA, 2005c [barium]; USEPA, 2005d [beryllium]

(8) Reproduction-based MATC for *Eisenia andrei* (earthworm)

(9) Toxicological threshold for earthworms (Efroymson et al., 1997a)

(10) Growth-based LOAEC for *Brassica oleracea* (broccoli) with a safety factor of 10 (USEPA, 2005g)

(11) Total TPH value represents the Puerto Rico Environmental Quality Board recommended screening value for soils

APPENDIX C

SUMMARY OF DETECTED LABORATORY RESULTS - SUBSURFACE SOIL
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE I RFI REPORT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Table References:

Baker Environmental, Inc, (2008). Revised Final II Summary Report for Environmental Background Concentrations of Inorganic Compounds, Naval Activity Puerto Rico, Ceiba, Puerto Rico. February 29, 2008.

Efroymson, R.A., M.E. Will, and G.W. Suter II. 1997a. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revisions. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-126/R2.

Ministry of Housing, Spatial Planning and Environment (MHSPE). 2000. Circular on Target Values and Intervention Values for Soil Remediation. Directorate-General for Environmental Protection, Department of Soil Protection, The Hague, Netherlands. February 4, 2000.

United States Environmental Protection Agency (USEPA). 2008. Ecological Soil Screening Levels for Chromium (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-66.

USEPA. 2007a. Ecological Soil Screening Levels for Polycyclic Aromatic Hydrocarbons (PAHs) (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-78.

USEPA. 2007b. Ecological Soil Screening Levels for Copper (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-68.

USEPA. 2007c. Ecological Soil Screening Levels for Nickel (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-76.

USEPA. 2005a. Ecological Soil Screening Levels for Arsenic (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C.

USEPA. 2005b. Ecological Soil Screening Levels for Cobalt (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-67

USEPA. 2005c. Ecological Soil Screening Levels for Barium (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-63.

USEPA. 2005d. Ecological Soil Screening Levels for Beryllium (Interim Final). Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-63.

APPENDIX C

SUMMARY OF DETECTED LABORATORY RESULTS - OPEN WATER SEDIMENT
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE I RFI REPORT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Site ID Sample ID Date Depth Range (ft bgs)	**Regional Screening Levels Residential**	*Regional Screening Levels Industrial*	Selected Ecological Sediment Screening Values	NAPR Basewide Background [1]	70SD01 70SD01 1/17/2009 0.0-0.5	70SD02 70SD02 1/17/2009 0.0-0.5	70SD03 70SD03 1/22/2009 0.0-0.5	70SD03 70SD03D 1/22/2009 0.0-0.5
Volatile Organic Compounds (ug/kg)								
Acetone	6,100,000 [2]	61,000,000 [2]	5.81 [4]	NE	140 J	300 J	140 J	240 J
Benzene	1,100	5,600	135 [4]	NE	1.1 U	1.2 U	1.6 J	1.4 UJ
Carbon disulfide	67,000 [2]	300,000 [2]	13.9 [4]	NE	8.5	17	5.7 J	5.9 J
Methylene Chloride	11,000	54,000	434 [4]	NE	2.5 J	3.2 J	1.9 UJ	1.7 UJ
Semivolatile Organic Compounds (ug/kg)								
3 & 4 Methylphenol	NE	NE	100 [5] [6]	NE	12 U	94	17 UJ	15 UJ
Benzo[a]anthracene	150	2,100	74.8 [7]	NE	9.9 J	2.9 U	4 UJ	3.4 UJ
Benzo[a]pyrene	15	210	88.8 [7]	NE	7.4 J	2.9 U	4 UJ	3.4 UJ
Benzo[b]fluoranthene	150	2,100	1,800 [8]	NE	8.2 J	4.1 J	4 UJ	3.4 UJ
Benzo[k]fluoranthene	1,500	21,000	1,800 [8]	NE	6.6 J	2.9 U	4 UJ	3.4 UJ
Bis(2-ethylhexyl) phthalate	35,000	120,000	182 [7]	NE	20 U	21 U	19 J	25 J
Chrysene	15,000	210,000	108 [7]	NE	6.8 J	2.9 U	4 UJ	3.4 UJ
Fluoranthene	230,000 [2]	2,200,000 [2]	113 [7]	NE	13	0.64 U	5.2 J	4 J
Phenanthrene	NE	NE	86.7 [7]	NE	3 J	2.9 U	4 UJ	3.4 UJ
Pyrene	170,000 [2]	1,700,000 [2]	153 [7]	NE	14	2.9 U	5.5 J	4.2 J
PCBs (ug/kg)								
None Detected								
Metals (mg/kg)								
Arsenic	0.39	1.6	7.24 [7]	10.5	***2***	***4.4***	***5.6*** J	***5.3*** J
Barium	1,500 [2]	19,000 [2]	48 [9]	11.82	7	12	13 J	13 J
Beryllium	16 [2]	200 [2]	NE	0.304	0.026 U	0.057 J	0.098 J	0.075 J
Chromium	280	1,400	52.3 [7]	17.6	2.9	21	18 J	16 J
Cobalt	2.3 [2]	30 [2]	10 [10]	3.9	0.85	**6.4**	**4.9** J	**4.3** J

APPENDIX C

SUMMARY OF DETECTED LABORATORY RESULTS - OPEN WATER SEDIMENT
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE I RFI REPORT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Site ID Sample ID Date Depth Range (ft bgs)	**Regional Screening Levels Residential**	*Regional Screening Levels Industrial*	Selected Ecological Sediment Screening Values	NAPR Basewide Background [1]	70SD01 70SD01 1/17/2009 0.0-0.5	70SD02 70SD02 1/17/2009 0.0-0.5	70SD03 70SD03 1/22/2009 0.0-0.5	70SD03 70SD03D 1/22/2009 0.0-0.5
Metals (mg/kg)								
Copper	310 [2]	4,100 [2]	18.7 [7]	29	1.8 J	21	29 J	25 J
Lead	400 [3]	800 [3]	30.2 [7]	5.4	0.51	1.3	2 J	1.9 J
Mercury	2.3 [2]	31 [2]	0.13 [7]	0.056	0.0057 U	0.015 J	0.015 J	0.014 J
Nickel	160 [2]	2,000 [2]	15.9 [7]	6.7	0.83	8.7	7.1 J	6.3 J
Selenium	39 [2]	510 [2]	1.0 [9]	1.08	0.17 U	0.2 J	0.3 UJ	0.33 UJ
Vanadium	55 [2]	720 [2]	57 [10]	47	4.3	35	45 J	37 J
Zinc	2,300 [2]	31,000 [2]	124 [7]	32	3.1 U	17	23 J	20 J
TPH DRO and GRO (mg/kg)								
Diesel Range Organics	NE	NE	NE	NE	1.2 U	1 U	29 J	13 UJ
Gasoline Range Organics	NE	NE	NE	NE	0.1 U	0.1 U	0.14 J	0.16 J
Total TPH	100 [11]	NE	NE	NE	1.3	1.1	29.1	0.16 J

APPENDIX C

SUMMARY OF DETECTED LABORATORY RESULTS - OPEN WATER SEDIMENT
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE I RFI REPORT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Notes/Qualifiers:

J - Estimated: The analyte was positively identified; the quantitation is an estimation
U - Undetected at the Method Detection Limit
UJ - Reported quantitation limit is qualified as estimated
ft bgs - feet below ground surface
ug/kg - micrograms per kilogram
mg/kg - miligrams per kilogram
NE - Not Established
NAPR - Naval Activity Puerto Rico
USEPA - United States Environmental Protection Agency

(1) NAPR basewide background sediment screening value (upper limit of the means concentration [mean plus two standard deviations]) (Baker, 2008)
(2) Noncarcinogenic RSLs based on a target hazard quotient of 0.1 for conservative screening purposes
(3) USEPA Action Level for lead in soils
(4) EqP-based screening value
(5) Minimum Apparent Effects Threshold (bivalve)
(6) The value shown is for 4-methylphenol.
(7) Threshold Effect Level
(8) Minimum Apparent Effects Threshold (Echinoderm larvae and infaunal commuity impacts)
(9) Minimum Apparent Effects Threshold (amphipod)
(10) Minimum Apparent Effects Threshold (Neanthes bioassays)
(11) Total TPH value represents the Puerto Rico Environmental Quality Board recommended screening value for soils

References:

Buchman, M.F. 2008. NOAA Screening Quick Reference Tables. NOAA OR&R Report 08-1. National Oceanic and Atmospheric Administration, Office of Response and Restoration Division, Seattle, WA.

MacDonald, D.D. 1994. Approach to the Assessment of Sediment Quality in Florida Waters: Volume 1 - Development and Evaluation of Sediment Quality Assessment Guidelines. Prepared for Florida Department of Environmental Protection, Tallahassee, Fl. November 1994.

USEPA. 1996. Ecotox Thresholds. Eco Update, Volume 3, Number 2. Office of Solid Waste and Emergency Response, Washington, D.C. EPA/F-95/038.

USEPA. 1993. Technical Basis for Deriving Sediment Quality Criteria for Nonionic Organic Contaminants for the Protection of Benthic Organisms by Using Equilibrium Partitioning. Office of Water, Washington, D.C. EPA-822-R-93-011.

APPENDIX C

SUMMARY OF DETECTED LABORATORY RESULTS - ESTUARINE SEDIMENT
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE I RFI REPORT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Site ID Sample ID Date Depth Range (ft bgs)	**Regional Screening Levels Residential**	*Regional Screening Levels Industrial*	Selected Ecological Sediment Screening Values	NAPR Basewide Background [1]	70SB06 70SD06 1/15/2009 0.0-0.5	70SB07 70SD07 1/15/2009 0.0-0.5	70SB08 70SD08 1/15/2009 0.0-0.5
Volatile Organic Compounds (ug/kg)							
Acetone	6,100,000 [2]	61,000,000 [2]	5.81 [4]	NE	48 J	7.6 J	25 J
Carbon disulfide	67,000 [2]	300,000 [2]	13.9 [4]	NE	1.4 U	1.5 U	6.6 J
Methylene Chloride	11,000	54,000	434 [4]	NE	1.5 J	1.3 J	2.5 J
Semivolatile Organic Compounds (ug/kg)							
Fluoranthene	230,000 [2]	2,200,000 [2]	113 [5]	NE	0.56 J	1.8 J	1.1 J
Pyrene	170,000 [2]	1,700,000 [2]	153 [5]	NE	2.4 U	2.7 J	2.5 U
PCBs (ug/kg)							
None Detected							
Metals (mg/kg)							
Arsenic	0.39	1.6	7.24 [5]	7.0	***3.5***	3 U	***5.5***
Barium	1,500 [2]	19,000 [2]	48 [6]	24.93	42 J	18 J	11 J
Chromium	280	1,400	52.3 [7]	50.05	10 J	54 J	31 J
Cobalt	2.3 [2]	30 [2]	10 [7]	22.35	**9.4** J	**22** J	**8** J
Copper	310 [2]	4,100 [2]	18.7 [5]	132.44	53 J	80 J	20 J
Lead	400 [3]	800 [3]	30.2 [5]	25.4	4.8 J	1.1 UJ	1.3 UJ
Mercury	2.3 [2]	31 [2]	0.13 [5]	0.17	0.005 U	0.0081 J	0.012 J
Nickel	160 [2]	2,000 [2]	15.9 [5]	17.31	7.2 J	24 J	9.8 J
Vanadium	55 [2]	720 [2]	57 [7]	230.43	**67** J	**290** J	**63** J
Zinc	2,300 [2]	31,000 [2]	124 [5]	96.9	47 J	39 J	15 UJ
TPH DRO and GRO (mg/kg)							
Not Detected							
Total Organic Carbon (mg/kg)							
Total Organic Carbon	NE	NE	NE	NE	30,000	5,400	36,000

APPENDIX C

SUMMARY OF DETECTED LABORATORY RESULTS - ESTUARINE SEDIMENT
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE I RFI REPORT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Notes/Qualifiers:

J - Estimated: The analyte was positively identified; the quantitation is an estimation
U - Undetected at the Method Detection Limit
UJ - Reported quantitation limit is qualified as estimated
ft bgs - feet below ground surface
ug/kg - micrograms per kilogram
mg/kg - miligrams per kilogram
NE - Not Established
NAPR - Naval Activity Puerto Rico
USEPA - United States Environmental Protection Agency

(1) NAPR basewide background sediment screening value (upper limit of the means concentration [mean plus two standard deviations]) (Baker, 2008)
(2) Noncarcinogenic RSLs based on a target hazard quotient of 0.1 for conservative screening purposes
(3) USEPA Action Level for lead in soils
(4) EqP-based screening value
(5) Threshold Effect Level
(6) Minimum Apparent Effects Threshold (amphipod)
(7) Minimum Apparent Effects Threshold (Neanthes bioassays)

References:

Buchman, M.F. 2008. NOAA Screening Quick Reference Tables. NOAA OR&R Report 08-1. National Oceanic and Atmospheric Administration, Office of Response and Restoration Division, Seattle, WA.

MacDonald, D.D. 1994. Approach to the Assessment of Sediment Quality in Florida Waters: Volume 1 - Development and Evaluation of Sediment Quality Assessment Guidelines. Prepared for Florida Department of Environmental Protection, Tallahassee, Fl. November 1994.

USEPA. 1996. Ecotox Thresholds. Eco Update, Volume 3, Number 2. Office of Solid Waste and Emergency Response, Washington, D.C. EPA/F-95/038.

USEPA. 1993. Technical Basis for Deriving Sediment Quality Criteria for Nonionic Organic Contaminants for the Protection of Benthic Organisms by Using Equilibrium Partitioning. Office of Water, Washington, D.C. EPA-822-R-93-011.

APPENDIX C

SUMMARY OF DETECTED LABORATORY RESULTS - GROUNDWATER
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE I RFI REPORT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Site ID Sample ID Date Depth Range	**Regional Tap Water Screening Levels**	*USEPA MCLs*	Ecological Groundwater Screening Values	NAPR Basewide Background [1]	70SB01 70GW01 1/17/2009	70SB02 70GW02 1/17/2009	70SB02 70GW02D 1/17/2009	70SB03 70GW03 1/17/2009	70SB04 70GW04 1/17/2009	70SB05 70 GW05 1/20/2009
Volatile Organic Compounds (ug/L)										
Acetone	2,200 [2]	NE	1,000 [3]	NE	5.5 J	5 R	6.4 J	5 U	5 U	14 J
Carbon disulfide	100 [2]	NE	15 [4]	NE	1.3 U	0.6 R	0.73 R	0.6 U	0.6 U	0.86 J
Vinyl chloride	0.016	2	930 [4]	NE	0.2 U	0.62 R	0.62 R	0.2 U	**0.23** J	0.62 R
Semivolatile Organic Compounds (ug/L)										
1,3-Dichlorobenzene	NE	NE	28.5 [5]	NE	0.12 U	0.12 U	0.12 U	0.12 U	0.12 U	0.21 J
2-Methylnaphthalene	15 [2]	NE	6 [6]	NE	0.023 U	0.023 U	0.023 U	0.022 U	0.022 U	0.027 J
3 & 4 Methylphenol	NE	NE	25 [7]	NE	0.4 J	0.73 J	0.49 J	0.15 U	0.26 J	0.15 UJ
Anthracene	1,100 [2]	NE	5.35 [8]	NE	0.027 U	0.027 U	0.025 U	0.025 U	0.025 U	0.026 U
Bis(2-ethylhexyl) phthalate	4.8	6	360 [9]	NE	0.36 UJ	0.49 J	1.8 J	0.35 J	0.4 J	0.35 U
Naphthalene	0.14	NE	23.5 [5]	NE	0.027 U	0.027 U	0.025 U	0.025 U	0.029 J	0.12 J
Phenanthrene	NE	NE	8.3 [10]	NE	0.032 U	0.032 U	0.03 U	0.03 U	0.03 U	0.039 J
PCBs (ug/L)										
None Detected										
Total Metals (ug/L)										
Barium	730 [2]	2,000	16,667 [11]	686	40 U	390	390	95 J	40 U	80 U
Chromium	NE	NE	50.4 [12]	162.41	12 U	21 J	12 U	12 U	12 U	24 U
Cobalt	1.1 [2]	NE	45 [13]	633.21	1.1 U	2.4 U	2.9 U	**67**	2.2 U	3.7 U
Copper	150 [2]	1300	3.73 [12]	324	24 U	25 J	24 U	24 U	24 U	48 U
Nickel	73 [2]	NE	8.28 [12]	95.74	6.4 U	12 J	6.4 U	35	6.4 U	13 U
Vanadium	26 [2]	NE	12 [14]	484.66	19 J	**34** J	24 J	16 U	16 U	32 U

APPENDIX C

SUMMARY OF DETECTED LABORATORY RESULTS - GROUNDWATER
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE I RFI REPORT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Site ID Sample ID Date Depth Range	**Regional Tap Water Screening Levels**	*USEPA MCLs*	Ecological Groundwater Screening Values	NAPR Basewide Background [1]	70SB01 70GW01 1/17/2009	70SB02 70GW02 1/17/2009	70SB02 70GW02D 1/17/2009	70SB03 70GW03 1/17/2009	70SB04 70GW04 1/17/2009	70SB05 70 GW05 1/20/2009
Dissolved Metals (ug/L)										
Arsenic	0.045	10	36 [15]	14.03	***44*** J	***13*** J	***16*** J	**9.4** J	***33*** J	15 U
Barium	730 [2]	2,000	16,667 [11]	260	40 U	400	390	93 J	40 U	80 U
Cobalt	1.1 [2]	NE	45 [13]	580.5	2.5 U	3.4 U	2.1 U	**66**	2.3 U	4.3 U
Copper	150 [2]	1,300	3.73 [12]	29	24 UJ	28 J	24 UJ	24 UJ	24 UJ	48 U
Nickel	73 [2]	NE	8.28 [12]	84.1	6.4 U	6.4 U	6.4 U	31	11 J	13 U
Vanadium	26 [2]	NE	12 [14]	20.96	17 J	**32** J	**31** J	16 U	16 U	32 U
TPH DRO and GRO (mg/L)										
Diesel Range Organics	NE	NE	NE	NE	1.5	0.65	0.5	0.64	0.12 U	0.2 U
Gasoline Range Organics	NE	NE	NE	NE	0.012 U	0.012 R	0.012 R	0.012 U	0.012 U	0.013 J
Total TPH	50 [16]	NE	NE	NE	1.5	0.65	0.5	0.64	0.132	0.013 J

APPENDIX C

SUMMARY OF DETECTED LABORATORY RESULTS - GROUNDWATER
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE I RFI REPORT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Site ID Sample ID Date Depth Range	**Regional Tap Water Screening Levels**	*USEPA MCLs*	Ecological Groundwater Screening Values	NAPR Basewide Background [1]	70SB06 70GW06 1/17/2009	70SB07 70GW07 1/17/2009	70SB08 70GW08 1/17/2009
Volatile Organic Compounds (ug/L)							
Acetone	2,200 [2]	NE	1,000 [3]	NE	5 U	5 U	5 U
Carbon disulfide	100 [2]	NE	15 [4]	NE	0.6 U	0.6 U	0.6 U
Vinyl chloride	0.016	2	930 [4]	NE	0.2 U	0.2 U	0.2 U
Semivolatile Organic Compounds (ug/L)							
1,3-Dichlorobenzene	NE	NE	28.5 [5]	NE	0.12 U	0.12 U	0.12 U
2-Methylnaphthalene	15 [2]	NE	6 [6]	NE	0.023 U	0.022 U	0.022 U
3 & 4 Methylphenol	NE	NE	25 [7]	NE	0.15 U	0.15 U	0.15 U
Anthracene	1,100 [2]	NE	5.35 [8]	NE	0.025 U	0.025 U	0.039 J
Bis(2-ethylhexyl) phthalate	4.8	6	360 [9]	NE	0.91 J	0.37 J	0.36 J
Naphthalene	0.14	NE	23.5 [5]	NE	0.025 U	0.025 U	0.025 U
Phenanthrene	NE	NE	8.3 [10]	NE	0.03 U	0.03 U	0.03 U
PCBs (ug/L)							
None Detected							
Total Metals (ug/L)							
Barium	730 [2]	2,000	16,667 [11]	686	70 J	55 J	77 J
Chromium	NE	NE	50.4 [12]	162.41	12 U	12 U	12 U
Cobalt	1.1 [2]	NE	45 [13]	633.21	1.4 U	6.7 U	2.1 U
Copper	150 [2]	1300	3.73 [12]	324	24 U	24 U	24 U
Nickel	73 [2]	NE	8.28 [12]	95.74	6.4 U	6.4 U	6.4 U
Vanadium	26 [2]	NE	12 [14]	484.66	16 U	16 J	17 J

APPENDIX C

SUMMARY OF DETECTED LABORATORY RESULTS - GROUNDWATER
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE I RFI REPORT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Site ID Sample ID Date Depth Range	**Regional Tap Water Screening Levels**	*USEPA MCLs*	Ecological Groundwater Screening Values	NAPR Basewide Background [1]	70SB06 70GW06 1/17/2009	70SB07 70GW07 1/17/2009	70SB08 70GW08 1/17/2009
Dissolved Metals (ug/L)							
Arsenic	0.045	10	36 [15]	14.03	5.6 U	5.6 U	5.6 U
Barium	730 [2]	2,000	16,667 [11]	260	72 J	56 J	80 J
Cobalt	1.1 [2]	NE	45 [13]	580.5	1.4 U	6.9 U	2.9 U
Copper	150 [2]	1,300	3.73 [12]	29	24 UJ	24 UJ	24 UJ
Nickel	73 [2]	NE	8.28 [12]	84.1	6.4 U	6.4 U	6.4 U
Vanadium	26 [2]	NE	12 [14]	20.96	16 U	16 U	17 J
TPH DRO and GRO (mg/L)							
Diesel Range Organics	NE	NE	NE	NE	0.12 U	0.078 U	0.45
Gasoline Range Organics	NE	NE	NE	NE	0.012 U	0.012 U	0.012 U
Total TPH	50 [16]	NE	NE	NE	0.132	0.09	0.45

APPENDIX C

SUMMARY OF DETECTED LABORATORY RESULTS - GROUNDWATER
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE I RFI REPORT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Notes:

U - Not detected at the Method Detection Limit
J - Analyte present - Reported value is estimated
UJ - Reported quantitation limit is qualified as estimated
R - Data is rejected and not usable
NE - Not Established
mg/l - micrograms per liter
ug/l - micrograms per liter
NAPR - Naval Activity Puerto Rico
USEPA - United States Environmental Protection Agency

(1) NAPR basewide background groundwater screening value (upper limit of the means concentration [mean plus two standard deviations]) (Baker, 2008)
(2) Noncarcinogenic RSLs based on a target hazard quotient of 0.1 for conservative screening purposes
(3) Minimum acute value (96-hr LC_{50} for *Lumbriculus variegatus* [Oligochaete]) with a safety factor of 100
(4) USEPA Region 5 ecological screening level
(5) USEPA Region 4 chronic screening value
(6) Minimum acute value (96-hr LC_{50} for *Penaeus aztecus* [brown shrimp]) with a safety factor of 100
(7) USEPA Region 5 ecological screening level (the value shown is for 4-methylphenol)
(8) Minimum acute value (48-hr LC_{50} for *Americamysis bahia* [opossum shrimp]) with a safety factor of 100
(9) Proposed Criteria Continuous Concentration
(10) Final Chronic Value
(11) Minimum acute value (96-hr NOEC for *Cyprinodon variegatus* [sheepshead minnow]) with a safety factor of 30
(12) Total recoverable Criteria Continuous Concentration for hexavalent chromium
(13) Minimum acute value (96-hr LC_{50} for *Nitocra spinipes* [Harpacticoid copepod]) with a safety factor of 100
(14) USEPA Region 5 ecological screening level
(15) Total recoverable Criteria Continuous Concentration for trivalent arsenic
(16) Total TPH value represents the Puerto Rico Environmental Quality Board recommended screening value for groundwater

APPENDIX C

SUMMARY OF DETECTED LABORATORY RESULTS - GROUNDWATER
SWMU 70 - DISPOSAL AREA NORTHWEST OF LANDFILL
PHASE I RFI REPORT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

References:

Buchman, M.F. 2008. NOAA Screening Quick Reference Tables. NOAA OR&R Report 08-1. National Oceanic and Atmospheric Administration, Office of Response and Restoration Division, Seattle, WA.

United States Environmental Protection Agency (USEPA). 2007a. ECOTOX User Guide: Ecotoxicology Database System. Version 4.0. http:/www.epa.gov/ecotox/. Accessed May 14, 2003, July 2, 2008, January 8, 2009, and April 1, 2009.

USEPA. 2006. National Recommended Water Quality Criteria. Office of Water and Office of Science and Technology, Washington, D.C.

USEPA. 2003. USEPA Region 5 Ecological Screening Levels Table. http://www.epa.gov/reg5rcra/ca/ESL.pdf.

USEPA. 2001. Region 4 Ecological Risk Assessment Bulletins - Supplement to RQGS. Waste Management Division, Atlanta, GA. http://www.epa.gov/region04/waste/ots/ecolbul.htm.

USEPA. 1996. Ecotox Thresholds. Eco Update, Volume 3, Number 2. Office of Solid Waste and Emergency Response, Washington, D.C. EPA/F-95/038.

APPENDIX D
USEPA REGION II GROUND WATER SAMPLING PROCEDURE
LOW STRESS (Low Flow) PURGING AND SAMPLING

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION II

GROUND WATER SAMPLING PROCEDURE
LOW STRESS (Low Flow) PURGING AND SAMPLING

I. SCOPE & APPLICATION

This Low Stress (or Low-Flow) Purging and Sampling Procedure is the EPA Region II standard method for collecting low stress (low flow) ground water samples from monitoring wells. Low stress Purging and Sampling results in collection of ground water samples from monitoring wells that are representative of ground water conditions in the geological formation. This is accomplished by minimizing stress on the geological formation and minimizing disturbance of sediment that has collected in the well. The procedure applies to monitoring wells that have an inner casing with a diameter of 2.0 inches or greater, and maximum screened intervals of ten feet unless multiple intervals are sampled. The procedure is appropriate for collection of ground water samples that will be analyzed for volatile and semi-volatile organic compounds (VOCs and SVOCs), pesticides, polychlorinated biphenyls (PCBs), metals, and microbiological and other contaminants in association with all EPA programs.

This procedure does not address the collection of light or dense non-aqueous phase liquids (LNAPL or DNAPL) samples, and should be used for aqueous samples only. For sampling NAPLs, the reader is referred to the following EPA publications: DNAPL Site Evaluation (Cohen & Mercer, 1993) and the RCRA Ground-Water Monitoring: Draft Technical Guidance (EPA/530-R-93-001), and references therein.

II. METHOD SUMMARY

The purpose of the low stress purging and sampling procedure is to collect ground water samples from monitoring wells that are representative of ground water conditions in the geological formation. This is accomplished by setting the intake velocity of the sampling pump to a flow rate that limits drawdown inside the well casing.

Sampling at the prescribed (low) flow rate has three primary benefits. First, it minimizes disturbance of sediment in the bottom of the well, thereby producing a sample with low turbidity (i.e., low concentration of suspended particles). Typically, this saves time and analytical costs by eliminating the need for collecting and analyzing an additional filtered sample from the same well. Second, this procedure

minimizes aeration of the ground water during sample collection, which improves the sample quality for VOC analysis. Third, in most cases the procedure significantly reduces the volume of ground water purged from a well and the costs associated with its proper treatment and disposal.

III. ADDRESSING POTENTIAL PROBLEMS

Problems that may be encountered using this technique include a) difficulty in sampling wells with insufficient yield; b) failure of one or more key indicator parameters to stabilize; c) cascading of water and/or formation of air bubbles in the tubing; and d) cross-contamination between wells.

Insufficient Yield

Wells with insufficient yield (i.e., low recharge rate of the well) may dewater during purging. Care should be taken to avoid loss of pressure in the tubing line due to dewatering of the well below the level of the pump's intake. Purging should be interrupted before the water level in the well drops below the top of the pump, as this may induce cascading of the sand pack. Pumping the well dry should therefore be avoided to the extent possible in all cases. Sampling should commence as soon as the volume in the well has recovered sufficiently to allow collection of samples. Alternatively, ground water samples may be obtained with techniques designed for the unsaturated zone, such as lysimeters.

Failure to Stabilize Key Indicator Parameters

If one or more key indicator parameters fails to stabilize after 4 hours, one of three options should be considered: a) continue purging in an attempt to achieve stabilization; b) discontinue purging, do not collect samples, and document attempts to reach stabilization in the log book; c) discontinue purging, collect samples, and document attempts to reach stabilization in the log book; or d) Secure the well, purge and collect samples the next day (preferred). The key indicator parameter for samples to be analyzed for VOCs is dissolved oxygen. The key indicator parameter for all other samples is turbidity.

Cascading

To prevent cascading and/or air bubble formation in the tubing, care should be taken to ensure that the flow rate is sufficient to maintain pump suction. Minimize the length and diameter of tubing (i.e., 1/4

or 3/8 inch ID) to ensure that the tubing remains filled with ground water during sampling.

Cross-Contamination

To prevent cross-contamination between wells, it is strongly recommended that dedicated, in-place pumps be used. As an alternative, the potential for cross-contamination can be reduced by performing the more thorough "daily" decontamination procedures between sampling of each well in addition to the start of each sampling day (see Section VII, below).

Equipment Failure

Adequate equipment should be on-hand so that equipment failures do not adversely impact sampling activities.

IV. PLANNING DOCUMENTATION AND EQUIPMENT

- Approved site-specific Field Sampling Plan/Quality Assurance Project Plan (QAPP). This plan must specify the type of pump and other equipment to be used. The QAPP must also specify the depth to which the pump intake should be lowered in each well. Generally, the target depth will correspond to the mid-point of the most permeable zone in the screened interval. Borehole geologic and geophysical logs can be used to help select the most permeable zone. However, in some cases, other criteria may be used to select the target depth for the pump intake. In all cases, the target depth must be approved by the EPA hydrogeologist or EPA project scientist.

- Well construction data, location map, field data from last sampling event.

- Polyethylene sheeting.

- Flame Ionization Detector (FID) and Photo Ionization Detector (PID).

- Adjustable rate, positive displacement ground water sampling pump (e.g., centrifugal or bladder pumps constructed of stainless steel or Teflon). A peristaltic pump may only be used for inorganic sample collection.

- Interface probe or equivalent device for determining the presence or absence of NAPL.

- Teflon or Teflon-lined polyethylene tubing to collect samples for organic analysis. Teflon or Teflon-lined polyethylene, PVC, Tygon or polyethylene tubing to collect samples for inorganic analysis. Sufficient tubing of the appropriate material must be available so that each well has dedicated tubing.

- Water level measuring device, minimum 0.01 foot accuracy, (electronic preferred for tracking water level drawdown during all pumping operations).

- Flow measurement supplies (e.g., graduated cylinder and stop watch or in-line flow meter).

- Power source (generator, nitrogen tank, etc.).
- Monitoring instruments for indicator parameters. Eh and dissolved oxygen must be monitored in-line using an instrument with a continuous readout display. Specific conductance, pH, and temperature may be monitored either in-line or using separate probes. A nephalometer is used to measure turbidity.

- Decontamination supplies (see Section VII, below).

- Logbook (see Section VIII, below).

- Sample bottles.

- Sample preservation supplies (as required by the analytical methods).

- Sample tags or labels, chain of custody.

V. SAMPLING PROCEDURES

Pre-Sampling Activities

1. Start at the well known or believed to have the least contaminated ground water and proceed systematically to the well with the most contaminated ground water. Check the well, the lock, and the locking cap for damage or evidence of tampering. Record observations.

2. Lay out sheet of polyethylene for placement of monitoring and sampling equipment.

3. Measure VOCs at the rim of the unopened well with a PID and FID instrument and record the reading in the field log book.

4. Remove well cap.

5. Measure VOCs at the rim of the opened well with a PID and an FID instrument and record the reading in the field log book.

6. If the well casing does not have a reference point (usually a V-cut or indelible mark in the well casing), make one. Note that the reference point should be surveyed for correction of ground water elevations to the mean geodesic datum (MSL).

7. Measure and record the depth to water (to 0.01 ft) in all wells to be sampled prior to purging. Care should be taken to minimize disturbance in the water column and dislodging of any particulate matter attached to the sides or settled at the bottom of the well.

8. If desired, measure and record the depth of any NAPLs using an interface probe. Care should be taken to minimize disturbance of any sediment that has accumulated at the bottom of the well. Record the observations in the log book. If LNAPLs and/or DNAPLs are detected, install the pump at this time, as described in step 9, below. Allow the well to sit for several days between the measurement or sampling of any DNAPLs and the low-stress purging and sampling of the ground water.

Sampling Procedures

9. Install Pump: Slowly lower the pump, safety cable, tubing and electrical lines into the well to the depth specified for that well in the EPA-approved QAPP or a depth otherwise approved by the EPA hydrogeologist or EPA project scientist. The pump intake must be kept at least two (2) feet above the bottom of the well to prevent disturbance and resuspension of any sediment or NAPL present in the bottom of the well. Record the depth to which the pump is lowered.

10. Measure Water Level: Before starting the pump, measure the water level again with the pump in the well. Leave the water level measuring device in the well.

11. Purge Well: Start pumping the well at 200 to 500 milliliters per minute (ml/min). The water level should be monitored approximately every five minutes. Ideally, a steady flow rate should be maintained that results in a stabilized water

level (drawdown of 0.3 ft or less). Pumping rates should, if needed, be reduced to the minimum capabilities of the pump to ensure stabilization of the water level. As noted above, care should be taken to maintain pump suction and to avoid entrainment of air in the tubing. Record each adjustment made to the pumping rate and the water level measured immediately after each adjustment.

12. Monitor Indicator Parameters: During purging of the well, monitor and record the field indicator parameters (turbidity, temperature, specific conductance, pH, Eh, and DO) approximately every five minutes. The well is considered stabilized and ready for sample collection when the indicator parameters have stabilized for three consecutive readings as follows (Puls and Barcelona, 1996):

    ±0.1 for pH
    ±3% for specific conductance (conductivity)
    ±10 mv for redox potential
    ±10% for DO and turbidity

    Dissolved oxygen and turbidity usually require the longest time to achieve stabilization. The pump must not be removed from the well between purging and sampling.

13. Collect Samples: Collect samples at a flow rate between 100 and 250 ml/min and such that drawdown of the water level within the well does not exceed the maximum allowable drawdown of 0.3 ft. VOC samples must be collected first and directly into sample containers. All sample containers should be filled with minimal turbulence by allowing the ground water to flow from the tubing gently down the inside of the container.

    Ground water samples to be analyzed for volatile organic compounds (VOCs) require pH adjustment. The appropriate EPA Program Guidance should be consulted to determine whether pH adjustment is necessary. If pH adjustment is necessary for VOC sample preservation, the amount of acid to be added to each sample vial prior to sampling should be determined, drop by drop, on a separate and equal volume of water (e.g., 40 ml). Ground water purged from the well prior to sampling can be used for this purpose.

14. Remove Pump and Tubing: After collection of the samples, the tubing, unless permanently installed, must be properly discarded or dedicated to the well for resampling by hanging the tubing inside the well.

15. Measure and record well depth.

16. Close and lock the well.

VI. FIELD QUALITY CONTROL SAMPLES

Quality control samples must be collected to determine if sample collection and handling procedures have adversely affected the quality of the ground water samples. The appropriate EPA Program Guidance should be consulted in preparing the field QC sample requirements of the site-specific QAPP.

All field quality control samples must be prepared exactly as regular investigation samples with regard to sample volume, containers, and preservation. The following quality control samples should be collected during the sampling event:

- Field duplicates
- Trip blanks for VOCs only
- Equipment blank (not necessary if equipment is dedicated to the well)

As noted above, ground water samples should be collected systematically from wells with the lowest level of contamination through to wells with highest level of contamination. The equipment blank should be collected after sampling from the most contaminated well.

VII. DECONTAMINATION

Non-disposable sampling equipment, including the pump and support cable and electrical wires which contact the sample, must be decontaminated thoroughly each day before use ("daily decon") and after each well is sampled ("between-well decon"). Dedicated, in-place pumps and tubing must be thoroughly decontaminated using "daily decon" procedures (see #17, below) prior to their initial use. For centrifugal pumps, it is strongly recommended that non-disposable sampling equipment, including the pump and support cable and electrical wires in contact with the sample, be decontaminated thoroughly each day before use ("daily decon").

EPA's field experience indicates that the life of centrifugal pumps may be extended by removing entrained grit. This also permits inspection and replacement of the cooling water in centrifugal pumps. All non-dedicated sampling equipment (pumps, tubing, etc.) must be

decontaminated after each well is sampled ("between-well decon," see #18 below).

17. **Daily Decon**

A) Pre-rinse: Operate pump in a deep basin containing 8 to 10 gallons of potable water for 5 minutes and flush other equipment with potable water for 5 minutes.

B) Wash: Operate pump in a deep basin containing 8 to 10 gallons of a non-phosphate detergent solution, such as Alconox, for 5 minutes and flush other equipment with fresh detergent solution for 5 minutes. Use the detergent sparingly.

C) Rinse: Operate pump in a deep basin of potable water for 5 minutes and flush other equipment with potable water for 5 minutes.

D) Disassemble pump.

E) Wash pump parts: Place the disassembled parts of the pump into a deep basin containing 8 to 10 gallons of non-phosphate detergent solution. Scrub all pump parts with a test tube brush.

F) Rinse pump parts with potable water.

G) Rinse the following pump parts with distilled/ deionized water: inlet screen, the shaft, the suction interconnector, the motor lead assembly, and the stator housing.

H) Place impeller assembly in a large glass beaker and rinse with 1% nitric acid (HNO_3).

I) Rinse impeller assembly with potable water.

J) Place impeller assembly in a large glass bleaker and rinse with isopropanol.

K) Rinse impeller assembly with distilled/deionized water.

18. **Between-Well Decon**

A) Pre-rinse: Operate pump in a deep basin containing 8 to 10 gallons of potable water for 5 minutes and flush other equipment with potable water for 5 minutes.
B) Wash: Operate pump in a deep basin containing 8 to 10 gallons of a non-phosphate detergent solution, such as Alconox, for 5

minutes and flush other equipment with fresh detergent solution for 5 minutes. Use the detergent sparingly.

C) Rinse: Operate pump in a deep basin of potable water for 5 minutes and flush other equipment with potable water for 5 minutes.

D) Final Rinse: Operate pump in a deep basin of distilled/deionized water to pump out 1 to 2 gallons of this final rinse water.

VIII. FIELD LOG BOOK

A field log book must be kept each time ground water monitoring activities are conducted in the field. The field log book should document the following:

- Well identification number and physical condition.
- Well depth, and measurement technique.
- Static water level depth, date, time, and measurement technique.
- Presence and thickness of immiscible liquid layers and detection method.
- Collection method for immiscible liquid layers.
- Pumping rate, drawdown, indicator parameters values, and clock time, at three to five minute intervals; calculate or measure total volume pumped.
- Well sampling sequence and time of sample collection.
- Types of sample bottles used and sample identification numbers.
- Preservatives used.
- Parameters requested for analysis.
- Field observations of sampling event.
- Name of sample collector(s).
- Weather conditions.
- QA/QC data for field instruments.

IX. REFERENCES

Cohen, R.M. and J.W. Mercer, 1993, DNAPL Site Evaluation, C.K. Smoley Press, Boca Raton, Florida.

Puls, R.W. and M.J. Barcelona, 1996, Low-Flow (Minimal Drawdown) Ground-water Sampling Procedures, EPA/540/S-95/504.

U.S. EPA, 1993, RCRA Ground-Water Monitoring: Draft Technical Guidance, EPA/530-R-93-001.

U.S. EPA Region II, 1989, CERCLA Quality Assurance Manual.

APPENDIX E
EQUILIBRIUM PARTIONING APPROACH

APPENDIX E

EQUILIBRIUM PARTITIONING APPROACH

The United States Environmental Protection Agency (USEPA, 1993) has chosen the equilibrium partitioning (EqP) approach for developing sediment quality criteria for nonionic organic chemicals. This approach was used to derive sediment screening values for organic chemicals lacking literature-based, bulk sediment screening values.

There are three underlying assumptions to the derivation of sediment quality criteria using EqP. First, it is assumed that sediment toxicity correlates with the concentration of the chemical in the sediment pore water and not the bulk sediment concentration (i.e., the pore water concentration represents the bioavailable fraction). Second, partitioning between sediment pore water and bulk sediment is assumed to be dependent on the organic content of the sediment with little dependence upon other chemical or physical properties. Third, the EqP approach assumes that equilibrium has been attained between the sediment pore water concentration and the bulk sediment concentration.

The relationship between the concentration of a nonionic organic chemical in sediment pore water and bulk sediment is described by the partitioning coefficient, K_p (USEPA, 1993):

$$K_p = (C_s)/(C_{pw}) \quad \text{(Equation E-1)}$$

Where C_s is the concentration in bulk sediment and C_{pw} is the concentration in sediment pore water. For a given organic chemical, the partition coefficient can be derived by multiplying the fraction of organic carbon (f_{oc}) present in the sediment by the chemical's organic carbon partition coefficient (K_{oc}) (USEPA, 1993):

$$K_p = (f_{oc})(K_{oc}) \quad \text{(Equation E-2)}$$

Combining Equations E-1 and E-2 yields the following:

$$C_s = (K_{oc})(f_{oc})(C_{PW}) \quad \text{(Equation E-3)}$$

If the organic carbon content of the sediment is known, a site-specific sediment screening value (SSV) can be calculated for a given organic chemical by setting C_{pw} equivalent to a conservative surface water screening value for that chemical (SWSV):

$$SSV = (K_{oc})(f_{oc})(SWSV) \quad \text{(Equation E-4)}$$

In this equation, SSV represents the concentration of the chemical in bulk sediment that, at equilibrium, will result in a sediment pore water concentration equal to the surface water screening value. Sediment concentrations less than SSV would be protective of sediment-associated biota. The use of surface water screening values (i.e., criteria and toxicological benchmarks) in Equation E-4 assumes that the sensitivities of sediment-associated biota and the species typically tested to derive surface water screening values such as USEPA NAWQC (predominantly water column species) are similar. Furthermore, it assumes that levels of protection afforded by the surface water screening values are appropriate for sediment-associated biota. It is noted that the EqP approach can only be used if the total organic carbon (TOC) content in sediment is greater than 0.2 percent (i.e., 2,000 mg/kg). At TOC concentrations less than 0.2 percent, other factors (e.g., particle size, sorption to nonorganic mineral fractions) become relatively more important (USEPA, 1993).

Although the EqP approach was developed by the USEPA for nonionic organic chemicals (e.g. semi-volatile organic chemicals [SVOCs]), this method was used to derive sediment screening values for all organic chemicals lacking literature-based, bulk sediment screening values, including ionic organic chemicals (e.g., volatile organic chemicals [VOCs]). Application of the EqP approach to ionic organic chemicals likely overestimates their pore water concentrations since adsorption mechanisms other than hydrophobicity may significantly increase the fraction of the chemical sorbed to sediment particles (Jones et al., 1997). The overly conservative nature of sediment quality benchmarks derived using EqP is documented in the literature (Fuschman, 2003). Regardless, application of the EqP approach to the development of sediment screening values for ionic chemicals is recognized in the literature (USEPA, 1996 and Jones et al., 1997).

Sediment screening values derived using EqP (see Table 4-3) are conservatively based on a default f_{oc} of 0.01 (USEPA, 1996). K_{oc} values used in the derivation of EqP-based sediment screening values are those listed in Table E-1. The K_{oc} values listed in Table E-1 were estimated from the following equation (USEPA, 1993 and 1996):

$$Log\ K_{oc} = 0.00028 + (0.983)(Log\ K_{ow}) \quad \text{(Equation E-5)}$$

In this equation, log K_{ow} represented the log octanol-water partition coefficient.

Appendix E References

Fuchsman, P.C. 2003. Modification of the Equilibrium Partitioning Approach for Volatile Organic Compounds in Sediment. Environ. Toxicol. Chem. 22(7):1532-1534.

U.S. Environmental Protection Agency (USEPA). 1993. Technical Basis for Deriving Sediment Quality Criteria for Nonionic Organic Contaminants for the Protection of Benthic Organisms by Using Equilibrium Partitioning. Office of Water, Washington, D.C. EPA-822-R-93-011.

USEPA. 1996. Ecotox Thresholds. Eco Update, Volume 3, Number 2. Office of Solid Waste and Emergency Response, Washington, D.C. EPA 540/F-95/038.

Jones, D.S., G.W. Suter II., and R.N. Hull. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-95/R4.