DRAFT CORRECTIVE MEASURES STUDY WORK PLAN SWMUs 27, 28 and 29

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:

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Michael Baker Jr., Inc.
Moon Township, PA

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

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

DRAFT

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SWMUs 27, 28, 29

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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.

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APPENDICES

LIST OF ACRONYMS AND ABBREVIATIONS

AET	Apparent Effects Threshold
AOCs	Areas of Concern
ATSDR	Agency for Toxic Substances and Disease Registry
AUF	Area Use Factor
AUF_j	Area Use Factor for Receptor j
AVS/SEM	Acid Volatile Sulfide/Simultaneously Extracted Metals
BAF	Bioaccumulation Factor
Baker	Michael Baker Jr., Inc.
BERA	Baseline Ecological Risk Assessment
bgs	below ground surface
BRAC	Base Realignment and Closure
BSAF	Biota-Sediment Accumulation Factor
BW	Body Weight
BW_j	Bodyweight for Receptor j
C_{xi}	Concentration of Chemical x in Food Item i
C_{xs}	Concentration of Chemical x in Soil/Sediment
CAOs	Corrective Action Objectives
CAO_x	Corrective Action Objective for Chemical x
CCC	Criteria Continuous Concentration
CCME	Canadian Council of Ministers of the Environment
CDIi	Chronic Daily Intake for Compound i
CDIs	Chronic Daily Intakes
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CMS	Corrective Measures Study
CNO	Chief of Naval Operations
CNRSE	Commander, Navy Region Southeast
COCs	Chemicals of Concern
COPC	Chemical of Potential Concern
CSFi	Cancer Slope Factor for Compound i
CSFs	Cancer Slope Factors
CSM	Conceptual Site Model
DAD	Dermally Absorbed Dose
DDT	Dichlorodiphenyltrichloroethane
DIx	Dietary Index for Chemical x
DMMP	Dredged Material Management Program
DO	Delivery Order
DoN	Department of the Navy
DRMO	Defense Reutilization and Marketing Office
DRO	Diesel Range Organics
EA	Environmental Assessment
ECs	Exposure Concentrations
EC_{50}	Median Effective Concentration
Eco-SSL	Ecological Soil Screening Level
ECOSAR	Ecological Structure Activity Relationships

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

EPCs	Exposure Point Concentrations
EqP	Equilibrium Partitioning
ERA	Ecological Risk Assessment
ER-L	Effects Range-Low
ER-M	Effects Range-Median
ESL	Ecological Screening Level
FC_{xi}	Maximum Concentration of Chemical x in Food Item i
FCV	Final Chronic Value
FIR	Food Ingestion Rate
FIR_j	Food Ingestion Rate for Receptor j
f_{oc}	Fraction of Organic Carbon
GPS	Global Positioning System
GRO	Gasoline Range Organics
HEAST	Health Effects Assessment Summary Table
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
HSA	Hollow-Stem Auger
HSWA	Hazardous and Solid Waste Amendments (to RCRA)
ID	Inside Diameter
IDW	Investigation Derived Waste
ILCR	Incremental Lifetime Cancer Risk
IR	Installation Restoration
IRIS	Integrated Risk Information System
ISQGs	Interim Freshwater Sediment Quality Guidelines
J	data qualifier: the analyte was positively identified; however, the concentration value is an estimate
K_d	Adsorption Coefficient
K_{oc}	Organic Carbon Partition Coefficient
K_{ow}	Octanol-Water Partition Coefficient
LANTDIV	United States Navy, Atlantic Division
LC_{50}	Median Lethal Concentration
LD_{50}	Median Lethal Dose
LEL	Lowest Effect Level
LOAEC	Lowest Observed Adverse Effect Concentration
LOAEL	Lowest Observed Adverse Effect Level
LOEC	Lowest Observed Effect Concentration
LOEL	Lowest Observed Effect Level
MATC	Maximum Acceptable Toxicant Concentration
MCLs	Maximum Contaminant Levels

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

MHSPE	Ministry of Housing, Spatial Planning and Environment
mg/kg	milligrams per kilogram
mg/kg-BW/day	milligrams per kilogram-body weight per day
mg/kg/day	milligrams per kilogram per day
mg/m3	milligrams per cubic meter
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NAPR	Naval Activity Puerto Rico
NAVFAC	Naval Facilities Engineering Command
NAWQC	National Ambient Water Quality Criteria
NCP	National Contingency Plan
NFESC	Naval Facilities Engineering Service Center
NOAA	National Oceanic and Atmospheric Administration
NOAEC	No Observed Adverse Effect Concentration
NOAEL	No Observed Adverse Effect Level
NOEC	No Observed Effect Concentration
NOEL	No Observed Effect Level
NSRR	Naval Station Roosevelt Roads
NTR	Navy Technical Representative
NTU	Nephelometric Turbidity Units
PAHs	Polynuclear Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyl
PDF_i	Proportion of Diet Composed of Food Item i
PDF_{ij}	Proportion of Diet Composed of Food Item i for Receptor j
PDS	Proportion of Diet Composed of Soil/Sediment
PDS_j	Proportion of Diet Composed of Soil/Sediment for Receptor j
PEL	Probable Effects Level
PMO	Program Management Office
PPRTV	Provisional Peer Reviewed Toxicity Values
ppt	parts per thousand
PRDNR	Puerto Rico Department of Natural Resources
PREQB	Puerto Rico Environmental Quality Board
PRGs	Preliminary Remedial Goals
PRWQS	Puerto Rico water Quality Standards
PRWQSR	Puerto Rico Water Quality Standards Regulation
PSQGs	Provincial Sediment Quality Guidelines
PVC	Polyvinyl Chloride
PWD	Public Works Department
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
R	The sample result is rejected; the presence or absence of the analyte cannot be verified
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

RFI	RCRA Facility Investigation
RME	Reasonable Maximum Exposure
SARs	Structure Activity Relationships
SC_x	Concentration of Chemical x in Soil/Sediment
SCVs	Secondary Chronic Values
SDWA	Safe Drinking Water Act
SE	Southeast
SERA	Screening Level Ecological Risk Assessment
SLs	Screening Levels
SQAGs	Sediment Quality Assessment Guidelines
SQGs	Sediment Quality Guidelines
SQUIRT	Screening Quick Reference Tables
SV_x	Medium-Specific Screening Value for Chemical x
SVOC	Semi-Volatile Organic Compound
SWMU	Solid Waste Management Unit
TCLP	Toxicity Characteristic Leaching Procedure
TEL	Threshold Effects Level
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbon
TRV	Toxicity Reference Value
TRV_x	Toxicity Reference Value for Chemical x
U	data qualifier: the analyte was analyzed for, but not detected above the reported sample quantitation limit
UCL	Upper Confidence Limit
UJ	The analyte was analyzed for, but not detected; the reported sample quantitation limit is qualified as estimated
ULM	Upper Limit of the Mean
UNEP	United Nations Environmental Program
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USTs	Underground Storage Tanks
VOCs	Volatile Organic Compounds
VSI	Visual Site Inspection
WWTP	Waste water Treatment Plant

1.0 INTRODUCTION

This Work Plan presents the technical approach for conducting a Corrective Measures Study (CMS) for:

- Solid Waste Management Unit (SWMU) 27 – Capehart Wastewater Treatment Plant (WWTP) Sludge Drying Beds,
- SWMU 28 – Bundy WWTP Sludge Drying Beds, and
- SWMU 29 – Industrial Area WWTP Sludge Drying Beds

The SWMUs are located at Naval Activity Puerto Rico (NAPR), Ceiba, Puerto Rico. This CMS 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 Resource Conservation and Recovery Act (RCRA) 7003 Administrative Order on Consent (United States Environmental Protection Agency [USEPA] Docket No. 02-2007-7301[USEPA, 2007]). This CMS Work Plan is designed to provide a guide for selecting corrective measures to mitigate human health and ecological risks associated with contamination related to site operations.

1.1 NAPR Description and History

NAPR occupies over 8,890 acres of the northern portion of the east coast of Puerto Rico, along Vieques Passage with Vieques Island lying to the east about 10 miles off the harbor entrance. NAPR also occupies the immediately adjacent islands of Piñeros and Cabeza de Perro. The northern entrance to NAPR is about 35 miles east along the coast road (Route 3) from San Juan (see Figure 1-1). 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 37,000), which is about 5 miles north of NAPR off Route 3. Ceiba (population approximately 17,000) adjoins the west boundary of NAPR.

The facility was commissioned in 1943 as a Naval Operations Base and re-designated Naval Station Roosevelt Roads (NSRR) in 1957. NSRR operated until March 31, 2004 when NSRR underwent operational closure. On April 1, 2004 NSRR was re-designated as NAPR. The current primary 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.

On October 20, 1994, a Final RCRA Part B permit was issued by USEPA Region II to NSRR. This permit listed 52 SWMUs and 4 Areas of Concern (AOCs) and contained requirements for RCRA Facility Investigation (RFI) activities at 24 of these SWMUs and three of these AOCs. An additional 25 SWMUs and 2 AOCs were added to the program over the years. Figure 1-2 shows the locations of all SWMUs and AOCs at NAPR. Prior to 1993, environmental activities at NSRR, exclusive of underground storage tanks (USTs), were conducted in compliance with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) regulations under the Department of the Navy's Installation Restoration (IR) Program. The RCRA Part B permit, issued for the Defense Reutilization and Marketing Office (DRMO) at NSRR, included provisions for corrective action under the Hazardous and Solid Waste Amendments (HSWA) to RCRA.

The USEPA issued a RCRA 7003 Administrative Order on Consent (USEPA Docket No. RCRA-02-2007-7301), which became effective on January 29, 2007. SWMUs 27, 28 and 29 were identified as the three SMWUs/treatment plants containing sludge drying beds that warranted Phase I RFIs, because of the NAPR closure. Phase I RFIs were conducted in November 2006 at SWMUs 27, 28 and 29 and based on the Phase I RFI data evaluation, "Full" RFIs were recommended by the Navy, and USEPA concurred in a comment letter dated June 28, 2007. The Full RFI investigation reports for the three sites were submitted on August 28, 2008 (Baker, 2008a, 2008b and 2008c).

1.2 Site Background

The following subsections present a brief description and operational background on the three SWMUs (27, 28 and 29) that are addressed in this CMS work plan.

1.2.1 Background for SWMU 27 - Capehart WWTP Sludge Drying Beds

SWMU 27 (also known as the Capehart WWTP Sludge Drying Beds) is located along the southern shoreline of NAPR as shown on Figure 1-2. The site consists of the domestic sewage treatment plant serving the Capehart housing area. Based on information available (verbal statements, and Navy letters of August 31, 1993 and June 30, 1992), this unit does not manage or generate RCRA hazardous wastes or constituents. NAPR has no knowledge or evidence of systematic and routine releases of hazardous wastes or constituents from this SWMU (United States Navy, Atlantic Division [LANTDIV], 2004).

The Capehart sludge drying beds are used on a limited basis due to the minimal amount of flow moving through the plant since the operational closure of Naval Station Roosevelt Roads on March 31, 2004 and the transition of the facility into caretaker status. A total of four concrete sludge drying beds are located along the south eastern side of the plant as shown on Figure 1-3. The areas to the northwest and southwest sides of the drying beds are concrete, while the areas to the southeast and northeast are grass and secondary growth vegetation. The open water is located south of the plant.

1.2.2 Background for SWMU 28 - Bundy WWTP Sludge Drying Beds

SWMU 28 (also known as the Bundy WWTP Sludge Drying Beds) is located at the southwestern corner of NAPR as shown on Figure 1-2. The site consists of the domestic sewage treatment plant serving the Bundy area. Based on information available (verbal statements, and Navy letters of August 31, 1993 and June 30, 1992), this unit does not manage or generate RCRA hazardous wastes or constituents. NAPR has no knowledge or evidence of systematic and routine releases of hazardous wastes or constituents from this SWMU (LANTDIV, 2004).

The Bundy sludge drying beds are utilized on a limited basis due to the minimal amount of flow moving through the plant since the operational closure of Naval Station Roosevelt Roads on March 31, 2004 and the transition of the facility into caretaker status. A total of seven concrete sludge drying beds are located centrally in the plant. These beds are split to three beds to the west and four beds to the east as shown on Figure 1-4. The area between the two sets of drying beds is covered in concrete. Grassy areas surround the sludge drying beds with a steep grade uphill to the west of the beds.

1.2.3 Background for SWMU 29 – Industrial Area WWTP Sludge Drying Beds

SWMU 29 (also known as the Industrial Area WWTP Sludge Drying Beds) is located at the southeastern corner of NAPR as shown on Figure 1-2. SWMU 29 consists of the sludge drying beds at the wastewater treatment plant for the "Industrial Area" of the base. The Industrial Area WWTP was placed into operation around 1963 and included three sludge drying beds. An upgrade to these three sludge drying beds occurred around 1969. Two additional sludge drying beds were added to the plant in 1996 for a total of five drying beds, which are still present at the facility. No visual evidence of releases of hazardous wastes or constituents was observed during the 1988 Visual Site Inspection (VSI) or 1993 follow-up inspection. The sludges generated by this unit have been tested since 1988 for "Characteristics of Hazardous Waste" pursuant to 40 Code of Federal Regulations (CFR) Part 261, and found not to be hazardous by characteristic. The permittee has verbally indicated it has no knowledge or evidence of systemic and routine releases of hazardous wastes or constituents from this unit (LANTDIV, 2004).

The Industrial Area sludge drying beds are currently used on a limited basis due to the minimal amount of flow moving through the plant since the operational closure of Naval Station Roosevelt Roads on March 31, 2004 and the transition of the facility into caretaker status. A total of five concrete sludge drying beds are located in the southern portion of the plant as shown on Figure 1-5. The area to the west is concrete and grass while the areas to the south and east are grassy and open water. Grass is located along the northern side of the beds.

1.3 <u>Investigative History and Basis for the Work Plan</u>

SWMUs 27, 28 and 29 were identified in the RCRA/ HSWA Permit dated October 20, 1994. No RFI was required for these SWMUs based on verbal statements and Navy letters of August 31, 1993 and June 30, 1992 stating that no knowledge or evidence of systematic and routine releases of hazardous wastes or constituents was known from these SWMUs. However, the NAPR RCRA § 7003 Administrative Order on Consent dated January 2007 required a Phase I RFI for all sludge drying beds at SWMUs 27, 28, and 29.

In anticipation of the requirements outlined in the NAPR RCRA § 7003 Administrative Order on Consent, a RFI Work Plan was developed. On September 15, 2006 the RFI Work Plan (Baker, 2006) was submitted and later approved by the USEPA on October 20, 2006. Mobilization for the RFI field activities occurred November 12, 2006 with demobilization on November 20, 2006.

The RFIs at SWMUs 27, 28 and 29 identified various elements and compounds above human health and ecological screening level criteria due to Navy activities (Baker 2007, 2008d and 2008e). Based on the RFI, Full RFI Investigations were recommended in order to better delineate site contamination above screening levels at all three SWMUs (27, 28 and 29), as well as evaluate the potential for human health and ecological risk.

The Full RFI Work Plan for SWMUs 27, 28 and 29 was approved by USEPA in a comment letter dated January 07, 2008. Mobilization for the Full RFI field activities occurred on February 11, 2008 with demobilization on February 19, 2008. The development of a CMS Work Plan is based on the results of these investigations as described in greater detail in Sections 1.3.1 to 1.3.3.

1.3.1 Summary of Findings – SWMU 27 - Capehart WWTP Sludge Drying Beds

Based on the Phase I RFI investigation and the Full RFI, there have been some impacts on the environment due to Navy activities at SWMU 27. The bulk of the exceedances in the surface soils were located to the northeast of the sludge drying beds. Arsenic, mercury and zinc were above their background values, as well as screening levels at multiple locations. The subsurface soil did not exhibit much contamination above background for compounds that exceeded the human health or ecological screening criteria, with the exception of chromium at three locations (ecological screening value exceedances). The lateral extent of the soil contamination was not fully defined during the Full RFI (Baker, 2008a).

The highest groundwater concentrations were found in locations 27MW05 and 27MW06, located northeast of the sludge drying beds. No significant contamination was found in the groundwater in the other monitoring wells. Barium exceeded the human health screening values and its respective background concentrations. It is likely that contamination from the operation of the SWMU has reached the groundwater at this site. However, it is unlikely that groundwater would be a pathway for human health risk due to the low yield and high salinity since the site is located adjacent to open ocean and estuarine wetlands.

The data generated during the Phase I RFI and the Full RFI indicated the surface soil, subsurface soil and groundwater were impacted by past activities at SWMU 27. A preliminary human health risk evaluation was conducted to address exceedances of screening criteria. This evaluation demonstrated that the concentrations of arsenic in SWMU 27 soil, and chloroform and barium in groundwater would not cause unacceptable risks to human receptors. Therefore, no further action was recommended to address human health concerns. However, concentrations of zinc and mercury in surface soil and chromium, copper and zinc in subsurface soil indicated the presence of contamination above their ecological screening values and background concentrations. Therefore, a CMS was recommended to quantify potential risk to ecological receptors. The CMS will include an ecological risk assessment (ERA) (Steps 1, 2 and 3a of the Navy ERA process described at http://web.ead.anl.gov/ecorisk/). Figures showing chemical distributions that exceed ecological screening criteria and background from the Full RFI report are provided as Appendix A (Baker, 2008a).

1.3.2 Summary of Findings – SWMU 28 – Bundy WWTP Sludge Drying Beds

Based on the Phase I RFI investigation and the Full RFI, there have been some impacts on the environment due to Navy activities at SWMU 28. Surface soil contamination in excess of human health and ecological screening criteria primarily consisted of Aroclor 1260, arsenic, barium, mercury and zinc. The highest levels of contamination are in the vicinity of 28SB03, 28SS10, 28SB08 and 28SB02 east and southeast of the sludge drying beds, and 28SB01, 28SB04 and 28SB07 south of the sludge drying beds. The lateral extent of contamination south, east and west of the sludge drying beds was not fully delineated during the Full RFI (Baker, 2008b).

Subsurface soils from 28SB06-01 (1.0 to 3.0 feet below the ground surface [bgs]), located south/southwest of the sludge drying beds, and 28SB03-01 (1.0 to 3.0 feet bgs) located east of the sludge drying beds appear to be impacted by barium contamination. The lateral distribution of this subsurface barium contamination was not fully defined.

Total and dissolved barium was detected in the groundwater samples collected from areas south and east of the sludge drying beds at levels in excess of background screening criteria and human health screening criteria, although Federal Maximum Contaminant Levels (MCLs) and ecological screening criteria were not exceeded.

Exceedances of human health and ecological screening criteria and exceedances of background screening criteria were observed in surface and subsurface soil indicating potential human health and/or ecological risks. The extent of Aroclor 1260 and metals contamination, primarily arsenic, barium, mercury, and zinc in surface soil east, south and west of the site has not been fully delineated.

Additionally, the presence of various metals at concentrations in excess of both ecological screening values and background values indicates further ecological evaluation is needed for this site. A CMS was recommended to further delineate contamination and to further define and quantify potential risk to human health and ecological receptors. The CMS will include a baseline human health risk assessment (HHRA) and an ERA (Steps 1, 2 and 3a of the Navy ERA process described at http://web.ead.anl.gov/ecorisk/). Figures showing chemical distributions from the Full RFI report are provided as Appendix B (Baker, 2008b).

1.3.3 Summary of Findings – SWMU 29 – Industrial Area WWTP Sludge Drying Beds

Based on the Phase I RFI investigation and the Full RFI, there have been some impacts on the environment due to Navy activities at SWMU 29. In surface soil, arsenic exceeded the USEPA Region IX industrial Preliminary Remedial Goals (PRGs) and background in two surface soil samples (29SB05 and 29SB01) on both the east and west side of the sludge drying beds. Additionally, cadmium (29SB01 and 11) and antimony (29SB11) exceeded the residential PRGs and background screening values in surface soil samples on the east side of the site. Barium, chromium, cobalt, copper, vanadium, zinc, and mercury exceeded ecological surface soil screening values. Of these, barium, copper, mercury and zinc also exceeded their background surface soil screening values. Mercury was found east, north, and west of the sludge drying beds, while the remaining metals were found elevated only to the east. The lateral distribution of the surface soil contamination was not fully defined during the Full RFI (Baker, 2008c).

There were no metals that exceeded both the human health criteria and background concentrations in subsurface soils. Chromium, cobalt, copper, and vanadium all exceeded the ecological surface soil screening levels. However, only copper exceeded both the ecological screening levels and the background concentration (at locations 29SB11 and 29SB13).

Based on the results of the Phase I RFI (Baker, 2008c), no significant contamination was found in the groundwater at the site.

Antimony, arsenic, and cadmium were detected in surface soil at concentrations exceeding soil PRGs and background. A preliminary human health risk evaluation was conducted to address these exceedances. This evaluation demonstrated that the concentrations of these inorganics in SWMU 29 surface soil would not cause unacceptable risks to human receptors. Therefore, no further action was recommended to address human health concerns. Additionally, no further action was recommended for groundwater at SWMU 29, since the Phase I RFI demonstrated no impacts to groundwater. However, concentrations of barium, copper, zinc, and mercury in surface soil and copper in subsurface soil were identified to be above the ecological screening values and background. A CMS was recommended to address potential risks to ecological receptors. The CMS will include an ERA (Steps 1, 2, and 3a of the Navy ERA process described at http://web.ead.anl.gov/ecorisk/). Figures showing chemical distributions that exceed ecological screening criteria and background from the Full RFI report are provided as Appendix C (Baker, 2008b).

1.3.4 PRGs vs. Regional Screening Levels

It should be noted that USEPA issued updated Regional Screening Levels on May 17, 2010 (USEPA, 2010). As recommended by the USEPA, these Screening Levels are to replace the Region IX PRGs. The Regional Screening Levels were developed to support the risk assessment screening process, while improving consistency across Regions and incorporating updated guidance in a timely manner. The environmental data for the Full RFIs were screened using the Region IX PRGs prior to the issuance of the Regional Screening Levels, and the screening criteria were not revised for the Full RFI. However, based on a review of the PRGs versus the Regional Screening Levels, it was expected that the results of the screening would not be significantly impacted and that the conclusions and recommendations of the Full RFIs would remain the same upon replacement of PRGs with the Regional Screening Levels. None the less, in keeping with current USEPA guidance, the most current Regional Screening Levels (May 17, 2010 update) will be incorporated in the CMS investigation reports.

1.4 Organization of the CMS Work Plan

This CMS Work Plan is organized into ten sections. Section 1.0, the Introduction, is designed to introduce the reader to the basis for the Work Plan and a summary of the site status. Section 2.0 provides the objectives and the corrective measure standards being utilized for this project. The CMS Investigations to be performed at SWMUs 27, 28 and 29 are discussed in Section 3.0, with the corresponding CMS Investigation reporting discussed in Section 4.0. The ecological risk assessments to be performed are described in Section 5.0. Section 6.0 provides a method for developing the human health risk assessment and establishing the corrective action objectives (CAOs), and the methods to be used to identify chemicals of concern (COCs) are discussed in Section 7.0. The tasks to be accomplished as part of the Corrective Measure Study are described in Section 8.0. The project schedule is provided in Section 9.0. Section 10.0 provides the project organization.

1.5 References

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2.0 CMS OBJECTIVES AND CORRECTIVE MEASURE STANDARDS

This section discusses the objectives of this CMS and the standards to assess the performance of the selected corrective measure. There are two distinct types of work associated with this CMS, (1) a CMS Investigation to further delineate the contamination at the SWMUs and the associated reports on these findings, and (2) the development of the corrective measures for the SWMUs. CAOs for ecological receptors (see Section 5.10) and human health receptors (see Sections 6.7) are to be developed in the CMS.

2.1 Objectives

Due to the two types of work associated with this CMS the objectives for each type will be discussed separately. The objectives of the CMS Investigation portion (see Sections 3.0 through 7.0) of this Work Plan are as follows:

- To identify those tasks required for the evaluation and delineation of the soil contamination that may pose a risk at SWMUs 27, 28 and 29. If groundwater is encountered (SWMU 28 only), the tasks will also include the evaluation and delineation of groundwater contamination that may pose a risk at this site.

- To identify realistic ecological and human health exposure pathways from contamination that may be present at the SWMUs.

The objectives of the development of the corrective measures to address the contamination present at each SWMU (see Section 8.0) are as follows:

- To develop the human health (see Section 6.7) and ecological (see Section 5.10) CAOs for each SWMU.

- To identify those tasks required for assisting in screening applicable remedial technologies for each SWMU.

- To justify and recommend the Corrective Measure or Measures for each SWMU.

This Work Plan documents the scope and objectives of a CMS for the SWMUs, as well as the activities required to implement the program. The Work Plan serves as a tool for assigning responsibilities and establishing the project schedule and costs. The reports for these investigations will be in the form of a "Task I" CMS Reports with establishment of CAOs for each of the SWMUs (i.e., 27, 28 and 29).

If, as a result of the CMS investigations, a streamlined CMS appears appropriate, then this approach will be implemented." A highly focused or streamlined CMS may be appropriate for the sludge drying beds facilities since these sites may have "straightforward remedial solutions" where standard engineering solutions can be applied that have proven effective in similar situations (USEPA, 1994). Therefore, the screening of clean-up technologies, normally conducted in a CMS, may not occur.

2.2 Corrective Measures Standards

Corrective measure standards that may be applicable to SWMUs 27, 28 and 29 will be developed as part of the CMS "Task I" reporting effort (see Section 8.1) unless a streamlined CMS is warranted.

Once the possible corrective measures are selected for applicability, the appropriate standards will be developed.

The corrective measure standards to be considered will include the applicable Federal MCLs established under the Safe Drinking Water Act (SDWA) and the Puerto Rico Environmental Quality Board (PREQB) standards. The RCRA Corrective Action Program requirements under 40 CFR 264.100 will also be reviewed for applicability to the site. In addition, human health and ecological risks will be considered in the development of corrective measures standards by incorporating standards that are determined to be protective of human and ecological receptors by the risk assessment process described in Sections 5.0 and 6.0.

Background inorganic concentrations will be considered in establishing exceedances of site contamination when appropriate. The *Revised Final II Summary Report for Environmental Background Concentrations of Inorganic Compounds* (Baker, 2010) will be used.

All of the above information to be considered for the corrective measure standards will be taken into account when the corrective action objectives for human health and the environment are developed as discussed in Section 6.0.

The corrective measures standards correlate with the development of the corrective action objectives. These standards are utilized during the selection of chemicals of potential concern (COPCs) as described in Sections 5.0 and 6.0.

2.3 References

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

USEPA. 1994. RCRA Corrective Action Plan. OSWER Directive 9902.3-2A, Office of Solid Waste and Emergency Response. May 1994.

3.0 CMS INVESTIGATION

CMS field investigations for SWMUs 27, 28 and 29 have been customized based on the findings of the RFIs. The subsections that follow detail the rationale and investigation scope for each SMWU separately. Tasks common to all three SWMUs will be discussed once, at the end of SWMU investigation scope subsections.

The objectives of this CMS Investigations are as follows:

SWMU 27 Capehart WWTP Sludge Drying Beds

- To delineate the boundary of the wetlands east of the facility
- To delineate the inorganic contamination in the surface soils, subsurface soils, surface water (if present) and sediments (if present)
- To identify ecological exposure pathways that may be present

SWMU 28 Bundy WWTP Sludge Drying Beds

- To delineate the boundary of the wetlands east of the facility
- To delineate polychlorinated biphenyl (PCB) contamination in the surface soils
- To delineate the inorganic contamination in the surface soils, subsurface soils, groundwater , surface water (if present) and sediments (if present)
- To identify ecological and human health exposure pathways that may be present

SWMU 29 Industrial Area WWTP Sludge Drying Beds

- To delineate the inorganic contamination in the surface soils and subsurface soils
- To identify ecological exposure pathways that may be present

It is proposed to collect surface soil, subsurface soil, surface water, sediment and groundwater samples as applicable to determine potential impacts to human health and ecological receptors to meet the stated objectives above.

The soil at SWMUs 27, 28 and 29 has been found to contain contamination from the historic activities at the WWTP Sludge Drying Beds based on the Full RFI Investigations (Baker, 2008a, 2008b and 2008c). Therefore, it will be assumed during this investigation that the soils from these areas will need to be remediated as part of a corrective measure. The approximate extent of contaminated soil/sediment will be estimated using the results from previous investigations and supplemented by the results from this CMS investigation.

3.1 SMWU 27 - Capehart WWTP Sludge Drying Beds

Based on the Full RFI (Baker, 2008a), mercury and zinc in surface soil, and chromium, copper and zinc in subsurface soil exceeded both the ecological screening values and background concentrations.

The extent of this contamination needs to be delineated and the exact boundary of the adjacent wetland needs to be defined, so that potential risk to ecological receptors may be evaluated.

3.1.1 Wetland Delineation

The estuarine wetland resource with a Cowardin classification of Estuarine, Intertidal, Scrub-Shrub, Broad-Leaved Evergreen (E2SS3) has approximate boundaries depicted on Figures 1-3, and 3-1, which were 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 field delineated jurisdictional boundaries. As part of this CMS, the estuarine wetland (E2SS3) boundaries within the borders of the SWMU will be field-delineated in accordance with the U.S. Army Corps of Engineers (USACE) Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Caribbean Islands Region (USACE, 2009). This boundary will be established to determine if subsequent samples are designated as sediments samples or surface soil samples. Additionally, during this reconnaissance, an inspection will be made to determine if there are locations available for collection of up to ten surface water samples.

3.1.2 Soil, Surface Water and Sediment Sampling

Mercury and zinc were detected in surface soil above ecological surface soil screening criteria and background surface soil screening criteria (Baker, 2008a). The highest concentrations occur at the northeastern end of the sludge drying beds. Chromium, copper and zinc were detected above ecological subsurface soil screening criteria and background in locations east and northeast of the sludge drying beds. Figures from the Full RFI (Baker, 2008a) presenting these exceedances are provided in Appendix A.

Surface soil and subsurface soil samples will be collected to define the lateral extent of contamination around the sludge drying beds. Because contamination may extend laterally eastward into the adjacent wetlands, provisions are included in this sampling plan to sample surface water and sediments east of the site.

3.1.2.1 Surface Soil Sampling

The extent of surface soil metals contamination was not defined during the Full RFI (Baker, 2008a), as shown on Figure A1 in Appendix A. It is estimated that eleven (11) surface soil samples (0 to 1 foot bgs) will be collected to complete the delineation of soil contamination as identified on Table 3-1. All surface soil samples will be tested for Appendix IX metals. The basis for the proposed sampling locations are described below. Sample locations are shown on Figure 3-1.

- Two surface soil samples 27SS08 and 27SS09 are proposed around soil boring 27SB03, where mercury and zinc were detected in surface soils above ecological screening criteria and background.

- Nine surface soil samples are proposed at borings 27SB09 through 27SB11 and 27SB15 through 27SB20. These borings are located around sampling points northeast of the sludge drying beds, where mercury and zinc have been detected in surface soils above ecological screening criteria and background.

Surface soil samples will be collected following the procedures in Final RCRA Facility Investigation Management Plans (Baker, 1995). Surface soil samples will be collected from 0 to 1 foot bgs using a stainless steel spoon, bucket auger and/or 66 DT Geoprobe® drill rig (or equivalent). All pertinent sampling information such as soil description (e.g., color and texture), lithology, water occurrence, sample number and location, presence or absence of soil discoloration, and the time of sample collection will be recorded in a field logbook. Surface material (e.g., vegetation and rocks) will be removed prior to sample collection. Soils for metals analyses will be placed in a disposable aluminum pan and homogenized prior to placement in the sample jars.

3.1.2.2 Subsurface Soil Sampling

The vertical extent of chromium, copper and zinc contamination was delineated during the Full RFI (Baker, 2008a); however, the lateral extent of subsurface soil contamination was not delineated as shown on Figure A2 in Appendix A. It is estimated that thirteen (13) subsurface soil samples (1 to 3 feet bgs) will be collected to complete the delineation of soil contamination as identified on Table 3-1. All subsurface soil samples will be tested for Appendix IX metals. The basis for the proposed sampling locations are described below. Sample locations are shown on Figure 3-1.

- Three subsurface soil samples from 1 to 3-feet bgs are proposed at borings 27SB09 through 27SB11 to delineate soils west of boring 27SB05, where chromium exceeded ecological screening criteria and background in subsurface soils.

- Three subsurface soil samples from 1 to 3 feet bgs are proposed at borings 27SB12 through 27SB14, around boring 27SB04, where subsurface soils exceeded ecological screening criteria and background for chromium and zinc.

- Five subsurface soil samples from 1 to 3 feet bgs are proposed at 27SB15 through 27SB19 east of borings 27SB05 and 27SB06, where chromium exceeded ecological screening criteria and background in subsurface soils.

- Two subsurface soil samples from 1 to 3 feet bgs will also be collected at 27SB20 and 27SB21 around boring 27SB02, where copper, chromium and zinc exceeded ecological screening criteria and background in subsurface soils. Boring 27SB20 is also south of 27SB06, where chromium exceeded ecological screening criteria and background in subsurface soils.

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), lithology, water occurrence, sample number and location, presence or absence of soil discoloration, and the time of sample collection will be recorded in a field logbook. Soils for metals analyses will be placed in a disposable aluminum pan and homogenized prior to placement in the sample jars.

The subsurface soil samples will be obtained with a 66DT Geoprobe® drill rig (or equivalent) capable of direct push and augering and/or bucket auger for areas where access by the Geoprobe® is not practical. Soil samples will be collected continuously from the ground surface to the desired depth using a 3 to 5 foot long stainless steel Macro Core Sampler with an acetate liner and/or bucket auger. During soil boring installation, care will be taken to achieve maximum recovery, to minimize the need for resampling. Because only ecological receptors are being evaluated, the borings will be terminated at a depth of three feet bgs.

3.1.2.3 Surface Water and Sediment Sampling

The actual estuarine surface water and sediment samples will be located in the field based on the findings of the wetland delineation (Section 3.1.1). Ocean sediment and surface water samples are not planned because groundwater contamination is not a concern at the site and surface water drains toward the estuarine wetland due to the presence of the bulkhead/sea wall. Sediment samples will be biased towards low lying areas and/or drainage features. The actual number of surface soil and sediment samples may need to be modified to provided for adequate lateral coverage and delineation of the contamination. Currently, it is estimated that approximately 22 sediment samples will be collected as listed on Table 3-1. However, there will be a minimum of ten sediment and ten surface water samples collected (if adequate water is available) . To the extent practical, the surface water samples will be collocated with the sediment samples. However, precedence will be given to delineation of the metals contamination in sediments over collocation, if there is minimal surface water available for sampling.

Surface water samples (27SW01 through 27SW10) will be collected (if present) using the direct-dip method from an appropriate water depth determined in the field. The direct dip method uses a 1-liter laboratory certified clean, unpreserved amber glass bottle. The surface water will then be decanted into appropriate laboratory supplied containers and placed on ice for laboratory-based chemical analysis. Samples for dissolved metals will be field filtered through a disposable 0.45 micron filter prior to placement in the laboratory supplied containers. To minimize the potential for suspending solids during sampling, surface water samples will be collected from downstream to upstream and prior to collection of the associated sediment samples. Field parameters will include: pH, specific conductance/salinity, temperature, and dissolved oxygen. Both filtered and unfiltered sample aliquots will be collected and analyzed for dissolved and total Appendix IX metals.

Sediment samples 27SD01 through 27SD22 have been located down-slope (east) from the surface soil areas that exceeded the ecological screening criteria and background for mercury and zinc and will provide additional characterization information, as depicted on Figure 3-1. Some of these locations may be converted into surface soil sampling locations depending on the outcome of the wetlands delineation (Section 3.1.1). All 22 sediment samples will be analyzed for Appendix IX metals and total organic carbon (TOC); 12 of the sediment samples will also be analyzed for Acid Volatile Sulfides/Simultaneously Extracted Metals (AVS/SEM) to better assess the bioavailability of the certain metals.

Sediment samples will be collected with a stainless steel spoon from a depth of 0 to 0.5 feet bgs. The fraction of sediments tested for the AVS/SEM will be placed directly into sample jars without homogenization/compositing and 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 for total metals and TOC will be placed in a disposable aluminum pan and homogenized with a stainless steel spoon and then placed in the sample containers. 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.

3.1.3 Analytical Testing

Fixed base laboratory analysis will include Appendix IX metals for each surface soil, subsurface soil, surface water and sediment sample as indicated on Table 3-1. Each of the sediment samples also will be tested for TOC. A maximum of twelve sediment samples will also be tested for AVS/SEM. Surface water samples will be tested for both total and dissolved Appendix IX metals. All analyses at the laboratory will be performed using current methodologies as presented in Table 3-2. Quality

Assurance/Quality Control (QA/QC) and Investigation Derived Waste (IDW) sampling are discussed in Sections 3.5 and 3.6.4, respectively.

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 as well as a certified licensed chemist from Puerto Rico will be determined at a later date.

3.2 SMWU 28 - Bundy WWTP Sludge Drying Beds

Based on the Full RFI (Baker, 2008b), primarily mercury, but also arsenic, barium, zinc and other metals were detected in surface soil above human health and/or ecological surface soil screening criteria and background. The highest concentrations occurred east and southeast (down-slope side) of the sludge drying beds. Aroclor 1260 was also detected above human health screening criteria and background in two surface soil samples. Barium was detected above human health and ecological subsurface soil screening criteria and background in subsurface soil samples from two borings. Total and dissolved barium as well as other metals were detected in the groundwater samples above human health screening criteria and background. Figures from the Full RFI (Baker, 2008b) presenting these exceedances are provided in Appendix B for reference.

3.2.1 Wetland Delineation

The estuarine wetland resource with a Cowardin classification of Estuarine, Intertidal, Forested, Broad-Leaved Evergreen (E2FO3) has an approximate boundary depicted on Figures 1-4, and 3-2, which was delineated by Geo-Marine, Inc. in December 1999 from 1993 color infrared and 1998 true color photography. As such, the wetland boundary does not represent a field delineated jurisdictional boundary. As part of this CMS, the estuarine wetland (E2FO3) boundary within the borders of the SWMU will be field-delineated in accordance with the USACE Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Caribbean Islands Region (USACE, 2009). This boundary will be established to determine if subsequent samples are designated as sediment samples or surface soil samples. Additionally, during this reconnaissance, an inspection will be made to determine if any standing water is present. Currently, it is not anticipated that saturated soils or surface water will be present within the investigation area that would function as an aquatic habitat for invertebrates and avian invertivores.

3.2.2 Soil Sampling, Well Installation, Surface Water and Sediment Sampling

The extent of mercury, zinc and other metals contamination in surface soils was not defined during the Full RFI (Baker, 2008b). The distribution of PCBs in surface soils is relatively well defined and needs only minor refinement. The vertical extent of barium contamination (maximum depth 3 feet) was delineated during the Full RFI; however, the lateral extent of subsurface barium contamination was not delineated. The extent of arsenic, barium, and vanadium in groundwater in excess of screening levels and background has not been fully characterized downgradient/sidegradient of the sludge drying beds. Figures B1 through B6 in Appendix B present these exceedances.

3.2.2.1 Surface Soil Sampling

Surface soil samples will be collected from locations shown on Figure 3-2 to define the lateral and vertical extent of soil contamination around the sludge drying beds, as summarized on Table 3-3. It is estimated that 32 surface soil samples (0 to 1 foot bgs) will be collected to complete the delineation of soil contamination at the site. The basis for the proposed sampling locations are described below. Sample locations are shown on Figure 3-2.

- Two surface soil samples 28SS13 and 28SS14 are proposed west of samples 28SS03 and 28SS04, where mercury was detected above ecological screening criteria and background in surface soils.

- Five surface soil samples (28SS15 through 28SS19) are proposed south of the sludge drying beds around and/or south of samples 28SB07-00, 28SB01-00, 28SB02-00 and 28SS09, where mercury, zinc and/or barium were detected above ecological screening criteria and background in surface soils.

- Eight surface soil samples from 28SB14-00, 28SB15-00 and 28SS20 through 28SS25 are proposed to characterize soils northeast of 28SB03-00, where surface soil exceeded human health screening criteria and background for mercury and ecological screening criteria and background for mercury and zinc.

- Seventeen surface soil samples (28SS26 through 28SS41 and 28SB10-00) are proposed to characterize surface soils down-slope to the east and southeast of the sludge drying beds and samples 28SB03-00, 28SS10, 28SB08-00, 28SB02-00, 28SS09 and 28SS11, where mercury and/or other metals such as zinc were detected above human health and ecological screening criteria and background in surface soils (see Figures B1 and B2 in Appendix B).

- In addition, surface soil samples from 28SS16, 28SS18, 28SS27, 28SS28 and 28SS32 also will be used to characterize surface soils for PCBs around borings 28SB02 and 28SS10, where Aroclor-1260 exceeded the human health screening criteria and background. Only a limited number of samples are required for PCB characterization, because there were limited PCB detections during the previous investigations, and the extent of Aroclor-1260 exceeding criteria was already relatively well delineated during the Full RFI (Baker, 2008b).

Surface soil samples will be collected following the procedures in Final RCRA Facility Investigation Management Plans (Baker, 1995). Soil samples will be collected from 0 to 1 foot bgs using a stainless steel spoon, bucket auger and/or 66 DT Geoprobe® drill rig (or equivalent). All pertinent sampling information such as soil description (e.g., color and texture), lithology, water occurrence, sample number and location, presence or absence of soil discoloration, and the time of sample collection will be recorded in a field logbook. Surface material (e.g., vegetation and rocks) will be removed prior to sample collection. Soils for metals will be placed in a disposable aluminum pan and homogenized prior to placement in the sample jars. All surface soil samples will be analyzed for Appendix IX metals. Samples 28SS16, 28SS18, 28SS27, 28SS28 and 28SS32 also will be analyzed for PCBs.

3.2.2.2 Subsurface Soil Sampling

Subsurface soil samples will be collected from six locations shown on Figure 3-2 to define the lateral and vertical extent of subsurface soil contamination around the sludge drying bed, as summarized on Table 3-3. Subsurface concentrations of barium exceed human health and/or ecological screening criteria at multiple locations as shown of Figures B-3 and B-4 in Appendix B. It is estimated that a minimum of 15 subsurface samples will be collected to complete the delineation of soil contamination at the site. All subsurface soil samples will be tested for Appendix IX metals. The basis for the proposed sampling locations are described below. Sample locations are shown on Figure 3-2.

- Three subsurface soil samples (28SB10-01, 28SB14-01 and 28SB15-01) are proposed, north and east of sample 28SB03-01, where concentrations of barium exceeded the ecological screening criteria and background for barium in subsurface soils. Because only ecological receptors are a concern relative sample results from 28SB03-01, the borings 28SB14 and 28SB15 will be terminated at a depth of three feet bgs. Boring 28SB10 will be extended approximately eight feet below the water table, because it is being used for a monitoring well; however, samples for analytical testing will also be terminated at three feet at boring 28SB10.

- Twelve subsurface soil samples from three borings (28SB16 through 28SB18) are proposed around boring 28SB06, where concentrations of barium exceeded the ecological and human health screening criteria and background concentrations for barium in subsurface soils. Because both ecological and human receptors are a concern at this location, the three borings (28SB16 through 28SB18) will be collected at two-foot intervals beginning at one foot bgs. and extending to a depth of nine feet bgs.

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), lithology, water occurrence, sample number and location, presence or absence of soil discoloration, and the time of sample collection will be recorded in a field logbook. Soils for metals analyses will be placed in a disposable aluminum pan and homogenized prior to placement in the sample jars.

The subsurface soil samples will be obtained with a 66DT Geoprobe® drill rig (or equivalent) capable of direct push and augering and/or bucket auger for areas where access by the Geoprobe® is not practical and the required boring depth is no more than three feet bgs. Soil samples will be collected continuously from the ground surface to the desired depth using a 5-foot long stainless steel Macro Core Sampler with an acetate liner and/or bucket auger. Based on the previous characterization at sample 28SB03-01, soil samples from borings 28SB10, 28SB14 and 28SB15 will be collected from a depth of one to three feet bgs. Based on the previous characterization activities at boring 28SB06, soil samples from the borings 28SB16 through 28SB18 will be collected continuously at two foot intervals from one to nine feet bgs to assess potential human health and ecological risks. During soil boring installation, care will be taken to achieve maximum recovery, to minimize the need for resampling. A boring log will be maintained indicating, among other things, lithology, water occurrence, and other observations.

3.2.2.3 Monitoring Well Installation

The lateral extent of arsenic, barium, and vanadium in excess of human health screening levels and background have not been fully characterized downgradient/sidegradient of the sludge drying beds as shown on Figure B-5 in Appendix B. Additionally, ecological screening criteria and background concentrations were exceeded at temporary well 28TW01 as shown on Figure B-6. Based on the Full RFI Report (Baker, 2008b), groundwater flows from west to east, as shown on Figure B-7 in Appendix B.

To better characterize the concentrations observed in the historic temporary well, the extent of these contaminants and to better characterize upgradient/sidegradient concentrations, five monitoring wells (28MW09, 28SB10 and 28MW11 through 28MW13) will be installed in the vicinity of SWMU 28. Well locations are shown on Figure 3-2. The purposes of the proposed wells are described below.

- Monitoring well 28MW09 is included to provide a geochemistry control point in the northern portion of the site and to provide additional information concerning the direction of groundwater flow.

- Monitoring well 28SB10 is anticipated to be immediately downgradient of the sludge drying beds and further downgradient from the existing monitoring well 28MW08 and downgradient of former temporary monitoring point 28TW02 that exceeded the human health screening criteria and background for barium and 28TW03 that exceeded the human health screening criteria and background for arsenic, beryllium vanadium and barium.

- Monitoring well 28MW11 is being installed in the vicinity of former temporary well 28TW01 that yielded the highest groundwater concentrations of total barium for the site. The temporary well no longer exists and it is proposed that groundwater data be collected from a properly constructed monitoring well to verify results that were observed in former temporary well 28TW01 that exceeded the human health and ecological screening criteria and background for several other metals.

- Monitoring well 28MW12 is included to provide a geochemistry control point in the southern portion of the site and to provide additional information concerning the direction of groundwater flow.

- Monitoring well 28MW13 is proposed to establish upgradient groundwater quality conditions for the site.

The monitoring well borings will be advanced with the 66DT Geoprobe rig (or equivalent). Monitoring wells will be installed through hollow-stem augers (HSAs). The wells will be constructed of 2-inch inside diameter (ID), Schedule 40 polyvinyl chloride (PVC), with flush joint threads. Well screens will be 10-feet long and installed to straddle the water table. Based on the geologic cross section and associated location map in Appendix B (Figures B-8 and B-9) the depth to bedrock is approximately 8 to 14 feet deep and the groundwater is perched above bedrock in the unconsolidated sand, silt and clay.

- 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 the prescribed drilling method. The well construction materials will be installed through the HSAs, casing, or in an open borehole.

- 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. The sand will extend to approximately 2 feet above the top of the screened interval. The thickness of the sand above the screened interval may be reduced if the well is too shallow 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, 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.

- Wells in high traffic areas (i.e., 28MW09, and 28MW11 through 28MW13) will be completed at the surface using a "flush" manhole type cover. The flush-mounted cover will be surrounded by a concrete pad and slightly elevated above the ground surface with the concrete sloping away from the cover to the existing ground surface.

- Wells in heavily vegetated areas (i.e., 28SB10) 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 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 monitoring well will be developed using pumping and surging 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 discharged water runs 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)

- Stability of pH, specific conductance, and temperature measurements (typically less than 10 percent change between three successive measurements)

- Clarity based on turbidity measurements [typically less than 20 Nephelometric Turbidity Units (NTU)]

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 <u>Final RCRA Facility Investigation Management Plans</u> (Baker, 1995).

3.2.2.4 Surface Water and Sediment Sampling

The actual number of surface water and sediment samples will be determined after the wetland delineation is completed. However, it is not anticipated that sediment or surface water samples will be required for this site. Surface water and sediment samples (if present) will be biased towards low lying areas and/or drainage features. If sediment is present, the sediment samples will replace applicable surface soil samples that are shown on Figure 3-2.

Up to ten surface water samples (28SW01 through 28SW10) may be collected. However, currently no surface water samples are anticipated at SWMU 28 due to the probable lack of water. Surface water samples (if present) will be collected using the direct-dip method from an appropriate water depth determined in the field. The direct dip method uses a 1-liter laboratory certified clean, unpreserved amber glass bottle. The surface water will then be decanted into appropriate laboratory supplied containers and placed on ice for laboratory-based chemical analysis. Samples for dissolved metals will be field filtered through a disposable 0.45 micron filter prior to placement in the laboratory supplied containers. To minimize the potential for suspending solids during sampling, surface water samples will be collected from downstream to upstream locations and prior to collection of the associated sediment samples. Field parameters will include: pH, specific conductance/salinity, temperature, and dissolved oxygen. Both filtered and unfiltered sample aliquots will be collected and analyzed for dissolved and total Appendix IX metals.

If sediment is present, a minimum of ten sediment samples (28SD01 through 28SD10) will be collected from 0 to 0.5 feet bgs. Each sediment sample will be analyzed for Appendix IX metals as specified in Table 3-3. Up to six samples will be tested for AVS/SEM, if sediments are present to better assess the bioavailability of the certain metals.

Sediment samples will be collected with a stainless steel spoon from a depth of 0 to 0.5 feet bgs. The fraction of sediments tested for the AVS/SEM will be placed directly into sample jars without homogenization/compositing and 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 for total metals and TOC will be placed in a disposable aluminum pan and homogenized with a stainless steel spoon and then placed in the sample containers. 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.

3.2.3 Groundwater Sampling

The lateral extent of arsenic, barium, and vanadium in excess of human health screening levels and background have not been fully characterized downgradient/sidegradient of the sludge drying beds as shown on Figure B-5 in Appendix B. Additionally, ecological screening criteria and background concentrations were exceeded at temporary well 28TW01 as shown on Figure B-6 in Appendix B. To better characterize the extent of these contaminants, to verify the concentrations observed at 28TW01, and to better characterize upgradient/sidegradient concentrations, nine groundwater samples will be collected from the existing and new wells at SWMU 28. The basis for the groundwater samples are as follows:

- Samples 28GW05, 28GW07 28GW08 will be collected to provide a second round of groundwater data to confirm historical results.

- Additionally, a sample (28GW06) will be attempted at existing well 28MW06, which did not produce adequate water for sampling during 2008.

- Sample 28GW09 is included to provide a geochemistry control data for the northern portion of the site.

- Sample 28GW10 will be used to evaluate data downgradient of the sludge drying beds and further downgradient from the existing monitoring well 28MW08 and downgradient of former temporary well 28TW02 that exceeded the human health screening criteria and background for barium and 28TW03 that exceeded the human health screening criteria and background for arsenic, beryllium vanadium and barium.

- Sample 28GW11 will be used to evaluate groundwater quality near the former temporary well 28TW01 that yielded the highest groundwater concentrations of total barium for the site and also exceeded the human health and ecological screening criteria and background for several other metals.

- Sample 28GW12 is included to provide geochemistry control data for the southern portion of the site.

- Sample 28GW13 is proposed to establish upgradient groundwater quality conditions for the site.

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 28. The groundwater flow direction is expected to be eastward. Water levels will be collected from the existing wells (28MW05, 28MW06, 28MW07 and 28MW08) and the new wells (28MW09, 28SB10, 28MW11, 28MW12, and 28MW13). Groundwater samples will be collected from these same nine (9) monitoring wells as summarized on Table 3-3.

The groundwater will be sampled using low-flow sampling methods. Appendix D 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 sampled will be filtered in the field for the dissolved metals analyses. Unfiltered samples for total metals will also be collected. The groundwater samples will be placed into appropriate laboratory supplied containers.

3.2.4 Analytical Testing

Fixed base laboratory analysis will include Appendix IX metals for all media as indicated on Table 3-3. Samples from locations 28SS16, 28SS18, 28SS27, 28SS28 and 28SS32 will also be analyzed for Appendix IX PCBs. Each of the sediment samples (if present) will be tested for TOC. Six sediment samples (if present) will also be tested for AVS/SEM. The locations for the AVS/SEM samples will be determined by the support staff responsible for sampling. Currently, it is not anticipated that surface water samples will be collected. However, if present, surface water will be tested for total and dissolved Appendix IX metals. QA/QC and IDW sampling are discussed in Sections 3.5 and 3.6.4, respectively.

All analyses at the laboratory will be performed using current methodologies as presented in Table 3-2. 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 as well as a certified licensed chemist from Puerto Rico will be determined at a later date.

3.3 SMWU 29 - Industrial Area WWTP Sludge Drying Beds

Based on the Full RFI (Baker, 2008c), primarily mercury and copper in surface soils and copper in subsurface soil require additional delineation to provide data for evaluation of ecological risks in soils associated with SWMU 29. Other metals of potential ecological concern identified at one to two surface soil locations included barium and zinc. Figures from the Full RFI (Baker, 2008c) presenting these exceedances are provided in Appendix C for reference. These exceedances occurred on the east and west sides of the sludge drying beds, with the higher concentrations along the eastern side of the sludge drying beds.

3.3.1 Soil Sampling

3.3.1.1 Surface Soil Sampling

The extent of surface soil metals contamination was not defined during the Full RFI (Baker, 2008c), as shown on Figure C1 in Appendix C. It is estimated that 20 surface soil samples (0 to 1 foot bgs) will be collected to complete the delineation of soil contamination as identified on Table 3-4. Sample locations are shown on Figure 3-3. All surface soil samples will be tested for Appendix IX metals. The basis for the proposed sampling locations are described below.

- Five surface soil samples 29SS03 through 29SS07 are proposed west of the sludge drying beds in the vicinity of borings 29SB05 and 29SB07, where surface soils exhibited concentrations of mercury above ecological screening criteria and background in surface soils.

- Fifteen surface soil samples 29SS08 through 29SS17 and 29SB16-00 through 29SB20-00 are proposed to be collected east and southeast of the sludge drying beds and east and south of surface samples 29SB01-00, 29SB12-00, 29SB11-00, 29SB02-00, and 29SB09-00, where mercury and/or copper and in some cases additional metals exceeded ecological screening criteria and background in surface soils (see Figure C1 in Appendix C).

Surface soil samples will be collected following the procedures in Final RCRA Facility Investigation Management Plans (Baker, 1995). Surface soil samples will be collected from 0 to 1 foot bgs using a stainless steel spoon, bucket auger and/or 66 DT Geoprobe® drill rig (or equivalent). All pertinent sampling information such as soil description (e.g., color and texture), lithology, water occurrence, sample number and location, presence or absence of soil discoloration, and the time of sample collection will be recorded in a field logbook. Surface material (e.g., vegetation and rocks) will be removed prior to sample collection. Soils for metals analyses will be placed in a disposable aluminum pan and homogenized prior to placement in the sample jars.

3.3.1.1 Subsurface Soil Sampling

The vertical extent of copper was delineated during the Full RFI (Baker, 2008c); however, the lateral extent of subsurface soil contamination was not delineated as shown on Figure C2 in Appendix C. A total of six subsurface samples (1 to 3 feet bgs) will be collected to complete the delineation of subsurface soil contamination as identified on Table 3-4. All subsurface soil samples will be tested for Appendix IX metals. The basis for the proposed sampling locations is described below. Sample locations are shown on Figure 3-3.

- Six subsurface soil samples from 1 to 3-feet bgs are proposed at borings 29SB15 through 29SB20 to delineate subsurface soils east of the sludge drying beds around borings 29SB11 and 29SB13, where copper was observed in subsurface soils samples above ecological screening criteria and background.

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), lithology, water occurrence, sample number and location, presence or absence of soil discoloration, and the time of sample collection will be recorded in a field logbook. Soils for metals analyses will be placed in a disposable aluminum pan and homogenized prior to placement in the sample jars.

The subsurface soil samples will be obtained with a 66DT Geoprobe® drill rig (or equivalent) capable of direct push and augering and/or bucket auger for areas where access by the Geoprobe® is not practical. Soil samples will be collected continuously from the ground surface to the desired depth using a 3 to 5 foot long stainless steel Macro Core Sampler with an acetate liner and/or bucket auger. During soil boring installation, care will be taken to achieve maximum recovery, to minimize the need for resampling. Because only ecological receptors are being evaluated, the borings will be terminated at a depth of three feet bgs.

3.3.2 Analytical Testing

Fixed base laboratory analysis will include Appendix IX metals as indicated on Table 3-4. All analyses at the laboratory will be performed using current methodologies as presented in Table 3-2. QA/QC and IDW sampling are discussed in Sections 3.5 and 3.6.4, respectively.

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, as well as a certified licensed chemist from Puerto Rico, will be determined at a later date.

3.4 Sample Labeling, Control and Shipping

Soil samples will be labeled in a manner consistent with previous sample designations at NAPR. Sample ID prefixes will correspond to the SWMU where collected (i.e., "27", "28", and "29"). Sample ID extensions will reflect the depth at which the sample was obtained. For the purposes of this work plan, two-foot discrete depths will be used (except for the surface sample which is a one-foot interval). Sample identification extensions will follow the pattern shown below.

29SB15-00 - SMWU 29
29SB15-00 - Soil Boring Sample
29SB15-00 - Soil Boring location identifier
29SB15-00 - Depth Designator - 0 to 12 inches bgs (surface soil) sampling interval

Subsurface soil samples will be designated as follows:

29SB15-01 - First subsurface sampling interval, 1 to 3 feet bgs
29SB15-02 - Second subsurface sampling interval, 3 to 5 feet bgs and so on.

Sample identification extensions will follow the pattern shown above. However, the actual sample depth will be determined in the field.

The groundwater sample designations will be as shown on Table 3-3. Sample identification extensions will follow the pattern below.

28GW10 - SMWU 28
28GW10 - Groundwater Sample
28GW10 – soil boring or location identifier (SB10/MW10)

Samples will be packed in ice and shipped next day air to the fixed-base laboratory. Because of previously encountered delays associated with sample shipments from Puerto Rico to the United States, additional insurance to cover re-sampling costs should be claimed on the bill of lading. At least one member of the field team will remain on the island until verification by the laboratory of receipt of all shipments. This will minimize any potential re-sampling costs associated with mobilization. Tracking numbers for each shipment will be forwarded to the data manager for assisting in verification of receipt of samples by the laboratory.

3.5 Quality Assurance/Quality Control Samples

Field specific QA/QC sample procedures are given below. QA/QC samples will be analyzed for parameters as shown in Table 3-5 (for SWMU 27), Table 3-6 (for SWMU 28) and Table 3-7 (for SWMU 29) by methods presented in Table 3-2. QA/QC samples collected during these investigations will include trip blanks, equipment rinsate samples, field blank samples, field duplicate samples and matrix spike/matrix spike duplicates (MS/MSD), as discussed below.

3.5.1 Trip Blanks

Trip blank samples will not be required since volatile organic compound analyses are not proposed.

3.5.2 Equipment Rinsates

Equipment rinsate samples are collected from an analyte-free water rinse of equipment. 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.

It is anticipated that a total of four equipment rinsates will be collected for SWMU 27, seven will be collected for SWMU 28 and three will be collected for SWMU 29. These samples will be associated with the surface and subsurface soil, sediment, and groundwater sampling equipment. The samples will be obtained from a stainless steel spoon for collection of soil and sediment, a split spoon sampler or macro core liner for collection of subsurface soil, a bucket auger (if used to collected surface and/or subsurface soil samples), the aluminum pan used during mixing of the samples, groundwater sampling equipment and from the associated tubing used during the collection of groundwater. These samples will be analyzed for the analytes presented on Tables 3-5 through 3-7.

3.5.3 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 on Tables 3-5 through 3-7 for each of the three SWMUs.

3.5.4 Field Duplicates

Field duplicate samples of the surface soil, subsurface soil, groundwater, surface water and sediment samples 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 Tables 3-1, 3-3, and 3-4.

3.5.5 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 Tables 3-1, 3-3, and 3-4.

3.6 <u>Other Investigation Considerations</u>

During the investigation, the following activities will be performed:

- Clearing and Grubbing
- Utility Clearance
- Decontamination
- IDW Management
- Surveying
- Health and Safety Procedures
- Chain of Custody

Each of these activities is discussed in the following sections.

3.6.1 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. Two days of site clearing will be performed by the direct push subcontractor and Baker.

3.6.2 Utility Clearance

The Baker Site Manager or designated alternate will be responsible for clearing all proposed soil boring and well locations.

3.6.3 Decontamination

All reusable (non-dedicated and non-disposable) soil sampling and monitoring well installation equipment (i.e. augers, drill bits, etc.), will be decontaminated between each sampling location in accordance with the 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.

3.6.4 Investigation Derived Waste Management

The generation of IDW associated with soil sampling and monitoring well installation, including soil cuttings and decontamination fluids, will be collected and stored temporarily in 55-gallon drums. However, the soil cuttings from the subsurface soil sampling will be placed back into the boring from which they came, unless contamination is noted by the field personnel. As much as possible, soils last out of the hole will be returned first, thereby, approximating original stratigraphy.

Three soil (one per site) IDW samples will be collected during this investigation. One composite aqueous sample will be collected from all drums containing decontamination fluids (from sampling equipment and drill rig) and purge water, (from all three sites combined) and three composite soil samples will be collected from each of the drums containing drill cuttings (if applicable).

The soil and water samples will be analyzed for parameters shown in Table 3-5 through 3-7, as well as by methods presented in Table 3-2. All IDW will be tested for Appendix IX metals. Soils from SWMU 28 will also be tested for PCBs. The soil and water will also be tested for Toxicity Characteristic Leaching Procedure (TCLP) metals and TCLP volatiles and the other RCRA characteristics (reactive sulfide and cyanide, corrosivity, and ignitability).

Upon completion of the field program, the drums will be moved and stored per the direction of Public Works Department (PWD) 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.

3.6.5 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. This methodology reduces the need for a surveyor to identify the sampling locations in the field. Any of the locations that may need to be field modified will be located utilizing a field-grade GPS unit. The GSP will be supplemented with a compass and measuring tape for locations with tree cover when a GPS signal cannot be received.

Any permanent monitoring wells will be located utilizing a survey grade GPS unit. Traditional survey equipment or a survey GPS unit will be used to obtain vertical (+/- 0.01 foot) and horizontal (+/- 0.1 foot) locations and top of PVC elevations for the permanent monitoring wells or generating groundwater contours.

3.6.6 Health and Safety Procedures

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

3.6.7 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 each shipment in which the samples are shipped. After the samples are properly packaged, the shipping container will be sealed and prepared for shipment to the analytical laboratory.

3.7 <u>Data Validation</u>

The third party validator 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.

3.8 References

Michael Baker Jr. Inc. (Baker), 2008a. Final Full RCRA Facility Investigation SWMU 27 – Capehart Wastewater Treatment Plant Sludge Drying Beds Naval Activity Puerto Rico, EPA ID No. PR2170027203, Ceiba, Puerto Rico. August 28, 2008.

Baker, 2008b. Final Full RCRA Facility Investigation SWMU 28 – Bundy Wastewater Treatment Plant Sludge Drying Beds Naval Activity Puerto Rico, EPA ID No. PR2170027203, Ceiba, Puerto Rico. August 28, 2008.

Baker, 2008c. Final Full RCRA Facility Investigation SWMU 29 – Industrial Area Wastewater Treatment Plant Sludge Drying Beds Naval Activity Puerto Rico, EPA ID No. PR2170027203, Ceiba, Puerto Rico. August 28, 2008.

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

United States Army Corps of Engineers (USACE). 2009. Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Caribbean Islands Region. Engineer Research and Development Center, Vicksburg, MS. ERDC/EL TR-09-8. August, 2009.

4.0 CMS REPORT

Reports will be prepared to describe the sampling and analytical activities and findings of the CMS investigations for SWMUs 27, 28 and 29. The CMS Report will include the following sections:

- Introduction
- Background
- Physical Characteristics of the Study Area
- CMS Investigation Activities
- Physical Results
- Analytical Results
- Screening Level ERA and Step 3a of the Baseline ERA
- Human Health Risk Assessment (as appropriate)
- Summary of COCs and CAOs
- Conclusions and Recommendations
- Corrective Measures Study

The following summarizes the sections that will be included in each of the three reports for SWMUs 27, 28 and 29.

4.1 Introduction

The introduction will provide the regulatory framework for the CMS as well as a discussion of the project scope and objectives.

4.2 Background

The background will consist of a discussion of the historical background of any investigations conducted previously at SWMUs 27, 28 and 29.

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 CMS Investigation Activities

This section will summarize the results of the previous investigation and describe the basis for this CMS investigation. This section will also describe the field activities of the most recent investigation to fulfill the CMS Work Plan objectives for each of the SWMUs. This 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

The physical characteristics of the SWMUs will be recorded in the field. This section will provide a discussion of current site conditions and site-specific geology, hydrogeology and wetlands boundaries (as applicable).

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, sediment, surface water, and groundwater (as applicable). Analytical results for environmental media will be compared to the appropriate background screening values as described the document *"Revised Final II Summary Report for Environmental Background Concentrations of Inorganic Compounds, Naval Activity Puerto Rico, Ceiba, Puerto Rico"* by Baker Environmental, Inc. prepared July 30, 2010.

4.7 Screening Level ERA and Step 3a of the Baseline ERA

A screening level ERA and Step 3a of the Baseline ERA will be conducted to evaluate surface soil, subsurface soil, surface water, sediment and groundwater (as applicable) for SWMUs 27, 28 and 29 as detailed in Section 5.0 of this Work Plan.

4.8 Human Health Risk Assessment (as appropriate)

A human health risk assessment will be conducted to evaluate soil, surface water (if applicable), sediment (if applicable) and groundwater at SWMU 28 as detailed in Section 6.0 of this Work Plan.

4.9 Summary of COCs and CAOs

COCs are those contaminants detected at a site at concentrations that exceed human-health or ecological-based screening values. CAOs are cleanup criteria for those COCs that have been determined through human health and ecological risk assessment process to cause unacceptable risk to potential receptors. COAs for each media will be compiled and evaluated including an examination of the spatial and concentration distributions of CAOs within the media in which they occur.

4.10 Conclusions and Recommendations

Information from the risk assessments will be synthesized into conclusions regarding site conditions. Recommendations will be made from these conclusions, which will then be incorporated into each SWMUs CMS as appropriate.

4.11 Corrective Measures Study

If the results of the investigation indicate that a streamlined CMS approach is appropriate, then a CMS will be prepared in accordance with Section 8, Tasks III and IV; otherwise, a full CMS will be prepared in accordance with Section 8, Tasks I through IV.

4.12 References

Source material used in the development of the CMS will be documented in the reference section of the report.

5.0 ECOLOGICAL RISK ASSESSMENT

This section presents the technical approach that will be used to conduct ERAs at SWMUs 27-Capehart WWTP Sludge Drying Beds, 28 - Bundy WWTP Sludge Drying Beds, and 29 - Industrial Area WWTP Sludge Drying Beds, located at NAPR, Ceiba, Puerto Rico. The ERA process at SWMUs 27, 28, and 29 will be completed in accordance with the Navy policy for conducting ERAs (Chief of Naval Operations [CNO], 1999) and the Navy guidance for conducting ERAs (available at http://web.ead.anl.gov/ecorisk/), as well as guidance provided by the USEPA (1997).

The Navy ERA process (see Figure 5-1) consists of eight steps organized into three tiers and represents a clarification and interpretation of the eight-step ERA process outlined in the USEPA ERA guidance for the Superfund program (USEPA, 1997). Tier 1 of the Navy ERA process represents the screening level ERA (SERA):

- Screening level problem formulation and ecological effects evaluation (Step 1).

- Screening level exposure estimate and risk calculation (Step 2).

Under Navy policy, if the results of Step 1 and Step 2 (Tier 1 SERA) indicate that, based on a set of conservative exposure assumptions, there are chemicals present in environmental media that may present a risk to receptor species/communities, the ERA process proceeds to the baseline ERA (BERA). According to Superfund guidance (USEPA, 1997), Step 3 represents the problem formulation phase of the BERA. Under Navy policy, the BERA is defined as Tier 2, and the first activity under Tier 2 is Step 3a. Step 3a precedes the BERA problem formulation (Step 3b). In Step 3a, the conservative exposure assumptions applied in Tier 1 are refined and risk estimates are recalculated using the same conceptual site model. The evaluation of risks in Step 3a may also include consideration of background data and chemical bioavailability. If the re-evaluation of the conservative exposure assumptions in Step 3a does not support an acceptable risk determination, the site continues in the BERA process (i.e., Steps 3b through 7; see Figure 5-1):

As CAOs for the protection of the environment will be developed at each SWMU (if necessary) based on the results of the SERA and the refinement of SERA exposure assumptions, this section only presents the approach that will be used in Steps 1, 2, and 3a of the Navy ERA process. The screening level problem formulation is presented, as well as the screening level exposure estimate. Methodology for conducting the screening level risk calculation and refinement of risk estimates in Step 3a of the BERA also are identified and discussed. The screening level problem formulation includes preliminary conceptual site models for each SWMU and a discussion of potential source areas, transport pathways, and exposure pathways and routes. Assessment and measurement endpoints also are presented and the receptor species selected to evaluate potential risks are identified. It is important to note that the screening level problem formulation for each SWMU was developed using limited information on habitats and potential biota. Therefore, SWMU-specific information presented within the sections that follow may require revisions based on site-specific observations made during the CMS field investigations. Where appropriate, specific knowledge gaps are identified and potential revisions to the methodology are identified. Revisions will be provided within the SWMU-specific ERAs included as part of the CMS Investigation Reports.

5.1 Environmental Setting

The sections that follow provide a description of the habitats and biota occurring at NAPR. The description relies primarily on literature-based information for Puerto Rico and is supplemented by information specific to NAPR. As discussed in Section 5.0 above, specific knowledge of SWMU-specific habitats and biota is limited. As such, the discussion will be revised, as necessary, to include SWMU-specific observations made during the CMS field investigations.

5.1.1 Terrestrial 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 communities at SWMUs 27, 28, and 29 are limited to maintained grasses of unknown species composition (likely to include *Bothriochloa ischaemum* [yellow bluestem], *Chloris barbata* [swollen fingergrass], and *Digitaria* spp. [crabgrass] based on maintained grasses identified during a habitat characterization conducted at SWMUs 1, 2, and 45 in May 2000 [Geo-Marine, Inc., 2000]). In addition to the maintained grasses, upland coastal forest communities are located north, south, and west of SWMU 27 and north and west of SWMU 28, while a coastal scrub forest community is located east of SWMU 29 (see Figure 5-2).

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 1,350 feet northwest of SWMU 27 (see Figure 5-3). 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).

5.1.2 Aquatic Habitats

Approximately 460 acres at NAPR are covered by palustrine habitat, which includes all freshwater wetlands. These wetlands include wet meadows and marshes, dominated by cattails (*Typha* spp.) and grasses (*Panicum* spp. and *Paspalum* spp.), as well as wet coastal scrub forests. The marine environment surrounding NAPR includes mudflats (approximately 161 acres), mangroves (approximately 2,700 acres) and seagrass beds (approximately 1,900 acres) (Geo-Marine, Inc., 1998). Coral reefs also are located in the offshore marine environment (see Figure 5-2). Coral reef types within the waters surrounding NAPR, as well as their associated acreage cover are as follows (Department of the Navy [DoN], 2007):

Reef Habitat Type	Area (acres)
Colonized bedrock	266
Linear reef	84
Patch reef (aggregated/individual)	146/175
Scattered coral-rock	5

Mangroves at NAPR mainly consist of red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*), and white mangrove (*Laguncularia racemosa*) (Geo-Marine, Inc., 2000 and 2005). Red mangroves tolerate relatively deep water levels, grow in unstable, soft soil, and tolerate a salinity range of 10 to 55 parts per thousand (ppt). They develop large prop roots which usually extend above the water surface. Black and white mangroves generally grow in areas that are not inundated by water. Mangroves at NAPR are natural filters for upland runoff and protect the coastline from storm damage (Lewis, 1986). They also provide habitat for wildlife, fish, and benthic invertebrates. Lewis (1986) reported 112 species of birds that use the NAPR mangroves as habitat for feeding, nesting, and roosting. The red mangrove prop root habitat in Puerto Rico also is used by at least 13 species of fish (including the gray snapper [*Lutijanus griseus*], lane snapper [*Lutijanus synagris*], and gold and black tricolor [*Holocanthus tricolor*]), several crustaceans (including the flat tree oyster [*Isognomon alatus*]), gastropods (including the coffee bean snail [*Melampus coffeus*] and mangrove periwinkle [*Littorina angulifera*]), echinoids (including the long-spined sea urchin [*Diadema antillarum*] and pencil sea urchin [*Eucidaris tribuloides*]), sponges (including the fire sponge [*Tedania ignis*]), ascidians (including the black tunicate [*Acsidia nigra*]), and hydroids (including the feathered hydroid [*Halocordyle distichа*]) (Geo-Marine, Inc., 2005).

The seagrass beds in eastern Puerto Rico are typical of well developed climax meadows found throughout the tropical Atlantic and Caribbean basin, consisting primarily of a dense, continuous coverage of turtle grass (*Thalassia testudinum*), with lesser amounts of manatee grass (*Syringodium filiforme*) and a wide diversity of calcareous algae (Reid et al., 2001). Patchy and sparse beds of mixed species, including shoal grass (*Halodule wrightii*), manatee grass, and paddle grass (*Halophila decipiens*), occur in localized areas affected and maintained by different wave regimes, substrate type, and turbidity than what is normally found in association with the climax turtle grass meadows.

The aquatic habitats occurring within and contiguous to SWMUs 27, 28, and 29 are depicted on Figures 5-4, 5-5, and 5-6, respectively. As evidenced by Figures 5-4 and 5-5, estuarine wetland units are located immediately east of SWMUs 27 and 28. The wetland units depicted on the figures, identified by the Cowardin Wetland Classification System (Cowardin et al., 1979; see Figure 5-7), 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 USACE (1987).

The wetland unit adjacent to SWMU 27 has a Cowardin classification of Estuarine, Intertidal, Scrub-Shrub, Broad-Leaved Evergreen (E2SS3), while the wetland unit adjacent to SWMU 28 has a Cowardin classification of Estuarine, Intertidal, Forested, Broad-Leaved Evergreen (E2F03). The vegetative composition of the E2SS3 wetland unit adjacent to SWMU 27 includes red mangroves (identified by their prop root system). However, the vegetative composition of the E2FO3 wetland unit adjacent to SWMU 28 is not known. Limited observations conducted during the Phase I and Full RFI field investigations indicate that this wetland unit functions as upland habitat (saturated sediments and standing water were not observed during the Full RFI field investigation). Additional evaluation of this wetland unit will be conducted during the SWMU 28 CMS field investigation. As evidenced by Figure 5-6, there are no wetland units immediately contiguous to SWMU 29. The nearest wetland unit is approximately 600 feet northeast of SWMU 29. This wetland unit is classified as E2SS3, with pockets of Estuarine, Intertidal, Unconsolidated Shore, Mud (E2US3), Estuarine, Intertidal, Unconsolidated Shore, Organic (E2US4), and Estuarine, Intertidal, Unconsolidated Shore, Dead (E2US5). Identical to the E2FO3 wetland unit adjacent to SWMU 28, the vegetative composition of these wetland units are not known. As discussed in Sections 3.1.1 and 3.2.1, the E2SS3 and E2FO3 wetland boundaries adjacent to SWMUs 27 and 28, respectively, will be field-delineated in accordance with the *Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Caribbean Islands Region* (USACE, 2009).

In addition to the estuarine wetland units discussed above, open water habitat also is contiguous to each SWMU. The Caribbean Sea borders SWMU 27 to the south (see Figures 1-2 and 5-4). This surface water feature also is located approximately 1,300 feet southeast of SWMU 28 (see Figures 1-2 and 5-5). SWMU 29 is located on a peninsula that extends into the Caribbean Sea, with Puerca Bay to the east and the Ensenada Honda to the west (see Figures 1-2 and 5-6). Seagrass beds are prevalent throughout much of the offshore marine environment at NAPR, including the offshore regions contiguous to SWMUs 27, 28, and 29 (see Figure 5-2). Seagrass meadows at NAPR 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). The turtle grass climax meadows represent potential grazing areas for the West Indian manatee (*Trichechas manatus*), a federally endangered species in Puerto Rico (United States Fish and Wildlife Service [USFWS], 2010), and the green sea turtle (*Chelonia mydas)*, a federally threatened species in Puerto Rico (USFWS, 2010).

5.1.3 Biota

A description of the biota occurring within Puerto Rico and the landmass encompassed by NAPR is provided in the sections that follow.

5.1.3.1 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 5-8. The figure (reproduced from DoN, 2007) includes information from most of the studies identified above. Feeding manatees are most often recorded within Pelican Cove and the Ensenada Honda (see Figure 5-8). Manatee sightings include the offshore marine environment immediately adjacent to SWMU 27.

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 have been implicated in the decline of native bird and reptile populations (Mac et al., 1998 and USFWS, 1996a).

5.1.3.2 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 to 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, twelve 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 5-1) 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). A study conducted by the (NFESC, 1996) reported that the mangrove forests surrounding NAPR should be considered the most important nesting habitat for the yellow-shouldered blackbird. Although SWMUs 27, 28, and 29 are not located within the critical habitat designation for the yellow-shouldered blackbird, potential feeding habitat (shrub and tree layers) is present within the upland coastal forest, coastal scrub forest, and/or estuarine wetland communities contiguous to SWMUs 27, 28, and 29. This presumption is based on the arboreal feeding behavior of the yellow-shouldered blackbird. A survey conducted by the Puerto Rico Department of Natural Resources (PRDNR) reported fifteen yellow-shouldered blackbirds (including five juveniles) at NAPR (PRDNR, 2002). At the time of the survey, the birds were using structures at the NAPR airport for resting cover. Although nesting pairs were not observed (the survey was not conducted during the breeding season), the airport structures contained several inactive nests. The inactive nests and juvenile birds indicate that a small breeding population is present at NAPR.

Other federally listed bird species (listed at http://www.fws.gov/endangered/species/us-species.html) 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).

5.1.3.3 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 5-9 and 5-10 (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. Based on the life history information for each turtle species, presented in the *Final Steps 3b and 4 of the Baseline Ecological Risk Assessment for SWMUs 1 and 2* (see Baker, 2007a) and the availability of forage material (in the form of seagrass), the green sea turtle has the potential to forage within the offshore marine environment adjacent to SWMU 27, downgradient from SWMU 28, and east and west of SWMU 29.

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 SWMUs 27, 28, and 29 or adjacent vegetative units.

5.1.3.4 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 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 estuarine wetland and open water marine habitats contiguous to SWMUs 27, 28, and 29 is not available.

5.2 Sources of Available Analytical Data

Sampling activities at SWMUs 27, 28, and 29 have been conducted under two investigations: Phase I and Full RFIs. Analytical results from these investigations were presented and discussed within the following documents:

- Revised Final Phase I RCRA Facility Investigation Report for SWMU 27 (Baker, 2008a)
- Final Full RCRA Facility Investigation for SWMU 27 (Baker, 2008b)
- Revised Final Phase I RCRA Facility Investigation Report for SWMU 28 (Baker, 2007b)
- Final Full RCRA Facility Investigation for SWMU 28 (Baker, 2008c)
- Revised Final Phase I RCRA Facility Investigation Report for SWMU 29 (Baker, 2008d)
- Final Full RCRA Facility Investigation for SWMU 29 (Baker, 2008e)

Surface soil (0.0 to 1.0 foot bgs), subsurface soil (1.0 to 3.0 feet bgs, 3.0 to 5.0 feet bgs, 5.0 to 7.0 feet bgs, 7.0 to 9.0 feet bgs, and/or 9.0 to 11.0 feet bgs), and groundwater were collected at each SWMU during the Phase I RFI field investigations and analyzed for Appendix IX volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), PCBs, and metals (total and dissolved), as well as total petroleum hydrocarbon (TPH) gasoline range organics (GRO) and TPH diesel range organics (DRO). Surface and subsurface soil samples also were collected at each SWMU during the Full RFI field investigations and analyzed for Appendix IX metals. In addition to Appendix IX metals, surface soil samples collected at SWMU 28 during the Full RFI field investigation were analyzed for Appendix IX PCBs. Groundwater also was collected at SWMUs 27 and 28 during the Full RFI field investigations and analyzed for Appendix IX metals (total and dissolved). Proposed sample collection activities for the CMS field investigations at SWMU 27, 28, and 29 (sample designations, sample depths, and analytical parameters) are summarized in Tables 3-1, 3-3, and 3-4, respectively.

Sampling activities also are discussed in Sections 3.1 (SWMU 27), 3.2 (SWMU 28), and 3.3 (SWMU 29).

Analytical data for soil samples collected from the 0.0 to 1.0-foot depth interval during the Phase I RFI, Full RFI, and CMS field investigations at each SWMU will be quantitatively evaluated as surface soil in the SERAs. This depth interval is the most active biological zone (most soil heterotrophic activity occurs within the surface soil and soil invertebrates occur on the surface or within the oxidized root zone [Suter II, 1995]). As discussed above, subsurface soil samples were collected from various depth intervals during the Phase I and Full RFIs. Subsurface soil samples also will be collected from various depth intervals during the CMS field investigations at each SWMU. Analytical data for subsurface soil samples collected from the 1.0 to 3.0-foot depth interval at each SWMU will be quantitatively evaluated as subsurface soil in the SERAs. Analytical data for subsurface samples collected from the deeper depth intervals will not be evaluated since these depths are not likely to represent a significant exposure point for ecological receptors. Finally, available groundwater data at each SWMU, as well as the proposed surface water and sediment samples at SWMU 27, will be quantitatively evaluated in the SERAs

5.3 Screening Level Problem Formulation

Problem formulation establishes the goals, scope, and focus of the ERA. The products of the screening level problem formulation are (1) the preliminary conceptual model and (2) the assessment and measurement endpoints. The purpose of the preliminary conceptual model is to describe how ecological receptors may be exposed to chemicals originating from the site. The preliminary conceptual model is developed using information regarding major habitats and ecological receptors, media of concern, and potential contaminant sources in conjunction with an understanding of potential transport pathways, exposure pathways, and exposure routes. The fate, transport, and toxicological properties of the chemicals present at the site are also considered during this process. Assessment and measurement endpoints define the ecological attributes to be protected. They are selected to evaluate those receptors for which complete and potentially significant exposure pathways are likely to exist.

5.3.1 Preliminary Conceptual Model

Figures 5-11, 5-12, and 5-13 present the preliminary conceptual models for SWMUs 27, 28, and 29, respectively. The conceptual models outline potential sources of contaminants, transport pathways, exposure media, potential exposure routes, and receptor groups. Specific components of the preliminary conceptual models (i.e., source areas, transport pathways, and exposure pathways and routes) are discussed in the sections that follow.

5.3.1.1 Source Areas

The SWMUs 27, 28, and 29 sludge drying beds represent potential sources for the release of chemicals to surface soil. Contaminated surface soil represents a potential source for the release of chemicals to subsurface soil and downgradient surface soil, including hydric surface soils within the E2FO3 wetland unit adjacent to SWMU 28. The portion of the E2FO3 wetland unit adjacent to SWMU 28 likely functions as upland habitat (saturated sediment and standing water were not observed during the Phase I and Full RFI field investigations at this SWMU). Surface and subsurface soil at each SWMU also represent potential source areas for the release of chemicals to groundwater. Finally, surface soil at SWMU 27 represents a potential source for the release of chemicals to surface water and sediment within the adjacent E2SS3 wetland unit.

5.3.1.2 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 Figures 5-11, 5-12, and 5-13, potential mechanisms for contaminant transport from potential source areas at SWMUs 27, 28, and 29 are believed to include the following:

- Overland transport of chemicals with surface soil via surface runoff to downgradient surface soil: SWMUs 27, 28, and 29

- Overland transport of chemicals with surface soil via surface run-off to downgradient surface water and sediment: SWMU 27

- Leaching of chemicals from surface soil and/or subsurface soil by infiltrating precipitation and transport to downgradient surface water and sediment: SWMUs 27, 28, and 29

- Uptake by biota from surface and subsurface soil and trophic transfer to upper trophic level receptors: SWMUs 27, 28, and 29

- Uptake by biota from surface water and sediment and trophic transfer to upper trophic level receptors: SWMU 27

Currently, it is not definitively known if saturated sediments and/or surface water are present within the E2FO3 wetland unit adjacent to SWMU 28. If encountered during the CMS field investigation, overland transport of chemicals with surface soil via surface run-off to downgradient surface water and sediment, as well as uptake by biota from surface water and sediment and trophic transfer to upper trophic level receptors will be acknowledged as potential transport pathways at SWMU 28.

As indicated by Figures 5-11 and 5-13, leaching of chemicals from surface soil and/or subsurface soil by infiltrating precipitation and transport with groundwater to surface water and sediment within the aquatic habitats contiguous to SWMUs 27 and SWMU 29 is considered a potentially complete, but insignificant transport pathway at both SWMUs. This conclusion is based on the findings of the Full RFI for SWMU 27 and the Phase I RFI for SWMU 29 (Baker, 2008b and 2008d, respectively), which showed that chemicals are not present in SWMUs 27 and 29 groundwater at concentrations greater than ecological-based screening values and background levels. Regardless, SERAs at SWMUs 27 and 29 will include an evaluation of available groundwater data using the methodology presented in Section 5.6.

5.3.1.3 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 Figures 5-11, 5-12 and 5-13, potentially complete and significant exposure pathways exist at each SWMU. 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 27, 28, and/or 29 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. Unrooted, floating aquatic plants, rooted submerged aquatic plants, and algae may be exposed to chemicals directly from the water or (for rooted plants) from sediments. Terrestrial and aquatic invertebrates may be exposed to chemicals in soil, surface water, and sediment, through dermal adsorption and ingestion. Much of the toxicological data available for terrestrial and aquatic invertebrates are based upon *in situ* studies that represent both pathways. Therefore, both pathways are typically considered together in SERAs. Invertebrates also represent a link between surface soil, surface water, and/or sediment 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 or sediment) 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 Figures 5-11, 5-12, and 5-13. Their relative importance depends in part on the chemical being evaluated. For chemicals having the potential to bioaccumulate (e.g., 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 ppt, the approximate toxic threshold for wildlife receptors (Humphreys, 1988). As evidenced by Figures 5-4, 5-5, and 5-6, there are no apparent drinking water sources within or immediately contiguous to SWMUs 27, 28, and 29. As such, ingestion of surface water does not represent a potential exposure pathway and will not be considered in risk calculations for upper trophic level dietary exposures. However, salinity measurements will be conducted during the CMS field investigation at SWMU 27 to verify that surface water within the adjacent E2SS3 wetland unit does not represent a potential drinking water source. If surface water is encountered within the E2FO3 wetland unit adjacent to SWMU 28 during the CMS field investigation, salinity measurements also will be conducted at this SWMU to determine if the surface water is suitable for use by upper trophic level receptors as a drinking water source.

Certain potential exposure pathways and/or routes depicted on Figures 5-11, 5-12, and 5-13 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 vegetative units contiguous to SWMUs 27, 28, and 29, 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 and petroleum compounds) 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 and/or sediment during feeding and preening activities by upper trophic level receptors, as well as direct contact exposures by lower trophic level receptors (i.e., terrestrial and aquatic invertebrates) are considered significant exposure routes (see Figures 5-11, 5-12 and 5-13).

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 SWMUs 27, 28, and 29 (maintained 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 were generally detected at a low frequency and/or concentration during the Phase I and Full RFI field investigations (Baker, 2007b, 2008a, 2008b, 2008c, 2008d, and 2008e).

Potentially complete and significant exposure pathways for terrestrial mammals (i.e., incidental ingestion of surface soil and ingestion of contaminated plant and/or animal tissues for chemicals that have entered food webs) were not selected for evaluation. The exclusion of ground mammals is appropriate because the potentially exposed mammalian receptors are limited to non-indigenous, nuisance species (see Section 5.1.3.1). However, because they represent a potential link between surface soil chemicals and terrestrial avian carnivores, they were included a food item in the SERAs. As discussed in Section 5.3.3, individual bat species will be considered for evaluation at a given SWMU if suitable foraging habitat is present within adjacent vegetative units evaluated by the proposed CMS sampling programs. If a bat species is selected for evaluation at a given SWMU, the preliminary conceptual model for that SWMU will be revised as appropriate to show a potentially complete exposure pathway for terrestrial mammals.

5.3.2 Endpoints and Risk Questions

The conclusion of the screening level problem formulation includes the selection of ecological endpoints, which are based on the preliminary conceptual model. Two types of endpoints, assessment endpoints and measurement endpoints, are defined as part of the ERA process as are risk hypotheses or risk questions (USEPA, 1997 and 1998). An assessment endpoint is an explicit expression of the environmental component or value that is to be protected. A measurement endpoint is a measurable ecological characteristic that is related to the component or value chosen as the assessment endpoint. The considerations for selecting assessment and measurement endpoints are summarized in USEPA (1992, and 1997) and discussed in detail by Suter II (1989, 1990, and 1993). Risk questions ask how the assessment endpoints could be affected by site-related constituents.

Endpoints in the SERA define ecological attributes that are to be protected (assessment endpoints) and a measurable characteristic of those attributes (measurement endpoints) that can be used to gauge the degree of impact that has or may occur. Assessment endpoints most often relate to attributes of biological populations or communities, and are intended to focus the risk assessment on particular components of the ecosystem that could be adversely affected by chemicals attributable to the site (USEPA, 1997). Assessment endpoints contain an entity (e.g., red-tailed hawk) and an attribute of that entity (e.g., survival rate). Individual assessment endpoints usually encompass a group of species or populations (the receptor) with some common characteristic, such as specific exposure route or contaminant sensitivity, with the receptor then used to represent the assessment endpoint in the risk evaluation.

Assessment and measurement endpoints may involve ecological components from any level of biological organization, from individual organisms to the ecosystem itself (USEPA, 1992). Effects on individuals are important for some receptors, such as rare and endangered species; however, population- and community-level effects are typically more relevant to ecosystems. Population- and community-level effects are usually difficult to evaluate directly without long-term and extensive study. However, measurement endpoint evaluations at the individual level, such as an evaluation of the effects of chemical exposure on reproduction, can be used to predict effects on an assessment endpoint at the population or community level. In addition, use of criteria values designed to protect the vast majority (e.g., 95 percent) of the components of a community (e.g., National Ambient Water Quality Criteria [NAWQC] for the Protection of Aquatic Life) can be useful in evaluating potential community- and/or population-level effects.

Table 5-2 summarizes the preliminary assessment endpoints, risk questions, and measurement endpoints selected for the SERAs at SWMUs 27, 28, and 29. As evidenced by Table 5-2, the assessment endpoints selected for the upland habitat at each SWMU are based on the survival, growth, and reproduction of lower trophic level terrestrial receptor groups (terrestrial plants and invertebrates), terrestrial amphibians and reptiles, and upper trophic level terrestrial birds (herbivores, omnivores, and carnivores), while assessment endpoints for the aquatic habitat at SWMU 27 (E2SS3 wetland unit) are based on the survival, growth, and reproduction of lower trophic level aquatic receptor groups (aquatic plants, invertebrates, and fish) and upper trophic level birds (i.e., invertivores and piscivores). The population traits of interest for each of the assessment endpoints represent components of a healthy population. Failure or impairment of survival, growth, or reproduction will adversely affect the ability of the population to be healthy and viable and fill its appropriate role in an ecosystem.

If suitable foraging habitat is encountered within the E2FO3 wetland unit adjacent to SWMU 28 during the CMS field investigation, assessment and measurement endpoints for lower trophic level aquatic receptor groups (e.g., aquatic invertebrates) and upper trophic level birds (e.g., avian invertivores and/or piscivores) will be established for this SWMU. Assessment and measurement endpoints also will be established for an individual bat species at a given SWMU if suitable foraging habitat for this receptor class is encountered.

5.3.3 Selection of Receptors

Because of the complexity of natural systems, it is generally not possible to directly assess the potential impacts to all ecological receptors present within an area. Therefore, specific receptor species (e.g., mourning dove) are often selected as surrogates to evaluate potential risks to larger components of the ecological community (e.g., avian herbivores) selected to represent the assessment endpoints (e.g., survival, growth, and reproduction of avian herbivores). Selection criteria typically include those species that:

- Are known to occur, or are likely to occur, at the site;
- Have a particular ecological, economic, or aesthetic value;
- Are representative of taxonomic groups, life history traits, and/or trophic levels in the habitats present at the site for which complete exposure pathways are likely to exist;
- Can, because of toxicological sensitivity or potential exposure magnitude, be expected to represent potentially sensitive populations at the site; and
- Have sufficient ecotoxicological information available on which to base an evaluation.

Lower trophic level receptor species were evaluated based on those taxonomic groupings (e.g., terrestrial and aquatic plants and invertebrates) for which screening values have been developed. These groupings and screening values are used in most ERAs. As such, specific receptor species of lower trophic level terrestrial and aquatic biota were not chosen because of the limited species-specific information available. These receptors were instead dealt with on a community level via a comparison to media-specific screening values.

The terrestrial upper trophic level receptor species listed below were chosen for dietary exposure modeling at each SWMU based on the criteria listed above, the general guidelines presented in USEPA (1991), the description of habitats and biota presented in Section 5.1, and the assessment endpoints (see Table 5-2).

- Mourning dove (*Zenaida macroura*) (avian herbivore)
- American robin (*Turdus migratorius*) (avian omnivore)
- Red-tailed hawk (*Buteo jamaicensis*) (avian carnivore)

The mourning dove and red-tailed hawk are known to occur in Puerto Rico (Raffaele, 1989). These two species also have been reported at NAPR (see Table 5-1). The American robin was selected as a surrogate species to represent birds reported from NAPR with similar feeding habits and dietary preferences (e.g., red-legged thrush). As discussed in Section 5.1.3.2, SWMUs 27, 28, and 29 are not located within the critical habitat designation for the yellow-shouldered blackbird. However, based on their arboreal feeding habits, the yellow-shouldered blackbird may forage within the terrestrial and/or estuarine wetland habitats contiguous to each SWMU. Regardless, aspects of the feeding ecology of the American robin and yellow-shouldered blackbird indicate that the American robin can be protectively used as a surrogate receptor:

- The American robin forages on the ground for soft-bodied invertebrates, whereas the yellow-shouldered blackbird is an arboreal feeder that forages within the canopy and sub-canopy of trees (USFWS, 1996a). The invertebrate prey item consumed by the American robin is assumed to be earthworms for each SERA. Because earthworms are in direct contact with soil, they will bioaccumulate soil contaminants at higher concentrations than the arboreal invertebrates consumed by the yellow-shouldered blackbird. Therefore, modeled dietary intakes that include earthworm ingestion will result in a conservative estimate of food web exposures for the yellow-shouldered blackbird.
- The diet of the American robin is assumed to include 10.5 percent soil, whereas soil consumption by the yellow-shouldered blackbird is likely to be negligible based on their

arboreal feeding behavior. Modeled dietary intakes that include soil ingestion also will result in a conservative estimate of food web exposures for the yellow-shouldered blackbird.

A terrestrial ground mammal was not selected as an ecological receptor for the following reasons.

- All native terrestrial ground mammals have been extirpated from Puerto Rico (Mac et al., 1998).
- The terrestrial ground 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 USFWS, 1996a).

Although habitat within the boundary of each SWMU is limited to maintained/manicured lawns (see Figures 5-4, 5-5, and 5-6), adjacent habitats may present foraging opportunities for fruit-eating and/or nectivorous bats. For a given SWMU, if suitable foraging habitat (i.e., habitat with fruit-bearing and/or flowering vegetation) is present within the area of investigation, individual bat species will be considered for inclusion as ecological receptors in the ERA. If chosen for evaluation, receptor-specific parameter values (e.g., body weights and food ingestion rates) will be provided as part of each SWMU-specific ERA. It is noted that an insectivorous bat will not be considered for evaluation at SWMUs 27, 28, and 29. As discussed in *Guidelines for Developing Ecological Soil Screening Levels* (USEPA, 2005a), aerial insectivorous birds and mammals are excluded from Eco-SSL development because they are considered inappropriate (i.e., they do not have a clear direct or indirect exposure pathway link to soil [direct exposure pathways involve ingestion of soil-dwelling biota and incidental ingestion of soil as a result of foraging at the soil surface, while indirect exposure pathways involve ingestion by carnivores of prey that have direct contact with soil]). While, insectivorous bats may potentially feed on flying insects which spend part of their life cycle living in soil/sediment, the exclusion of aerial insectivorous mammals from Eco-SSL development by the USEPA supports the presumption that insectivorous bats would not be expected to have any appreciable exposure to chemicals in soil (or sediment) at SWMUs 27, 28, and 29.

While exposure pathways to terrestrial reptiles and amphibians are likely to be complete, specific reptilian and/or amphibian species will not be selected as receptors for the SERAs since the life history and toxicological database concerning the effects of chemicals on herpafauna is severely limited, rendering a quantitative evaluation problematic (USEPA, 2000a and 2003a). It is assumed that reptiles and amphibians potentially present at the site and/or adjacent habitats are not exposed to significantly higher concentrations of chemicals and are not more sensitive to chemicals than the other upper trophic level receptor species evaluated in the risk assessments. For reptiles, this approach is consistent with USEPA Region III guidance (USEPA, 2010a; available at http://www.epa.gov/reg3hwmd/risk/eco/index.htm), which states that "*As a general rule in Region 3, impacts to reptiles do not have to be considered as an assessment endpoint in the screening level ERA. However, the screening ERA would need to state that impacts to reptiles are being assessed qualitatively through the use of surrogate receptors. An exception to this rule is when a threatened or endangered reptile has been identified as a potential receptor on the site. In this situation, it may be appropriate to consider impact on reptiles when identifying assessment endpoints*." It is noted that reptiles and amphibians are poikilotherms (body temperature varies with environmental temperature), while birds are homeotherms (temperature is regulated, constant, and largely independent of environmental temperatures). Therefore, reptiles and amphibians tend to have much lower metabolic rates and lower caloric intake requirements than birds. As a consequence, birds are likely to consume more food than amphibians or reptiles on a daily dietary intake basis, assuming similar caloric content of the food items. Therefore, potential risks to terrestrial amphibians and reptiles are likely overstated when risk estimates for avian dietary intakes are applied to terrestrial herpetofauna.

In addition to the terrestrial avian receptors identified above (i.e., mourning dove, American robin, and red-tailed hawk), the following avian receptor species were chosen for dietary exposure modeling within the E2SS3 wetland unit adjacent to SWMU 27:

- Spotted sandpiper (*Actitis macularius*) (avian invertivore)
- Green heron (*Butorides virescens*) (avian piscivore)

Both species are known to occur in Puerto Rico (Raffaele, 1989). The spotted sandpiper and green heron also have been reported at NAPR (see Table 5-1). These two species also will be selected for evaluation at SWMU 28 if suitable foraging habitat is encountered within the E2FO3 wetland unit during the CMS field investigation at this SWMU.

5.3.4 Fate and Transport Mechanisms

In the absence of measured values of chemicals within biotic media, the transport and partitioning of constituents into particular environmental compartments, and their ultimate fate in those compartments, can be predicted from key physical-chemical characteristics. The physical-chemical characteristics that are most relevant for exposure modeling in this assessment include water solubility, adsorption to solids, octanol-water partitioning, and degradability. These characteristics are defined below.

The water solubility of a compound influences it's partitioning to aqueous media. Highly water-soluble chemicals, such as most VOCs, have a tendency to remain dissolved in the water column rather than partitioning to sediment (Howard, 1991). Compounds with high water solubility also generally exhibit a lower tendency to bioconcentrate in aquatic organisms and a greater likelihood of biodegredation, at least over the short term (Howard, 1991).

Adsorption is a measure of a compound's affinity for binding to solids, such as soil or sediment particles. Adsorption is expressed in terms of partitioning, with either the adsorption coefficient (K_d), a unitless expression of the equilibrium concentration in the solid phase versus the water phase, or the organic carbon partition coefficient (K_{oc}, K_d normalized to the organic carbon content of the solid phase; again unitless) (Howard, 1991). For a given organic chemical, the higher the K_{oc} or K_d, the greater the tendency for that chemical to adhere strongly to soil or sediment particles. K_{oc} values can be measured directly or can be estimated from either water solubility or the octanol-water partition coefficient (K_{ow}) using one of several available regression equations (Howard, 1991).

Octanol-water partitioning indicates whether a compound is hydrophilic or hydrophobic. The K_{ow} expresses the relative partitioning of a compound between octanol (lipids) and water. A high affinity for lipids equates to a high K_{ow} and vice versa. As discussed above, K_{ow} has been shown to correlate well with adsorption to soil or sediment particles and the potential to bioaccumulate in the food chain (Howard, 1991). Typically expressed as log K_{ow}, a value of 3.0 or less generally indicates that the chemical will not bioconcentrate to a significant degree (Maki and Duthie, 1978). Log K_{ow} values and K_{oc} values for organic chemicals analyzed for in environmental media collected at each SWMU during the Phase I and Full RFIs (i.e., Appendix IX VOCs, SVOCs, and PCBs) are presented in Table 5-3.

Degradability is an important factor in determining whether there will be significant loss of mass or change in the form of a chemical over time in the environment. The half-life of a compound is typically used to describe losses from either degradation (biological or abiotic) or from transfer from one compartment to another (e.g., volatilization from soil to air). The half-life is the time required for one-half of the mass of a compound to undergo the loss through degradation.

5.4 Screening Level Effects Evaluation

The purpose of the screening level effects evaluation is the establishment of chemical exposure levels (screening values) that represent conservative thresholds for adverse ecological effects. One set of screening values is typically developed for each selected assessment endpoint. For the SERAs at SWMUs 27, 28, and 29, two types of screening values were developed (media-specific screening values and toxicity reference values [TRVs]). Media-specific screening values were developed for soil, groundwater, surface water, and sediment, while TRVs were developed for the evaluation of potential risks to upper trophic level terrestrial receptors (i.e., avian omnivores, herbivores, and carnivores) and aquatic receptors (i.e., avian invertivores and piscivores) from food web (dietary) exposures (i.e., ingested chemical doses).

5.4.1 Media-Specific Screening Values for Soil, Groundwater, Surface Water, and Sediment

The sections that follow describe the various criteria and toxicological benchmarks that will be used as media-specific screening values for chemicals in soil (surface and subsurface soil) at SWMUs 27, 28, and 29, groundwater at SWMUs 27, 28, and 29, estuarine wetland surface water at SWMU 27, and estuarine wetland sediment at SWMUs 27 and 28. The media-specific screening values, listed in Tables 5-4 (soil), 5-5 (groundwater and surface water), and 5-6 (sediment), represent conservative exposure thresholds above which adverse ecological effects may occur.

5.4.1.1 Soil Screening Values for Terrestrial Plants and Invertebrates

The literature-based toxicological benchmarks that will be used as media-specific screening values for chemicals in SWMUs 27, 28, and 29 surface soil (0.0 to 1.0-feet bgs) and subsurface soil (1.0 to 3.0-feet bgs) are summarized in Table 5-4. USEPA Eco-SSLs (documentation is available at http://www.epa.gov/ecotox/ecossl/) for terrestrial plants and invertebrates were preferentially selected as soil screening values. For a given chemical, if an Eco-SSL was available for both receptor groups, the lowest value was chosen as the soil screening value. In the case of chromium and vanadium, insufficient data are available from the literature for derivation of plant- and invertebrate-based Eco-SSLs (USEPA, 2008 and 2005b). However, both Eco-SSL documents list toxicological data from studies eligible for Eco-SSL derivation. The chromium Eco-SSL document cites two studies (Van Gestel et al., 1992 and 1993) that investigated the effect of chromium on earthworm (*Eisenia andrei*) reproduction, while the vanadium Eco-SSL document cites one study (Kaplan et al., 1990) that investigated the effect of vanadium on broccoli (*Brassica oleracea*) growth. The chromium studies using earthworms reported Maximum Acceptable Toxicant Concentration (MATC) values of 57 milligrams per kilogram (mg/kg), while the vanadium study using broccoli reported a Lowest Observed Adverse Effect Concentration (LOAEC) of 100 mg/kg and a No Observed Adverse Effect Concentration (NOAEC) of 100 mg/kg. For the SERAs, the MATC value of 57 mg/kg based on earthworm reproduction was selected as the soil screening value for chromium, while the LOAEC value based on broccoli growth (with a safety factor of 5; Wentsel et al., 1996) was selected as the soil screening value for vanadium.

For those chemicals lacking terrestrial plant and invertebrate Eco-SSLs or toxicological data eligible for Eco-SSL derivation, the literature-based toxicological benchmarks listed below were selected 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 an Eco-SSL, toxicological data eligible for Eco-SSL derivation, and a toxicological threshold from Efroymson et al. (1997a and 1997b), the following literature-based values, listed in their order of decreasing preference, were chosen as soil screening values:

- TRVs 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 value within the adjustment range (2.0 to 30.0 percent). Soil quality guidelines developed by CCME were given the lowest preference since many are background-based interim guidelines that do not represent effect-based concentrations.

5.4.1.2 Groundwater and Surface Water Screening Values

As discussed in Section 5.1.2, surface water features contiguous to SWMUs 27, 28, and 29 are represented by marine environments (estuarine wetland and/or open water marine environments). Because these surface water features represent potential discharge points for groundwater, available groundwater data will be screened against the marine toxicological thresholds listed in Table 5-5. Data for surface water samples collected from the estuarine wetland system adjacent to SWMU 27 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 Qualiity standards regulation (PRWQSR) dated march 31, 2010 (PREQB, 2010) will be preferentially used a screening values. PRWQS for Class SB coastal and estuarine waters were selected based on the classifications contained within Rule 1302.1 or the PRWQSR. For those chemicals lacking a PRWQS for Class SB coastal and estuarine waters, screening values were identified from the following information listed in their order of decreasing preference:

- Chronic saltwater 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 MATC values based on reproduction, growth, or survival) for marine species reported in the ECOTOX Database System (USEPA, 2007a)

- 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 5 (Wentsel et al., 1996)

The order of preference was selected based on their level of protection. For example, NAWQC and 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 NAWQC, FCVs, USEPA Region 4 chronic screening values, chronic test endpoints, and chronic LOELs, screening values were derived from the literature-based acute saltwater 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, 2007a)
- 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:

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

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

- A safety 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 5-5, the screening value selected for mercury is a USEPA saltwater NAWQC (i.e., criteria continuous concentrations [CCC]). The USEPA saltwater CCC values for this metal is expressed as a dissolved concentration (USEPA, 2009a). A total recoverable CCC value for mercury was derived for use as a screening value in the Step 2 screening-level risk calculation by dividing the dissolved CCC value (0.94 ug/l) by 0.85 (saltwater conversion factor for mercury listed in Appendix A of National Recommended Water Quality Criteria [USEPA, 2009a]).

For those chemicals lacking saltwater toxicological thresholds and literature values, groundwater and surface water screening values were identified from the following information listed in their order of decreasing preference:

- PRWQS for Class SD surface waters (PREQB, 2010)

- Chronic freshwater NAWQC (USEPA, 2009a)

- 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, 2003b)

- Minimum chronic toxicity test endpoints (NOEC, NOEL, and MATC values based on reproduction, growth, or survival) for freshwater species reported in the ECOTOX Database System (USEPA, 2007a)

- Great Lakes basin Tier II Secondary Chronic Values (SCVs) listed in the Great Lakes Initiative Toxicity Data Clearinghouse (http://www.epa.gov/gliclearinghouse/) (USEPA, 2009b)

- Chronic LOELs for freshwater contained in NOAA SQUIRTs (Buchman, 2008) with a safety factor of 5 (Wentsel et al., 1996)

PRWQS for Class SD surface waters were selected based on the classifications contained within Rule 1302.2 of the PRWQR (PREQB, 2010). Identical to the marine/estuarine-based groundwater screening values discussed above, the order of preference is 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 screening value. In the absence of the above-mentioned freshwater PRWQS, freshwater NAWQC, FCVs, freshwater USEPA Region 4 and Region 5 screening values, freshwater chronic test endpoints, and freshwater chronic LOELs, screening values were derived from the following literature-based acute freshwater values:

- 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 previously identified for literature-based acute saltwater values.

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. 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 selected as the screening value only if that chemical lacks freshwater and saltwater literature-based benchmarks and/or toxicity test endpoints.

5.4.1.3 Sediment Screening Values

The marine and estuarine bulk sediment toxicological benchmarks listed below will be 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).

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 Equilibrium Partitioning (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 10^{th} percentile and 50^{th} percentile concentrations of the "effects" data were calculated. The 10^{th} and 50^{th} 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. With the exception of antimony, ER-Ls based on marine only SQGs from Long et al. (1995) were considered for use as sediment screening values. In the case of antimony, an ER-L value is not available from Long et al. (1995). Therefore, the ER-L value reported by Long and Morgan (1991) was considered as a potential sediment screening value.

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. (1995) 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 15^{th} percentile in the "effects" data set and the 50^{th} percentile in the "no effects" data set, while PELs were derived by calculating the geometric mean of the 50^{th} percentile in the "effects" data set and the 85^{th} 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 5-6 represent minimum AET values 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 State Department of Ecology (1995) as sediment management standards for Puget Sound. Minimum AET values also are used by the USACE (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, EqP-based screening values were either developed using USEPA methodology (USEPA, 1993a 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 (1993a 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. As discussed in Appendix E, EqP-based screening values developed in accordance with USEPA (1993a and 1996) methodology are based, in part, on the fraction of organic carbon (f_{oc}) measured in sediment. The EqP-based screening values listed in Table 5-6 are based on a default f_{oc} of 0.01. As sediment samples collected from the estuarine wetlands contiguous to SWMUs 27 will be analyzed for TOC (see Table 3-1), the EqP-based screening values listed in Table 5-6 will be adjusted to reflect site-specific f_{oc} values. For the SERA, the minimum f_{oc} measured in SWMU 27 sediment will be used in the adjustment. The minimum f_{oc} value also was used to adjust the Di Toro and McGrath (2000) EqP-based toxicological benchmarks selected as sediment screening values for chloroethane, trans-1,2-dichloroethene, 4-bromophenyl phenyl ether, and 4-chlorophenyl phenyl ether (published values for these four organics are based on a default f_{oc} of 0.01).

It is noted that consideration was given to the following literature-based freshwater toxicological thresholds for chemicals lacking marine and estuarine bulk sediment 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 for chemicals lacking marine and estuarine bulk sediment toxicological thresholds were available from these sources.

5.4.2 Toxicity Reference Values for Avian Dietary Exposures

TRVs for avian dietary exposures to chemicals in surface soil, subsurface soil, and sediment were compiled from the literature for each receptor species and chemical evaluated for food web exposures. If available, TRVs identified and used by the USEPA in the derivation of avian Eco-SSLs were preferentially used to evaluate risks from ingested dietary doses.

For chemicals lacking an avian Eco-SSL, toxicological information from the literature for wildlife species most closely related to the receptor species was used if available. This information was supplemented by laboratory studies of non-wildlife species when necessary. Chronic No Observed Adverse Effect Levels (NOAELs) based on growth or reproduction were preferentially selected as TRVs for upper trophic level receptors. NOAELs represent the highest dose of a chemical at which an effect being measured in a toxicity test does not occur. If several chronic toxicity studies were available from the literature, the most appropriate study was selected for each receptor species based on study design, study methodology, study duration, study endpoint, and test species. When chronic NOAEL values were unavailable, estimates were derived or extrapolated from chronic Lowest Observed Adverse Effect Levels (LOAELs) or median lethal dose (LD_{50}) acute values. LOAELs represent the lowest dose of a chemical at which an effect being measured in a toxicity test occurs, while an LD_{50} represents the dose of a chemical at which half of the organisms being tested die. An uncertainty factor of 5 was used to convert a reported chronic LOAEL to a chronic NOAEL (Wentsel et al., 1996), while an uncertainty factor of 100 was used to convert the acute LD_{50} to a chronic NOAEL (i.e., the LD_{50} was multiplied by 0.01 to obtain the chronic NOAEL [Wentsel et al., 1996 and USEPA, 1997]).

TRVs for the terrestrial and aquatic bird species selected as ecological receptors (American robin, mourning dove, red-tailed hawk, spotted sandpiper, and green heron), expressed as milligrams of the chemical per kilogram body weight of the receptor per day (mg/kg-BW/day) are provided in Table 5-7. Sample et al. (1996) consider a scaling factor of 1.0 most appropriate for interspecies extrapolation between birds. Therefore, the NOAEL and LOAEL values listed in Table 5-7 were not adjusted to reflect differences in body weights between avian test species and avian receptor species.

Not all chemicals analyzed in surface and subsurface soil will be evaluated for terrestrial food web exposures. The organic chemicals evaluated for food web exposures will be limited to those listed in Table 5-3 with the potential to bioaccumulate to a significant extent. Bioaccumulative organic chemicals are defined as those with a maximum reported log K_{ow} greater than or equal to 3.0. Rational for using a log K_{ow} of 3.0 to define an organic chemical with the potential to bioaccumulate is included as Appendix F. For conservatism, all inorganic chemicals (i.e., metals) also will be evaluated for food web exposures. The list of chemicals selected for evaluation of food web exposures contains many chemicals that are not identified as "important bioaccumulative compounds" by the USEPA (2000b). Their inclusion in the evaluation of terrestrial food web exposures is consistent with the conservatism of the SERAs.

5.5 <u>Screening Level Exposure Estimation</u>

This section presents the analytical data, exposure assumptions, and the exposure models and input parameters that will be used to estimate the potential exposure of ecological receptors to chemicals in soil, groundwater, surface water, and sediment.

5.5.1 Selection Criteria for Analytical Data

The analytical data used in the SERAs (see Section 5.2) will be reviewed against a set of selection criteria to identify specific data that will be used to estimate potential exposures to ecological receptors. The criteria used to select these analytical data are listed below.

- Data must have been validated by a qualified data validator using acceptable data validation methodology. Rejected (R) values will not be used in the SERAs. Unqualified data and data qualified as J (estimated) will be treated as detected, while data qualified as U or UJ (estimated) will be treated as non-detected.

- The available soil analytical data will be divided into surface soil data (i.e., analytical data for soil samples collected from the 0 to 1.0-foot depth interval) and subsurface soil data (analytical data for soil samples collected from the 1.0 to 3.0-foot depth interval), and evaluated independently from each other. The evaluation of available soil analytical data will be limited to these depth ranges since most soil heterotrophic activity and soil invertebrates occur on the surface or within the oxidized root zone (Suter II, 1995).

- For surface water and groundwater, only total (unfiltered) analytical data will be used in the Step 2 screening level risk calculation.

- Maximum reporting limits will be conservatively used to estimate exposure for non-detected chemicals.

- In some instances, duplicate samples were collected during previous field investigations (i.e., Phase I and Full RFIs [Baker, 2007b, 2008a, 2008b, 2008c, 2008d, and 2008e] and will be collected during the CMS field investigations (see Tables 3-1, 3-3, and 3-4). The maximum concentration of each chemical (or the maximum non-detected value) in the original or duplicate sample will be used as a conservative estimate of contaminant concentrations at a particular sampling point. Results from duplicate samples will not be evaluated individually.

5.5.2 Exposure Estimation

Maximum detected concentrations in soil (surface and subsurface soil), groundwater, surface water, and sediment will be used to conservatively estimate potential chemical exposures for the ecological receptors selected to represent the assessment endpoints. For conservatism, maximum reporting limits for chemicals that were analyzed for but not detected also will be compared to media-specific screening values and (where appropriate) used for food web exposure modeling. This was done to ensure that reporting limits are similar to, or less than, chemical concentrations at which potential adverse effects to ecological receptors may occur. For samples with duplicate analyses, the higher of the two concentrations will be used in the screening (when both values were detects or both values were non-detects). In cases where one result was a detection and the other a non-detect, the detected value will be used in the assessment at each SWMU.

5.5.2.1 <u>Terrestrial and Aquatic Receptor Groups</u>

Maximum measured chemical concentrations in soil, groundwater, surface water, and sediment will be compared to the media-specific screening values discussed in Section 5.4.1 and summarized in Tables 5-4 through 5-6 to conservatively evaluate the potential for adverse ecological effects to the lower trophic level receptor groups selected as assessment endpoints (e.g., terrestrial and aquatic plants and invertebrates). Exposure point concentrations for the lower trophic level receptor groups will be maximum measured media concentrations.

5.5.2.2 Upper Trophic Level Receptors

Exposures for upper trophic level terrestrial receptor species via the food web will be determined by estimating chemical-specific concentrations in each dietary component using uptake and food web models. Incidental ingestion of soil and sediment also will be included when calculating the total level of exposure. As indicated previously, maximum measured soil and sediment concentrations will be used in all calculations to provide a conservative assessment.

For the screening level exposure estimation, tissue concentrations will be modeled for terrestrial plants (food item for the mourning dove), soil invertebrates (exclusive food item assumed for the American robin), small mammals (food item for the red-tailed hawk), benthic invertebrates (food item for the spotted sandpiper), and fish (food item for the little green heron). The omnivorous Norway rat was selected as the small mammal food item for the red-tailed hawk. A small mammal herbivore and/or insectivore were excluded as potential food items for the red-tailed hawk because they are not part of the Puerto Rican mammalian fauna (see Section 5.1.3.1).

5.5.2.2.1 Exposure Point Concentrations

The uptake of chemicals from the abiotic media into terrestrial and aquatic food items is based (where available) on chemical-specific uptake equations (i.e., regressions based on measured soil and tissue concentrations) or conservative (e.g., maximum or 90th percentile) bioaccumulation factors (BAFs) from the literature. Generic models based on Log K_{ow} values (presented in USEPA [2007b]) or default factors of 1.0 were used for chemicals only when uptake equations and/or BAF data were unavailable from the literature. The methodology and models used to derive these estimates are described below.

Terrestrial Plants. Tissue concentrations in the aboveground vegetative portion of terrestrial plants will be estimated by chemical-specific uptake equations (i.e. regressions developed from measured soil and tissue data) or by multiplying maximum measured soil concentrations by conservative, chemical-specific BAFs (maximum or 90th percentile values) either obtained directly from the literature or derived from literature-based data sets (see Table 5-8). The chemical-specific BAF values listed in Table 5-8 are based on root uptake from soil and on the ratio between dry-weight soil and dry-weight plant tissue. Literature values based on the ratio between dry-weight soil and wet-weight plant tissue were converted to a dry-weight basis by dividing the wet-weight BAF by the estimated solids content of terrestrial plants (15 percent [0.15]; Sample et al., 1997). Chemical-specific regressions developed by Bechtel Jacobs (1998) and USEPA (2007b) were given preference over high-end BAF values (i.e., maximum and 90th percentile values) if the available regressions were significant ($p < 0.05$).

For bioaccumulative organic chemicals lacking significant regressions and literature-based BAFs, soil-to-plant BAFs were estimated from their Log K_{ow} using the rinsed foliage regression equation provided in Figure 5, Panel B of USEPA (2007b):

$$Log\ BAF = (-0.4057)\ (Log\ K_{ow}) + 1.781$$

where:

Log BAF = Log Soil-to-plant BAF (unitless; dry-weight basis)
Log K_{ow} = Log Octanol-water partitioning coefficient (unitless)

The Log K_{ow} values used in this equation are listed in Table 5-3.

Earthworms. Tissue concentrations in soil invertebrates (earthworms) were estimated by chemical-specific uptake equations (i.e. regressions developed from measured soil and tissue data) or by multiplying maximum measured soil concentrations by conservative, chemical-specific soil-to-invertebrate BAFs (90th percentile values) obtained directly from the literature or derived from literature-based data sets (see Table 5-8). The chemical-specific BAF values listed in Table 5-8 are based on the ratio between dry-weight soil and dry-weight earthworm tissue. Literature values based on the ratio between dry-weight soil and wet-weight earthworm tissue were converted to a dry-weight basis by dividing the wet-weight BAF by the estimated solids content for earthworms (16 percent [0.16]; USEPA, 1993b). BAFs based on depurated analyses (soil was purged from the gut of the earthworm prior to analysis) were given preference over undepurated analyses since direct ingestion of surface soil is accounted for separately in the food web model. Chemical-specific regressions developed by Sample et al. (1998a) were given preference over high-end BAF values (i.e., 90th percentile values) if the available regressions were significant ($p < 0.05$).

For inorganic chemicals without available chemical-specific uptake equations or high-end BAFs, an earthworm BAF of 1.0 was assumed. For bioaccumulative organic chemicals lacking chemical-specific uptake equations or high-end BAFs, earthworm BAF values were estimated from the model presented in Section 3.2.2 of USEPA (2007b) and the chemical-specific Log K_{ow} values listed in Table 5-3.

Small Mammals. Whole-body tissue concentrations in small mammals (omnivores) were estimated using one of two methodologies. When available, chemical-specific uptake equations (i.e., regressions developed from measured soil and tissue data) or conservative, chemical-specific soil-to-small mammal BAFs obtained directly from the literature or derived from literature-based data sets were used to estimate whole-body tissue concentrations (see Table 5-9). The chemical-specific BAFs listed in Table 5-9 are based on the ratio between dry-weight soil and dry-weight tissue. Literature values based on the ratio between dry-weight soil and wet-weight tissue were converted to a dry-weight basis by dividing the wet-weight BAF by the estimated solids content of small mammals (32 percent [0.32]; USEPA, 1993b). Chemical-specific regressions developed by Sample et al. (1998b) for general small mammals were given preference over high-end BAF values (i.e., 90th percentile values) if the available regressions were significant ($p < 0.05$).

For those chemicals lacking chemical-specific uptake equations or literature-based BAF values, an alternate approach was used to estimate whole-body tissue concentrations. Because most chemical exposure for small mammal species is via the diet, it was assumed that the concentration of each chemical in a small mammal's tissues is equal to the chemical concentration in its diet multiplied by a diet to whole-body BAF (wet-weight basis) derived from the literature. For chemicals lacking literature-based diet to whole-body BAF values, a diet to whole-body BAF of 1.0 was assumed. Resulting tissue concentrations (wet-weight) were converted to dry weight concentrations using an estimated solids content for small mammals of 32 percent (see above). The use of a diet to whole-body BAF of 1.0 is likely to result in a conservative estimate of chemical concentrations for chemicals that are not known to biomagnify in terrestrial food chains (e.g., aluminum). For chemicals that are known to biomagnify, a diet to whole-body BAF value of one will likely result in a realistic estimate of tissue concentrations based on reported literature values. For example, a maximum BAF (wet weight) value of 1.0 was reported by Simmons and McKee (1992) for PCBs based on laboratory studies with white-footed mice. Menzie et al. (1992) reported BAF values (wet-weight) for dichlorodiphenyltrichloroethane (DDT) of 0.3 for voles and 0.2 for short-tailed shrews. Reported BAF (wet-weight) values for dioxin are only slightly above one (1.4) for the deer mouse (USEPA, 1990).

Aquatic Invertebrates. Tissue concentrations in aquatic invertebrates were estimated by multiplying maximum measured soil concentrations for each chemical by conservative, chemical-specific soil-to-invertebrate BAFs (90th percentile values) obtained directly from the literature or derived from literature-based data sets (see Table 5-10). BAFs based on depurated analyses (sediment was purged from the gut of the organism prior to analysis) were given preference over undepurated analyses since direct ingestion of sediment is accounted for separately within the food web model. The chemical-specific BAFs listed in Table 5-10 are based on the ratio between dry-weight soil and dry-weight tissue. Literature values based on the ratio between dry-weight soil and wet-weight tissue were converted to a dry-weight basis by dividing the wet-weight BAF by the estimated solids content for aquatic invertebrates (21 percent [0.21]; USEPA, 1993b).

For those chemicals lacking literature-based BAF values, BAFs were estimated from the available biota-sediment accumulation factors (BSAFs) listed in Table 5-11. The conservative (90^{th} percentile) BSAF values included within Table 5-11 were converted to BAF values (dry weight basis) for use in the food web models using a lipid content of 3.44 percent (mean value for aquatic invertebrate percent lipid data listed in Table 5-12), a percent solids content of 21 percent for aquatic invertebrates (see above), and an assumed sediment organic carbon content of 1.0 percent. Because all of the sediment samples collected from the estuarine wetlands contiguous to SWMUs 27 and 28 will be analyzed for TOC (see Tables 3-1 and 3-3), the BSAF values listed in Table 5-11 will be converted to BAF values using site-specific organic carbon data. For the SERA, the minimum organic carbon content measured at each SWMU will be used in the conversion.

For those inorganic chemicals and bioaccumulative organic chemical lacking literature-based BAF and BSAF values, an aquatic invertebrate BAF of 1.0 was assumed.

Fish. Tissue concentrations in fish were estimated by multiplying maximum measured sediment concentrations for each chemical by chemical-specific soil-to-invertebrate BAFs (90th percentile values) obtained directly from the literature (see Table 5-10). High-end BAFs (i.e., maximum BAF values) were given preference. The chemical-specific BAFs listed in Table 5-10 are based on the ratio between dry-weight soil and dry-weight tissue. Literature values based on the ratio between dry-weight soil and wet-weight tissue were converted to a dry-weight basis by dividing the wet-weight BAF by the estimated solids content for fish (25 percent [0.25]; USEPA, 1993b).

For those chemicals lacking literature-based values, BAFs were estimated from the available BSAFs listed in Table 5-13. The conservative (90^{th} percentile) BSAF values included within Table 5-13 were converted to BAF values (dry weight basis) for use in the food web models using a lipid content of 5.90 percent (mean value for the lipid data listed in Table 5-14), a percent solids content of 25 percent (see above), and an assumed sediment organic carbon content of 1.0 percent. Identical to aquatic invertebrates, the BSAF values listed in Table 5-13 for fish will be converted to BAF values using site-specific organic carbon data. For those inorganic chemicals and bioaccumulative organic chemical lacking literature-based BAF and BSAF values, an aquatic invertebrate BAF of 1.0 was assumed.

5.5.2.2.2 Dietary Intakes

Dietary intakes for each upper trophic level receptor species will be calculated using the following formula modified from USEPA (1993b).

$$DI_{xj} = \frac{[[\sum_i [(FIR)(FC_{xi})(PDF_i)]] + [(FIR)(SC_x)(PDS)]][AUF]}{BW}$$

where:

DI_{xj} = Dietary intake of chemical x by receptor j (mg chemical/kg body weight/day)
FIR = Food ingestion rate for receptor j (kilograms per day [kg/day]; dry-weight)
FC_{xi} = Maximum concentration of chemical x in food item i (mg/kg; dry weight)
PDF_i = Proportion of diet composed of food item i (unitless; dry weight basis)
SC_x = Maximum concentration of chemical x in soil/sediment (mg/kg; dry weight)
PDS = Proportion of diet composed of soil/sediment (unitless; dry weight basis)
BW = Body weight (kg; wet weight basis)
AUF = Area Use Factor (unitless)

When a literature-based BAF value is used to derive the chemical concentration in a receptor food item, FC_{xi} is derived using the following equation:

$$FC_{xi} = (SC_x)(BAF_{xi})$$

where SC_x is as previously described and BAF_{xi} is the soil/sediment BAF for chemical x in food item i. When an uptake equation is used to derive the chemical concentration in a receptor food item, FC_{xi} is set equal to the chemical-specific uptake equation.

Conservative receptor-specific exposure parameters (maximum food ingestion rates and minimum body weights) for the American robin, mourning dove, and red-tailed hawk are provided in Table 5-15. Although a suitable drinking water source is not present at each SWMU (based on the absence of fresh surface water bodies), Table 5-15 includes maximum water ingestion rates for each receptor. These values are included within the table should salinity measurements conducted within the E2SS3 wetland unit adjacent to SWMU 27 indicate that surface water within this wetland unit can serve as a potential drinking water source (i.e., salinity of surface water is less than 15 ppt). If a suitable drinking water source is identified, the equation presented above will be modified to include water ingestion.

The food items selected for each receptor species are provided in Table 5-16. Although American robins are omnivores, an exclusive diet of earthworms was assumed for the SERA. Table 5-15 contains exposure parameters and Table 5-16 contains a dietary composition for the Norway rat (assumed diet of the red-tailed hawk. This assumption is based on likely small mammal prey species present in Puerto Rico (rats). Identification of exposure parameters and food items was necessary when estimating small mammal whole body tissue concentrations for those chemicals that lack a literature-based soil-to-small mammal BAF (i.e., an exposure dose was necessary to estimate tissue concentrations). Identical to the American robin, an exclusive diet of earthworms was assumed.

For the SERA, an AUF of 1.0 was assumed (i.e., each receptor is assumed to spend 100 percent of its time on the site). As such, receptor-specific home ranges were not considered in the estimation of dietary intakes.

5.6 Screening Level Risk Calculation

The screening level risk calculation represents the final step for the SERAs. In this step, maximum chemical concentrations in abiotic media or maximum exposure doses for upper trophic level receptor species are compared with the corresponding screening values to derive screening level risk estimates. The outcome of this step is a list of potential ecological COPCs for each media-pathway-receptor combination evaluated or a conclusion of negligible risk.

Ecological COPCs will be selected using the hazard quotient (HQ) method. For a given chemical, an HQ will be calculated by dividing the maximum chemical concentration in the medium being evaluated by the corresponding medium-specific screening value or, in the case of upper trophic level receptors, by dividing the maximum exposure dose (derived by the equation presented in Section 5.5.2.2.2) by the corresponding TRV.

The following conservative methodology will be used to identify ecological COPCs for lower trophic level receptor exposures to chemicals in soil (surface and subsurface soil), groundwater, surface water, and sediment.

- The maximum detected concentrations in surface soil, subsurface soil, groundwater, surface water, and sediment will be used to calculate media-specific HQs. For a given medium, chemicals with HQs greater than 1.0 based on maximum detected concentrations will be identified as ecological COPCs.

- For non-detected chemicals, maximum reporting limits will be used to calculate media-specific HQ values. For a given medium, non-detected chemicals with HQs greater than 1.0 based on maximum reporting limits will be identified as ecological COPCs.

- Detected and non-detected chemicals without media-specific screening values will be identified as ecological COPCs.

To select preliminary ecological COPCs for terrestrial food web exposures, maximum chemical concentrations in soil (surface and subsurface soil), sediment, and surface water will be used to estimate dietary doses for each receptor. HQs will be calculated with NOAELs, LOAELs, and MATCs. The MATC is derived by taking the geometric mean of the NOAEL and LOAEL. Calculations with NOAELs provide the most conservative risk estimate, while calculations with LOAELs provide the least conservative risk estimate. Calculations with MATCs provide realistic risk estimates since the MATC represents an estimation of the threshold concentration (i.e., the concentration above which a toxic effect on the test endpoint is produced). For the SERA, chemicals (detected and non-detected) with NOAEL-based HQs greater than 1.0 will be identified as ecological COPCs. Identical to the media-specific screening evaluation, detected and non-detected chemicals without literature-based TRVs also will be identified as ecological COPCs for upper trophic level receptor exposures.

HQs greater than 1.0 indicate the potential for risk since the chemical concentration or dose (exposure) exceeds the screening value (effect). However, screening values and exposure doses are derived using intentionally conservative assumptions (maximum media concentrations, maximum ingestion rates, and minimum body weights) such that HQs greater than 1.0 do not necessarily indicate that risks are present or impacts are occurring. Rather, they identify chemical-pathway-receptor combinations requiring further evaluation. Following the same reasoning, HQs less than or equal to 1.0 indicate that risks are very unlikely, enabling a conclusion of no unacceptable risk to be reached with high confidence.

In most cases, the SERA will consider independent effects of chemicals. However, the potential does exist for multiple chemicals in environmental media to interact. Much uncertainty is involved with the interpretation of chemical interactions due to the complexity of potential effects (e.g., synergistic, antagonistic, or additive), and due to varying toxicities of compounds in different species. For these reasons, cumulative effects will not be addressed for most chemicals in the SERAs. Chemical interactions can be addressed by site-specific studies conducted in Step 6 of the Navy ERA process (i.e., site investigation and data analysis [see Figure 5-1]).

5.7 Uncertainties

Once the SERA is complete at a given SWMU, the results will be evaluated to identify the type and magnitude of uncertainty associated with the risk conclusions. Reliance on results from a risk assessment can be misleading without a consideration of uncertainties, limitations, and assumptions inherent in the process. Uncertainties are present in all risk assessments because of the limitations of the available data and the need to make certain assumptions and extrapolations based on incomplete information.

5.8 Screening Level Ecological Risk Assessment Decision Point

The results of the screening level ERAs will be used to evaluate the status of each SWMU in terms of potential ecological risk. Possible decision points following completion of the screening level ERA at a given SWMU are:

- **No further action is warranted**. This decision is appropriate if the SERA indicates that sufficient data are available on which to base a conclusion of no unacceptable risk (HQ values for each media-pathway-receptor combination is less than one).

- **Further evaluation is warranted**. This decision is appropriate if the SERA indicates that there is the potential for unacceptable risk for one or more media-pathway-receptor combinations. In this instance, the ERA process will proceed to Step 3a wherein the risk estimates are refined based on more realistic and site-specific assumptions and data.

- **Further data are required**. This decision is appropriate if the SERA indicates that there are insufficient data on which to base a risk estimate. This decision may also be appropriate if the potential for unacceptable risks is identified following the screening level ERA and additional data are needed to refine these estimates in Step 3a.

- **Take remedial action**. This decision may be appropriate if the potential for unacceptable risks is identified following the screening level ERA but these potential risks could be best addressed through remedial action (e.g., presumptive remedy, soil removal) rather than additional study.

5.9 Step 3a of the Baseline Ecological Risk Assessment

If the results of the screening level risk calculation indicate that, based on a set of conservative assumptions, there are one or more chemicals at a given SWMU that may present risks to ecological receptor groups and/or specific species, the ERA process at that SWMU will proceed to the BERA. According to Superfund guidance (USEPA, 1997), Step 3 initiates the problem formulation phase of the BERA. Under Navy guidance (CNO, 1999), the BERA is defined as Tier 2, and the first activity under Tier 2 is Step 3a (see Figure 5-1). In Step 3a, the conservative assumptions employed in the SERA (Tier 1) are refined and risk estimates are recalculated using the same conceptual model. Step 3a may also include consideration of background data and chemical bioavailability.

5.9.1 Methodology for Step 3a

The specific assumptions, parameters, and methods that will be modified for the recalculation of media-specific and food web HQ values are identified below, along with justification for each modification. These refinements and methods will be used in Step 3a of the BERA to weigh the evidence of potential risk for each ecological COPC identified for each medium and receptor to determine whether the ecological COPCs should be identified as ecological COCs.

- Lower trophic level and upper trophic level risk estimates for ecological COPCs in surface soil and sediment will be refined using 95 percent upper confidence limit (UCL) of the mean chemical concentrations rather than maximum concentrations. 95 percent UCL of the mean concentrations will be calculated using USEPA ProUCL Version 4.00.05 software [USEPA, 2010b). This approach was agreed upon in the Navy's responses (dated February 15, 2008) to USEPA comments (dated December 11, 2007) on the *Final Additional Data Collection Work Plan for SWMU 14* (Baker, 2007c). However, as specified in the USEPA's December 11, 2007 comment letter, 95% UCL of the mean concentrations will not be derived for those ecological COPCs with data sets that do not have less than 70 percent non-detected results and a minimum of eight detected values.

  For individual upper trophic-level receptor species, 95 percent UCL of the mean concentrations provide a better estimate of the likely level of chemical exposure because each receptor would be expected to forage in several different areas of the site, and, in many cases, off-site. 95 percent UCL of the mean concentrations are also appropriate for evaluating impacts to *populations* of lower trophic level receptors (e.g., terrestrial invertebrates). Because some of these receptors are relatively immobile, *individuals* are likely to be impacted by locations of maximum concentrations. However, an evaluation of exposure based on 95 percent UCL of the mean concentrations is more indicative of the level of impact that might be expected at the *population* level. It is noted that the magnitude of detections above screening values will be considered when evaluating refined risk estimates based on 95% UCL of the mean concentrations (Parker et al., 2003). This consideration ensures that potential effects of "hot spots" are not diluted by calculating 95% UCL of the mean concentrations.

- The chemical-specific uptake equations used in the SERA to estimate tissue concentrations in terrestrial plants and invertebrates will be used in Step 3a of the BERA. However, soil concentrations used in the estimation will be 95 percent UCL of mean values (in place of maximum concentrations) for those ecological COPCs with data sets that meet the criteria specified within the bullet item above (i.e., less than 70 percent non-detected results and a minimum of eight detected values). In addition, the uptake equations used for small mammals (general uptake equations for all small mammals developed by Sample et al. [1998b]) will be replaced by uptake equations developed specifically for small mammal omnivores. Identical to uptake equations for terrestrial plants and invertebrates, 95 percent UCL of the mean concentrations will be used to estimate small mammal tissue concentrations for those ecological COPCs with data sets having less than 70 percent non-detected results and a minimum of eight detected values. When chemical-specific BAFs are used to estimate prey item tissue concentrations, BAFs based on central tendency estimates (e.g., mean, median, midpoint) will be used in place of maximum or high-end (e.g., 90th percentile) values. Finally, in the case of aquatic invertebrates and fish, BAF values estimated from 90th percentile BSAF values will be replaced by BAF values estimated from median BSAF values. An assumed BAF of 1.0 will still be used for those chemicals lacking a chemical-specific uptake equation or BAF. The chemical-specific uptake equations and BAFs that will be used for those chemicals carried into Step 3a of the BERA are summarized in Tables 5-17 (terrestrial plants and invertebrates, 5-18 (small mammals) and 5-19 (aquatic invertebrates and fish).

- Central tendency estimates (e.g., mean, median, midpoint) for body weight, food ingestion rate, and, if necessary, water ingestion rate (see Table 5-20) will be used to develop exposure estimates for upper trophic level receptors rather than the minimum values/rates used in the SERA. The use of central tendency estimates is more relevant because they represent the characteristics of a greater proportion of the individuals in the population. The evaluation of food web exposures will still assume an AUF of 1.0.

- The diet of the American robin and Norway rat (food item for the red-tailed hawk) will be adjusted to reflect their omnivorous feeding behavior. Wheelwright (1986), as cited in USEPA (1993b), reported seasonal dietary compositions for American robins in the western United States. Martin et al. (1951) also reported seasonal dietary compositions for the American robin throughout North America. The highest percentage of invertebrates in the diet of the American robin was reported during the spring: 83.0 percent by Wheelwright (1986) and 78.9 percent by Martin et al. 1951). For conservatism, the contribution that earthworms have to the total diet of the American robin in the BERA was assumed to be 83 percent (highest seasonal contribution reported by Wheelwright (1986) and Martin et al. (1951). Using the relationship presented in Sample and Sutter II (1994), a diet of 83.0 percent earthworms extrapolates to a soil contribution of 8.7 percent to the total diet. The remainder of the diet was assumed to be plants (7.3 percent). The diet of the Norway rat was assumed to be 49.0 percent terrestrial invertebrates, 49.0 percent terrestrial plants, and 2.0 percent soil. In addition to the diet adjustments discussed above for the American robin and Norway rat, the diet of the green heron also will be modified to include aquatic invertebrates (29 percent aquatic invertebrates and 71 percent fish [Sample et al., 1997]). The specific diets that will be used in Step 3a of the BERA for the American robin, mourning dove, red-tailed hawk, spotted sandpiper, and green heron are summarized in Table 5-21.

- In addition to the NOAEL-based risk estimates used in the SERA for the mourning dove, red-tailed hawk, spotted sandpiper, and green heron, consideration also will be given to food web risk estimates based on LOAELs and MATCs. However, because the American robin is being used as a surrogate species for the yellow-shouldered blackbird, only NOAEL-based risk estimates will be considered for this receptor.

- For detected chemicals lacking medium-specific screening values from the literature, the USEPA (2009c and 2009d) Ecological Structure Activity Relationships (ECOSAR) Class Program (MS-Windows Version 1.00a; available at http://www.epa.gov/opptintr/newchems/tools/21ecosar.htm) will be used to estimate their toxicity based on their structural similarity to chemicals for which toxicity data are available (i.e., structure activity relationships [SARs]).

- For inorganic ecological COPCs (i.e., metals) in soil, groundwater, surface water, and sediment, consideration will be given to available background data. This will be accomplished by statistically comparing SWMU-specific media concentrations to background concentrations in accordance with Navy guidance (NFESC, 2002, 2003, and 2004). Statistical comparisons will include descriptive summaries of each data set (e.g., maximum, mean, and 95% UCL of the mean concentrations), statistical tests on the mean/median of the distributions (i.e., two sample t-test, Wilcoxon rank sum test, Gehan test, or Satterthwaite's t-test), and statistical tests on the right tail of the distributions (i.e., quantile test and slippage test). The significance level (i.e., the probability criteria for rejecting the null hypothesis that the SWMU-specific and background data sets were sampled from the same population) will be set at 0.05 for all statistical tests (NFESC, 2002, 2003, and 2004). The background data sets used in the statistical comparisons are those presented in the *Revised Final II Summary Report for Environmental Background Concentrations of Inorganic Compounds* (Baker, 2010)

- As exposure does not necessarily equate to risk, consideration will be given to site-specific factors that can affect the bioavailability of chemicals in surface water and sediment to aquatic receptor groups. For surface water, consideration will be given to the concentration of metals in the dissolved (unfiltered) fraction. For sediment, consideration will be given to the affect TOC and AVS has on the bioavailability of organic and inorganic chemicals, respectively.

- Chemicals that are not identified as ecological COPCs because maximum detected concentrations (or maximum reporting limits in the case of non-detected chemicals) are less than media-specific screening values will not be evaluated in Step 3a of the BERA since a conclusion of no unacceptable risk can be made with high confidence. Detected and non-detected chemicals with maximum dietary intakes less than NOAEL-based TRVs also will be excluded from further evaluation in Step 3a of the BERA.

- Non-detected chemicals lacking media-specific screening values (or, in the case of food web exposures, TRVs) will be excluded from further evaluation in Step 3a of the BERA. It is not possible to quantitatively address the potential for risk from chemicals that are not detected and that do not have established screening values with which to compare them. Even considerations of the most conservative measurement (the maximum reporting limit) are not informative when no threshold value has been established. Because of these limitations, the approach will follow that outlined in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR 300 Appendix A), which does not establish a release when the sample measurement is less than the contract required detection limit as determined by an USEPA certified laboratory. As all samples will be analyzed by a certified laboratory, and will be validated by an independent third party, the exclusion of non-detected chemicals is considered reasonable and appropriate. Although eliminated from further evaluation, they will remain ecological COPCs but will not be considered ecological COCs. It is additionally noted that any site-specific studies, which may be conducted during a BERA, would indirectly evaluate the impacts of non-detected chemicals.

5.9.2 Step 3a Decision Points

Possible decision points based on the results of Step 3a include:

- **No further action is warranted.** This decision is appropriate for a given SWMU if Step 3a of the BERA indicates that there is no reasonable potential for unacceptable ecological risk within acceptable uncertainty.

- **Evaluate the need for corrective measures.** This decision is appropriate for a given SWMU if Step 3a of the BERA indicates that there is a reasonable likelihood for unacceptable ecological risks within acceptable uncertainty. Whether or not corrective measures are taken will depend upon a number of risk management factors such as the results of any human health risk assessments and the potential impact of the remedial action itself on the habitats and biota present on the site.

5.10 Development of Ecological Corrective Action Objectives

This section presents the methodology that will be used to develop CAOs protective of ecological receptors. Risk-based CAOs will be established for those chemicals identified as ecological COCs for one or more of the receptor/receptor groups evaluated in Step 3a of the Navy ERA process. Background-based CAOs also will be established for each inorganic ecological COC.

5.10.1 Methodology for Corrective Action Objective Development

CAOs for lower trophic level receptor direct contact exposures to chemicals in abiotic media (soil, groundwater, surface water, and sediment) will be developed by multiplying medium-specific screening values by 1.0:

$$CAO_x = (SV_x)(1.0)$$

where CAO_x is the Corrective Action Objective for chemical x, SV_x is the medium-specific screening value for chemical x, and 1.0 represents a default HQ for the derivation of CAOs. CAOs calculated using the default HQ value of 1.0 correspond to medium-specific chemical concentrations that result in risk estimates (HQs) equal to 1.0. As discussed in Section 5.6, HQs greater than 1.0 indicate the potential for risk since the chemical concentration exceeds the screening value (effect).

CAOs for American robin, mourning dove, red-tailed hawk, spotted sandpiper, and green heron dietary exposures to chemicals in soil and/or sediment will be developed using one of two methods. For those chemical-receptor combinations where literature-based BAF values were used to estimate chemical concentrations in each food item, CAOs will be calculated by modifying the dietary intake equation presented in Section 5.5.2.2.2. Specifically, CAOs for avian dietary exposures will be calculated as follows:

$$CAO_x = \frac{(1.0)(TRV_x)(BW_j)}{[[\sum_i [(FIR_j)(BAF_{xi})(PDF_{ij})]] + [(FIR_j)(PDS)]][AUF_j]}$$

where:

CAO_x	=	Corrective Action Objective for chemical x (mg/kg, dry weight)
TRV_x	=	NOAEL-based TRV for chemical x (mg/kg-BW/day)
BWj	=	Body weight for receptor j (kg, wet weight)
FIR_j	=	Food ingestion rate for receptor j (kg/day, dry-weight)
BAF_{xi}	=	Soil/sediment BAF for chemical x in food item i (dry weight basis)

PDF_{ij} = Proportion of diet composed of food item i for receptor j (dry weight basis)
PDS_j = Proportion of diet composed of soil/sediment for receptor j (dry weight basis)
AUF_j = Area Use Factor for receptor j (unitless)

Input parameters for TRV_x are summarized in Table 5-7, input parameters for BW_j, FIR_j, and AUF_j are summarized in Table 5-20, input parameters for PDF_{ij}, and PDS_j are summarized in Table 5-21, while input parameters for BAF_{ix} are summarized in Tables 5-17 (soil-to plant BAFs), 5-18 (soil-to-small mammal BAFs), and 5-19 (sediment-to-invertebrate and sediment-to-fish BAFs). Identical to CAOs for lower trophic level direct contact exposures, a default HQ of 1.0 will be used in the derivation of CAOs for upper trophic level avian dietary exposures.

For those chemical-receptor combinations where uptake equations were used to estimate chemical concentration in one or more of the food items, CAOs will be identified through an interative process using the dietary intake equation presented and discussed in Section 5.5.2.2.2 and the exposure parameters identified above. In this process, values for SC_x will be entered into the equation until a dietary intake (DI_x) is calculated that equals the NOAEL-based TRVs listed in Table 5-7. The soil concentration that results in a dietary intake equal to the NAOEL-based TRV corresponds to an HQ value of 1.0.

Surface water ingestion will not be considered in the derivation of the risk-based soil and sediment CAOs due to the extremely low contribution that this exposure route has to the total risk. It is noted that current information indicates that suitable drinking water sources (surface water with a salinity less than 15 ppt) are not present at or contiguous to SWMUs 27, 28, and 29.

In addition to the risk-based CAOs discussed above, background-based CAOs will be established for inorganic chemicals identified as ecological COC for lower trophic level direct contact exposures to chemicals in surface soil, subsurface soil, groundwater, surface water, and sediment and/or upper trophic level avian dietary exposures to chemicals in surface soil, subsurface soil, and sediment. Upper limit of the mean (ULM) concentrations presented in the document entitled *Revised Final II Summary Report for Environmental Background Concentrations of Inorganic Compounds* (Baker, 2010) will be used directly as background-based CAOs for inorganic chemicals.

5.10.2 Identification of Final Corrective Action Objectives

The final CAO for ecological COCs will be identified as follows:

- For a given medium, the minimum risk-based CAO for organic chemicals will be identified as the final CAO.

- For a given medium, the minimum risk-based CAO for inorganic chemicals will be identified as the final CAO if the background-based CAO is less than the minimum risk-based CAO.

- For a given medium, the background-based CAO for inorganic chemicals will be identified as the final CAO if the background-based CAO is greater than the minimum risk-based CAO. This approach is consistent with the *Navy Policy for use of Background Chemical Levels* (CNO, 2004), which states that "*The action level for the remediation of sites should be risk based, should not be below background levels, and should target the risk associated with the COC or contaminant concentration exceeding background chemical levels*".

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6.0 HUMAN HEALTH RISK ASSESSMENT AND DEVELOPMENT OF CAOs

An HHRA will be conducted in accordance with the USEPA Risk Assessment Guidance for Superfund (RAGS). This section of the Work Plan will serve as the guideline for the HHRA to be conducted at SWMU 28 (Bundy WWTP Sludge Drying Beds) during the CMS. The results of the HHRA will be incorporated into the CMS report.

The primary documents that will be utilized include:

- RAGS: Volume I – Human Health Evaluation Manual (Part A), December 1989.

- Risk Assessment Guidance for Superfund: Volume I Human Health Evaluation Manuel (Part D, Standardizing Planning, Reporting, and Review of Superfund Risk Assessments), Interim. Office of Emergency and Remedial Response. Publication 9285.7-01D. December 2001.

- Risk Assessment Guidance for Superfund. Volume 1: Human Health Evaluation Manual Part E Supplemental Guidance for Dermal Risk Assessment. Interim. Final. Office of Emergency and Remedial Response. Washington, DC. EPA 540/R/99/005. July 2004.

- Risk Assessment Guidance for Superfund. Volume 1: Human Health Evaluation Manual Part F, Supplemental Guidance for Inhalation Risk Assessment. Final. OSWER 9285.7-82. January 2009.

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- Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, OSWER 9355.4-24, Office of Solid Waste and Emergency Response, Washington, D.C., December 2002.

- Exposure Factors Handbook. Office of Research and Development. Washington, D.C. EPA/600/P-95/002F. August 1997.

- Risk Assessment Guidance for Superfund Volume I. Human Health Evaluation Manual Supplemental Guidance: "Standard Default Exposure Factors" Interim Final. Office Solid Waste and Emergency Response. Washington, D.C. OSWER Directive 9285.6-03. March 25, 1991.

- Land Use in the CERCLA Remedy Selection Process, Office of Solid Waste and Emergency Response Directive 9355.7-04, Washington, D.C., May 25, 1995.

- Regional Screening Levels Table. http://epa-prgs.ornl.gov/chemicals/index.shtml

The human health risk assessment will include the following major components:

- Identification of COPCs
- Exposure assessment
- Toxicity assessment

- Risk characterization and
- Uncertainty evaluation and comparison to background concentrations

6.1 Land Use and Potentially Exposed Receptors

This section will be presented at the beginning of the HHRA to provide an overview of the characteristics, location and general description of the SWMU. The physical characteristics of the SWMU and the geographical areas of concern will be discussed. This description of the SWMU will help to characterize the exposure setting.

To focus on developing practicable and cost-effective corrective measures alternatives for SWMU 28, and to streamline its environmental cleanup process, USEPA guidance ("Land Use in the CERCLA Remedy Selection Process," (USEPA, 1995) and U.S. Department of Defense (Longuemare, 1997) direct that CAOs should reflect the reasonably anticipated land use.

SWMU 28 is in an industrial area of NAPR and consists of the domestic sewage treatment plant serving the Bundy area. Future property use of this SWMU is expected to remain industrial. As a result, potential human exposure will most likely be limited to industrial or commercial property use, now and in the future.

Therefore, based on USEPA and Department of Defense guidance that CAOs should reflect actual anticipated land use, the assumed land use will be industrial, with industrial workers (i.e., civilians, military personnel stationed at NAPR, and/or construction workers) the most likely receptors. It is unlikely this site would ever be developed into a residential area given the current use of the area. As such, CAOs will not be developed based on future residential land use. However, this scenario will be evaluated to provide the most conservatively protective risk estimation and for conservative comparison with other exposure scenarios.

6.2 Selection of Chemicals of Potential Concern

6.2.1 Data Evaluation

Sampling activities at SWMU 28 have been conducted under two investigations: Phase I and Full RFIs. Analytical results from these investigations were presented and discussed within the Final Phase I RCRA Facility Investigation Report for SWMU 28 (Baker, 2007) and the Final Full RCRA Facility Investigation for SWMU 28 (Baker, 2008).

Surface soil (0.0 to 1.0 foot bgs), subsurface soil (1.0 to 3.0 feet bgs, 3.0 to 5.0 feet bgs, 5.0 to 7.0 feet bgs, 7.0 to 9.0 feet bgs, and/or 9.0 to 11.0 feet bgs), and groundwater samples were collected at SWMU 28 during the Phase I RFI field investigation and analyzed for Appendix IX VOCs, SVOCs, PCBs, and metals (total and dissolved), as well as TPH GRO and TPH DRO. Surface and subsurface soil samples were collected at SWMU 28 during the Full RFI field investigation and analyzed for Appendix IX metals and PCBs. Groundwater samples were also collected during the Full RFI field investigation and analyzed for Appendix IX metals (total and dissolved). Proposed sample collection activities for the CMS field investigation at SWMU 28 (sample designations, sample depths, and analytical parameters) are summarized in Table 3-3 of this CMS Work Plan, while sampling activities are discussed in Section 3.2.

In selecting data to include in the HHRA, the objective is to characterize, as accurately as possible, the distribution and concentration of chemicals at SWMU 28. It is anticipated that all data collected from the Phase I and Full RFIs, as well as data obtained during the CMS field investigation will be used in the HHRA. Data summary tables will be developed for each medium sampled (e.g., soil, groundwater, surface water [if encountered], and sediment [if encountered]). A statistical analysis, including the minimum, maximum, mean, standard deviation and 95% UCL, will be run for applicable data sets (i.e., soil, groundwater, surface water [if encountered], and sediment [if encountered] COPCs). For duplicate samples, the higher of the two concentrations (environmental versus duplicate) will be used, not both.

In the case of groundwater data, the total and dissolved metals analytical results from groundwater samples will be included in the COPC selection. However, only the analytical results for total metals will be used to estimate exposure concentrations. The dissolved metals data are presented to indicate that the observed metals in the groundwater samples could be associated with suspended particles in the water samples. Further, RAGS Part A (USEPA, 1989) guidance states that filtered groundwater data can provide useful information for understanding chemical transport within an aquifer. As appropriate, dissolved groundwater data will be qualitatively evaluated in relationship to corresponding total groundwater data.

6.2.2 COPC Selection

COPCs are those chemicals having the greatest potential to cause adverse human health effects if receptors come in contact with site media. For each environmental medium, COPCs will be selected in accordance with USEPA's RAGS, Volume I, Human Health Evaluation Manual (Part A), Interim Final, (USEPA, 1989). It should be noted that although some of the inorganic analytes may occur above the risk-based screening values but below background concentrations, no inorganics will be eliminated from the risk evaluation based on their occurrence at background levels. The final site recommendations will be based on results of the HHRA and comparisons with the background levels as appropriate for the inorganic analytes.

6.2.3 COPC Selection Criteria

The COPCs will be selected by comparing the maximum concentrations detected in environmental samples to risk-based screening levels. Chemicals exceeding screening levels will be retained as COPCs for further evaluation; chemicals detected at concentrations below these criteria will not be evaluated unless other circumstances (frequency of exposure detected in other media, same chemical class [i.e., PAHs] or documented usage) warrant the re-inclusion and further evaluation of chemicals selected as COPCs. The risk-based screening levels to be used in selecting chemicals as COPCs in the revised HHRA for SWMU 28 are the USEPA Regional Screening Levels (SLs) (USEPA, 2010a). The current versions of these SLs applicable to this CMS investigation are included in Table 6-1.

In conjunction with concentration comparisons to the USEPA Regional SLs, a comparison to concentrations detected in field and laboratory blanks will conducted by a third-party data validator, to ensure that only site-related contaminants are evaluated in the quantitative estimation of human health effects. As previously mentioned, inorganic constituents were also compared to corresponding background screening concentrations. The background data to be used for comparison purposes in this HHRA are taken from the Revised Final II Summary Report for Environmental Background Concentrations of Inorganic Compounds (Baker, 2010), for NAPR. The criterion used for screening is the ULM, which is calculated as the mean plus two times the standard deviation of the mean.

The toxicity of a chemical detected in a given environmental medium, as well as the history of site-related activities are other important criteria applied in selecting COPCs at SWMU 28. Therefore, in conjunction with concentration comparisons to USEPA Regional SLs, evaluations of toxicity and site history will be considered to determine whether chemicals eliminated by a direct comparison to SL values should be re-included as COPCs.

Tables will be provided which summarize the data for the media identified at SWMU 28 (soil, groundwater, surface water [if encountered] and sediment [if encountered]) and the COPC selection process.

6.3 Exposure Assessment

The objectives of the exposure assessment will be to characterize the exposure setting, identify exposure pathways, and quantify the exposure. When characterizing the exposure setting, the potentially exposed populations will be described. The exposure pathway will identify the source, or medium, for the released chemical (e.g., groundwater), the point of potential human contact with the contaminated medium, and the exposure route(s) (e.g., ingestion). The magnitude, frequency, and duration for each exposure pathway identified will be quantified during this process.

6.3.1 Conceptual Site Model

Development of a conceptual site model (CSM) of potential exposure is critical in evaluating exposures for the human receptors and serves as the basis for exposure pathway evaluations in the human health risk assessment. The CSM considers all reasonable current and future potential exposures and media of concern under a no-action scenario. Potentially affected media at SWMU 28 may include one or more of the following: surface soil and subsurface soil (i.e., total soil), surface water, sediment, and groundwater. Potential contaminant release mechanisms from affected media include storm water runoff, leaching to underlying groundwater, and advective transport in the direction of groundwater flow. Based on the available information for SWMU 28, potential migration, exposure pathways, and human receptors are identified in Figure 6-1.

6.3.2 Analysis of Probable Fate and Transport of Site-Specific Chemicals

To determine the environmental fate and transport of the chemicals of concern at the site, the physical/chemical and environmental fate properties of the chemicals will be reviewed. Some of these properties include volatility, photolysis, hydrolysis, oxidation, reduction, biodegradation, accumulation, persistence, and migration potential. This information will assist in predicting potential current and future exposures. It will help in determining those media that are currently receiving site-related chemicals or may receive site-related chemicals in the future. The evaluation of fate and transport may be necessary where the potential for changes in future chemical characteristics is likely and for those media where site-specific data on the chemical distribution is lacking.

6.3.3 Identification of Potentially Exposed Human Populations

NSRR underwent operational closure on March 31, 2004. On April 1, 2004, NSRR was re-designated as NAPR. The current primary 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. It is assumed that long-term plans for the facility would be similar to those that had been in place prior to closure with land use also generally the same. Based on information available regarding the physical features, site setting, site historical activities, and current and expected land uses, four potential human receptors include:

- Current/Future On-site Adult Trespasser
- Current/Future On-site Youth (6-16 years) Trespasser
- Future Adult Resident
- Future Young Child (1-6 years) Resident

- Future Industrial/Commercial Adult Worker
- Future Construction Worker

For the continued industrial/commercial land use scenario at this site, the industrial/commercial worker and construction worker will be used to characterize potential future exposure to contaminated soil and groundwater. The future industrial/commercial worker is included in the RCRA § 7003 Administrative Order on Consent (USEPA, 2007) as a potential human receptor under expected usage conditions (i.e., expected future land usage being similar to the land usage patterns currently in place). Specifically, an industrial worker could be exposed to total soil (defined as 0 to 10 feet bgs), as well as volatiles in groundwater emitted through soil into buildings. At NAPR, it is considered that soil up to 10 feet bgs could be exposed during construction activities. Construction workers that may perform excavation and construction at the site could also be exposed to total soil (0 to 10 feet bgs) and shallow groundwater at SWMU 28. Construction workers may be directly exposed to groundwater following excavation because groundwater at SWMU 28 is relatively shallow at some locations (i.e., less than 10 feet bgs). Additionally, it is conservatively assumed that adult and/or youth trespassers may gain access to the site now or in the future and could be exposed to soil, surface water, and sediment. Trespasser receptors are listed in the RCRA § 7003 Administrative Order on Consent (USEPA, 2007).

Future residential land use will be conservatively evaluated for SWMU 28, although residential receptors are not included as potential human receptors in the RCRA § 7003 Administrative Order on Consent (USEPA, 2007). Additionally, the industrial setting of the SWMU precludes its use as a residential site. However, a future residential exposure scenario will be included for conservative comparison with other exposure scenarios. A residential land use is also assumed to estimate the worst-case exposure conditions. Although a residential scenario will be evaluated, CAOs will not be developed based on future residential land use.

The following exposure scenarios are not final. Exposure scenarios will be finalized after the data collected in the field has been analyzed and evaluated. Generally, current and future exposure pathways will be considered preliminarily as follows:

- Soil Pathway

  - Ingestion (current/future trespassers, future industrial/commercial worker, future residents, future construction worker)

  - Dermal contact (current/future trespassers, future industrial/commercial worker, future residents, future construction worker)

  - Inhalation of fugitive dust (current/future trespassers, future industrial/commercial worker, future residents, future construction worker)

- Groundwater

  - Ingestion (future residents, future construction worker, [for groundwater encountered at or above 10 feet bgs])

  - Dermal contact (future residents, future construction worker [for groundwater encountered at or above 10 feet bgs])

- Surface Water Pathway

  - Ingestion (current/future trespassers, future residents)
  - Dermal contact (current/future trespassers, future residents)

- Sediment Pathway

  - Ingestion (current/future trespassers, future residents)
  - Dermal contact (current/future trespassers, future residents)

Note that past investigations did not indicate the presence of volatile organic compounds at this SWMU and are not included for analysis during this CMS investigation. Therefore, the inhalation of volatiles in groundwater (either directly or indirectly) will not be quantitatively evaluated in this HHRA unless new information is obtained during the CMS field investigation.

The exposure scenarios presented above represent USEPA's reasonable maximum exposure (RME). RME is defined as the highest exposure that is reasonably expected to occur at a site. Relevant equations for assessing exposure doses will be obtained from RAGS Part A (USEPA, 1989), RAGS Part E Supplemental Guidance for Dermal Risk Assessment (USEPA, 2004), RAGS Part F Supplemental Guidance for Inhalation Risk Assessment (USEPA, 2009), and Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (USEPA, 2002a).

6.3.4 Exposure Point Concentrations

After the potential exposure points and potential receptors have been defined, exposure point concentrations (EPCs) must be calculated. The data from site investigations will be used to estimate EPCs. USEPA’s most recent guidance, Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites (USEPA, 2002b), provides tools to calculate upper confidence limits to be used as EPCs in risk assessments. The USEPA 2002 guidance recommends the use of the software package, ProUCL (USEPA, 2010b and 2010c), to calculate UCLs for use in risk assessments. ProUCL Version 4.00.05 (or the most recent version available at that time) will be used in this HHRA to calculate 95% UCLs. The ProUCL software has been developed by USEPA to compute an appropriate 95% UCL of the unknown population mean. All upper confidence limit computation methods contained in the USEPA guidance documents are available in ProUCL, Version 4.00.05. ProUCL 4.00.05 contains statistical methods to address various environmental issues for both full data sets without nondetects and for data sets with nondetects (also known as left-censored data sets). Note that estimated concentrations, such as "J" qualified data, will also be included in the calculation of the 95% UCL. However, reported concentrations qualified with an "R" will not be used in the statistical evaluation.

6.3.5 Exposure Input Parameters

Exposure doses (i.e., chronic daily intakes [CDIs]/dermally absorbed doses [DADs]/exposure concentrations [ECs]) will be estimated for each exposure scenario from COPC concentrations at the point of contact by applying conservative default exposure assumptions promulgated by the USEPA for standard exposure scenarios that account for contact frequency, contact duration, body weight, and other route-specific factors such as ingestion rate. Relevant exposure parameters will primarily be obtained from Exposure Factors Handbook (USEPA, 1997a), Standard Default Exposure Factors, Interim Final (USEPA, 1991), RAGS Part E Supplemental Guidance for Dermal Risk Assessment (USEPA, 2004), and Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (USEPA, 2002a). When USEPA exposure parameters are not available, best professional judgment and site-specific information will be used to derive a conservative and defensible value.

These factors will then be incorporated into exposure algorithms that convert the environmental concentrations into exposure doses. CDIs/DADs will be reported in milligrams of chemical taken in by the receptor per kilogram body weight per day (mg/kg/day) or milligrams of chemical per cubic meter (mg/m^3) for inhalation. CDIs/DADs/ECs for potentially exposed populations will be calculated separately for the appropriate exposure routes and chemicals. Table 6-2 presents the exposure parameters to be used in the estimation of exposure doses for this HHRA.

6.4 Toxicity Assessment

Toxicity values (i.e., numerical values derived from dose-response toxicity data for individual compounds) will be used in conjunction with the intake determinations to characterize risk. Toxicity values may be taken or derived from various sources, as described in the paragraph below.

The primary source of chemical-specific health effects criteria to be used during the CMS will be USEPA's Integrated Risk Information System (IRIS) database (USEPA, 2010d). IRIS is a computer-housed catalog of USEPA health effects criteria and information. Data in IRIS are reviewed and updated monthly. If health effects criteria are not available in IRIS, USEPA recommends use of the Provisional Peer Reviewed Toxicity Values (PPRTVs) (database of values developed on a chemical-specific basis when requested by USEPA's Superfund program) as a secondary data source (USEPA, 2003). Additional health effects criteria not provided in IRIS or as PPRTVs are obtained from other USEPA (e.g., Health Effects Assessment Summary Table [HEAST] [USEPA, 1997b]) and non-USEPA (e.g., Agency for Toxic Substances and Disease Registry [ATSDR] Minimal Risk Levels) sources of toxicity information. These sources should provide toxicity information based on similar methods and procedures as those used for IRIS and PPRTVs, contain values which are peer reviewed, are available to the public, and are transparent about the methods and processes used to develop the values.

Health effects criteria are available only for the oral and inhalation routes, and most of these criteria are based on the administered rather than the absorbed dose (i.e., the amount of chemical at a human exchange boundary, such as skin, that is available for absorption, but not the amount actually absorbed into the blood).

Adjustment will be made using oral absorption efficiency data (i.e., data on gastrointestinal absorption) from the species on which the oral health effects criteria are based. The administered dose oral health effects criterion will be multiplied (for reference doses [RfDs]) or divided (for cancer slope factors [CSFs]) by the gastrointestinal absorption factor to derive the absorbed dose criterion. Recommended oral absorption efficiencies for those compounds/analytes with chemical-specific dermal absorption factors from soil will be obtained from RAGS Part E (USEPA, 2004).

For some chemicals, the principal references previously mentioned do not contain the required information to present toxicity values. However, such chemicals should not be excluded as COPCs because of this, and their potential health effects should be considered in the HHRA. When a chemical has no chronic toxicity values, the value of a chemical that is related both chemically and toxicologically is used. The implications of the presence of chemicals without toxicity values and their absence from the quantitative risk assessment will be discussed as an uncertainty.

6.5 Risk Characterization

The risk characterization will combine the results of the hazard assessment, exposure assessment and toxicity assessment to produce a quantitative estimate of current and future potential human health risk. For each compound, the human health risks expected due to chronic exposure will be estimated. Separate calculations will be performed for carcinogenic and noncarcinogenic effects.

The incremental lifetime cancer risk (ILCR) will be derived using the following linear equation:

$$ILCR = \sum_{i=1}^{n} CDI_i \bullet CSF_i$$

where CSF_i is the CSF $(mg/kg/day)^{-1}$ for compound i, and CDI_i is the chronic daily intake (mg/kg/day) for compound i. ILCR values will be compared to USEPA's target risk range of 1×10^{-06} to 1×10^{-04}, which is considered to be generally acceptable at most sites.

Quantitative risk calculations for noncarcinogenic compounds assume that a toxicological threshold concentration exists, below which, no adverse health effects will occur. Therefore, the potential for noncarcinogenic effects will be derived by comparing CDIs with USEPA promulgated RfDs. Noncarcinogenic human health effects will be estimated by deriving the hazard index (HI), which is defined as the sum of each individual constituent HQ. HQs will be determined using the following algorithm:

$$HQ_i = CDI_i / RfD_i$$

The HI will be derived using the following equation:

$$HI = \sum_{i=1}^{n} HQ$$

HQ_i is the hazard quotient for chemical i, and RfD_i is the reference dose (mg/kg/day) of compound i. The HI is an indicator of potential adverse health effects and is not an absolute indicator of the severity of the effect. The HI serves only to identify whether health effects will or will not occur subsequent to exposure.

HI values greater than 1.0, or unity, indicate the potential for adverse effects to occur. HI values less than one indicate that adverse effects are unlikely. This procedure assumes that the risks from exposure to multiple chemicals are additive, an assumption that is probably valid for compounds that have the same target organ or cause the same toxic effect. In some cases when the HI exceeds unity it may be appropriate to segregate effects (as expressed by the HI) by target organ since those effects would not be additive. Where information is available about the antagonism or synergism of chemical mixtures, it will be appropriately discussed in the uncertainty analysis.

Summary and conclusion discussions will be provided for each of the receptor populations evaluated for SWMU 28. Risks will be totaled by medium and combined risks across media and pathways will be presented as appropriate.

6.6 Uncertainty Analysis and Comparison to Background

Uncertainties are encountered throughout the risk assessment process. This section discusses the sources of uncertainty inherent in the following elements of the HHRA performed for SWMU 28:

- Sampling and analysis
- Selection of COPCs
- Exposure assessment
- Toxicity assessment
- Risk characterization

A qualitative discussion of uncertainty associated with the SWMU will be presented. The background levels for inorganic chemicals will be included in this portion of the report to determine if the risk characterization included chemicals that were not specific to the SWMU. Final site human health risk and related impacts discussions will identify chemicals related to SWMU 28 operations.

6.7 Human Health Corrective Action Objectives

The CMS process from a human health risk assessment perspective continues when potential exposure to a site is considered to pose unacceptable levels of risk and hazard and medium- and chemical-specific CAOs are calculated for comparison to the site data to determine if and where potential cleanup may occur.

CAOs are medium- and chemical-specific goals for protecting human health and the environment. The CAOs are used to focus the development of corrective measure alternatives on technologies that may achieve appropriate target levels, thereby limiting the number of alternatives analyzed.

CAOs can be general and descriptive (i.e., qualitative) or specific and numerical (i.e., quantitative). They are achieved by reducing exposure (e.g., installing a soil cover or limiting access) or by reducing contaminant levels (e.g., active remediation; USEPA, 1988). CAOs are used to evaluate which samples/areas within a site may require corrective measures, and which corrective measures alternative best protects human health and the environment.

6.7.1 Qualitative CAOs

6.7.1.1 Groundwater

There is no direct current exposure to contaminated groundwater at SWMU 28 nor is future exposure likely based on the future land use scenarios discussed in Section 6.3. Groundwater is not currently used for potable purposes as described in the RCRA § 7003 Administrative Order on Consent (USEPA, 2007).

Under nonresidential land use, particularly the continued industrial future land use scenario in which the U.S. Navy determines the specific use of the property, it is reasonable to assume that no groundwater well will be installed within the limited volume of contaminated groundwater and be used for domestic purposes. The qualitative CAOs for contaminated groundwater are:

- To prevent further degradation of Puerto Rico’s waters (Anti-degradation Policy, Regulation No. 4282, Puerto Rico Water Quality Standards Regulation, effective August 19, 1990.)

- To further restrict and prevent possible exposure to contaminated groundwater (e.g., by institutional controls).

- To protect public health and the environment in accordance with regulatory requirements (i.e., the general objective of all corrective measures).

6.7.1.2 Soil

Under the continued industrial land use scenario, contact with contaminants will occur from both surface and subsurface soil at SWMU 28. The qualitative CAOs for soil are:

- To prevent further degradation of Puerto Rico's waters (Anti-degradation Policy, Regulation No. 4282, Puerto Rico Water Quality Standards Regulation, effective August 19, 1990.)

- To protect human health and the environment in accordance with regulatory requirements (i.e., the general objective of all corrective measures).

6.7.2 Quantitative CAOs

Quantitative CAOs are acceptable residual contaminant concentrations. The following components will be used to determine CAOs for soil/sediment, surface water, and groundwater, as applicable:

- Intake by assumed exposure pathways.
- Chemical-specific toxicity data in the form of health effects criteria (see Section 6.4).
- Assumed target cancer risk level and noncarcinogenic HQ.

The target risk level and HQ are general health effects levels deemed acceptable for exposure to individual carcinogenic and noncarcinogenic contaminants, respectively.

For those chemicals presenting excess human health risk, CAOs will be developed per USEPA guidance, similar to the methodology used for developing USEPA Regional SLs (USEPA, 2010a). A quantitative CAO will be calculated for those media and chemicals presenting excess cancer risk or HI above an acceptable risk range or HI value. CAOs will not be calculated for chemicals and media that represent low risks and HIs.

6.7.3 Background Concentrations as CAOs

Background concentrations of inorganics may be used as quantitative CAOs when they exceed risk-based CAOs. The NCP preamble (55 *Federal Register*, 8717) states that preliminary remediation goals (i.e., the CERCLA equivalent to quantitative CAOs) may be revised based on consideration of "technical factors," which may include background levels of contaminants. Therefore, if a calculated CAO is less than background inorganic constituents, the background concentration is used as the CAO.

6.8 References

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7.0 IDENTIFICATION OF COCs

COCs are those contaminants detected at a site at concentrations that exceed human-health or ecological-based screening values. CAOs are clean up criteria for those COCs that have been determined through the human health and ecological risk assessment process to cause unacceptable risk to potential receptors. CAOs for each media will be compiled and evaluated including an examination of the spatial and concentration distributions of COCs within the media in which they occur.

8.0 CORRECTIVE MEASURES STUDY

This section of the CMS Work Plan describes the stepwise approach to be taken in performing the CMS for SWMUs 27 - Capehart WWTP Sludge Drying Beds, SWMUs 28 - Bundy WWTP Sludge Drying Beds and SWMUs 29 - Industrial Area WWTP Sludge Drying Beds. The CMS consists of four tasks, which are described in the sections that follow. These will be prepared for each SWMU.

8.1 Task I - Identification and Development of the Corrective Measure Alternative or Alternatives

This task will identify, screen, and develop the alternative or alternatives for removal, containment, treatment and/or other disposition of the contamination based on the objectives established for the corrective measures. The analysis will be based on the results of the all previous investigations at SWMUs 27, 28 and 29 as well as the CMS investigations described in Sections 3.0 and 4.0 of this document.

8.1.1 Description of the Current Situations

The current situation and the known nature and extent of contamination at SWMUs 27, 28 and 29 will be described in this section. A statement of the purpose for the response, based on the results of the Full RFI and CMS investigations will be provided, as will the actual or potential exposure pathways to potential human or ecological receptors of concern that will be addressed by the corrective measures.

8.1.2 Establishment of Corrective Action Objectives

Site specific objectives for the corrective action will be established in conjunction with the USEPA. These objectives will be based on public health and environmental criteria, information obtained from site investigations, USEPA guidance, and any applicable federal or Commonwealth of Puerto Rico statutes. The CAOs will be consistent with 40 CFR 264.100 as applicable.

8.1.3 Screening of Corrective Measure Technologies

The corrective measure technologies, which are applicable at the facility, will be reviewed based on all the available data and information at SWMUs 27, 28 and 29. This screening process focuses on eliminating those technologies that have severe limitations for a given set of waste and site-specific conditions or due to inherent technology limitations.

8.1.4 Identification of the Corrective Measure Alternative or Alternatives

The corrective measure alternative or alternatives will be developed based on the CAOs and analysis of the corrective measure technologies. Those alternatives that appear most suitable for the site based on sound engineering will be retained. Technologies can be combined to form the overall corrective action alternative or alternatives. The reasons for excluding any technology shall be documented.

8.2 Task II - Evaluation of the Corrective Measure Alternative or Alternatives

Each corrective measure technology and its components that passed through the initial screening in Task I will be described and evaluated. This evaluation will be based on technical, environmental, human health, and institutional concerns. Cost estimates for each corrective measure will also be developed.

8.2.1 Technical/Environmental/Human Health/Institutional

A description of each corrective measure alternative which includes but is not limited to preliminary process flow sheets, preliminary sizing and type of construction for buildings and structures, and rough quantities of utilities required will be provided. Each alternative will be evaluated in the following four areas:

8.2.1.1 Technical

Each corrective measure alternative will be evaluated based on performance, reliability, implementability, and safety.

8.2.1.2 Environmental

An environmental assessment will be performed for each alternative, which will focus on the facility conditions and pathways of contamination actually addressed by each alternative. The environmental assessment for each alternative will include, at a minimum, an evaluation of: the short and long term beneficial and adverse effects of the response alternative; any adverse effects on environmentally sensitive areas; and an analysis of measures to mitigate adverse effects.

8.2.1.3 Human Health

Each alternative will be assessed in terms of the extent to which it mitigates short- and long-term potential exposure to any residual contamination and protects human health both during and after implementation of the corrective measure. The assessment will describe the levels and characterizations of contaminants on-site, potential exposure routes, and potentially affected populations. Each alternative will be evaluated to determine the level of exposure to contaminants and the reduction over time. For management of mitigation measures, the relative reduction of impact will be determined by comparing residual levels of each alternative with existing criteria, standards, or guidelines acceptable to the USEPA.

8.2.1.4 Institutional

The relevant institutional needs for each alternative will be assessed. Specifically the effects of Federal, State, and local environmental and public health standards, regulations, guidance, advisories, ordinances, or community relations on the design, operation, and timing of each alternative will be examined.

8.2.2 Cost Estimate

A cost estimate of each corrective measure alternative will be developed. The cost estimate will include capital, operation, and maintenance costs.

8.3 Task III - Justification and Recommendation of the Corrective Measure or Measures

The corrective measure alternative will be recommended and justified using technical, human health, and environmental criteria. Tradeoffs among health risks, environmental effects, and other pertinent factors will be highlighted. The USEPA will select the corrective measure alternative or alternatives to be implemented based on the results of Task II and III. At a minimum the criteria in the sections that follow will be used to justify the final corrective measure or measures.

8.3.1 Technical

8.3.1.1 Performance

Corrective measure or measures that are most effective at performing their intended functions and maintaining the performance over extended periods of time will be given preference.

8.3.1.2 Reliability

Corrective measure or measures that do not require frequent or complex operation and maintenance activities and that have proven effective under waste and facility conditions similar to those anticipated will be given preference.

8.3.1.3 Implementability

Corrective measure or measures that can be constructed and operated to reduce levels of contamination to attain or exceed applicable standards in the shortest period of time will be preferred.

8.3.1.4 Safety

Corrective measure or measures that pose the least threat to the safety of nearby residents and environments as well as workers during implementation will be preferred.

8.3.2 Human Health

The corrective measure or measures will comply with existing USEPA criteria, standards, or guidelines for the protection of human health. Corrective measures that provide the minimum level of exposure to contaminants and the maximum reduction in exposure with time are preferred.

8.3.3 Environmental

The corrective measure or measures posing the least adverse impact (or greatest improvement) over the shortest period of time on the environment will be favored.

8.4 Task IV - Reports

Three CMS Task I Reports will be prepared and submitted for approval within sixty (60) days after receipt of the data validation report for data collected during the CMS Investigation described in this work plan. The Task I Report shall include the items listed in Section 8.1 of this work plan, including establishment of CAOs. Alternatively, a CMS Report will be prepared and submitted, proposing a streamlined CMS process.

Upon approval of the CMS Task I Report or CMS Report, a CMS Final Report will be prepared and submitted for approval within sixty (60) days. The CMS Final Report to be developed will include all the information gathered under the approved CMS Work Plan. At a minimum the report will include:

- A description of the facility;
  - Site topographic map & preliminary layouts.

- A summary of the corrective measure or measures;
  - Description of the corrective measure or measures and rationale for selection;
  - Performance expectations;
  - Preliminary design criteria and rationale;
  - General operation and maintenance requirements; and
  - Long-term monitoring requirements (if any).

- A summary of the previous (or proposed) investigations and impact on the selected corrective measure or measures;
  - Field studies (for applicable media); and
  - Proposed Laboratory studies (bench scale treatability studies – if required),
  - Proposed Pilot-scale tests (if required)

- Design and Implementation Precautions;
  - Special technical problems;
  - Additional engineering data required;
  - Permits and regulatory requirements;
  - Access, easements, right-of-way;
  - Health and safety requirements; and
  - Community relations activities.

- Cost Estimates and Schedules;
  - Capital cost estimate;
  - Operation and maintenance cost estimate; and
  - Project schedule (design, construction, operation).

9.0 SCHEDULE

Schedules for the implementation of this work plan, and follow-up reports for the CMS for SWMUs 27, 28 and 29 are provided as Figures 9-1, 9-2 and 9-3, respectively. Currently, it is anticipated that the investigation programs for the three sites will be staggered by approximately one month.

It should be noted that this schedule is dependent upon USEPA review time. Many other factors can also extend the schedule such as resampling if further re-characterization is required, weather delays in the field, or consensus cannot be reached on how the USEPA's comments are to be incorporated.

10.0 PROJECT ORGANIZATION

An organizational chart presenting the proposed staffing for this project is provided on Figure 10-1. This section also outlines the responsibilities and reporting requirements of field personnel and staff.

10.1 Project Team Responsibilities

Mr. Mark Kimes, P.E., Activity Coordinator 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 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 a Baker Geologist or Environmental Scientist. The Geologist/Environmental Scientist'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 CMS Reports for SWMUs 27, 28 and 29.

10.2 Field Reporting Requirements

The Geologist/Environmental Scientist will maintain a daily summary of each day's field activities. The following information will be included in this summary:

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

The Geologist/Environmental Scientist will receive direction from the Project Manager regarding any changes in scope of the investigation.

TABLES

TABLE 3-1

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM
SWMU 27 - CAPEHART WWTP SLUDGE DRYING BEDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

		Analysis Requested				
Media	**Sample Depth (ft bgs)**	**App IX Metals (Total)**	**App IX Metals (Dissolved)**	**AVS/SEM Metals**	**TOC**	**Comment**
Surface Soil Samples						
27SS08	0.0-1.0	X				
27SS09	0.0-1.0	X				
27SS09D	0.0-1.0	X				Duplicate
27SB09-00	0.0-1.0	X				
27SB10-00	0.0-1.0	X				
27SB11-00	0.0-1.0	X				
27SB15-00	0.0-1.0	X				
27SB16-00	0.0-1.0	X				
27SB16-00D	0.0-1.0	X				Duplicate
27SB16-00MS/MSD	0.0-1.0	X				Matrix Spike/Matrix Spike Duplicate
27SB17-00	0.0-1.0	X				
27SB18-00	0.0-1.0	X				
27SB19-00	0.0-1.0	X				
27SB20-00	0.0-1.0	X				
Subsurface Soil Samples						
27SB09-01	1.0-3.0	X				
27SB10-01	1.0-3.0	X				
27SB11-01	1.0-3.0	X				
27SB12-01	1.0-3.0	X				
27SB13-01	1.0-3.0	X				
27SB14-01	1.0-3.0	X				
27SB15-01	1.0-3.0	X				
27SB15-01D	1.0-3.0	X				Duplicate
27SB16-01	1.0-3.0	X				
27SB17-01	1.0-3.0	X				
27SB18-01	1.0-3.0	X				
27SB19-01	1.0-3.0	X				
27SB20-01	1.0-3.0	X				
27SB20-01D	1.0-3.0	X				Duplicate
27SB20-01MS/MSD	1.0-3.0	X				Matrix Spike/Matrix Spike Duplicate
27SB21-01	1.0-3.0	X				
Surface Water Samples						
27SW01	NA	X	X			
27SW02	NA	X	X			
27SW03	NA	X	X			
27SW04	NA	X	X			
27SW05	NA	X	X			

TABLE 3-1

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM
SWMU 27 - CAPEHART WWTP SLUDGE DRYING BEDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Media	Sample Depth (ft bgs)	Analysis Requested: App IX Metals (Total)	Analysis Requested: App IX Metals (Dissolved)	Analysis Requested: AVS/SEM Metals	Analysis Requested: TOC	Comment
Surface Water Samples						
27SW06	NA	X	X			
27SW06D	NA	X	X			Duplicate
27SW06MS/MSD	NA	X	X			Matrix Spike/Matrix Spike Duplicate
27SW07	NA	X	X			
27SW08	NA	X	X			
27SW09	NA	X	X			
27SW10	NA	X	X			
Estuarine Sediment Samples						
27SD01	0-0.5	X		X	X	
27SD02	0-0.5	X			X	
27SD03	0-0.5	X		X	X	
27SD04	0-0.5	X			X	
27SD05	0-0.5	X		X	X	
27SD06	0-0.5	X		X	X	
27SD07	0-0.5	X			X	
27SD08	0-0.5	X			X	
27SD09	0-0.5	X		X	X	
27SD09D	0-0.5	X				Duplicate
27SD09MS/MSD	0-0.5	X		X		Matrix Spike/Matrix Spike Duplicate
27SD10	0-0.5	X			X	
27SD11	0-0.5	X			X	
27SD12	0-0.5	X		X	X	
27SD13	0-0.5	X			X	
27SD14	0-0.5	X		X	X	
27SD14D	0-0.5	X				Duplicate
27SD15	0-0.5	X		X	X	
27SD16	0-0.5	X		X	X	
27SD17	0-0.5	X		X	X	
27SD18	0-0.5	X		X	X	
27SD19	0-0.5	X			X	
27SD20	0-0.5	X		X	X	
27SD21	0-0.5	X			X	
27SD22	0-0.5	X			X	
27SD22D	0-0.5	X				Duplicate
27SD22MS/MSD	0-0.5	X				Matrix Spike/Matrix Spike Duplicate

Notes:

ft bgs - feet below ground surface
App IX - Appendix IX
AVS - Acid Volatile Sulfides
NA - Not Applicable
SEM - Simultaneously Extracted Metals
TBD - To be determined in the field
TOC - Total Organic Carbon

TABLE 3-2

METHOD PERFORMANCE LIMITS
PARAMETER LIST AND CONTRACT
REQUIRED QUANTITATION LIMITS (CRQL)
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

PCBs	Method Number	Quantitation Limits*		Preparation Methods		Method Description
		Water (µg/L)	Low Soil (µg/kg)	Water	Soil	
Aroclor-1016	8082A	1.0	33	3520C	3550B	GC
Aroclor-1221	8082A	2.0	67	3520C	3550B	GC
Aroclor-1232	8082A	1.0	33	3520C	3550B	GC
Aroclor-1242	8082A	1.0	33	3520C	3550B	GC
Aroclor-1248	8082A	1.0	33	3520C	3550B	GC
Aroclor-1254	8082A	1.0	33	3520C	3550B	GC
Aroclor-1260	8082A	1.0	33	3520C	3550B	GC
Appendix IX Metals	**Method Number**	**Quantitation Limits***		**Preparation Methods**		**Method Description**
		Water (µg/L)	**Low Soil (mg/kg)**	**Water**	**Soil**	
Antimony	6020A	20	2.0	3005A	3050B	ICP/MS
Arsenic	6020A	10	1.0	3005A	3050B	ICP/MS
Barium	6020A	10	1.0	3005A	3050B	ICP/MS
Beryllium	6020A	4.0	0.4	3005A	3050B	ICP/MS
Cadmium	6020A	5.0	0.5	3005A	3050B	ICP/MS
Chromium	6020A	10	1.0	3005A	3050B	ICP/MS
Cobalt	6020A	10	1.0	3005A	3050B	ICP/MS
Copper	6020A	20	2.0	3005A	3050B	ICP/MS
Lead	6020A	5.0	0.5	3005A	3050B	ICP/MS
Mercury	7470A/7471A	0.2	0.02	7470A	7471A	Cold Vapor AA
Nickel	6020A	40	4.0	3005A	3050B	ICP/MS
Selenium	6020A	10	1.0	3005A	3050B	ICP/MS
Silver	6020A	10	1.0	3005A	3050B	ICP/MS
Thallium	6020A	10	1.0	3005A	3050B	ICP/MS
Tin	6020A	10	5.0	3005A	3050B	ICP/MS
Vanadium	6020A	10	1.0	3005A	3050B	ICP/MS
Zinc	6020A	20	2.0	3005A	3050B	ICP/MS
Total Organic Carbon	**Method Number**	**Quantitation Limits***		**Preparation Methods**		**Method Description**
		Water (mg/L)	**Soil (mg/kg)**	**Water**	**Soil**	
TOC	9060A	NA	1	NA	NA	Carbonaceous Analyzer
AVS/SEM Metals	**Method Number**	**Quantitation Limits***		**Preparation Methods**		**Method Description**
		Water (mg/L)	**Soil (umol/g)**	**Water**	**Soil**	
Cadmium	6010C	N/A	0.00089	NA	821/R-91-100	SEM/ICP
Copper	6010C	N/A	0.0079	N/A	821/R-91-100	SEM/ICP
Lead	6010C	N/A	0.0012	N/A	821/R-91-100	SEM/ICP
Nickel	6010C	N/A	0.0085	N/A	821/R-91-100	SEM/ICP
Silver	6010C	N/A	0.0023	N/A	821/R-91-100	SEM/ICP
Zinc	6010C	N/A	0.0276	N/A	821/R-91-100	SEM/ICP
AVS	821/R-91-100	N/A	TBD	N/A	821/R-91-100	AVS

TABLE 3-2

METHOD PERFORMANCE LIMITS
PARAMETER LIST AND CONTRACT
REQUIRED QUANTITATION LIMITS (CRQL)
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Reactivity, Corrosivity,	Method Number	Quantitation Limits*		Preparation Methods		Method Description
		Water (mg/L)	Soil (mg/kg)	Water	Soil	
Cyanide	9012B	1	1	9012A	9012A	Titrimetric
Flashpoint	1010A/1030	NA	NA	NA	NA	Pensky-Martens Closed Cup Tester
pH	9040C/9045D	NA	NA	NA	NA	Electrometric
Sulfide	9034	1	10	9030B	9030B	Titrimetric
TCLP Metals	**Method Number**	**Quantitation Limits***		**Preparation Methods**		**Method Description**
		Water (µg/L)	**Soil (µg/L)**	**Water**	**Soil**	
Arsenic	6010C(3050B/ 3010A)	NA	10	NA	1311/3010A	TCLP/ICP
Barium	6010C(3050B/ 3010A)	NA	10	NA	1311/3010A	TCLP/ICP
Cadmium	6010C(3050B/ 3010A)	NA	5	NA	1311/3010A	TCLP/ICP
Chromium	6010C(3050B/ 3010A)	NA	10	NA	1311/3010A	TCLP/ICP
Lead	6010C(3050B/ 3010A)	NA	5	NA	1311/3010A	TCLP/ICP
Mercury	7471B/7470A	NA	0.20	NA	1311/7470A	TCLP/Cold Vapor AA
Selenium	6010C(3050B/ 3010A)	NA	10	NA	1311/3010A	TCLP/ICP
Silver	6010C(3050B/ 3010A)	NA	10	NA	1311/3010A	TCLP/ICP

Notes:

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

µg/kg - micrograms per kilogram
µg/L - micrograms per liter
mg/L - milligrams per liter
mg/kg - milligrams per kilogram
umole/g - micromoles per gram
AVS - Acid Volatile Sulfides
AA - Atomic Adsorption
GC - Gas Chromotography

ICP - Inductively Coupled Plasma
MS - Mass Spectrometry
NA - Not applicable
PCB - Polychlorinated Biphenyls
SEM - Simultaneously Extracted Metals
TCLP - Toxicity Characteristic Leaching Procedure
TBD - To be detetermined upon laboratory selection

TABLE 3-3

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM
SWMU 28 - BUNDY WWTP SLUDGE DRYING BEDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

		Analysis Requested					
Media	Sample Depth (ft bgs)	App IX Metals (Total)	App IX Metals (Dissolved)	App IX PCBs	AVS/SEM Metals	TOC	Comment
Surface Soil Samples							
28SS13	0.0 - 1.0	X					
28SS13D	0.0 - 1.0	X					Duplicate
28SS13MS/MSD	0.0 - 1.0	X					Matrix Spike/Matrix Spike Duplicate
28SS14	0.0 - 1.1	X					
28SS15	0.0 - 1.0	X					
28SS16	0.0 - 1.0	X		X			
28SS17	0.0 - 1.0	X					
28SS18	0.0 - 1.0	X		X			
28SS19	0.0 - 1.0	X					
28SS20	0.0 - 1.0	X					
28SS20D	0.0 - 1.0	X					Duplicate
28SS21	0.0 - 1.0	X					
28SS22	0.0 - 1.0	X					
28SS23	0.0 - 1.0	X					
28SS24	0.0 - 1.0	X					
28SS25	0.0 - 1.0	X					
28SS26	0.0 - 1.0	X					
28SS27	0.0 - 1.0	X		X			
28SS28	0.0 - 1.0	X		X			
28SS29	0.0 - 1.0	X					
28SS30	0.0 - 1.0	X					
28SS31	0.0 - 1.0	X					
28SS32	0.0 - 1.0	X		X			
28SS32D	0.0 - 1.0	X		X			Duplicate
28SS32MS/MSD	0.0 - 1.0	X		X			Matrix Spike/Matrix Spike Duplicate
28SS33	0.0 - 1.0	X					
28SS34	0.0 - 1.0	X					
28SS35	0.0 - 1.0	X					
28SS36	0.0 - 1.0	X					
28SS37	0.0 - 1.0	X					
28SS38	0.0 - 1.0	X					
28SS38D	0.0 - 1.0	X					Duplicate
28SS39	0.0 - 1.0	X					
28SS40	0.0 - 1.0	X					
28SS41	0.0 - 1.0	X					
28SB10-00	0.0 - 1.0	X					
28SB14-00	0.0 - 1.0	X					
28SB15-00	0.0 - 1.0	X					

TABLE 3-3

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM
SWMU 28 - BUNDY WWTP SLUDGE DRYING BEDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Media	Sample Depth (ft bgs)	Analysis Requested					Comment
		App IX Metals (Total)	App IX Metals (Dissolved)	App IX PCBs	AVS/SEM Metals	TOC	
Subsurface Soil Samples							
28SB10-01	1.0 - 3.0	X					
28SB14-01	1.0 - 3.0	X					
28SB14-01D	1.0 - 3.0	X					Duplicate
28SB15-01	1.0 - 3.0	X					
28SB16-01	1.0 - 3.0	X					
28SB16-02	3.0 - 5.0	X					
28SB16-03	5.0 -7.0	X					
28SB16-04	7.0 - 9.0	X					
28SB17-01	1.0 - 3.0	X					
28SB17-01D	1.0 - 3.0	X					Duplicate
28SB17-01MS/MSD	1.0 - 3.0	X					Matrix Spike/Matrix Spike Duplicate
28SB17-02	3.0 - 5.0	X					
28SB17-03	5.0 -7.0	X					
28SB17-04	7.0 - 9.0	X					
28SB18-01	1.0 - 3.0	X					
28SB18-02	3.0 - 5.0	X					
28SB18-03	5.0 -7.0	X					
28SB18-04	7.0 - 9.0	X					
Esturarine Surface Water Samples (if required)							
28SW01	NA	X	X				
28SW02	NA	X	X				
28SW03	NA	X	X				
28SW04	NA	X	X				
28SW05	NA	X	X				
28SW06	NA	X	X				
28SW07	NA	X	X				
28SW08	NA	X	X				
28SW08D	NA	X	X				Duplicate
28SW08MS	NA	X	X				Matrix Spike
28SW08MSD	NA	X	X				Matrix Spike Duplicate
28SW09	NA	X	X				
28SW10	NA	X	X				

TABLE 3-3

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM
SWMU 28 - BUNDY WWTP SLUDGE DRYING BEDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

		Analysis Requested					
Media	Sample Depth (ft bgs)	App IX Metals (Total)	App IX Metals (Dissolved)	App IX PCBs	AVS/SEM Metals	TOC	Comment
Esturarine Sediment Samples (if required)							
28SD01	0.0 - 0.5	X				X	
28SD02	0.0 - 0.5	X			X	X	
28SD03	0.0 - 0.5	X				X	
28SD04	0.0 - 0.5	X			X	X	
28SD05	0.0 - 0.5	X			X	X	
28SD06	0.0 - 0.5	X			X	X	
28SD07	0.0 - 0.5	X				X	
28SD08	0.0 - 0.5	X			X	X	
28SD08D	0.0 - 0.5	X					Duplicate
28SD08MS/MSD	0.0 - 0.5	X			X		Matrix Spike/Matrix Spike Duplicate
28SD09	0.0 - 0.5	X			X	X	
28SD10	0.0 - 0.5	X				X	
Groundwater Samples							
28GW05	NA	X	X				
28GW06	NA	X	X				(if water present)
28GW07	NA	X	X				
28GW08	NA	X	X				
28GW09	NA	X	X				
28GW10	NA	X	X				
28GW10D	NA	X	X				Duplicate
28GW10MS	NA	X	X				Matrix Spike
28GW10MSD	NA	X	X				Matrix Spike Duplicate
28GW11	NA	X	X				
28GW12	NA	X	X				
28GW13	NA	X	X				

Notes:

ft bgs - feet below ground surface
App IX - Appendix IX
AVS - Acid Volatile Sulfides
NA - Not Applicable
PCB - Polychlorinated Biphenyl
SEM - Simultaneously Extracted Metals
TBD - To be determined in the field
TOC - Total Organic Carbon

TABLE 3-4

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM
SWMU 29 - INDUSTRIAL AREA WWTP SLUDGE DRYING BEDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

		Analysis Requested	
Media	**Sample Depth (ft bgs)**	**App IX Metals**	**Comment**
Surface Soil Samples			
29SS03	0.0 - 1.0	X	
29SS04	0.0 - 1.0	X	
29SS04D	0.0 - 1.0	X	Duplicate
29SS05	0.0 - 1.0	X	
29SS06	0.0 - 1.0	X	
29SS07	0.0 - 1.0	X	
29SS08	0.0 - 1.0	X	
29SS09	0.0 - 1.0	X	
29SS10	0.0 - 1.0	X	
29SS11	0.0 - 1.0	X	
29SS12	0.0 - 1.0	X	
29SS13	0.0 - 1.0	X	
29SS14	0.0 - 1.0	X	
29SS15	0.0 - 1.0	X	
29SS16	0.0 - 1.0	X	
29SS17	0.0 - 1.0	X	
29SB16-00	0.0 - 1.0	X	
29SB17-00	0.0 - 1.0	X	
29SB18-00	0.0 - 1.0	X	
29SB18-00D	0.0 - 1.0	X	Duplicate
29SB18-00MS/MSD	0.0 - 1.0	X	Matrix Spike/Matrix Spike Duplicate
29SB19-00	0.0 - 1.0	X	
29SB20-00	0.0 - 1.0	X	
Subsurface Soil Samples			
29SB15-01	1.0-3.0	X	
29SB16-01	1.0-3.0	X	
29SB17-01	1.0-3.0	X	
29SB18-01	1.0-3.0	X	
29SB19-01	1.0-3.0	X	
29SB19-01D	1.0-3.0	X	Duplicate
29SB19-01MS/MSD	1.0-3.0	X	Matrix Spike/Matrix Spike Duplicate
29SB20-01	1.0-3.0	X	

Notes:
ft bgs - feet below ground surface
App IX - Appendix IX

TABLE 3-5

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM
QA/QC AND IDW SAMPLES FOR SWMU 27
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

		Analysis Requested				
Sample Media	**Media**	**App IX Metals (Total)**	**TCLP (Metals)**	**TCLP (Volatiles)**	**RCRA Characteristics (flashpoint, corrosivity, reactivity)**	**Comment**
Equipment Rinsates	27ER01	X				Geoprobe Macro Core Sampler
	27ER02	X				Aluminum Pan
	27ER03	X				Stainless Steel Spoon
	27ER04	X				Bucket Auger
Field Blanks	27FB01	X				Store-bought Distilled Water
	27FB02	X				Laboratory-Grade Deionized Water
IDW	27IDW01	X	X	X	X	Solid

Note:
App IX - Appendix IX
TCLP - Toxicity Characteristic Leaching Procedure
IDW - Investigation Derived Waste
RCRA - Resource Conservation and Recovery Act

TABLE 3-6

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM
QA/QC AND IDW SAMPLES FOR SWMU 28
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Sample Media	Media	Analysis Requested: App IX Metals (Total)	App IX PCBs	TCLP (Metals)	TCLP (Volatiles)	RCRA Characteristics (flashpoint, corrosivity, reactivity)	Comment
Equipment Rinsates	28ER01	X					Geoprobe Macro Core Sampler
	28ER02	X	X				Stainless Steel Spoon
	28ER03	X					Stainless Steel Spoon
	28ER04	X					Aluminum Pan
	28ER05	X					Bucket Auger
	28ER06	X					Groundwater Equipment
	28ER07	X					Groundwater Tubing
Field Blanks	28FB03	X	X				Store-bought Distilled Water
	28FB04	X	X				Laboratory-Grade Deionized Water
IDW	28IDW01	X	X	X	X	X	Solid
	28IDW02	X		X	X	X	Liquid purge water and decon water from all three sites

Note:

App IX - Appendix IX
TCLP - Toxicity Characteristic Leaching Procedure
IDW - Investigation Derived Waste
PCB - Polychlorinated Biphenyl
RCRA - Resource Conservation and Recovery Act

TABLE 3-7

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM
QA/QC AND IDW SAMPLES FOR SWMU 29
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

		Analysis Requested				
Sample Media	**Media**	**App IX Metals (Total)**	**TCLP (Metals)**	**TCLP (Volatiles)**	**RCRA Characteristics (flashpoint, corrosivity, reactivity)**	**Comment**
Equipment Rinsates	29ER01	X				Geoprobe Macro Core Sampler
	29ER02	X				Aluminum Pan
	29ER03	X				Stainless Steel Spoon
Field Blanks	29FB05	X				Store-bought Distilled Water
	29FB06	X				Laboratory-Grade Deionized Water
IDW	29IDW01	X	X	X	X	Solid

Note:

App IX - Appendix IX
TCLP - Toxicity Characteristic Leaching Procedure
IDW - Investigation Derived Waste
RCRA - Resource Conservation and Recovery Act

TABLE 5-1
LIST OF BIRDS REPORTED FROM OR HAVING THE POTENTIAL TO OCCUR AT NAVAL ACTIVITY PUERTO RICO
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Common Name [1]		
Pied-billed grebe	Red-billed tropicbird	Brown pelican
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 5-1
LIST OF BIRDS REPORTED FROM OR HAVING THE POTENTIAL TO OCCUR AT NAVAL ACTIVITY PUERTO RICO
CMS 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 5-2
PRELIMINARY SCREENING-LEVEL ASSESSMENT ENDPOINTS, RISK QUESTIONS, AND MEASUREMENT ENDPOINTS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Assessment Endpoints	Risk Questions	Measurement Endpoints	SWMU
Terrestrial Habitat: Survival, growth, and reproduction of terrestrial soil invertebrate communities.	Are site-related chemical concentrations in surface and subsurface soil sufficient to adversely affect terrestrial soil invertebrate communities?	Comparison of maximum chemical concentrations in surface and subsurface soil with soil screening values.	27, 28, and 29
Survival, growth, and reproduction of terrestrial plant communities.	Are site-related surface and subsurface soil concentrations sufficient to adversely affect terrestrial plant communities?	Comparison of maximum chemical concentrations in surface and subsurface soil with soil screening values.	27, 28, and 29
Survival, growth, and reproduction of terrestrial avian herbivores.	Are site-related chemical concentrations in surface and subsurface soil sufficient to cause adverse effects (on growth, survival, or reproduction) to avian species that may consume terrestrial plants from the site?	Comparison of literature-derived chronic No Observed Adverse Effect Level (NOAEL) values for survival, growth, and/or reproductive effects with modeled dietary exposure doses based on maximum chemical concentrations in surface and subsurface soil.	27, 28, and 29
Survival, growth, and reproduction of terrestrial avian omnivores.	Are site-related chemical concentrations in surface and subsurface soil sufficient to cause adverse effects (on growth, survival, or reproduction) to avian species that may consume terrestrial plants and soil invertebrates from the site?	Comparison of literature-derived chronic No Observed Adverse Effect Level (NOAEL) values for survival, growth, and/or reproductive effects with modeled dietary exposure doses based on maximum chemical concentrations in surface and subsurface soil.	27, 28, and 29
Survival, growth, and reproduction of terrestrial avian carnivores.	Are site-related chemical concentrations in surface and subsurface soil sufficient to cause adverse effects (on growth, survival, or reproduction) to avian species that may consume small mammals from the site?	Comparison of literature-derived chronic No Observed Adverse Effect Level (NOAEL) values for survival, growth, and/or reproductive effects with modeled dietary exposure doses based on maximum chemical concentrations in surface and subsurface soil.	27, 28, and 29
Survival, growth, and reproduction of terrestrial amphibian and reptile communities.	Are site-related chemical concentrations in surface soil sufficient to cause adverse effects (on growth, survival, or reproduction) to terrestrial amphibians and reptiles?	Qualitative examination of exposures and risks to ecological receptors occupying similar trophic levels.	27, 28, and 29

TABLE 5-2
PRELIMINARY SCREENING-LEVEL ASSESSMENT ENDPOINTS, RISK QUESTIONS, AND MEASUREMENT ENDPOINTS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Assessment Endpoints	Risk Questions	Measurement Endpoints	SWMU
Estuarine Wetland [1]:			
Survival, growth, and reproduction of aquatic invertebrate communities.	Are site-related chemical concentrations in surface water and sediment sufficient to adversely affect aquatic invertebrate communities?	Comparison of maximum chemical concentrations in surface watre and sediment with surface water and sediment screening values.	27
Survival, growth, and reproduction of aquatic plant communities.	Are site-related chemical concentrations in surface water and sediment sufficient to adversely affect aquatic plant communities?	Comparison of maximum chemical concentrations in surface water and sediment with surface water and sediment screening values.	27
Survival, growth, and reproduction of fish communities	Are site-related chemical concentrations in surface water and sediment sufficient to adversely affect fish communities?	Comparison of maximum chemical concentrations in surface water and sediment with surface water and sediment screening values.	27
Survival, growth, and reproduction of avian invertebrate consumers.	Are site-related chemical concentrations in sediment sufficient to cause adverse effects (on growth, survival, or reproduction) to avian species that may consume aquatic invertebrates from the site?	Comparison of literature-derived chronic No Observed Adverse Effect Level (NOAEL) values for survival, growth, and/or reproductive effects with modeled dietary exposure doses based on maximum chemical concentrations in sediment.	27
Survival, growth, and reproduction of avian piscivores.	Are site-related chemical concentrations in sediment sufficient to cause adverse effects (on growth, survival, or reproduction) to avian species that may consume fish from the site?	Comparison of literature-derived chronic No Observed Adverse Effect Level (NOAEL) values for survival, growth, and/or reproductive effects with modeled dietary exposure doses based on maximum chemical concentrations in sediment.	27

Notes:

[1] Observations during the Full RCRA facility Investigation (RFI) at SWMU 28 indicate that the portion of the E2F03 wetland unit depicted on Figure 1-4 immediately adjacent to the sludge drying beds functions as upland habitat (i.e., saturated sediments and standing water are not present). As such, the proposed soil samples collected within this portion of the wetland unit will be evaluated using terrestrial receptors/receptor groups. It is noted that avaialble habitat and wildlife usage will be documented during the Corrective Measures Study field investigation to verify observations made during the Full RFI field investigation.

TABLE 5-3
LOG K_{ow} AND K_{oc} VALUES FOR ORGANIC CHEMICALS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Log K_{ow} Range	Recommended Log K_{ow}	Reference	K_{oc} [(1)] (L/Kg)	Bioaccumulative Chemical [(2)]
Volatile Organics:					
1,1,1,2-Tetrachloroethane	2.63 to 3.03	2.63	USEPA 1995	385	Yes
1,1,1-Trichloroethane	2.47 to 2.51	2.48	USEPA 1995	274	No
1,1,2,2-Tetrachloroethane	2.31 to 2.64	2.39	USEPA 1995	224	No
1,1,2-Trichloroethane	2.03 to 2.07	2.05	USEPA 1995	104	No
1,1-Dichloroethane	1.78 to 1.85	1.79	USEPA 1995	57.5	No
1,1-Dichloroethene	2.13 to 2.37	2.13	USEPA 1995	124	No
1,2,3-Trichloropropane	1.98 to 2.63	2.25	USEPA 1995	163	No
1,2-Dibromo-3-chloropropane	2.26 to 2.41	2.34	USEPA 1995	200	No
1,2-Dichloroethane	1.4 to 1.48	1.47	USEPA 1995	27.9	No
1,2-Dichloropropane	1.94 to 1.99	1.97	USEPA 1995	86.5	No
2-Butanone (MEK)	0.28 to 0.69	0.28	USEPA 1995	1.89	No
2-Chloro-1,3-butadiene	2.03 to 2.13	2.08	USEPA 1995	124.00	No
2-Hexanone	Not Reported	1.38	USEPA 1996a	22.7	No
3-Chloro-1-propene	Not Reported	1.93	SRC 1998	79.0	No
4-Methyl-2-pentanone (MIBK)	Not Reported	1.31	SRC 1998	19.4	No
Acetone	-0.21 to -0.24	-0.24	USEPA 1995	0.58	No
Acetonitrile	-0.34 to -0.39	-0.34	USEPA 1995	0.46	No
Acrolein	-0.01 to 0.90	-0.01	USEPA 1995	0.98	No
Acrylonitrile	-0.92 to 1.20	0.25	USEPA 1995	1.76	No
Benzene	1.83 to 2.50	2.13	USEPA 1995	124	No
Bromoform	2.30 to 2.38	2.35	USEPA 1995	204	No
Bromomethane	Not Reported	1.19	USEPA 1996a	14.8	No
Carbon disulfide	1.84 to 2.16	2.00	USEPA 1995	92.5	No
Carbon tetrachloride	2.03 to 3.10	2.73	USEPA 1995	483	Yes
Chlorobenzene	2.56 to 3.79	2.86	USEPA 1995	648	Yes
Clorodibromomethane	2.13 to 2.24	2.17	USEPA 1995	136	No
Chloroethane	Not Reported	1.43	USEPA 1996a	25.5	No
Chloroform	1.81 to 3.04	1.92	USEPA 1995	77.2	Yes
Chloromethane	Not Reported	0.91	USEPA 1996a	7.85	No
cis-1,3-Dichloropropene	Not Reported	2.06	SRC 1998	106	No
Dibromomethane	Not Reported	1.53	USEPA 1996a	31.9	No
Dichlorobromomethane	1.88 to 2.14	2.10	USEPA 1995	116	No
Dichlorodifluoromethane	2.0 to 2.37	2.16	USEPA 1995	133	No
Ethylbenzene	3.07 to 3.57	3.14	USEPA 1995	1,222	Yes
Ethylene dibromide	Not Reported	2.00	USEPA 1996a	92.5	No
Ethyl methacrylate	1.59 to 1.65	1.59	USEPA 1996a	36.6	No
Iodomethane	Not Reported	1.51	SRC 1998	30.5	No
Isobutyl alcohol	0.65 to 0.76	0.75	USEPA 1995	5.46	No
Methacrylonitrile	0.54 to 0.70	-0.54	USEPA 1996a	0.29	No
Methylene chloride	1.22 to 1.40	1.25	USEPA 1995	16.9	No
Methyl methacrylate	1.11 to 1.38	1.38	USEPA 1995	22.7	No
Pentachloroethane	Not Reported	3.06	USEPA 1996a	1,019	Yes
Propionitrile	Not Reported	0.16	SRC 1998	1.44	No
Styrene	2.76 to 3.16	2.94	USEPA 1995	777	Yes
Tetrachloroethene	2.53 to 2.98	2.67	USEPA 1995	422	No
Toluene	2.21 to 3.13	2.75	USEPA 1995	505	Yes
trans-1,2-Dichloroethene	1.77 to 2.10	2.07	USEPA 1995	108	No
trans-1,3-Dichloropropene	Not Reported	2.03	SRC 1998	99.0	No
trans-1,4-Dichloro-2-butene	Not Reported	2.60	SRC 1998	360	No
Trichloroethene	2.42 to 3.14	2.71	USEPA 1995	462	Yes

TABLE 5-3
LOG K_{ow} AND K_{oc} VALUES FOR ORGANIC CHEMICALS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Log K_{ow} Range	Recommended Log K_{ow}	Reference	K_{oc} (1) (L/Kg)	Bioaccumulative Chemical (2)
Volatile Organics:					
Trichlorofluoromethane	2.44 to 2.58	2.53	USEPA 1995	307	No
Vinyl acetate	0.21 to 0.83	0.73	USEPA 1995	5.22	No
Vinyl chloride	1.23 to 1.52	1.50	USEPA 1995	29.8	No
Xylenes (total) (3)	2.77 to 3.54	3.13	USEPA 1995	1,194	Yes
Semi-Volatile Organics:					
1,2,4,5-Tetrachlorobenzene	4.51 to 4.83	4.64	USEPA 1995	36,425	Yes
1,2,4-Trichlorobenzene	3.89 to 4.23	4.01	USEPA 1995	8,752	Yes
1,3,5-Trinitrobenzene	1.18 to 1.37	1.18	USEPA 1995	14.5	No
1,1-Biphenyl	Not Reported	3.98	SRC 1998	8,177	Yes
1,2-Dichlorobenzene	3.20 to 3.61	3.43	USEPA 1995	2,355	Yes
1,3-Dichlorobenzene	Not Reported	3.60	USEPA 1996a	3,460	Yes
1,3-Dinitrobenzene	1.49 to 1.63	1.50	USEPA 1995	29.8	No
1,4,-Dichlorobenzene	3.26 to 3.78	3.42	USEPA 1995	2,302	Yes
1,4-Dioxane	Not Reported	-0.27	USEPA 1996a	0.54	No
1,4-Naphthoquinone	Not Reported	1.71	SRC 1998	48.0	No
2,3,4,6-Tetrachlorophenol	Not Reported	4.45	USEPA 1996a	23,694	Yes
2,4,5-Trichlorophenol	Not Reported	3.72	USEPA 1996a	4,540	Yes
2,4,6-Trichlorophenol	3.29 to 4.05	3.70	USEPA 1995	4,339	Yes
2,2'-Oxybis(1-chloropropane)	Not Reported	2.48	USEPA 1996a	274	No
2,4-Dichlorophenol	2.80 to 3.30	3.08	USEPA 1995	1,066	Yes
2,4-Dimethylphenol	1.99 to 2.49	2.36	USEPA 1995	209	No
2,4-Dinitrophenol	1.40 to 1.79	1.55	USEPA 1995	33.4	No
2,4-Dinitrotoluene	1.98 to 2.05	2.01	USEPA 1995	94.6	No
2,6-Dichlorophenol	Not Reported	2.75	SRC 1998	505	No
2,6-Dinitrotoluene	1.72 to 2.03	1.87	USEPA 1995	68.9	No
2-Acetylaminofluorene	Not Reported	3.12	SRC 1998	1,167	Yes
2-Chloronaphthalene	Not Reported	3.38	USEPA 1996a	2,103	Yes
2-Chlorophenol	0.83 to 2.32	2.15	USEPA 1995	130	No
2-Methylphenol	1.90 to 2.04	1.99	USEPA 1995	90.5	No
2-Naphthylamine	2.09 to 2.42	2.28	USEPA 1995	174	No
2-Nitroaniline	Not Reported	1.85	USEPA 1996a	65.9	No
2-Nitrophenol	Not Reported	1.79	USEPA 1996a	57.5	No
2-Picoline	Not Reported	1.11	SRC 1998	12.3	No
2-Toluidine	Not Reported	1.32	SRC 1998	19.9	No
3,4-Methylphenol (4)	1.92 to 2.05	1.97	USEPA 1995	86.5	No
3,3'-Dichlorobenzidine	3.51 to 3.95	3.51	USEPA 1995	2,822	Yes
3,3'-Dimethylbenzidine	2.34 to 3.01	2.68	USEPA 1995	431	Yes
3-Methylcholanthrene	6.42 to 6.76	6.42	USEPA 1995	2,047,104	Yes
3-Nitroaniline	Not Reported	1.37	USEPA 1996a	22.2	No
4,6-Dinitro-2-methylphenol	Not Reported	2.12	USEPA 1996a	121	No
4-Aminobiphenyl	Not Reported	2.86	SRC 1998	648	No
4-Bromophenyl phenyl ether	4.89 to 5.24	5.00	USEPA 1995	82,277	Yes
4-Chloro-3-methylphenol	Not Reported	3.10	SRC 1998	1,116	Yes
4-Chloroaniline	1.57 to 2.02	1.85	USEPA 1995	65.9	No
4-Chlorophenyl phenyl ether	4.08 to 5.09	4.95	USEPA 1995	73,473	Yes
4-Nitroaniline	Not Reported	1.39	USEPA 1996a	23.3	No
4-Nitrophenol	Not Reported	1.91	SRC 1998	75.5	No
4-Nitroquinoline-1-oxide	Not Reported	1.09	SRC 1998	11.8	No
7,12-Dimethylbenz(a)anthracene	5.98 to 6.66	6.62	USEPA 1995	3,219,141	Yes
Acetophenone	1.55 to 1.72	1.64	USEPA 1995	41.0	No

TABLE 5-3
LOG K_{ow} AND K_{oc} VALUES FOR ORGANIC CHEMICALS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Log K_{ow} Range	Recommended Log K_{ow}	Reference	K_{oc} (1) (L/Kg)	Bioaccumulative Chemical (2)
Semi-Volatile Organics:					
A, A-Dimethyl phenethylamine	Not Reported	1.90	USEPA 1996a	73.8	No
Aniline	0.78 to 1.24	0.98	USEPA 1995	9.20	No
Aramite, total	Not Reported	4.82	SRC 1998	54,744	Yes
Benzyl alcohol	0.87 to 1.22	1.11	USEPA 1995	12.3	No
bis(2-Chloroethoxy)methane	Not Reported	0.75	USEPA 1996a	5.46	No
bis(2-Chloroethyl)ether	1.0 to 1.29	1.21	USEPA 1995	15.5	No
bis(2-Ethylhexyl)phthalate	4.20 to 8.61	7.30	USEPA 1995	15,003,065	Yes
Butyl benzyl phthalate	3.57 to 5.02	4.84	USEPA 1995	57,280	Yes
Diallate	3.79 to 5.23	4.49	USEPA 1995	25,939	Yes
Dibenzofuran	Not Reported	4.20	USEPA 1996a	13,455	Yes
Diethyl phthalate	1.40 to 3.00	2.50	USEPA 1995	287	Yes
Dimethyl phthalate	1.34 to 1.90	1.57	USEPA 1995	35.0	No
Di-n-butyl phthalate	3.74 to 4.79	4.61	USEPA 1995	34,034	Yes
Di-n-octyl phthalate	8.03 to 9.49	8.06	USEPA 1995	83,803,084	Yes
Dinoseb	Not Reported	3.69	USEPA 1996a	4,242	Yes
Ethyl methanesulfonate	0.01 to 0.05	0.05	USEPA 1995	1.12	No
Hexachlorobenzene	5.00 to 7.42	5.89	USEPA 1995	616,808	Yes
Hexachlorobutadiene	4.74 to 5.16	4.81	USEPA 1995	53,519	Yes
Hexachlorocyclopentadiene	5.04 to 5.51	5.39	USEPA 1995	198,907	Yes
Hexachloroethane	3.82 to 4.14	4.00	USEPA 1995	8,556	Yes
Hexachlorophene	7.08 to 7.60	7.54	USEPA 1995	25,828,548	Yes
Hexachloropropene	Not Reported	4.38	SRC 1998	20,222	Yes
Isophorone	1.67 to 1.90	1.70	USEPA 1995	46.9	No
Isosafrole	Not Reported	3.37	SRC 1998	2,056	Yes
Methapyrilene	Not Reported	2.87	SRC 1998	663	No
Methyl methanesulfonate	Not Reported	-0.66	SRC 1998	0.22	No
N-Nitro-o-toluidine	Not Reported	1.87	SRC 1998	68.90	No
n-Nitrosodiethylamine	0.29 to 0.56	0.48	USEPA 1995	2.97	No
n-Nitrosodimethylamine	-0.77 to -0.48	-0.57	USEPA 1995	0.28	No
n-Nitroso-di-n-butylamine	2.41 to 2.45	2.41	USEPA 1995	234	No
n-Nitroso-di-n-propylamine	1.31 to 1.45	1.40	USEPA 1995	23.8	No
n-Nitrosodiphenylamine	3.13 to 3.45	3.16	USEPA 1995	1,278	Yes
n-Nitrosomethylethylamine	-0.24 to 1.35	-0.12	USEPA 1995	0.76	No
n-Nitrosomorpholine	Not Reported	-0.44	SRC 1998	0.37	No
n-Nitrosopiperidine	0.25 to 0.63	0.63	USEPA 1995	4.16	No
n-Nitrosopyrrolidine	-0.29 to -0.19	-0.19	USEPA 1995	0.65	No
Nitrobenzene	Not Reported	1.84	USEPA 1996a	64.4	No
p-Dimethylamino azobenzene	Not Reported	4.58	SRC 1998	31,799	Yes
Pentachlorobenzene	4.88 to 6.12	5.26	USEPA 1995	148,204	Yes
Pentachloronitrobenzene	4.18 to 4.64	4.64	USEPA 1995	36,425	Yes
Pentachlorophenol	3.29 to 5.24	5.09	USEPA 1995	100,867	Yes
Phenacetin	Not Reported	1.58	SRC 1998	35.8	No
Phenol	0.79 to 1.55	1.48	USEPA 1995	28.5	No
p-Phenylene diamine	Not Reported	-0.30	SRC 1998	0.51	No
Pronamide	3.26 to 3.86	3.51	USEPA 1995	2,822	Yes
Pryridine	0.62 to 1.28	0.67	USEPA 1995	4.56	No
Safrole, total	2.66 to 2.88	2.66	USEPA 1995	412	No
PAHs:					
2-Methylnaphthalene	Not Reported	3.90	USEPA 1996a	6,823	Yes
Acenaphthene	3.77 to 4.49	3.92	USEPA 1995	7,139	Yes

TABLE 5-3
LOG K_{ow} AND K_{oc} VALUES FOR ORGANIC CHEMICALS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Log K_{ow} Range	Recommended Log K_{ow}	Reference	K_{oc} [(1)] (L/Kg)	Bioaccumulative Chemical [(2)]
PAHs:					
Acenaphthylene	Not Reported	4.10	USEPA 1996a	10,730	Yes
Anthracene	3.45 to 4.80	4.55	USEPA 1995	29,712	Yes
Benzo(a)anthracene	4.00 to 5.79	5.70	USEPA 1995	401,218	Yes
Benzo(a)pyrene	5.98 to 6.42	6.11	USEPA 1995	1,014,869	Yes
Benzo(b)fluoranthene	5.79 to 6.40	6.20	USEPA 1995	1,244,171	Yes
Benzo(g,h,i)perylene	6.63 to 7.05	6.70	USEPA 1995	3,858,158	Yes
Benzo(k)fluoranthene	6.12 to 6.27	6.20	USEPA 1995	1,244,171	Yes
Chrysene	5.41 to 5.79	5.70	USEPA 1995	401,218	Yes
Dibenzo(a,h)anthracene	6.50 to 6.88	6.69	USEPA 1995	3,771,812	Yes
Fluoranthene	4.31 to 5.39	5.12	USEPA 1995	107,954	Yes
Fluorene	4.04 to 4.40	4.21	USEPA 1995	13,763	Yes
Indeno(1,2,3-cd)pyrene	6.58 to 6.72	6.65	USEPA 1995	3,445,323	Yes
Naphthalene	3.01 to 4.70	3.36	USEPA 1995	2,010	Yes
Phenanthrene	4.28 to 4.57	4.55	USEPA 1995	29,712	Yes
Pyrene	4.76 to 5.52	5.11	USEPA 1995	105,538	Yes
PCBs:					
Aroclor-1016	Not Reported	5.62	SRC 1998	334,765	Yes
Aroclor-1221	Not Reported	4.53	SRC 1998	28,397	Yes
Aroclor-1232	Not Reported	4.53	SRC 1998	28,397	Yes
Aroclor-1242	Not Reported	6.29	SRC 1998	1,525,281	Yes
Aroclor-1248	Not Reported	6.34	SRC 1998	1,708,048	Yes
Aroclor-1254	Not Reported	6.79	SRC 1998	4,729,879	Yes
Aroclor-1260	Not Reported	8.27	SRC 1998	134,800,033	Yes

Notes:

K_{ow} = Octanol-Water Partition Coefficient
K_{oc} = Organic Carbon Partition Coefficient
L/kg = liter per kilogram
PAH = Polynuclear Aromatic Hydrocarbon
PCB = Polychlorinated Biphenyl
SRC = Syracuse Research Corporation
USEPA = United States Environmental Protection Agency

(1) K_{oc} values were estimated from the following equation: Log K_{oc} = 0.00028 + (0.983)(Log K_{ow}) (USEPA 1993 and 1996b).

(2) An organic chemical is considered a bioaccumulative chemical if its Log K_{ow} value is greater than or equal to 3.0. When a range of Log K_{ow} values is reported, the upper value within the range was conservatively used to identify bioaccumulative chemicals.

(3) The K_{ow} values shown are for o-xylene

(4) The K_{ow} values shown are for 3-methylphenol.

Table References:

Syracuse Research Corporation (SRC). 1998. Experimental Octanol/Water partition Coefficient (Log P) Database. Available at http://www.syrres.com/esc/est_kowdemo.htm

United States Environmental Protection Agency (USEPA). 1996a. Superfund Chemical Data Matrix. EPA/540/R-96/028.

TABLE 5-3
LOG K_{ow} AND K_{oc} VALUES FOR ORGANIC CHEMICALS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Table References (continued);

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

USEPA. 1995. Internal Report on Summary of Measured, Calculated and Recommended Log K_{ow} Values. Environmental Research Laboratory, Athens, GA. April 10, 1995.

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 5-4
SOIL SCREENING VALUES FOR PLANTS AND INVERTEBRATES
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Soil Screening Value	Reference	Comment
Volatile Organics (ug/kg):			
1,1,1,2-Tetrachloroethane	100	CCME 2007	Canadian soil quality guideline based on agricultural land uses
1,1,1-Trichloroethane	100	CCME 2007	Canadian soil quality guideline based on agricultural land uses
1,1,2,2-Tetrachloroethane	100	CCME 2007	Canadian soil quality guideline based on agricultural land uses
1,1,2-Trichloroethane	100	CCME 2007	Canadian soil quality guideline based on agricultural land uses
1,1-Dichloroethane	100	CCME 2007	Canadian soil quality guideline based on agricultural land uses
1,1-Dichloroethene	100	CCME 2007	Canadian soil quality guideline based on agricultural land uses
1,2,3-Trichloropropane	NA	---	---
1,2-Dibromo-3-chloropropane	NA	---	---
1,2-Dichloroethane	402 (1)	MHSPE 2000	---
1,2-Dichloropropane	700,000	Efroymson et al. 1997a	Toxicological threshold for earthworms
2-Butanone (MEK)	NA	---	---
2-Chloro-1,3-butadiene	NA	---	---
2-Hexanone	NA	---	---
3-Chloro-1-propene	NA	---	---
4-Methyl-2-pentanone (MIBK)	NA	---	---
Acetone	NA	---	---
Acetonitrile	NA	---	---
Acrolein	NA	---	---
Acrylonitrile	1,000,000	Efroymson et al. 1997a	Toxicological threshold for soil microorganisms and microbial processes
Benzene	101 (1)	MHSPE 2000	---
Bromoform	NA	---	---
Bromomethane	NA	---	---
Carbon disulfide	NA	---	---
Carbon tetrachloride	1,000,000	Efroymson et al. 1997a	Toxicological threshold for soil microorganisms and microbial processes
Chlorobenzene	40,000	Efroymson et al. 1997a	Toxicological threshold for earthworms
Chlorodibromomethane	NA	---	---
Chloroethane	NA	---	---
Chloroform	1,002 (1)	MHSPE 2000	---
Chloromethane	NA	---	---
cis-1,3-Dichloropropene	100	CCME 2007	Canadian soil quality guideline based on agricultural land uses
Dibromomethane	NA	---	---
Dichlorobromomethane	NA	---	---
Dichlorodifluoromethane	NA	---	---
Ethylbenzene	5,003 (1)	MHSPE 2000	---
Ethylene dibromide	300	CCME 2007	Canadian soil quality guideline based on agricultural land uses

TABLE 5-4
SOIL SCREENING VALUES FOR PLANTS AND INVERTEBRATES
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Soil Screening Value	Reference	Comment
Volatile Organics (ug/kg):			
Ethyl methacrylate	NA	---	---
Iodomethane	NA	---	---
Isobutyl alcohol	NA	---	---
Methacrylonitrile	NA	---	---
Methylene chloride	1,040 (1)	MHSPE 2000	---
Methyl methacrylate	NA	---	---
Pentachloroethane	NA	---	---
Propionitrile	NA	---	---
Styrene	10,030 (1)	MHSPE 2000	---
Tetrachloroethene	400 (1)	MHSPE 2000	---
Toluene	13,001 (1)	MHSPE 2000	---
trans-1,2-Dichloroethene	100	CCME 2007	Canadian soil quality guideline based on agricultural land uses
trans-1,3-Dichloropropene	100	CCME 2007	Canadian soil quality guideline based on agricultural land uses
trans-1,4-Dichloro-2-butene	1,000,000	Efroymson et al. 1997a	Toxicological threshold for soil microorganisms and microbial processes
Trichloroethene	6,010 (1)	MHSPE 2000	---
Trichlorofluoromethane	NA	---	---
Vinyl acetate	NA	---	---
Vinyl chloride	11.0 (1)	MHSPE 2000	---
Xylenes, total	2,510 (1)	MHSPE 2000	---
Semi-Volatile Organics (ug/kg):			
1,2,4,5-Tetrachlorobenzene	50.0	CCME 2007	Canadian soil quality guideline based on agricultural land uses
1,2,4-Trichlorobenzene	20,000	Efroymson et al. 1997a	Toxicological threshold for earthworms
1,3,5-Trinitrobenzene	40,000	---	Value for nitrobenzene used as a surrogate
1,1-Biphenyl	NA	---	---
1,2-Dichlorobenzene	3,003 (1)	MHSPE 2000	Value for total chlorobenzenes (2)
1,3-Dichlorobenzene	3,003 (1)	MHSPE 2000	Value for total chlorobenzenes (2)
1,3-Dinitrobenzene	40,000	---	Value for nitrobenzene used as a surrogate
1,4-Dichlorobenzene	20,000	Efroymson et al. 1997a	Toxicological threshold for earthworms
1,4-Dioxane	NA	---	---
1,4-Naphthoquinone	NA	---	---
2,3,4,6-Tetrachlorophenol	1,001 (1)	MHSPE 2000	Value for total chlorophenols (3)
2,4,5-Trichlorophenol	4,000	Efroymson et al. 1997b	Toxicological threshold for plants
2,4,6-Trichlorophenol	10,000	Efroymson et al. 1997a	Toxicological threshold for earthworms

TABLE 5-4
SOIL SCREENING VALUES FOR PLANTS AND INVERTEBRATES
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Soil Screening Value	Reference	Comment
Semi-Volatile Organics (ug/kg):			
2,2'-Oxybis(1-chloropropane)	NA	---	---
2,4-Dichlorophenol	1,001 (1)	MHSPE 2000	Value for total chlorophenols (3)
2,4-Dimethylphenol	100	CCME 2007	Canadian soil quality guideline based on agricultural land uses
2,4-Dinitrophenol	20,000	Efroymson et al. 1997b	Toxicological threshold for plants
2,4-Dinitrotoluene	NA	---	---
2,6-Dichlorophenol	1,001 (1)	MHSPE 2000	Value for total chlorophenols (3)
2,6-Dinitrotoluene	NA	---	---
2-Acetylaminofluorene	NA	---	---
2-Chloronaphthalene	NA	---	---
2-Chlorophenol	1,001 (1)	MHSPE 2000	Value for total chlorophenols (3)
2-Methylphenol	100	CCME 2007	Canadian soil quality guideline based on agricultural land uses
2-Naphthylamine	NA	---	---
2-Nitroaniline	NA	---	---
2-Nitrophenol	7,000	---	Value for 4-nitrophenol used as a surrogate
2-Picoline	NA	---	---
2-Toluidine	NA	---	---
3,3'-Dichlorobenzidine	NA	---	---
3,3'-Dimethylbenzidine	NA	---	---
3,4-Methylphenol	100	CCME 2007	Canadian soil quality guideline based on agricultural land uses
3-Methylcholanthrene	NA	---	---
3-Nitroaniline	NA	---	---
4,6-Dinitro-2-methylphenol	NA	---	---
4-Aminobiphenyl	NA	---	---
4-Bromophenyl phenyl ether	NA	---	---
4-Chloro-3-methylphenol	NA	---	---
4-Chloroaniline	NA	---	---
4-Chlorophenyl phenyl ether	NA	---	---
4-Nitroaniline	NA	---	---
4-Nitrophenol	7,000	Efroymson et al. 1997a	Toxicological threshold for earthworms
4-Nitroquinoline-1-oxide	NA	---	---
7,12-Dimethylbenz(a)anthracene	NA	---	---
Acetophenone	NA	---	---
A,A-Dimethylphenethylamine	NA	---	---
Aniline	NA	---	---
Aramite, total	NA	---	---

TABLE 5-4
SOIL SCREENING VALUES FOR PLANTS AND INVERTEBRATES
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Soil Screening Value	Reference	Comment
Semi-Volatile Organics (ug/kg):			
Benzyl alcohol	NA	---	---
bis(2-Chloroethoxy)methane	NA	---	---
bis(2-Chloroethyl)ether	NA	---	---
bis(2-Ethylhexyl)phthalate	6,010 (1)	MHSPE 2000	Value for total phthalates (4)
Butyl benzyl phthalate	6,010 (1)	MHSPE 2000	Value for total phthalates (4)
Diallate	NA	---	---
Dibenzofuran	NA	---	---
Diethyl phthalate	100,000	Efroymson et al. 1997b	Toxicological threshold for plants
Dimethyl phthalate	200,000	Efroymson et al. 1997a	Toxicological threshold for earthworms
Di-n-butyl phthalate	200,000	Efroymson et al. 1997b	Toxicological threshold for plants
Di-n-octyl phthalate	6,010 (1)	MHSPE 2000	Value for total phthalates (4)
Dinoseb	NA	---	---
Ethyl methanesulfonate	NA	---	---
Hexachlorobenzene	1,000,000	Efroymson et al. 1997a	Toxicological threshold for soil microorganisms and microbial processes
Hexachlorobutadiene	NA	---	---
Hexachlorocyclopentadiene	10,000	Efroymson et al. 1997b	Toxicological threshold for plants
Hexachloroethane	NA	---	---
Hexachlorophene	NA	---	---
Hexachloropropene	NA	---	---
Hexachlorophene	NA	---	---
Hexachloropropene	NA	---	---
Isophorone	NA	---	---
Isosafrole	NA	---	---
Methapyrilene	NA	---	---
Methyl methanesulfonate	NA	---	---
N-Nitro-o-toluidine	NA	---	---
N-Nitrosodiethylamine	20,000	---	Value for n-Nitrosdiphenylamine used as a surrogate
N-Nitrosodimethylamine	20,000	---	Value for n-Nitrosdiphenylamine used as a surrogate
N-Nitroso-di-n-butylamine	20,000	---	Value for n-Nitrosdiphenylamine used as a surrogate
N-Nitroso-di-n-propylamine	20,000	---	Value for n-Nitrosdiphenylamine used as a surrogate
N-Nitrosodiphenylamine	20,000	Efroymson et al. 1997a	Toxicological threshold for earthworms
N-Nitrosomethylethylamine	20,000	---	Value for n-Nitrosdiphenylamine used as a surrogate
N-Nitrosomorpholine	NA	---	---
N-Nitrosopiperidine	NA	---	---
N-Nitrosopyrrolidine	NA	---	---

TABLE 5-4
SOIL SCREENING VALUES FOR PLANTS AND INVERTEBRATES
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Soil Screening Value	Reference	Comment
Semi-Volatile Organics (ug/kg):			
Nitrobenzene	40,000	Efroymson et al. 1997a	Toxicological threshold for earthworms
p-Dimethylamino azobenzene	NA	---	---
Pentachlorobenzene	1,150	USEPA 1999	Toxicological threshold for earthworms
Pentachloronitrobenzene	NA	---	---
Pentachlorophenol	5,000	USEPA 2007a	Ecological soil screening level for plants
Phenacetin	NA	---	---
Phenol	30,000	Efroymson et al. 1997a	Toxicological threshold for earthworms
p-Phenyl diamine	NA	---	---
Pronamide	NA	---	---
Pyridine	NA	---	---
Safrole, total	NA	---	---
PAHs (ug/kg):			
Low molecular weight PAHs [5]	29,000	USEPA 2007b	Ecological soil screening level for soil invertebrates
High molecular weight PAHs [6]	18,000	USEPA 2007b	Ecological soil screening level for soil invertebrates
PCBs (ug/kg):			
Aroclor-1016	2,510	USEPA 1999	Toxicological threshold for earthworms
Aroclor-1221	2,510	---	Value for Aroclor-1016 and Aroclor-1254 used as a surrogate
Aroclor-1232	2,510	---	Value for Aroclor-1016 and Aroclor-1254 used as a surrogate
Aroclor-1242	2,510	---	Value for Aroclor-1016 and Aroclor-1254 used as a surrogate
Aroclor-1248	2,510	---	Value for Aroclor-1016 and Aroclor-1254 used as a surrogate
Aroclor-1254	2,510	USEPA 1999	Toxicological threshold for earthworms
Aroclor-1260	2,510	---	Value for Aroclor-1016 and Aroclor-1254 used as a surrogate
Metals (mg/kg):			
Antimony	78.0	USEPA 2005a	Ecological soil screening level for soil invertebrates
Arsenic	18.0	USEPA 2005b	Ecological soil screening level for plants
Barium	330	USEPA 2005c	Ecological soil screening level for soil invertebrates
Beryllium	40.0	USEPA 2005d	Ecological soil screening level for soil invertebrates
Cadmium	32.0	USEPA 2005e	Ecological soil screening level for plants
Chromium, total	57.0	USEPA 2008	Reproduction-based MATC for *Eisenia andrei* (earthworm)
Cobalt	13.0	USEPA 2005f	Ecological soil screening level for plants
Copper	70.0	USEPA 2007c	Ecological soil screening level for plants
Lead	120	USEPA 2005g	Ecological soil screening level for plants
Mercury	0.10	Efroymson et al. 1997a	Toxicological threshold for earthworms
Nickel	38.0	USEPA 2007d	Ecological soil screening level for plants
Selenium	0.52	USEPA 2007e	Ecological soil screening level for plants

TABLE 5-4
SOIL SCREENING VALUES FOR PLANTS AND INVERTEBRATES
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Soil Screening Value	Reference	Comment
Metals (mg/kg):			
Silver	560	USEPA 2006	Ecological soil screening level for plants
Thallium	1.00	Efroymson et al. 1997b	Toxicological threshold for plants
Tin	50.0	Efroymson et al. 1997b	Toxicological threshold for plants
Vanadium	20.0	USEPA 2005h	Growth-based LOAEC for *Brassica oleracea* (broccoli) with a safety factor of 5
Zinc	120	USEPA 2007f	Ecological soil screening level for soil invertebrates

Notes:

NA = Not Available
MHSPE = Ministry of Housing, Spatial Planning and Environment
CCME = Canadian Council of Ministers of the Environment
USEPA = United States Environmental Protection Agency
MATC = Maximum Acceptable Toxicant Concentration
LOAEC = Lowest Observed Adverse Effect Concentration
PAH = Polynuclear Aromatic Hydrocarbon
PCB = Polychlorinated Biphenyl
ug/kg = micrograms per kilogram
mg/kg = milligrams per kilogram

(1) The screening value shown is an average of the target and intervention soil standards for soil remediation. 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).

(2) The value represents a total concentration for chlorobenzenes (mono, di, tri, tetra, penta, and hexachlorobenzene).

(3) The value represents a total concentration for all chlorophenols (mono, di, tri, tetra, and pentachlorophenol).

(4) The value represents a total concentration for all phthalates.

(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 56 soil were 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, fluoranthene, fluorene, naphthalene, and phenanthrene.

(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 56 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.

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

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TABLE 5-5
MARINE/ESTUARINE GROUNDWATER AND SURFACE WATER SCREENING VALUES
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	GW/SW Screening Value [1]	Reference	Comment [2]
Volatile Organics (µg/L):			
1,1,1,2-Tetrachloroethane	200 [3]	USEPA 2007a	Minimum acute value (96-hour LC_{50} for *Lepomis macrochirus* [bluegill]) with a safety factor of 100
1,1,1-Trichloroethane	312	USEPA 2001	USEPA Region 4 chronic screening value
1,1,2,2-Tetrachloroethane	90.2	USEPA 2001	USEPA Region 4 chronic screening value
1,1,2-Trichloroethane	340	USEPA 2007a	Minimum acute value (48-hr LC_{50} for *Pleuronectes platessa* [sand dab]) with a safety factor of 100
1,1-Dichloroethane	47.0 [3]	USEPA 2003	USEPA Region 5 ecological screening level
1,1-Dichloroethene	2,240	USEPA 2001	USEPA Region 4 chronic screening value
1,2,3-Trichloropropane	274 [3]	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Pimephales promelas* [fathead minnow]) with a safety factor of 100
1,2-Dibromo-3-chloropropane	100	USEPA 2007a	Minimum acute value (48-hr EC_{50} for *Mercenaria mercenaria* [hard clam]) with a safety factor of 100
1,2-Dichloroethane	1,130	USEPA 2001	USEPA Region 4 chronic screening value
1,2-Dichloropropane	2,400	USEPA 2001	USEPA Region 4 chronic screening value
2-Butanone (MEK)	13,333	USEPA 2007a	Minimum acute value (96-hour NOEC for *Cyprinodon variegatus* [sheepshead minnow]) with a safety factor of 30
2-Chloro-1,3-butadiene	NA	---	---
2-Hexanone	99.0 [3]	USEPA 2003	USEPA Region 5 ecological screening level
3-Chloro-1-propene	3.40 [3]	USEPA 2007a	Minimum acute value (48-hr LC_{50} for *Xenopus laevis* [clawed toad]) with a safety factor of 100
4-Methyl-2-pentanone (MIBK)	170 [3]	USEPA 2003	USEPA Region 5 ecological screening level
Acetone	1,000	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Lumbriculus variegatus* [Oligochaete]) with a safety factor of 100
Acetonitrile	12,000 [3]	USEPA 2003	USEPA Region 5 ecological screening level
Acrolein	0.55	USEPA 2001	USEPA Region 4 chronic screening value
Acrylonitrile	58.1	USEPA 2007a	Minimum acute value (96-hr $LC_{50\ for}$ *Americamysis bahia* [opossum shrimp]) with a safety factor of 100
Benzene	109	USEPA 2001	USEPA Region 4 chronic screening value
Bromoform	640	USEPA 2001	USEPA Region 4 chronic screening value
Bromomethane	120	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Menidia beryllina* [inland silverside]) with a safety factor of 100
Carbon disulfide	15.0 [3]	USEPA 2003	USEPA Region 5 ecological screening level
Carbon tetrachloride	1,500	USEPA 2001	USEPA Region 4 chronic screening value
Chlorobenzene	105	USEPA 2001	USEPA Region 4 chronic screening value
Chlorodibromomethane	340 [3]	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Cyprinus carpio* [common carp] with a safety factor of 100
Chloroethane	NA	---	---
Chloroform	815	USEPA 2001	USEPA Region 4 chronic screening value
Chloromethane	2,700	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Menidia beryllina* [inland silverside]) with a safety factor of 100
cis-1,3-Dichloropropene	7.90	USEPA 2001	USEPA Region 4 chronic screening value (cis and trans)
Dibromomethane	1,280	Buchman 2008	Chronic LOEL for chemical class with a safety factor of 5
Dichlorobromomethane	2,400 [3]	USEPA 2007a	Minimum acute value (24-hr LC_{50} for *Tetrahymena pyriformis* [ciliate]) with a safety factor of 100
Dichlorodifluoromethane	1,280	---	Value for trichlorofluoromethane used as a surrogate
Ethylbenzene	4.30	USEPA 2001	USEPA Region 4 chronic screening value
Ethylene dibromide	48.0	USEPA 2007a	Minimum acute value (48-hr LC_{50} for *Cyprinodon variegatus* [sheepshead minnow]) with a safety factor of 100
Ethyl methacrylate	18,000 [3]	USEPA 2007a	Minimum chronic value (21-day NOEC for *Daphnia magna* [cladoceron] based on reproduction [progeny counts])
Iodomethane	NA	---	---
Isobutyl alcohol	10,000	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Alburnus alburnus* [bleak]) with a safety factor of 100
Methacrylonitrile	NA	---	---

TABLE 5-5
MARINE/ESTUARINE GROUNDWATER AND SURFACE WATER SCREENING VALUES
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	GW/SW Screening Value [1]	Reference	Comment [2]
Volatile Organics (µg/L):			
Methylene chloride	2,560	USEPA 2001	USEPA Region 4 chronic screening value
Methyl methacrylate	2,800 [3]	USEPA 2003	USEPA Region 5 ecological screening level
Pentachloroethane	56.2	Buchman 2008	Chronic LOEL with a safety factor of 5
Propionitrile	15,200 [3]	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Pimephales promelas* [fathead minnow]) with a safety factor of 100
Styrene	170	USEPA 2007a	Minimum acute value (96-hr NOEC for *Cyprinodon variegatus* [sheepshead minnow]) with a safety factor of 30
Tetrachloroethene	45.0	USEPA 2001	USEPA Region 4 chronic screening value
Toluene	37.0	USEPA 2001	USEPA Region 4 chronic screening value
trans-1,2-dichloroethene	4,480	Buchman 2008	Acute LOEL (summation of all isomers) with a safety factor of 50
trans-1,3-Dichloropropene	7.90	USEPA 2001	USEPA Region 4 chronic screening value (cis and trans)
trans-1,4-Dichloro-2-butene	NA	---	---
Trichloroethene	40.0	Buchman 2008	Acute LOEL with a safety factor of 50
Trichlorofluoromethane	1,280	Buchman 2008	Chronic LOEL for chemical class with a safety factor of 5
Vinyl acetate	100	USEPA 2007a	Minimum acute value (48-hr LC_{50} for *Crangon crangon* [sand shrimp]) with a safety factor of 100
Vinyl chloride	930 [3]	USEPA 2003	USEPA Region 5 ecological screening level
Xylenes, total	27.0 [3][4]	USEPA 2003	USEPA Region 5 ecological screening level
Semi-Volatile Organics (µg/L):			
1,2,4,5-Tetrachlorobenzene	10.0	USEPA 2007a	Minimum acute value (96-hr NOEC for *Cyprinodon variegatus* [sheepshead minnow]) with a safety factor of 30
1,2,4-Trichlorobenzene	4.50	USEPA 2001	USEPA Region 4 chronic screening value
1,3,5-Trinitrobenzene	80.0 [3]	USEPA 2007a	Minimum chronic value (71-day NOEC for *Oncorhynchus mykiss* [rainbow trout] based on reproduction)
1,1-Biphenyl	230 [3]	USEPA 2007a	Minimum chronic value (21-day MATC for *Daphnia magna* [cladoceron] based on reproduction)
1,2-Dichlorobenzene	19.7	USEPA 2001	USEPA Region 4 chronic screening value
1,3-Dichlorobenzene	28.5	USEPA 2001	USEPA Region 4 chronic screening value
1,3-Dinitrobenzene	22.0 [3]	USEPA 2003	USEPA Region 5 ecological screening level
1,4-Dichlorobenzene	19.9	USEPA 2001	USEPA Region 4 chronic screening value
1,4-Dioxane	67,000	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Menidia beryllina* [inland silverside]) with a safety factor of 100
1,4-Naphthoquinone	NA	---	---
2,3,4,6-Tetrachlorophenol	8.80	Buchman 2008	Acute LOEL with a safety factor of 50
2,4,5-Trichlorophenol	11.0	Buchman 2008	Proposed Criteria Continuous Concentration
2,4,6-Trichlorophenol	12.1	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Palaemonetes pugio* [daggerblade grass shrimp]) with a safety factor of 100
2,2'-Oxybis(1-chloropropane)	NA	---	---
2,4-Dichlorophenol	1.67	USEPA 2007a	Minimum acute value (96-hr NOEC for *Allorchestes compressa* [scud]) with a safety factor of 30
2,4-Dimethylphenol	131	USEPA 2007a	Minimum chronic value (28-day NOEC for *Menidia beryllina* [inland silverside] based on survival)
2,4-Dinitrophenol	48.5	USEPA 2001	USEPA Region 4 chronic screening value
2,4-Dinitrotoluene	44.0 [3]	USEPA 2003	USEPA Region 5 ecological screening level
2,6-Dichlorophenol	54.0	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Platichthys flesus* [european flounder]) with a safety factor of 100
2,6-Dinitrotoluene	81.0 [3]	USEPA 2003	USEPA Region 5 ecological screening level
2-Acetylaminofluorene	20.0 [3]	USEPA 2007a	Minimum acute value (96-hr LOEC for *Xenopus laevis* [clawed toad]) with a safety factor of 50
2-Chloronaphthalene	0.15	Buchman 2008	Acute LOEL for chemical class with a safety factor of 50
2-Chlorophenol	53.0	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Crangon septemspinosa* [bay shrimp]) with a safety factor of 100

TABLE 5-5
MARINE/ESTUARINE GROUNDWATER AND SURFACE WATER SCREENING VALUES
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Chemical	GW/SW Screening Value [(1)]	Reference	Comment [(2)]
Semi-Volatile Organics (µg/L):			
2-Methylphenol	102	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Elasmopus pectinicrus* [scud]) with a safety factor of 100
2-Naphthylamine	NA	---	---
2-Nitroaniline	48.9 [(3)]	USEPA 2007a	Minumum acute value (48-hr EC_{50} for *daphnia magna* [cladoceron]) with a safety factor of 100
2-Nitrophenol	10,000	USEPA 2007a	Minimum chronic value (28-day MATC for *Cyprinodon variegatus* [sheepshead minnow] based on egg hatchability)
2-Picoline	8,979 [(3)]	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Pimephales promelas* [fathead minnow]) with a safety factor of 100
2-Toluidine	5.20 [(3)]	USEPA 2007a	Minimum acute value (48-hr LC_{50} for *Daphnia magna* [cladoceron]) with a safety factor of 100
3,4-Methylphenol	25 [(3)(5)]	USEPA 2003	USEPA Region 5 ecological screening level (the value shown is for 4-methylphenol)
3,3'-Dichlorobenzidine	4.50 [(3)]	USEPA 2003	USEPA Region 5 ecological screening level
3,3'-Dimethylbenzidine	160 [(3)]	USEPA 2007a	Minimum chronic value (21-day NOEC for *Daphnia magna* [cladoceron] based on behavior [equilibrium])
3-Methylcholanthrene	NA	---	---
3-Nitroaniline	9.80 [(3)]	USEPA 2007a	Minimum acute value (48-hr EC_{50} for *Daphnia magna* [cladoceron]) with a safety factor of 100
4,6-Dinitro-2-methylphenol	23.0 [(3)]	USEPA 2003	USEPA Region 5 ecological screening level
4-Aminobiphenyl	NA	---	---
4-Bromophenyl phenyl ether	1.50 [(3)]	USEPA 2003	USEPA Region 5 ecological screening level
4-Chloro-3-methylphenol	0.30 [(3)]	USEPA 2003	USEPA Region 5 ecological screening level
4-Chloroaniline	10.0 [(3)]	USEPA 2007a	Minimum chronic value (21-day NOEC for *Daphnia magna* [cladoceron]) based on reproduction)
4-Chlorophenyl phenyl ether	7.30 [(3)]	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Salvelinus fontinalis* [brook trout]) with a safety factor of 100
4-Nitroaniline	170 [(3)]	USEPA 2007a	Minimum acute value (48-hr EC_{50} for *Daphnia magna* [cladoceron]) with a safety factor of 100
4-Nitrophenol	71.7	USEPA 2001	USEPA Region 4 chronic screening value
4-Nitroquinoline-1-oxide	NA	---	---
7,12-Dimethylbenz(a)anthracene	6.00	Buchman 2008	Acute LOEL for chemical class with a safety factor of 50 (value for high molecular weight PAHs)
Acetophenone	1,550 [(3)]	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Pimephales promelas* [fathead minnow]) with a safety factor of 100
A,A-Dimethyl phenethylamine	NA	---	---
Aniline	294	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Crangon septemspinosa* [sand shrimp]) with a safety factor of 100
Aramite, total	3.09 [(3)]	USEPA 2003	USEPA Region 5 ecological screening level
Benzyl alcohol	150	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Menidia beryllina* [inland silverside]) with a safety factor of 100
bis(2-Chloroethoxy)methane	1840 [(3)]	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Pimephales promelas* [fathead minnow]) with a safety factor of 100
bis(2-Chloroethyl)ether	2,380 [(3)]	USEPA 2001	USEPA Region 4 chronic screeing value
bis(2-Ethylhexyl)phthalate	360	Buchman 2008	Proposed Criteria Continuous Concentration
Butyl benzyl phthalate	29.4	USEPA 2001	USEPA Region 4 chronic screening value
Diallate	82.0 [(3)]	USEPA 2007a	Minimum acute value (48-hr LC_{50} for *Rasbora heteromorpha* [harlequinfish]) with a safety factor of 100
Dibenzofuran	33.3	USEPA 2007a	Minimum acute value (96-hr NOEC for *Cyprinodon variegatus* [sheepshead minnow]) with a safety factor of 30
Diethyl phthalate	75.9	USEPA 2001	USEPA Region 4 chronic screening value
Dimethyl phthalate	580	USEPA 2001	USEPA Region 4 chronic screening value
Di-n-butyl phthalate	3.40	USEPA 2001	USEPA Region 4 chronic screening value (lowest reported plant value)
Di-n-octyl phthalate	1,150	USEPA 2007a	Minimum acute value (96-hr NOEC for *Americamysis bahia* [opossum shrimp]) with a safety factor of 30
Dinoseb	1.70	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Americamysis bahia* [opossum shrimp]) with a safety factor of 100
Ethyl methanesulfonate	40.0 [(3)]	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Clarias batrachus* [walking catfish]) with a safety factor of 100

TABLE 5-5
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Chemical	GW/SW Screening Value [(1)]	Reference	Comment [(2)]
Semi-Volatile Organics (µg/L):			
Hexachlorobenzene	10.0	USEPA 2007a	Minimum acute value (48-hr EC_{50} for *Crassostrea virginica* [Virginia oyster]) with a safety factor of 100
Hexachlorobutadiene	0.32	USEPA 2001	USEPA Region 4 chronic screening value
Hexachlorocyclopentadiene	0.07	USEPA 2001	USEPA Region 4 chronic screening value
Hexachloroethane	9.40	USEPA 2001	USEPA Region 4 chronic screening value
Hexachlorophene	8.80 [(3)]	USEPA 2007a	Minimum chronic value (34-day NOEC for *Pimephales promelas* [fathead minnow] based on survival and growth)
Hexachloropropene	NA	---	---
Isophorone	129	USEPA 2001	USEPA Region 4 chronic screening value
Isosafrole	NA	---	---
Methapyrilene	NA	---	---
Methyl methanesulfonate	NA	---	---
Nitrobenzene	66.8	USEPA 2001	USEPA Region 4 chronic screening value
N-Nitro-o-toluidine	220 [(3)]	USEPA 2007a	Minimum acute value (48-hr EC_{50} for *Daphnia magna* [cladoceron] based on immobilization) with a safety factor of 100
N-Nitrosodiethylamine	768 [(3)]	USEPA 2003	USEPA Region 5 ecological screening level
N-Nitrosodimethylamine	25.0 [(3)]	---	Value for N-nitrosodiphenylamine used as a surrogate
N-Nitroso-di-n-butylamine	25.0 [(3)]	---	Value for N-nitrosodiphenylamine used as a surrogate
N-Nitroso-di-n-propylamine	25.0 [(3)]	---	Value for N-nitrosodiphenylamine used as a surrogate
N-Nitrosodiphenylamine	25.0 [(3)]	USEPA 2007b	Indiana Department of Environmental Management Great Lakes Basin Tier II chronic criterion
N-Nitrosomethylethylamine	25.0 [(3)]	---	Value for N-nitrosodiphenylamine used as a surrogate
N-Nitrosomorpholine	NA	---	---
N-Nitrosopiperidine	NA	---	---
N-Nitrosopyrrolidine	NA	---	---
p-Dimethylamino azobenzene	NA	---	---
Pentachlorobenzene	129	USEPA 2001	USEPA Region 4 chronic screening value
Pentachloronitrobenzene	0.23	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Americamysis bahia* [opossum shrimp]) with a safety factor of 100
Pentachlorophenol	7.90	PREQB 2010	Puerto Rico Water Quality Standard for Class SB coastal and estuarine waters
Phenacetin	NA	---	---
Phenol	58.0	USEPA 2001	USEPA Region 4 chronic screening value
p-Phenylene diamine	200 [(3)]	USEPA 2007a	Minimum acute value (48-hr LC_{50} for *Oryzias latires* [medika, high-eyes]) with a safety factor of 100
Pronamide	35.0	USEPA 2007a	Minimum acute value (96-hr EC_{50} for *Crassostrea virginica* [Virginia oyster]) with a safety factor of 100
Pyridine	500	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Crangon septemspinosa* [sand shrimp]) with a safety factor of 100
Safrole	NA	---	---
PAHs (µg/L):			
2-Methylnaphthalene	6.00	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Penaeus aztecus* [brown shrimp]) with a safety factor of 100
Acenaphthene	9.70	USEPA 2001	USEPA Region 4 chronic screening value
Acenaphthylene	6.00	Buchman 2008	Acute LOEL for chemical class with a safety factor of 50 (value for low molecular weight PAHs)
Anthracene	5.35	USEPA 2007a	Minimum acute value (48-hr LC_{50} for *Americamysis bahia* [opossum shrimp]) with a safety factor of 100
Benzo(a)anthracene	0.025 [(3)]	USEPA 2003	USEPA Region 5 ecological screening level
Benzo(a)pyrene	10.0	USEPA 2004	Acute value (LC_{50}) with a safety factor of 100
Benzo(b)fluoranthene	6.00	Buchman 2008	Acute LOEL for chemical class with a safety factor of 50 (value for high molecular weight PAHs)

TABLE 5-5
MARINE/ESTUARINE GROUNDWATER AND SURFACE WATER SCREENING VALUES
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Chemical	GW/SW Screening Value [(1)]	Reference	Comment [(2)]
PAHs (μg/L):			
Benzo(g,h,i)perylene	6.00	Buchman 2008	Acute LOEL for chemical class with a safety factor of 50 (value for high molecular weight PAHs)
Benzo(k)fluoranthene	6.00	Buchman 2008	Acute LOEL for chemical class with a safety factor of 50 (value for high molecular weight PAHs)
Chrysene	10.0	USEPA 2004	Acute value (LC_{50}) with a safety factor of 100
Dibenzo(a,h)anthracene	6.00	Buchman 2008	Acute LOEL for chemical class with a safety factor of 50 (value for high molecular weight PAHs)
Fluoranthene	11.0	USEPA 1996	Final Chronic Value
Fluorene	10.0	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Nereis arenaceodentata* [polychaete]) with a safety factor of 100
Indeno(1,2,3-cd)pyrene	6.00	Buchman 2008	Acute LOEL for chemical class with a safety factor of 50 (value for high molecular weight PAHs)
Naphthalene	23.5	USEPA 2001	USEPA Region 4 chronic screening value
Phenanthrene	8.30	USEPA 1996	Final Chronic Value
Pyrene	0.248	USEPA 2007a	Minimum acute value (48-hr LC_{50} for *Americamysis bahia* [opossum shrimp]) with a safety factor of 100
Total Recoverable Metals (μg/L):			
Antimony	500	Buchman 2008	Proposed Criteria Continuous Concentration
Arsenic	36.0	PREQB 2010	Total recoverable Puerto Rico Water Quality Standard for Class SB coastal and estuarine waters
Barium	16,667	USEPA 2007a	Minimum acute value (96-hr NOEC for *Cyprinodon variegatus* [sheepshead minnow]) with a safety factor of 30
Beryllium	310	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Fundulus heteroclitus* [mummichog]) with a safety factor of 100
Cadmium	8.85	PREQB 2010	Total recoverable Puerto Rico Water Quality Standard for Class SB coastal and estuarine waters
Chromium, total	50.4 [(6)]	PREQB 2010	Total recoverable Puerto Rico Water Quality Standard for Class SB coastal and estuarine waters
Cobalt	45.0	USEPA 2007a	Minimum acute value (96-hr LC_{50} for *Nitocra spinipes* [Harpacticoid copepod]) with a safety factor of 100
Copper	3.73	PREQB 2010	Total recoverable Puerto Rico Water Quality Standard for Class SB coastal and estuarine waters
Lead	8.52	PREQB 2010	Total recoverable Puerto Rico Water Quality Standard for Class SB coastal and estuarine waters
Mercury	1.11	USEPA 2009	Total recoverable Criteria Continuous Concentration
Nickel	8.28	PREQB 2010	Total recoverable Puerto Rico Water Quality Standard for Class SB coastal and estuarine waters
Selenium	71.1	PREQB 2010	Total recoverable Puerto Rico Water Quality Standard for Class SB coastal and estuarine waters
Silver	2.24	PREQB 2010	Total recoverable Puerto Rico Water Quality Standard for Class SB coastal and estuarine waters
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	Total recoverable Puerto Rico Water Quality Standard for Class SB coastal and estuarine waters

Notes:

NA = Not Available
SW/GW = Surface Water/Groundwater
PREQB = Puerto Rico Environmental Quality Board
USEPA = United States Environmental Protection Agency
PAH = Polynuclear Aromatic Hydrocarbon
LOEL = Lowest Observed Effect Level
MATC = Maximum Acceptable Toxicant Concentration
NOEC = No Observed Effect Concentration
EC_{50} = Median Effective Concentration
LC_{50} = Median Lethal Concentration
μg/L = microgram per liter

TABLE 5-5
MARINE/ESTUARINE GROUNDWATER AND SURFACE WATER SCREENING VALUES
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Notes (continued):

(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 value shown is for o-xylene.
(5) The value shown is for 4-methylphenol.
(6) The value shown is for hexavalent chromium.

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TABLE 5-6
MARINE/ESTUARINE SEDIMENT SCREENING VALUES
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value [1]	Reference	Comment [2][3]
Volatile Organics (ug/kg):			
1,1,1,2-Tetrachloroethane [4]	770	USEPA 1993 and 1996	EqP-based screening value
1,1,1-Trichloroethane	856	USEPA 1993 and 1996	EqP-based screening value
1,1,2,2-Tetrachloroethane	202	USEPA 1993 and 1996	EqP-based screening value
1,1,2-Trichloroethane	352	USEPA 1993 and 1996	EqP-based screening value
1,1-Dichloroethane [4]	27.0	USEPA 1993 and 1996	EqP-based screening value
1,1-Dichloroethene	2,782	USEPA 1993 and 1996	EqP-based screening value
1,2,3-Trichloropropane [4]	446	USEPA 1993 and 1996	EqP-based screening value
1,2-Dibromo-3-chloropropane	200	USEPA 1993 and 1996	EqP-based screening value
1,2-Dichloroethane	315	USEPA 1993 and 1996	EqP-based screening value
1,2-Dichloropropane	2,075	USEPA 1993 and 1996	EqP-based screening value
2-Butanone (MEK)	251	USEPA 1993 and 1996	EqP-based screening value
2-Chloro-1,3-butadiene	NA	---	---
2-Hexanone [4]	22.5	USEPA 1993 and 1996	EqP-based screening value
3-Chloro-1-propene [4]	2.69	USEPA 1993 and 1996	EqP-based screening value
4-Methyl-2-pentanone (MIBK) [4]	33.0	USEPA 1993 and 1996	EqP-based screening value
Acetone	5.81	USEPA 1993 and 1996	EqP-based screening value
Acetonitrile [4]	55.6	USEPA 1993 and 1996	EqP-based screening value
Acrolein	0.0054	USEPA 1993 and 1996	EqP-based screening value
Acrylonitrile	1.02	USEPA 1993 and 1996	EqP-based screening value
Benzene	135	USEPA 1993 and 1996	EqP-based screening value
Bromoform	1,308	USEPA 1993 and 1996	EqP-based screening value
Bromomethane	17.8	USEPA 1993 and 1996	EqP-based screening value
Carbon disulfide [4]	13.9	USEPA 1993 and 1996	EqP-based screening value
Carbon tetrachloride	7,244	USEPA 1993 and 1996	EqP-based screening value
Chlorobenzene	681	USEPA 1993 and 1996	EqP-based screening value
Chlorodibromomethane [4]	462	USEPA 1993 and 1996	EqP-based screening value
Chloroethane	2,890	Di Toro and McGrath 2000	EqP-based toxicological threshold
Chloroform	629	USEPA 1993 and 1996	EqP-based screening value
Chloromethane	212	USEPA 1993 and 1996	EqP-based screening value
cis-1,3-Dichloropropene	8.37	USEPA 1993 and 1996	EqP-based screening value
Dibromomethane	408	USEPA 1993 and 1996	EqP-based screening value
Dichlorobromomethane [4]	2,785	USEPA 1993 and 1996	EqP-based screening value
Dichlorodifluoromethane	1,701	USEPA 1993 and 1996	EqP-based screening value
Ethylbenzene	4.00	Buchman 2008	Minimum Apparent Effects Threshold (Echinoderm larvae and larvalmax)
Ethylene dibromide	44	USEPA 1993 and 1996	EqP-based screening value
Ethyl methacrylate [4]	6,584	USEPA 1993 and 1996	EqP-based screening value
Iodomethane	NA	---	---

TABLE 5-6
MARINE/ESTUARINE SEDIMENT SCREENING VALUES
CMS WORK PLAN
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Chemical	Sediment Screening Value [1]	Reference	Comment [2][3]
Volatile Organics (ug/kg):			
Isobutyl alcohol	546	USEPA 1993 and 1996	EqP-based screening value
Methacrylonitrile	NA	---	---
Methylene chloride	434	USEPA 1993 and 1996	EqP-based screening value
Methyl methacrylate [4]	637	USEPA 1993 and 1996	EqP-based screening value
Pentachloroethane	573	USEPA 1993 and 1996	EqP-based screening value
Propionitrile [4]	218	USEPA 1993 and 1996	EqP-based screening value
Styrene	1,321	USEPA 1993 and 1996	EqP-based screening value
Tetrachloroethene	57.0	Buchman 2008	Minimum Apparent Effects Threshold (infaunal community impacts)
Toluene	187	USEPA 1993 and 1996	EqP-based screening value
trans-1,2-dichloroethene	4,614	Di Toro and McGrath 2000	EqP-based toxicological threshold
trans-1,3-Dichloropropene	7.82	USEPA 1993 and 1996	EqP-based screening value
trans-1,4-Dichloro-2-butene	NA	---	---
Trichloroethene	185	USEPA 1993 and 1996	EqP-based screening value
Trichlorofluoromethane	3,931	USEPA 1993 and 1996	EqP-based screening value
Vinyl acetate	5.22	USEPA 1993 and 1996	EqP-based screening value
Vinyl chloride [4]	277	USEPA 1993 and 1996	EqP-based screening value
Xylenes, total	4.00	Buchman 2008	Minimum Apparent Effects Threshold for total xylenes (bivalve)
Semi-Volatile Organics (ug/kg):			
1,2,4,5-Tetrachlorobenzene	3,643	USEPA 1993 and 1996	EqP-based screening value
1,2,4-Trichlorobenzene	4.8	Buchman 2008	Minimum Apparent Effects Threshold (Echinoderm larvae)
1,3,5-Trinitrobenzene [4]	11.6	USEPA 1993 and 1996	EqP-based screening value
1,1-Biphenyl [4]	18,807	USEPA 1993 and 1996	EqP-based screening value
1,2-Dichlorobenzene	13.0	Buchman 2008	Minimum Apparent Effects Threshold (Neanthes bioassays)
1,3-Dichlorobenzene	986	USEPA 1993 and 1996	EqP-based screening value
1,3-Dinitrobenzene	6.56	USEPA 1993 and 1996	EqP-based screening value
1,4-Dichlorobenzene	110	Buchman 2008	Minimum Apparent Effects Threshold (infaunal community impacts and Microtox)
1,4-Dioxane	364	USEPA 1993 and 1996	EqP-based screening value
1,4-Naphthoquinone	NA	---	---
2,3,4,6-Tetrachlorophenol	2,085	USEPA 1993 and 1996	EqP-based screening value
2,4,5-Trichlorophenol	3.00	Buchman 2008	Minimum Apparent Effects Threshold (infaunal community impacts)
2,4,6-Trichlorophenol	6.00	Buchman 2008	Minimum Apparent Effects Threshold (infaunal community impacts)
2,2'-Oxybis(1-chloropropane)	NA	---	---
2,4-Dichlorophenol	0.2083	Buchman 2008	Minimum Apparent Effects Threshold (basis of value not specified)
2,4-Dimethylphenol	18.0	Buchman 2008	Minimum Apparent Effects Threshold (Neanthes bioassays)
2,4-Dinitrophenol	16.2	USEPA 1993 and 1996	EqP-based screening value
2,4-Dinitrotoluene [4]	41.6	USEPA 1993 and 1996	EqP-based screening value
2,6-Dichlorophenol	273	USEPA 1993 and 1996	EqP-based screening value
2,6-Dinitrotoluene [4]	55.8	USEPA 1993 and 1996	EqP-based screening value

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MARINE/ESTUARINE SEDIMENT SCREENING VALUES
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Chemical	Sediment Screening Value [1]	Reference	Comment [2][3]
Semi-Volatile Organics (ug/kg):			
2-Acetylaminofluorene [4]	233	USEPA 1993 and 1996	EqP-based screening value
2-Chloronaphthalene	3.15	USEPA 1993 and 1996	EqP-based screening value
2-Chlorophenol	0.333	Buchman 2008	Minimum Apparent Effects Threshold (basis of value not specified)
2-Methylphenol	8.00	Buchman 2008	Minimum Apparent Effects Threshold (bivalve)
2-Naphthylamine	NA	---	---
2-Nitroaniline [4]	32.2	USEPA 1993 and 1996	EqP-based screening value
2-Nitrophenol	5,752	USEPA 1993 and 1996	EqP-based screening value
2-Picoline [4]	1,108	USEPA 1993 and 1996	EqP-based screening value
2-Toluidine [4]	1.03	USEPA 1993 and 1996	EqP-based screening value
3,4-Methylphenol [4]	100 [5]	Buchman 2008	Minimum Apparent Effects Threshold (bivalve)
3,3'-Dichlorobenzidine [4]	127	USEPA 1993 and 1996	EqP-based screening value
3,3'-Dimethylbenzidine [4]	690	USEPA 1993 and 1996	EqP-based screening value
3-Methylcholanthrene	NA	---	---
3-Nitroaniline [4]	2.18	USEPA 1993 and 1996	EqP-based screening value
4,6-Dinitro-2-methylphenol [4]	27.9	USEPA 1993 and 1996	EqP-based screening value
4-Aminobiphenyl	NA	---	---
4-Bromophenyl phenyl ether [4]	312	Di Toro and McGrath 2000	EqP-based toxicological threshold
4-Chloro-3-methylphenol [4]	3.35	USEPA 1993 and 1996	EqP-based screening value
4-Chloroaniline [4]	6.59	USEPA 1993 and 1996	EqP-based screening value
4-Chlorophenyl phenyl ether [4]	287	Di Toro and McGrath 2000	EqP-based toxicological threshold
4-Nitroaniline [4]	39.5	USEPA 1993 and 1996	EqP-based screening value
4-Nitrophenol	54.1	USEPA 1993 and 1996	EqP-based screening value
4-Nitroquinoline-1-oxide	NA	---	---
7,12-Dimethylbenz(a)anthracene	193,148	USEPA 1993 and 1996	EqP-based screening value
Acetophenone [4]	635	USEPA 1993 and 1996	EqP-based screening value
A,A-Dimethylphenethylamine	NA	---	---
Aniline	27.0	USEPA 1993 and 1996	EqP-based screening value
Aramite, total [4]	1,692	USEPA 1993 and 1996	EqP-based screening value
Benzyl alcohol	52.0	Buchman 2008	Minimum Apparent Effects Threshold (bivalve)
bis(2-Chloroethoxy)methane [4]	101	USEPA 1993 and 1996	EqP-based screening value
bis(2-Chloroethyl)ether [4]	368	USEPA 1993 and 1996	EqP-based screening value
bis(2-Ethylhexyl)phthalate	182	MacDonald 1994	Threshold Effect Level
Butyl benzyl phthalate	63.0	Buchman 2008	Minimum Apparent Effects Threshold (Microtox)
Diallate [4]	21,270	USEPA 1993 and 1996	EqP-based screening value
Dibenzofuran	110	Buchman 2008	Minimum Apparent Effects Threshold (Echinoderm larvae)

TABLE 5-6
MARINE/ESTUARINE SEDIMENT SCREENING VALUES
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value [1]	Reference	Comment [2][3]
Semi-Volatile Organics (ug/kg):			
Diethyl phthalate	630 [6]	MacDonald et al. 2003	Threshold Effect Concentration
Dimethyl phthalate	6.00	Buchman 2008	Minimum Apparent Effects Threshold (bivalve)
Di-n-butyl phthalate	58.0	Buchman 2008	Minimum Apparent Effects Threshold (bivalve and larvalmax)
Di-n-octyl phthalate	61.0	Buchman 2008	Minimum Apparent Effects Threshold (bivalve and larvalmax)
Dinoseb	72.1	USEPA 1993 and 1996	EqP-based screening value
Ethyl methanesulfonate [4]	0.45	USEPA 1993 and 1996	EqP-based screening value
Hexachlorobenzene	6.00	Buchman 2008	Minimum Apparent Effects Threshold (bivalve)
Hexachlorobutadiene	1.30	Buchman 2008	Minimum Apparent Effects Threshold (Echinoderm larvae)
Hexachlorocyclopentadiene	139	USEPA 1993 and 1996	EqP-based screening value
Hexachloroethane	73.0	Buchman 2008	Minimum Apparent Effects Threshold (bivalve and larvalmax)
Hexachlorophene [4]	2,272,912	USEPA 1993 and 1996	EqP-based screening value
Hexachloropropene	NA	---	---
Isophorone	60.5	USEPA 1993 and 1996	EqP-based screening value
Isosafrole	NA	---	---
Methapyrilene	NA	---	---
Methyl methanesulfonate	NA	---	---
N-Nitro-o-toluidine [4]	152	USEPA 1993 and 1996	EqP-based screening value
N-Nitrosodiethylamine [4]	22.8	USEPA 1993 and 1996	EqP-based screening value
N-Nitrosodimethylamine [4]	0.069	USEPA 1993 and 1996	EqP-based screening value
N-Nitroso-di-n-butylamine [4]	58.5	USEPA 1993 and 1996	EqP-based screening value
N-Nitroso-di-n-propylamine [4]	5.95	USEPA 1993 and 1996	EqP-based screening value
N-Nitrosodiphenylamine [4]	28.0	Buchman 2008	Minimum Apparent Effects Threshold (infaunal community impacts)
N-Nitrosomethylethylamine [4]	0.19	USEPA 1993 and 1996	EqP-based screening value
N-Nitrosomorpholine	NA	---	---
N-Nitrosopiperidine	NA	---	---
N-Nitrosopyrrolidine	NA	---	---
Nitrobenzene	21.0	Buchman 2008	Minimum Apparent Effects Threshold (Neanthes bioassays)
p-Dimethylamino azobenzene	NA	---	---
Pentachlorobenzene	191,183	USEPA 1993 and 1996	EqP-based screening value
Pentachloronitrobenzene	83.8	USEPA 1993 and 1996	EqP-based screening value
Pentachlorophenol	17.0	Buchman 2008	Minimum Apparent Effects Threshold (bivalve)
Phenacetin	NA	---	---
Phenol	130	Buchman 2008	Minimum Apparent Effects Threshold (Echinoderm larvae)
p-Phenylene diamine [4]	1.02	USEPA 1993 and 1996	EqP-based screening value
Pronamide	988	USEPA 1993 and 1996	EqP-based screening value
Pyridine	22.8	USEPA 1993 and 1996	EqP-based screening value
Safrole, total	NA	---	---

TABLE 5-6
MARINE/ESTUARINE SEDIMENT SCREENING VALUES
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value [1]	Reference	Comment [2][3]
PAHs (ug/kg):			
2-Methylnaphthalene	20.2	MacDonald 1994	Threshold Effect Level
Acenaphthene	6.71	MacDonald 1994	Threshold Effect Level
Acenaphthylene	5.87	MacDonald 1994	Threshold Effect Level
Anthracene	46.9	MacDonald 1994	Threshold Effect Level
Benzo(a)anthracene	74.8	MacDonald 1994	Threshold Effect Level
Benzo(a)pyrene	88.8	MacDonald 1994	Threshold Effect Level
Benzo(b)fluoranthene	1,800	Buchman 2008	Minimum Apparent Effects Threshold (Echinoderm larvae and infaunal commuity impacts)
Benzo(g,h,i)perylene	670	Buchman 2008	Minimum Apparent Effects Threshold (Echinoderm larvae)
Benzo(k)fluoranthene	1,800	Buchman 2008	Minimum Apparent Effects Threshold (Echinoderm larvae and infaunal commuity impacts)
Chrysene	108	MacDonald 1994	Threshold Effect Level
Dibenzo(a,h)anthracene	6.22	MacDonald 1994	Threshold Effect Level
Fluoranthene	113	MacDonald 1994	Threshold Effect Level
Fluorene	21.2	MacDonald 1994	Threshold Effect Level
Indeno(1,2,3-cd)pyrene	600	Buchman 2008	Minimum Apparent Effects Threshold (Microtox)
Naphthalene	34.6	MacDonald 1994	Threshold Effect Level
Phenanthrene	86.7	MacDonald 1994	Threshold Effect Level
Pyrene	153	MacDonald 1994	Threshold Effect Level
PCBs (ug/kg):			
Aroclor-1016	48.0	MacDonald et al. 2000b	Consensus-based Threshold Effect Concentration for total PCBs
Aroclor-1221	48.0	MacDonald et al. 2000b	Consensus-based Threshold Effect Concentration for total PCBs
Aroclor-1232	48.0	MacDonald et al. 2000b	Consensus-based Threshold Effect Concentration for total PCBs
Aroclor-1242	48.0	MacDonald et al. 2000b	Consensus-based Threshold Effect Concentration for total PCBs
Aroclor-1248	48.0	MacDonald et al. 2000b	Consensus-based Threshold Effect Concentration for total PCBs
Aroclor-1254	48.0	MacDonald et al. 2000b	Consensus-based Threshold Effect Concentration for total PCBs
Aroclor-1260	48.0	MacDonald et al. 2000b	Consensus-based Threshold Effect Concentration for total PCBs
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	---	---

TABLE 5-6
MARINE/ESTUARINE SEDIMENT SCREENING VALUES
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value [1]	Reference	Comment [2][3]
Metals (mg/kg):			
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:

NA = Not Available
USEPA = United States Environmental Protection Agency
PAH = Polynuclear Aromatic Hydrocarbon
PCB = Polychlorinated Biphenyl
ug/kg = microgram per kilogram
mg/kg = milligram per kilogram
EqP = Equilibrium Partitioning

(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.
(4) The EqP-based sediment screening value was derived using a freshwater screeing value (the chemical lacks a saltwater screening value).
(5) The value shown is for 4-methylphenol.
(6) The chemical lacks a literature-based marine/estuarine bulk sediment screening value/toxicological benchmark. The value shown is a literature-based freshwater bulk sediment screening value/toxicological benchmark.

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MARINE/ESTUARINE SEDIMENT SCREENING VALUES
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

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TABLE 5-7
TOXICITY REFERENCE VALUES FOR BIRDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Test Organism	Body Weight (kg)	Duration	Exposure Route	Effect/Endpoint	Test Material	NOAEL (mg/kg/d)	MATC [1] (mg/kg/d)	LOAEL (mg/kg/d)	Source Document [2]	Comments
Volatile Organics:											
1,1,1,2-Tetrachloroethane	---	---	---	---	---	---	NA	NA	NA	---	---
Carbon tetrachloride	---	---	---	---	---	---	NA	NA	NA	---	---
Chlorobenzene	---	---	---	---	---	---	NA	NA	NA	---	---
Chloroform	---	---	---	---	---	---	NA	NA	NA	---	---
Ethylbenzene	---	---	---	---	---	---	NA	NA	NA	---	---
Pentachloroethane	---	---	---	---	---	---	NA	NA	NA	---	---
Styrene	---	---	---	---	---	---	NA	NA	NA	---	---
Toluene	---	---	---	---	---	---	NA	NA	NA	---	---
Trichloroethene	---	---	---	---	---	---	NA	NA	NA	---	---
Xylenes, total	Quail	0.191	Unknown	Oral in diet	Mortality	---	40.5 [3]	90.7	203 [4]	Hill and Camardese 1986	---
Semi-Volatile Organics:											
1,2,4,5-Tetrachlorobenzene	---	---	---	---	---	---	NA	NA	NA	---	---
1,2,4-Trichlorobenzene	---	---	---	---	---	---	NA	NA	NA	---	---
1,1-Biphenyl	---	---	---	---	---	---	NA	NA	NA	---	---
1,2-Dichlorobenzene	---	---	---	---	---	---	16.0	35.8	80.0	---	Values for 1,4-dichlorobenzene used as surrogates
1,3-Dichlorobenzene	---	---	---	---	---	---	16.0	35.8	80.0	---	Values for 1,4-dichlorobenzene used as surrogates
1,4-Dichlorobenzene	Northern bobwhite	0.157	14 days	Oral (gavage)	Mortality	Not Applicable	16.0 [3]	35.8	80.0 [4]	USEPA 2004 [13]	---
2,3,4,6-Tetrachlorophenol	---	---	---	---	---	---	NA	NA	NA	---	---
2,4,5-Trichlorophenol	---	---	---	---	---	---	NA	NA	NA	---	---
2,4,6-Trichlorophenol	---	---	---	---	---	---	NA	NA	NA	---	---
2,4-Dichlorophenol	---	---	---	---	---	---	NA	NA	NA	---	---
2-Acetylaminofluorene	---	---	---	---	---	---	NA	NA	NA	---	---
2-Chloronaphthalene	---	---	---	---	---	---	NA	NA	NA	---	---
3,3'-Dichlorobenzidine	---	---	---	---	---	---	NA	NA	NA	---	---
3,3-Dimethylbenzidine	---	---	---	---	---	---	NA	NA	NA	---	---
3-Methylcholanthrene	---	---	---	---	---	---	NA	NA	NA	---	---
4-Bromophenyl phenyl ether	---	---	---	---	---	---	NA	NA	NA	---	---
4-Chloro-3-methylphenol	---	---	---	---	---	---	NA	NA	NA	---	---
4-Chlorophenyl phenyl ether	---	---	---	---	---	---	NA	NA	NA	---	---
7-12-Dimethylbenz(a)anthracene	European starling	0.055	5 days	Oral (gavage)	Growth	---	2.00	6.32	20.0	USEPA 2007a [13]	---
Aramite, total	---	---	---	---	---	---	NA	NA	NA	---	---
bis(2-Ethylhexyl) phthalate	Ringed dove	0.155	4 weeks	Oral in diet	Reproduction	Not Applicable	1.11	2.48	5.55 [4]	Sample et al. 1996 [13]	---
Butyl benzyl phthalate	---	---	---	---	---	---	NA	NA	NA	---	---
Diallate	---	---	---	---	---	---	NA	NA	NA	---	---
Dibenzofuran	---	---	---	---	---	---	NA	NA	NA	---	---
Diethyl phthalate	---	---	---	---	---	---	NA	NA	NA	---	---
Di-n-butyl phthalate	Ringed dove	0.155	4 weeks	Oral in diet	Reproduction	Not Applicable	0.222 [5]	0.50	1.11	Sample et al. 1996 [13]	---
Di-n-octyl phthalate	Ring-necked pheasant	1.00	5 days	Oral	Mortality	Not Applicable	50 [3]	112	250 [4]	USEPA 2007b [13]	---
Dinoseb	Ring-necked pheasant	Unknown	14 days	Oral (gavage)	Mortality	Not Applicable	0.264 [3]	0.590	1.32 [4]	USEPA 2004 [13]	---
Hexachlorobenzene	Japanese quail	0.15	90 days	Oral	Reproduction	Not Applicable	0.11	0.25	0.57	Coulston and Kolbye 1994	---
Hexachlorobutadiene	Japanese quail	0.15	90days	Oral	Reproduction	Not Applicable	17.0	7.59	3.39 [4]	Coulston and Kolbye 1994	---
Hexachlorocyclopentadiene	---	---	---	---	---	---	NA	NA	NA	---	---
Hexachloroethane	---	---	---	---	---	---	NA	NA	NA	---	---
Hexachlorophene	---	---	---	---	---	---	NA	NA	NA	---	---
Hexachloropropene	---	---	---	---	---	---	NA	NA	NA	---	---
Isosafrole	---	---	---	---	---	---	NA	NA	NA	---	---
N-Nitrosodiphenylamine	---	---	---	---	---	---	NA	NA	NA	---	---
p-Dimethylamino azobenzene	---	---	---	---	---	---	NA	NA	NA	---	---
Pentachlorobenzene	---	---	---	---	---	---	NA	NA	NA	---	---

TABLE 5-7
TOXICITY REFERENCE VALUES FOR BIRDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Test Organism	Body Weight (kg)	Duration	Exposure Route	Effect/Endpoint	Test Material	NOAEL (mg/kg/d)	MATC (1) (mg/kg/d)	LOAEL (mg/kg/d)	Source Document (2)	Comments
Semi-Volatile Organics:											
Pentachloronitrobenzene	Chicken	1.50	35 weeks	Oral in diet	Reproduction	Not Applicable	7.07	22.4	70.7	Sample et al. 1996 (13)	---
Pentachlorophenol	Chicken	0.66	1 week	Oral in diet	Growth	Pentachlorophenol (purified)	6.73 (6)	21.3	67.3	USEPA 2007c (13)	---
Pronamide	---	---	---	---	---	---	NA	NA	NA	---	---
PAHs:											
2-Methylnaphthalene	---	---	---	---	---	---	39.5	88.4	198	---	Values for benzo(a)pyrene used as surrogates
Acenaphthene	---	---	---	---	---	---	39.5	88.4	198	---	Values for benzo(a)pyrene used as surrogates
Acenaphthylene	---	---	---	---	---	---	39.5	88.4	198	---	Values for benzo(a)pyrene used as surrogates
Anthracene	---	---	---	---	---	---	39.5	88.4	198	---	Values for benzo(a)pyrene used as surrogates
Benzo(a)anthracene	---	---	---	---	---	---	39.5	88.4	198	---	Values for benzo(a)pyrene used as surrogates
Benzo(a)pyrene	White leghorn chicken	1.50	35 days	Oral in diet	Reproduction	Not Applicable	39.5	88.4	198 (5)	Rigdon and Neal 1963	---
Benzo(b)fluoranthene	---	---	---	---	---	---	39.5	88.4	198	---	Values for benzo(a)pyrene used as surrogates
Benzo(g,h,i)perylene	---	---	---	---	---	---	39.5	88.4	198	---	Values for benzo(a)pyrene used as surrogates
Benzo(k)fluoranthene	---	---	---	---	---	---	39.5	88.4	198	---	Values for benzo(a)pyrene used as surrogates
Chrysene	---	---	---	---	---	---	39.5	88.4	198	---	Values for benzo(a)pyrene used as surrogates
Dibenz(a,h)anthracene	---	---	---	---	---	---	39.5	88.4	198	---	Values for benzo(a)pyrene used as surrogates
Fluoranthene	---	---	---	---	---	---	39.5	88.4	198	---	Values for benzo(a)pyrene used as surrogates
Fluorene	---	---	---	---	---	---	39.5	88.4	198	---	Values for benzo(a)pyrene used as surrogates
Indeno(1,2,3-cd)pyrene	---	---	---	---	---	---	39.5	88.4	198	---	Values for benzo(a)pyrene used as surrogates
Naphthalene	---	---	---	---	---	---	39.5	88.4	198	---	Values for benzo(a)pyrene used as surrogates
Phenanthrene	---	---	---	---	---	---	39.5	88.4	198	---	Values for benzo(a)pyrene used as surrogates
Pyrene	---	---	---	---	---	---	39.5	88.4	198	---	Values for benzo(a)pyrene used as surrogates
PCBs:											
Aroclor-1016	---	---	---	---	---	---	0.41	0.92	2.05	---	Values for Aroclor-1242 used as surrogates
Aroclor-1221	---	---	---	---	---	---	0.41	0.92	2.05	---	Values for Aroclor-1242 used as surrogates
Aroclor-1232	---	---	---	---	---	---	0.41	0.92	2.05	---	Values for Aroclor-1242 used as surrogates
Aroclor-1242	Screech owl	0.181	2 generations	Oral in diet	Reproduction	Not Applicable	0.41	0.92	2.05 (4)	Sample et al. 1996	---
Aroclor-1248	---	---	---	---	---	---	0.41	0.92	2.05	---	Values for Aroclor-1242 used as surrogates
Aroclor-1254	Ring-ncked pheasant	1.0	17 weeks	Oral	Reproduction	Not Applicable	0.36	0.80	1.8	Sample et al. 1996	---
Aroclor-1260	---	---	---	---	---	---	0.41	0.92	2.05	---	Values for Aroclor-1242 used as surrogates
Metals:											
Antimony	Northern bobwhite	0.19	6 weeks	Oral	Unknown	Unknown	4,740	14,989	47,400	Opresko et al. 1993	---
Arsenic	Chicken	1.6	19 days	Oral in diet	Growth	Arsenic oxide	2.24 (6)	3.18	4.51 (7)	USEPA 2005a (13)	---
Barium	One-day old chicks	0.121	4 weeks	Oral in diet	Mortality	Barium hydroxide	20.8	29.5	41.7	Sample et al. 1996 (13)	---
Beryllium	---	---	---	---	---	---	NA	NA	NA	---	---
Cadmium	Multiple species	Various	Various	Oral in diet/water	Reproduction/growth	Cadmium, cadmium sulfate, and cadmium chloride	1.47 (8)	3.06	6.36 (9)	USEPA 2005b	---
Chromium, total	Multiple species	Various	Various	Oral in diet	Reproduction/growth	Sodium and potassium dichromate	2.66 (8)(10)	6.44	15.6 (9)	USEPA 2008	---
Cobalt	Multiple species	Various	Various	Oral in diet	Growth	Cobalt, cobalt chloride, and cobalt carbonate	7.61 (8)	11.8	18.3 (9)	USEPA 2005c	---
Copper	Chicken	1.52	84 days	Oral in diet	Reproduction	Copper	4.05 (11)	7.00	12.1	USEPA 2007d (13)	---
Lead	Chicken	1.81	4 weeks	Oral in diet	Reproduction	Lead acetate	1.63 (11)	2.31	3.26	USEPA 2005d (13)	---
Mercury	Mallard duck	1.00	3 generations	Oral in diet	Reproduction	Methyl mercury dicyandiamide	0.026	0.045	0.078	USEPA 1997a (13)	---
Nickel	Multiple species	Various	Various	Oral in diet	Reproduction/growth	Nickel acetate, chloride, and sulfate	6.71 (8)	11.2	18.6 (9)	USEPA 2007e	---
Selenium	Chicken	0.328	2 weeks	Oral in diet	Mortality	Sodium selenite	0.29 (11)	0.410	0.579	USEPA 2007f (13)	---
Silver	Turkey	0.662	5 weeks	Oral in diet	Growth	Silver acetate	2.02 (12)	6.39	20.2	USEPA 2006	---
Thallium	European starling	Unknown	acute	Oral	Survival	Unknown	0.35 (3)	0.78	1.75 (4)	USEPA 1999 (13)	---
Tin	Japanese quail	0.15	6 weeks	Oral in diet	Reproduction	bis(Tributyltin)-oxide	6.80	11	16.9	Sample et al. 1996 (13)	---

TABLE 5-7
TOXICITY REFERENCE VALUES FOR BIRDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Test Organism	Body Weight (kg)	Duration	Exposure Route	Effect/Endpoint	Test Material	NOAEL (mg/kg/d)	MATC [1] (mg/kg/d)	LOAEL (mg/kg/d)	Source Document [2]	Comments
Metals:											
Vanadium	Chicken	1.042	5 weeks	Oral in diet	Growth	Sodium metavanadate	0.344 [11]	0.486	0.688	USEPA 2005e [13]	---
Zinc	Multiple species	Various	Various	Oral in diet	Reproduction/growth	Zinc carbonate, oxide, and sulfate	66.1 [8]	106	171 [9]	USEPA 2007g	---

Notes:

PAH = Polynuclear Aromatic Hydrocarbon
PCB = Polychlorinated Biphenyl
NOAEL = No Observed Adverse Effect Level
LOAEL = Lowest Observed Adverse Effect Level
MATC = Maximum Acceptable Toxicant Concentration
USEPA = United States Environmental Protection Agency
mg/kg/d = milligrams per kilogram-body weight per day
NA = Not Available
kg = kilograms

(1) MATC values were derived by calculating the geometric mean of the NOAEL and LOAEL values (values were calculated by Baker Environmental, Inc.).
(2) Source documents for NOAEL and LOAEL values represent primary data sources (as reported by original authors) unless otherwise noted.
(3) The chronic NOAEL value was estimated by applying a safety factor of 100 to a LD_{50} value (Wentsel et al., 1996 and USEPA, 1997).
(4) A chronic LOAEL value was not available from the study used as the source of the chronic NOAEL value. Therefore, a chronic LOAEL value was estimated by applying a safety factor of 5 to the chronic NOAEL value (Wentsel et al., 1996).
(5) A chronic NOAEL value was not available from the study used as the source of the chronic LOAEL value. Therefore, the chronic NOAEL value shown was estimated by applying a safety factor of 5 to the chronic LOAEL value (Wentsel et al., 1996).
(6) The NOAEL value represents the lowest value of all reproduction, growth, and survival-based NOAEL values listed in the cited ecological soil screening levels document that meet the required data evaluation score. The value was used by the USEPA to derive the avian ecological soil screening level. It is noted that a geometric mean of NOAEL values for growth and reproduction could not be calculated by the USEPA because insufficient NOAEL values meeting the minimum required data evaluation score were identified from the literature.
(7) A LOAEL value was not available from the study chosen by the USEPA as the source of the NOAEL value selected as the ecological soil screening level. Therefore, the LOAEL value represents a geometric mean of all reproduction- and growth-based LOAEL values listed within the cited ecological soil screening level document that meet the minimum required data evaluation score (value was calculated by Baker Environmental, Inc.).
(8) The NOAEL value represents the geometric mean of all reproduction and growth-based NOAEL values listed within the cited ecological soil screening level document that meet the minimum required data evaluation score. Because this value is lower than the lowest bounded LOAEL for reproduction, growth, or survival, it was selected by the USEPA as the toxicity reference value for avian ecological soil screening level development.
(9) The NOAEL value selected by the USEPA as the ecological soil screening level represents a geometric mean of all reproduction and growth-based NOAEL values that meet the minimum required data evaluation score. Therefore, the LOAEL value shown represents a geometric mean of all reproduction and growth-based LOAEL values listed within the cited ecological soil screening level document that meet the minimum required data evaluation score (value was calculated by Baker Environmental, Inc.).
(10) The NOAEL value shown is for trivalent chromium.
(11) The NOAEL value shown represents the highest bounded NOAEL below the lowest bounded LOAEL for reproduction, growth, or survival listed within the cited ecological soil screening levels that meet the minimum required data evaluation score. The value was used by the USEPA as the toxicity reference value for avian ecological soil screening value development. It is noted that a geometric mean of available NOAEL values for growth and reproduction was not used as the toxicity reference value by the USEPA for ecological soil screening value development since the geometric mean is higher than the lowest bounded LOAEL for reproduction, growth, and survival.
(12) The NOAEL is equal to the lowest value of all reproduction- and growth-based LOAELs listed in the cited ecological soil screening levels document that meet the minimum required data evaluation score divided by ten. The value was used by the USEPA to derive the avian ecological soil screening level. It is noted that a geometric mean of NOAEL values for growth and reproduction could not be calculated by the USEPA based on the lack of NOAEL values for reproduction and growth.
(13) The data reference represents a secondary data source.

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TABLE 5-7
TOXICITY REFERENCE VALUES FOR BIRDS
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NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Table References (continued):

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TABLE 5-8
SOIL TO PLANT AND SOIL TO EARTHWORM BIOACCUMULATION FACTORS AND BIOACCUMULATION UPTAKE EQUATIONS FOR THE ESTIMATION OF CHEMICAL CONCENTRATIONS IN TERRESTRIAL PLANT AND INVERTEBRATE TISSUE: STEP 2 SCREENING LEVEL RISK CALCULATION
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	Soil-Plant BAF (dry weight) or Uptake Equation (dry weight)			Soil-Invertebrate BAF (dry weight) or Uptake Equation (dry weight)		
Chemical	**BAF Value/Uptake Equation**	**Source Document**	**Description**	**BAF Value/Uptake Equation**	**Source Document**	**Description**
Volatile Organics:						
1,1,1,2-Tetrachloroethane	5.176	USEPA 2007	Regression-based BAF (1)	3.151	USEPA 2007	Modeled BAF (10)
Carbon tetrachloride	4.715	USEPA 2007	Regression-based BAF (1)	3.070	USEPA 2007	Modeled BAF (10)
Chlorobenzene	4.175	USEPA 2007	Regression-based BAF (1)	2.968	USEPA 2007	Modeled BAF (10)
Chloroform	10.047	USEPA 2007	Regression-based BAF (1)	3.790	USEPA 2007	Modeled BAF (10)
Ethylbenzene	3.214	USEPA 2007	Regression-based BAF (1)	2.759	USEPA 2007	Modeled BAF (10)
Pentachloroethane	3.464	USEPA 2007	Regression-based BAF (1)	2.818	USEPA 2007	Modeled BAF (10)
Styrene	3.875	USEPA 2007	Regression-based BAF (1)	2.907	USEPA 2007	Modeled BAF (10)
Toluene	4.627	USEPA 2007	Regression-based BAF (1)	3.054	USEPA 2007	Modeled BAF (10)
Trichloroethene	4.803	USEPA 2007	Regression-based BAF (1)	3.086	USEPA 2007	Modeled BAF (10)
Xylene, total	3.245	USEPA 2007	Regression-based BAF (1)	2.766	USEPA 2007	Modeled BAF (10)
Semi-Volatile Organics:						
1,1-Biphenyl	1.467	USEPA 2007	Regression-based BAF (1)	2.218	USEPA 2007	Modeled BAF (10)
1,2,4,5-Tetrachlorobenzene	0.792	USEPA 2007	Regression-based BAF (1)	1.868	USEPA 2007	Modeled BAF (10)
1,2,4-Trichlorobenzene	1.426	USEPA 2007	Regression-based BAF (1)	2.200	USEPA 2007	Modeled BAF (10)
1,2-Dichlorobenzene	2.452	USEPA 2007	Regression-based BAF (1)	2.559	USEPA 2007	Modeled BAF (10)
1,3-Dichlorobenzene	2.092	USEPA 2007	Regression-based BAF (1)	2.448	USEPA 2007	Modeled BAF (10)
1,4,-Dichlorobenzene	2.475	USEPA 2007	Regression-based BAF (1)	2.565	USEPA 2007	Modeled BAF (10)
2,3,4,6-Tetrachlorophenol	0.945	USEPA 2007	Regression-based BAF (1)	1.962	USEPA 2007	Modeled BAF (10)
2,4,5-Trichlorophenol	1.870	USEPA 2007	Regression-based BAF (1)	2.373	USEPA 2007	Modeled BAF (10)
2,4,6-Trichlorophenol	1.905	USEPA 2007	Regression-based BAF (1)	2.385	USEPA 2007	Modeled BAF (10)
2,4-Dichlorophenol	3.400	USEPA 2007	Regression-based BAF (1)	2.803	USEPA 2007	Modeled BAF (10)
2-Acetylaminofluorene	3.275	USEPA 2007	Regression-based BAF (1)	2.774	USEPA 2007	Modeled BAF (10)
2-Chloronaphthalene	2.569	USEPA 2007	Regression-based BAF (1)	2.592	USEPA 2007	Modeled BAF (10)
3,3'-Dichlorobenzidine	2.275	USEPA 2007	Regression-based BAF (1)	2.506	USEPA 2007	Modeled BAF (10)
3,3'-Dimethylbenzidine	4.940	USEPA 2007	Regression-based BAF (1)	3.110	USEPA 2007	Modeled BAF (10)
3-Methylcholanthrene	0.150	USEPA 2007	Regression-based BAF (1)	1.175	USEPA 2007	Modeled BAF (10)
4-Bromophenyl phenyl ether	0.566	USEPA 2007	Regression-based BAF (1)	1.701	USEPA 2007	Modeled BAF (10)
4-Chloro-3-methylphenol	3.337	USEPA 2007	Regression-based BAF (1)	2.788	USEPA 2007	Modeled BAF (10)
4-Chlorophenyl phenyl ether	0.593	USEPA 2007	Regression-based BAF (1)	1.723	USEPA 2007	Modeled BAF (10)
7,12-Dimethylbenz(a)anthracene	0.125	USEPA 2007	Regression-based BAF (1)	1.116	USEPA 2007	Modeled BAF (10)
Aramite, total	0.669	USEPA 2007	Regression-based BAF (1)	1.782	USEPA 2007	Modeled BAF (10)
Bis(2-ethylhexyl)phthalate	0.066	USEPA 2007	Regression-based BAF (1)	0.935	USEPA 2007	Modeled BAF (10)
Butyl benzyl phthalate	0.657	USEPA 2007	Regression-based BAF (1)	1.773	USEPA 2007	Modeled BAF (10)

TABLE 5-8
SOIL TO PLANT AND SOIL TO EARTHWORM BIOACCUMULATION FACTORS AND BIOACCUMULATION UPTAKE EQUATIONS FOR THE ESTIMATION OF CHEMICAL CONCENTRATIONS IN TERRESTRIAL PLANT AND INVERTEBRATE TISSUE: STEP 2 SCREENING LEVEL RISK CALCULATION
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	Soil-Plant BAF (dry weight) or Uptake Equation (dry weight)			Soil-Invertebrate BAF (dry weight) or Uptake Equation (dry weight)		
Chemical	**BAF Value/Uptake Equation**	**Source Document**	**Description**	**BAF Value/Uptake Equation**	**Source Document**	**Description**
Semi-Volatile Organics:						
Diallate	0.911	USEPA 2007	Regression-based BAF [1]	1.942	USEPA 2007	Modeled BAF [10]
Dibenzofuran	1.194	USEPA 2007	Regression-based BAF [1]	2.094	USEPA 2007	Modeled BAF [10]
Diethyl phthalate	5.845	USEPA 2007	Regression-based BAF [1]	3.259	USEPA 2007	Modeled BAF [10]
Di-n-butyl phthalate	0.814	USEPA 2007	Regression-based BAF [1]	1.882	USEPA 2007	Modeled BAF [10]
Di-n-octyl phthalate	0.032	USEPA 2007	Regression-based BAF [1]	0.767	USEPA 2007	Modeled BAF [10]
Dinoseb	1.923	USEPA 2007	Regression-based BAF [1]	2.391	USEPA 2007	Modeled BAF [10]
Hexachlorobenzene	0.246	USEPA 2007	Regression-based BAF [1]	1.349	USEPA 2007	Modeled BAF [10]
Hexachlorobutadiene	0.675	USEPA 2007	Regression-based BAF [1]	1.787	USEPA 2007	Modeled BAF [10]
Hexachlorocyclopentadiene	0.393	USEPA 2007	Regression-based BAF [1]	1.536	USEPA 2007	Modeled BAF [10]
Hexachloroethane	1.439	USEPA 2007	Regression-based BAF [1]	2.206	USEPA 2007	Modeled BAF [10]
Hexachlorophene	0.053	USEPA 2007	Regression-based BAF [1]	0.878	USEPA 2007	Modeled BAF [10]
Hexachloropropene	1.009	USEPA 2007	Regression-based BAF [1]	1.998	USEPA 2007	Modeled BAF [10]
Isosafrole	2.593	USEPA 2007	Regression-based BAF [1]	2.599	USEPA 2007	Modeled BAF [10]
n-Nitrosodiphenylamine	3.155	USEPA 2007	Regression-based BAF [1]	2.745	USEPA 2007	Modeled BAF [10]
p-Dimethylamino azobenzene	0.837	USEPA 2007	Regression-based BAF [1]	1.897	USEPA 2007	Modeled BAF [10]
Pentachlorobenzene	0.444	USEPA 2007	Regression-based BAF [1]	1.589	USEPA 2007	Modeled BAF [10]
Pentachloronitrobenzene	0.792	USEPA 2007	Regression-based BAF [1]	1.868	USEPA 2007	Modeled BAF [10]
Pentachlorophenol	46.02	USEPA 2007	Maximum BAF [2]	88.12	USEPA 2007	90th percentile BAF [11]
Pronamide	2.275	USEPA 2007	Regression-based BAF [1]	2.506	USEPA 2007	Modeled BAF [10]
PAHs:						
2-Methylnaphthalene	1.580	USEPA 2007	Regression-based BAF [1]	2.264	USEPA 2007	Modeled BAF [10]
Acenaphthene	$In(C_p) = -0.8556[ln[C_s]) - 5.562$	USEPA 2007	Uptake equation [3]	2.252	USEPA 2007	Modeled BAF [10]
Acenaphthylene	1.311	USEPA 2007	Regression-based BAF [1]	2.149	USEPA 2007	Modeled BAF [10]
Anthracene	$ln(C_p) = 0.7784[ln(C_s)] - 0.9887$	USEPA 2007	Uptake equation [3]	1.912	USEPA 2007	Modeled BAF [10]
Benzo(a)anthracene	$In(C_p) = 0.5944[In(C_s)] - 2.7078$	USEPA 2007	Uptake equation [3]	1.417	USEPA 2007	Modeled BAF [10]
Benzo(a)pyrene	$ln(C_p) = 0.975[ln(C_s)] - 2.0615$	USEPA 2007	Uptake equation [3]	1.274	USEPA 2007	Modeled BAF [10]
Benzo(b)fluoranthene	0.48	USEPA 2007	Maximum BAF [4]	1.245	USEPA 2007	Modeled BAF [10]
Benzo(g,h,i)perylene	$ln(C_p) = 1.1829[ln(C_s)] - 0.9313$	USEPA 2007	Uptake equation [3]	1.093	USEPA 2007	Modeled BAF [10]
Benzo(k)fluoranthene	$ln(C_p) = 0.8595[ln(C_s)] - 2.1579$	USEPA 2007	Uptake equation [3]	1.245	USEPA 2007	Modeled BAF [10]
Chrysene	$In(C_p) = 0.5944[In(C_s)] - 2.7078$	USEPA 2007	Uptake equation [3]	1.417	USEPA 2007	Modeled BAF [10]
Dibenzo(a,h)anthracene	0.23	USEPA 2007	Maximum BAF [4]	1.096	USEPA 2007	Modeled BAF [10]
Fluoranthene	6.0	USEPA 2007	Maximum BAF [4]	1.648	USEPA 2007	Modeled BAF [10]
Fluorene	$In(C_p) = -0.8556[ln[C_s]) - 5.562$	USEPA 2007	Uptake equation [3]	2.089	USEPA 2007	Modeled BAF [10]

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SOIL TO PLANT AND SOIL TO EARTHWORM BIOACCUMULATION FACTORS AND BIOACCUMULATION UPTAKE EQUATIONS FOR THE ESTIMATION OF CHEMICAL CONCENTRATIONS IN TERRESTRIAL PLANT AND INVERTEBRATE TISSUE: STEP 2 SCREENING LEVEL RISK CALCULATION
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	Soil-Plant BAF (dry weight) or Uptake Equation (dry weight)			Soil-Invertebrate BAF (dry weight) or Uptake Equation (dry weight)		
Chemical	**BAF Value/Uptake Equation**	**Source Document**	**Description**	**BAF Value/Uptake Equation**	**Source Document**	**Description**
PAHs:						
Indeno(1,2,3-cd)pyrene	0.15	USEPA 2007	Maximum BAF (4)	1.107	USEPA 2007	Modeled BAF (10)
Naphthalene	48	USEPA 2007	Maximum BAF (4)	2.606	USEPA 2007	Modeled BAF (10)
Phenanthrene	$\ln(C_p) = 0.6203[\ln(C_s)] - 0.1665$	USEPA 2007	Uptake equation (3)	1.912	USEPA 2007	Modeled BAF (10)
Pyrene	3.7	USEPA 2007	Maximum BAF (4)	1.653	USEPA 2007	Modeled BAF (10)
PCBs (ug/kg):						
Aroclor-1016	0.317	USEPA 2007	Regression-based BAF (1)	15.91	Sample et al. 1998	90th percentile BAF (14)
Aroclor-1221	0.877	USEPA 2007	Regression-based BAF (1)	15.91	Sample et al. 1998	90th percentile BAF (14)
Aroclor-1232	0.877	USEPA 2007	Regression-based BAF (1)	15.91	Sample et al. 1998	90th percentile BAF (14)
Aroclor-1242	0.169	USEPA 2007	Regression-based BAF (1)	15.91	Sample et al. 1998	90th percentile BAF (14)
Aroclor-1248	0.162	USEPA 2007	Regression-based BAF (1)	15.91	Sample et al. 1998	90th percentile BAF (14)
Aroclor-1254	0.106	USEPA 2007	Regression-based BAF (1)	15.91	Sample et al. 1998	90th percentile BAF (14)
Aroclor-1260	0.027	USEPA 2007	Regression-based BAF (1)	15.91	Sample et al. 1998	90th percentile BAF (14)
Metals:						
Antimony	$\ln(C_p) = 0.938[\ln(C_s)] - 3.233$	USEPA 2007	Uptake equation (5)	1.00	USEPA 2007	Assumed BAF
Arsenic	$\ln(C_p) = 0.564[\ln[C_s]) - 1.992$	Bechtel Jacobs 1998	Uptake equation (6)	$\ln(C_e) = 0.706[\ln(C_s)] - 1.421$	USEPA 2007	Uptake equation (12)
Barium	0.447	Bechtel Jacobs 1998	90th percentile BAF (7)	0.16	Sample et al. 1998	90th percentile BAF (13)
Beryllium	$\ln(C_p) = 0.7345[\ln[C_s]) - 0.5361$	USEPA 2007	Uptake equation (8)	1.182	Sample et al. 1998	90th percentile BAF (13)
Cadmium	$\ln(C_p) = 0.546[\ln(C_s)] - 0.475$	USEPA 2007	Uptake equation (9)	$\ln(C_e) = 0.795[\ln(C_s)] + 2.114$	USEPA 2007	Uptake equation (12)
Chromium, total	0.0839	Bechtel Jacobs 1998	90th percentile BAF (7)	3.162	Sample et al. 1998	90th percentile BAF (14)
Cobalt	0.0248	Bechtel Jacobs 1998	90th percentile BAF (7)	0.291	Sample et al. 1998	90th percentileBAF (13)
Copper	$\ln(C_p) = 0.394[\ln(C_s)] + 0.668$	USEPA 2007	Uptake equation (9)	$\ln(C_e) = 0.264[\ln(C_s)] + 1.675$	Sample et al. 1998	Uptake equation (15)
Lead	$\ln(C_p) = 0.561[\ln(C_s)] - 1.328$	USEPA 2007	Uptake equation (9)	$\ln(C_e) = 0.807[\ln(C_s)] - 2.18$	USEPA 2007	Uptake equation (12)
Mercury	$\ln(C_p) = 0.544[\ln[C_s]) - 0.996$	Bechtel Jacobs 1998	Uptake equation (6)	20.63	Sample et al. 1998	90th percentile BAF (14)
Nickel	$\ln(C_p) = 0.748[\ln(C_s)] - 2.224$	USEPA 2007	Uptake equation (9)	4.73	Sample et al. 1998	90th percentile BAF (16)
Selenium	$\ln(C_p) = 0.1.104[\ln(C_s)] - 0.678$	USEPA 2007	Uptake equation (9)	$\ln(C_e) = 0.733[\ln(C_s)] - 0.075$	USEPA 2007	Uptake equation (12)
Silver	0.0367	Bechtel Jacobs 1998	90th percentile BAF (7)	15.338	Sample et al. 1998	90th percentile BAF (13)
Thallium	0.004	Baes et al. 1984	Geometric mean BAF	1.00	---	Assumed BAF
Tin	0.03	Baes et al. 1984	Geometric mean BAF	1.00	---	Assumed BAF
Vanadium	0.0097	Bechtel Jacobs 1998	90th percentile BAF (7)	0.088	Sample et al. 1998	90th percentile BAF (13)
Zinc	$\ln(C_p) = 0.555[\ln(C_s)] + 1.575$	USEPA 2007	Uptake equation (9)	$\ln(C_e) = 0.328[\ln(C_s)] + 4.449$	USEPA 2007	Uptake equation (12)

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SOIL TO PLANT AND SOIL TO EARTHWORM BIOACCUMULATION FACTORS AND BIOACCUMULATION UPTAKE EQUATIONS FOR THE ESTIMATION OF CHEMICAL CONCENTRATIONS IN TERRESTRIAL PLANT AND INVERTEBRATE TISSUE: STEP 2 SCREENING LEVEL RISK CALCULATION
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Notes:

USEPA = United States Environmental Protection Agency
BAF = Bioaccumulation Factor (unitless)
PAH = Polynuclear Aromatic Hydrocarbon
PCB = Polychlorinated Biphenyl
ln = natural logarithm
C_e = Concentration in earthworm tissue (mg/kg - dry weight)
C_p = Concentration in plant tissue (mg/kg - dry weight)
C_s = Maximum concentration in soil (mg/kg - dry weight)

(1) BAF value was estimated using an inter-chemical regression equation for non-ionic organics based on rinsed plant foliage BAF data: logBAF = -0.4057(logK_{ow}) + 1.781, where BAF is the bioaccumulation factor and K_{ow} is the octanol-water partition coefficient (see Figure 5, Panel B in USEPA, 2007). The K_{ow} value used in the estimation of the BAF value is listed in Table 5-3.

(2) Maximum BAF value listed in Appendix F, Table F-1 of USEPA (2007).

(3) The concentration in plant tissue was estimated using a chemical-specific bioaccumulation uptake equation (i.e., regression equation) based on rinsed plant foliage BAF data (see Appendix C in USEPA, 2007).

(4) Maximum BAF value for rinsed plant foliage data listed in Appendix C of USEPA (2007).

(5) The concentration in plant tissue was estimated using a chemical-specific bioaccumulation uptake equation (i.e., regression equation; see Table 4a of USEPA[2007]) derived from measured BAF data (see Appendix A, Table A-1 of USEPA, 2007).

(6) The concentration in plant tissue was estimated using a chemical-specific bioaccumulation uptake equation (i.e., regression equation) listed in Table 7 of Bechtel Jacobs (1998).

(7) 90th percentile BAF value listed in Appendix D, Table D-1 of Bechtel Jacobs (1998).

(8) The concentration in plant tissue was estimated using a chemical-specific bioaccumulation uptake equation (i.e., regression equation; see Table 4a of USEPA, 2007) derived from measured BAF data (see Appendix A, Table A-2 of USEPA, 2007).

(9) The concentration in plant tissue was estimated using a chemical-specific bioaccumulation uptake equation (i.e., regression equation) developed by Bechtel Jacobs (1998) and cited in Table 4a of USEPA (2007).

(10) BAF value was estimated using the relationship BAF = K_{ww}/K_d where K_{ww} is the biota to soil pore water partition coefficient (L soil pore water/kg ww tissue; converted to L soil pore water/kg dw tissue by assuming 16 percent soilds [USEPA, 1993] and dividing by 0.16) and K_d is the soil to pore water partition coefficient (L soil pore water/kg dw soil) (relationship developed by Jager, 1998 and cited in USEPA, 2007). Chemical-specific values for K_{ww} and K_d were derived using the following relationships:

log(K_{ww}) = 0.87(logK_{ow}) - 2.0 where K_{ow} is the octanol-water partition coefficient (K_{ow} value listed in Table 7-3)

K_d = (f_{oc})(K_{oc}) where f_{oc} is the fraction of organic carbon in soil (assumed to be 0.01 [one percent]) and K_{oc} is the organic carbon partition coefficient (K_{oc} value listed in Table 7-3)

(11) 90th percentile BAF calculated from individual BAF values listed in Appendix F-2 of USEPA (2007).

(12) The concentration in earthworm tissue was estimated using a chemical-specific bioaccumulation uptake equation (i.e., regression equation) developed by Sample et al. (1998 and 1999) and cited in Table 4a of USEPA (2007).

(13) 90th percentile BAF listed in Appendix C, Table C.1 of Sample et al. (1998).

(14) 90th percentile BAF value listed in Table 11 of Sample et al. (1998).

(15) The concentration in earthworm tissue was estimated using a chemical-specific bioaccumulation uptake equation (i.e., regression equation) listed in Table 12 of Sample et al. (1998).

TABLE 5-8
SOIL TO PLANT AND SOIL TO EARTHWORM BIOACCUMULATION FACTORS AND BIOACCUMULATION UPTAKE EQUATIONS FOR THE ESTIMATION OF CHEMICAL CONCENTRATIONS IN TERRESTRIAL PLANT AND INVERTEBRATE TISSUE: STEP 2 SCREENING LEVEL RISK CALCULATION
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Table References:

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Table References (continued):

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TABLE 5-9
SOIL BIOACCUMULATION FACTORS AND BIOACCUMULATION UPTAKE EQUATIONS FOR THE ESTIMATION OF CHEMICAL CONCENTRATIONS IN SMALL MAMMAL TISSUE: STEP 2 SCREENING LEVEL RISK CALCULATION
CMS WORK PLAN
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	Soil-Small Mammal BAF (dry weight)		
Chemical	**BAF Value/Uptake Equation**	**Source Document**	**Description**
Volatile Organics:			
1,1,1,2-Tetrachloroethane	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Carbon tetrachloride	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Chlorobenzene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Chloroform	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Ethylbenzene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Pentachloroethane	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Styrene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Toluene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Trichloroethene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Xylenes, total	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Semi-Volatile Organics:			
1,2,4,5-Tetrachlorobenzene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
1,2,4-Trichlorobenzene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
1,2-Dichlorobenzene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
1,3-Dichlorobenzene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
1,4,-Dichlorobenzene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
2,3,4,6-Tetrachlorophenol	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
2,4,5-Trichlorophenol	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
2,4,6-Trichlorophenol	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
2,4-Dichlorophenol	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
2-Acetylaminofluorene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
2-Chloronaphthalene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
3,3'-Dichlorobenzidine	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
3,3'-Dimethylbenzidine	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
3-Methylcholanthrene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
4-Bromophenyl phenyl ether	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
4-Chloro-3-methylphenol	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)

TABLE 5-9
SOIL BIOACCUMULATION FACTORS AND BIOACCUMULATION UPTAKE EQUATIONS FOR THE ESTIMATION OF CHEMICAL CONCENTRATIONS IN SMALL MAMMAL TISSUE: STEP 2 SCREENING LEVEL RISK CALCULATION
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	Soil-Small Mammal BAF (dry weight)		
Chemical	**BAF Value/Uptake Equation**	**Source Document**	**Description**
Semi-Volatile Organics:			
4-Chlorophenyl phenyl ether	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
7,12-Dimethylbenz(a)anthracene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Aramite, total	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Bis(2-ethylhexyl)phthalate	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Butyl benzyl phthalate	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Diallate	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Dibenzofuran	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Diethyl phthalate	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Di-n-butyl phthalate	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Di-n-octyl phthalate	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Dinoseb	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Hexachlorobenzene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Hexachlorobutadiene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Hexachlorocyclopentadiene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Hexachloroethane	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Hexachlorophene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Hexachloropropene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Isosafrole	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
n-Nitrosodiphenylamine	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
p-Dimethylamino azobenzene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Pentachlorobenzene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Pentachloronitrobenzene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Pentachlorophenol	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Pronamide	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
PAHs:			
2-Methylnaphthalene	0.000	---	BAF value for other PAH compounds used as a surrogate
Acenaphthene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
Acenaphthylene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible

TABLE 5-9
SOIL BIOACCUMULATION FACTORS AND BIOACCUMULATION UPTAKE EQUATIONS FOR THE ESTIMATION OF CHEMICAL CONCENTRATIONS IN SMALL MAMMAL TISSUE: STEP 2 SCREENING LEVEL RISK CALCULATION
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Chemical	Soil-Small Mammal BAF (dry weight)		
	BAF Value/Uptake Equation	**Source Document**	**Description**
PAHs:			
Anthracene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
Benzo(a)anthracene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
Benzo(a)pyrene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
Benzo(b)fluoranthene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
Benzo(g,h,i)perylene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
Benzo(k)fluoranthene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
Chrysene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
Dibenzo(a,h)anthracene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
Fluoranthene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
Fluorene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
Indeno(1,2,3-cd)pyrene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
Naphthalene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
Phenanthrene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
Pyrene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
PCBs:			
Aroclor-1016	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 [(1)]
Aroclor-1221	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 [(1)]
Aroclor-1232	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 [(1)]
Aroclor-1242	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 [(1)]
Aroclor-1248	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 [(1)]
Aroclor-1254	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 [(1)]
Aroclor-1260	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 [(1)]
Metals:			
Antimony	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1
Arsenic	$\ln(C_m) = 0.8188[\ln(C_s)] - 4.8471$	USEPA 2007	Regression-based uptake equation for all small mammals [(2)]
Barium	0.1121	Sample et al. 1998	90th percentile BAF for all small mammals [(3)]
Beryllium	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1
Cadmium	$\ln(C_m) = 0.4865[\ln(C_s)] - 0.4306$	Sample et al. 1998	Regression-based uptake equation for all small mammals [(4)]
Chromium, total	$\ln(C_m) = 0.7338[\ln(C_s)] - 1.4599$	USEPA 2007	Regression-based uptake equation for all small mammals [(2)]
Cobalt	$\ln(C_m) = 1.3070[\ln(C_s)] - 4.4669$	USEPA 2007	Regression-based uptake equation for all small mammals [(2)]

TABLE 5-9
SOIL BIOACCUMULATION FACTORS AND BIOACCUMULATION UPTAKE EQUATIONS FOR THE ESTIMATION OF CHEMICAL CONCENTRATIONS IN SMALL MAMMAL TISSUE: STEP 2 SCREENING LEVEL RISK CALCULATION
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

	Soil-Small Mammal BAF (dry weight)		
Chemical	**BAF Value/Uptake Equation**	**Source Document**	**Description**
Metals:			
Copper	$\ln(C_m) = 0.1444[\ln(C_s)] + 0.2042$	USEPA 2007	Regression-based uptake equation for all small mammals (2)
Lead	$\ln(C_m) = 0.4422[\ln(C_s)] + 0.0761$	USEPA 2007	Regression-based uptake equation for all small mammals (2)
Mercury	0.192	Sample et al. 1998	90th percentile BAF for all small mammals (5)
Nickel	$\ln(C_m) = 0.4658[\ln(C_s)] - 0.2462$	USEPA 2007	Regression-based uptake equation for all small mammals (2)
Selenium	$\ln(C_m) = 0.3764[\ln(C_s)] - 0.4158$	USEPA 2007	Regression-based uptake equation for all small mammals (2)
Silver	0.5013	Sample et al. 1998	90th percentile BAF for all small mammals (3)
Thallium	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1
Tin	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1
Vanadium	0.0179	Sample et al. 1998	90th percentile BAF for all small mammals (3)
Zinc	$\ln(C_m) = 0.0738[\ln(C_s)] + 4.4713$	Sample et al. 1998	Regression-based uptake equation for all small mammals (4)

Notes:

USEPA = United States Environmental Protection Agency
PAH = Polynuclear Aromatic Hydrocarbon
PCB = Polychlorinated Biphenyl
BAF = Bioaccumulation Factor
C_m = Concentration in small mammal tissue (mg/kg - dry weight)
C_s = Maximum concentration in soil (mg/kg - dry weight)
BAF_d = diet-to-small mammal bioaccumulation factor (wet weight)
DI = Small mammal dietary intake (mg/kg-BW/day)

(1) Most chemical exposure for small mammals is via the diet. Therefore, it is assumed that the concentration of the chemical in the small mammal's tissues is equal to the chemical concentration in its diet multiplied by a diet to whole-body BAF (BAF_d - wet weight basis). In the absence of literature-based diet to whole-body BAF, a value of 1.0 was assumed. The resulting tissue concentration was converted to a dry weight basis using an estimated solids content for small mammals of 0.32 (USEPA, 1993). Additional explanation is provided in Section 5.5.2.2.1.

(2) The concentration in plant tissue was estimated using a chemical-specific bioaccumulation uptake equation for all small mammals (i.e., regression equation) developed by Sample et al. (1998) and cited in Table 4a of USEPA (2007).

(3) 90th percentile BAF value for all small mammals listed in Appendix C, Table C-1 of Sample et al. (1998).

TABLE 5-9
SOIL BIOACCUMULATION FACTORS AND BIOACCUMULATION UPTAKE EQUATIONS FOR THE ESTIMATION OF CHEMICAL CONCENTRATIONS IN SMALL MAMMAL TISSUE: STEP 2 SCREENING LEVEL RISK CALCULATION
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Notes (continued):

(4) The concentration in plant tissue was estimated using a chemical-specific bioaccumulation uptake equation for all small mammals (i.e., regression equation) listed in Table 8 of Sample et al. (1998).

(5) 90th percentile BAF value for all small mammals listed in Table 7 of Sample et al. (1998).

Table References:

Sample, B.E., J.J. Beauchamp, R.A. Efroymson, and G.W. Suter II. 1998. Development and Validation of Bioaccumulation Models for Small Mammals. Oak Ridge National Laboratory, Environmental Restoration Division, ORNL Environmental Restoration Program. ES/ER/TM-219.

United States Environmental Protection Agency (USEPA). 2007. Attachemnt 4-1 of Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs): Exposure Factors and Bioaccumulation Models for Derivation of Wildlife Eco-SSLs. Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-55.

TABLE 5-10
BIOACCUMULATION FACTORS FOR THE ESTIMATION OF CHEMICAL CONCENTRATIONS IN AQUATIC INVERTEBRATES AND FISH: SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

	Sediment-Invertebrate BAF (dry weight)			Sediment-Fish BAF (dry weight)		
Chemical	**Value**	**Source Document**	**Description**	**Value**	**Source Document**	**Description**
Volatile Organics:						
1,1,1,2-Tetrachloroethane	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Carbon tetrachloride	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Chlorobenzene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Chloroform	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Ethylbenzene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Pentachloroethane	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Styrene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Toluene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Trichloroethene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Xylene, total	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Semi-Volatile Organics:						
1,1-Biphenyl	18.419	---	BAF derived from 90th percentile BSAF value listed in Table 5-11 [1]	1.525		BAF derived from 90th percentile BSAF value listed in Table 5-13 [5]
1,2,4,5-Tetrachlorobenzene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
1,2,4-Trichlorobenzene	1.00	---	Assumed BAF	4.134	---	BAF derived from the single BSAF value listed in Table 5-13 [5]
1,2-Dichlorobenzene	1.00	---	Assumed BAF	2.641	---	BAF derived from the single BSAF value listed in Table 5-13 [5]
1,3-Dichlorobenzene	1.00	---	Assumed BAF	0.477	---	BAF derived from the single BSAF value listed in Table 5-13 [5]
1,4,-Dichlorobenzene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
2,3,4,6-Tetrachlorophenol	1.00	---	Assumed BAF	1.00	---	Assumed BAF
2,4,5-Trichlorophenol	1.00	---	Assumed BAF	1.00	---	Assumed BAF
2,4,6-Trichlorophenol	1.00	---	Assumed BAF	1.00	---	Assumed BAF
2,4-Dichlorophenol	1.00	---	Assumed BAF	1.00	---	Assumed BAF
2-Acetylaminofluorene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
2-Chloronaphthalene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
3,3'-Dichlorobenzidine	1.00	---	Assumed BAF	1.00	---	Assumed BAF
3,3'-Dimethylbenzidine	1.00	---	Assumed BAF	1.00	---	Assumed BAF
3-Methylcholanthrene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
4-Bromophenyl phenyl ether	1.00	---	Assumed BAF	1.00	---	Assumed BAF
4-Chloro-3-methylphenol	1.00	---	Assumed BAF	1.00	---	Assumed BAF
4-Chlorophenyl phenyl ether	1.00	---	Assumed BAF	1.00	---	Assumed BAF
7,12-Dimethylbenz(a)anthracene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Aramite, total	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Bis(2-ethylhexyl)phthalate	210.759	---	BAF derived from 90th percentile BSAF value listed in Table 5-11 [1]	72.827	---	BAF derived from 90th percentile BSAF value listed in Table 5-13 [5]
Butyl benzyl phthalate	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Diallate	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Dibenzofuran	1.00	---	Assumed BAF	0.842	---	BAF derived from 90th percentile BSAF value listed in Table 5-13 [5]
Diethyl phthalate	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Di-n-butyl phthalate	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Di-n-octyl phthalate	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Dinoseb	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Hexachlorobenzene	120.334	---	BAF derived from 90th percentile BSAF value listed in Table 5-11 [1]	2.124	---	BAF derived from the single BSAF value listed in Table 5-13 [5]
Hexachlorobutadiene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Hexachlorocyclopentadiene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Hexachloroethane	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Hexachlorophene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Hexachloropropene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Isosafrole	1.00	---	Assumed BAF	1.00	---	Assumed BAF
n-Nitrosodiphenylamine	1.00	---	Assumed BAF	1.00	---	Assumed BAF
p-Dimethylamino azobenzene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Pentachlorobenzene	1.00	---	Assumed BAF	0.944	---	BAF derived from the single BSAF value listed in Table 5-13 [5]

TABLE 5-10
BIOACCUMULATION FACTORS FOR THE ESTIMATION OF CHEMICAL CONCENTRATIONS IN AQUATIC INVERTEBRATES AND FISH: SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT
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Chemical	Sediment-Invertebrate BAF (dry weight)			Sediment-Fish BAF (dry weight)		
	Value	Source Document	Description	Value	Source Document	Description
Semi-Volatile Organics:						
Pentachloronitrobenzene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Pentachlorophenol	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Pronamide	1.00	---	Assumed BAF	1.00	---	Assumed BAF
PAHs:						
2-Methylnaphthalene	95.373	---	BAF derived from 90th percentile BSAF value listed in Table 5-11 (1)	4.302	---	BAF derived from 90th percentile BSAF value listed in Table 5-13 (5)
Acenaphthene	12.821	---	BAF derived from 90th percentile BSAF value listed in Table 5-11 (1)	1.010	---	BAF derived from 90th percentile BSAF value listed in Table 5-13 (5)
Acenaphthylene	16.445	---	BAF derived from 90th percentile BSAF value listed in Table 5-11 (1)	0.628	---	BAF derived from 90th percentile BSAF value listed in Table 5-13 (5)
Anthracene	7.350	---	BAF derived from 90th percentile BSAF value listed in Table 5-11 (1)	0.309	---	BAF derived from 90th percentile BSAF value listed in Table 5-13 (5)
Benzo(a)anthracene	17.498	---	BAF derived from 90th percentile BSAF value listed in Table 5-11 (1)	0.732	---	BAF derived from 90th percentile BSAF value listed in Table 5-13 (5)
Benzo(a)pyrene	8.197	---	BAF derived from 90th percentile BSAF value listed in Table 5-11 (1)	0.083	---	BAF derived from 90th percentile BSAF value listed in Table 5-13 (5)
Benzo(b)fluoranthene	60.895	---	BAF derived from 90th percentile BSAF value listed in Table 5-11 (1)	0.093	---	BAF derived from 90th percentile BSAF value listed in Table 5-13 (5)
Benzo(g,h,i)perylene	6.810	---	BAF derived from 90th percentile BSAF value listed in Table 5-11 (1)	1.339	---	BAF derived from 90th percentile BSAF value listed in Table 5-13 (5)
Benzo(k)fluoranthene	99.532	---	BAF derived from 90th percentile BSAF value listed in Table 5-11 (1)	0.086	---	BAF derived from 90th percentile BSAF value listed in Table 5-13 (5)
Chrysene	14.867	---	BAF derived from 90th percentile BSAF value listed in Table 5-11 (1)	0.527	---	BAF derived from 90th percentile BSAF value listed in Table 5-13 (5)
Dibenzo(a,h)anthracene	3.075	---	BAF derived from 90th percentile BSAF value listed in Table 5-11 (1)	0.086	---	BAF derived from 90th percentile BSAF value listed in Table 5-13 (5)
Fluoranthene	12.944	---	BAF derived from 90th percentile BSAF value listed in Table 5-11 (1)	0.227	---	BAF derived from 90th percentile BSAF value listed in Table 5-13 (5)
Fluorene	18.596	---	BAF derived from 90th percentile BSAF value listed in Table 5-11 (1)	2.936	---	BAF derived from 90th percentile BSAF value listed in Table 5-13 (5)
Indeno(1,2,3-cd)pyrene	13.685	---	BAF derived from 90th percentile BSAF value listed in Table 5-11 (1)	0.943	---	BAF derived from 90th percentile BSAF value listed in Table 5-13 (5)
Naphthalene	21.657	---	BAF derived from 90th percentile BSAF value listed in Table 5-11 (1)	5.939	---	BAF derived from 90th percentile BSAF value listed in Table 5-13 (5)
Phenanthrene	22.155	---	BAF derived from 90th percentile BSAF value listed in Table 5-11 (1)	1.474	---	BAF derived from 90th percentile BSAF value listed in Table 5-13 (5)
Pyrene	16.478	---	BAF derived from 90th percentile BSAF value listed in Table 5-11 (1)	1.091	---	BAF derived from 90th percentile BSAF value listed in Table 5-13 (5)
PCBs (ug/kg):						
Aroclor-1016	21.886	Bechtel Jacobs 1998	90th percentile BAF (2)	11.24	Oliver and Niimi 1988	Maximum BAF
Aroclor-1221	21.886	Bechtel Jacobs 1998	90th percentile BAF (2)	11.24	Oliver and Niimi 1988	Maximum BAF
Aroclor-1232	21.886	Bechtel Jacobs 1998	90th percentile BAF (2)	11.24	Oliver and Niimi 1988	Maximum BAF
Aroclor-1242	21.886	Bechtel Jacobs 1998	90th percentile BAF (2)	11.24	Oliver and Niimi 1988	Maximum BAF
Aroclor-1248	21.886	Bechtel Jacobs 1998	90th percentile BAF (2)	11.24	Oliver and Niimi 1988	Maximum BAF
Aroclor-1254	21.886	Bechtel Jacobs 1998	90th percentile BAF (2)	11.24	Oliver and Niimi 1988	Maximum BAF
Aroclor-1260	21.886	Bechtel Jacobs 1998	90th percentile BAF (2)	11.24	Oliver and Niimi 1988	Maximum BAF
Metals:						
Antimony	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Arsenic	0.690	Bechtel Jacobs 1998	90th percentile BAF (3)	0.126	Pascoe et al. 1996	Mean BAF
Barium	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Beryllium	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Cadmium	3.073	Bechtel Jacobs 1998	90th percentile BAF (2)	0.164	Pascoe et al. 1996	Mean BAF
Chromium, total	0.468	Bechtel Jacobs 1998	90th percentile BAF (3)	0.038	Krantzberg and Boyd 1992	Mean BAF
Cobalt	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Copper	7.957	Bechtel Jacobs 1998	90th percentile BAF (2)	0.10	Krantzberg and Boyd 1992	Mean BAF
Lead	0.326	Bechtel Jacobs 1998	90th percentile BAF (2)	0.07	Krantzberg and Boyd 1992	Mean BAF
Mercury	2.868	Bechtel Jacobs 1998	90th percentile BAF (3)	4.58	Cope et al. 1990	Maximum BAF
Nickel	0.214	Bechtel Jacobs 1998	90th percentile BAF (2)	1.00	---	Assumed BAF
Selenium	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Silver	0.18	Hirsch 1998	Mean BAF (4)	1.00	---	Assumed BAF
Thallium	1.00	---	Assumed BAF	1.00	---	Assumed BAF

TABLE 5-10
BIOACCUMULATION FACTORS FOR THE ESTIMATION OF CHEMICAL CONCENTRATIONS IN AQUATIC INVERTEBRATES AND FISH: SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Sediment-Invertebrate BAF (dry weight)			Sediment-Fish BAF (dry weight)		
	Value	**Source Document**	**Description**	**Value**	**Source Document**	**Description**
Metals:						
Tin	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Vanadium	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Zinc	4.759	Bechtel Jacobs 1998	90th percentile BAF (2)	0.147	Pascoe et al. 1996	Mean BAF

Notes:

BAF = Bioaccumulation Factor
PAH = Polynuclear Aromatic Hydrocarbon
PCB = Polychlorinated Biphenyl
BSAF = Biota-Sediment Accumulation Factor

(1) 90th percentile BSAF values (wet weight) listed in Table 5-11 were converted to BAF values (dry weight) using a lipid content of 3.44 percent, solids content of 21 percent, and a sediment organic carbon content of 1.0 percent (default value).
(2) 90th percentile BAF value listed in Table 2 of Bechtel Jacobs (1998) for depurated organisms.
(3) 90th percentile BAF value listed in Table 2 of Bechtel Jacobs (1998) for depurated and non-depurated organisms. A combined depurated/non-depurated data set was used as the source of the 90th percentile BAF value due to the low number of data points for the depurated data set.
(4) Mean BAF value for depurated oligochates (*Lumbriculus variegatus*).
(5) 90th percentile/single value BSAF values (wet weight) listed in Table 5-13 were converted to BAF values (dry weight) using a lipid content of 5.90 percent, solids content of 25 percent, and a sediment organic carbon content of 1.0 percent (default value).

Table References:

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TABLE 5-11
LITERATURE-BASED BIOTA-SEDIMENT ACCUMULATION FACTORS USED TO DERIVE SEDIMENT-TO-INVERTEBRATE BIOACCUMULATION FACTORS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Organism	BSAF (wet weight)	Reference
PAHs:			
2-Methylnaphthalene	Fiddler Crab (*Uca* sp.)	9.0575	USEPA 2010
		9.1329	USEPA 2010
	Hard-Shell Clam (*Pitar morrhuana*)	0.9692	USEPA 2010
		0.7676	USEPA 2010
	Little-Neck Clam (*Mercenaria mercenaria*)	0.8919	USEPA 2010
	Blue Mussel (*Mytilus edulis*)	0.5199	USEPA 2010
		0.7835	USEPA 2010
		0.0540	USEPA 2010
		0.1326	USEPA 2010
		0.6825	USEPA 2010
		0.1655	USEPA 2010
		0.5478	USEPA 2010
		0.1687	USEPA 2010
		0.0037	USEPA 2010
		0.9443	USEPA 2010
		0.0507	USEPA 2010
	2-Methylnaphthalene Statistics:		
	90th Percentile BSAF (wet weight)	5.0133	
	Median BSAF (wet weight)	0.6152	
Acenaphthene	Hard-Shell Clam (*Pitar morrhuana*)	0.6578	USEPA 2010
		1.4306	USEPA 2010
		0.4541	USEPA 2010
		1.311	USEPA 2010
		0.6007	USEPA 2010
		0.0452	USEPA 2010
		0.1203	USEPA 2010
		0.0705	USEPA 2010
	Little-Neck Clam (*Mercenaria mercenaria*)	1.4262	USEPA 2010
		0.0523	USEPA 2010
		0.0331	USEPA 2010
		0.115	USEPA 2010
		0.1192	USEPA 2010
		0.042	USEPA 2010
		0.0695	USEPA 2010
		0.0238	USEPA 2010
		0.0518	USEPA 2010
		0.084	USEPA 2010
		0.0154	USEPA 2010
		0.0364	USEPA 2010
		0.0098	USEPA 2010
		0.0042	USEPA 2010
		0.0513	USEPA 2010
	Blue Mussel (*Mytilus edulis*)	0.866	USEPA 2010
		1.3867	USEPA 2010
		0.0245	USEPA 2010
		0.0754	USEPA 2010
		0.1437	USEPA 2010
		0.1675	USEPA 2010
		0.0977	USEPA 2010
		0.2931	USEPA 2010

TABLE 5-11
LITERATURE-BASED BIOTA-SEDIMENT ACCUMULATION FACTORS USED TO DERIVE SEDIMENT-TO-INVERTEBRATE BIOACCUMULATION FACTORS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Organism	BSAF (wet weight)	Reference
PAHs:			
Acenaphthene (continued)	Blue Mussel (*Mytilus edulis*) (continued)	0.0524	USEPA 2010
		0.0049	USEPA 2010
		0.0008	USEPA 2010
		0.0109	USEPA 2010
		0.0005	USEPA 2010
		0.0033	USEPA 2010
		0.0102	USEPA 2010
		0.5173	USEPA 2010
		0.003	USACE 2010
		0.005	USACE 2010
	Bent-Nosed Clam (*Macoma nasuta*)	0.016	USACE 2010
		0.012	USACE 2010
	Unidentified Crayfish	0.0014	USEPA 2010
		0.0442	USEPA 2010
	Acenaphthene Statistics:		
	90th Percentile BSAF (wet weight)	0.7827	
	Median BSAF (wet weight)	0.0518	
Acenaphthylene	Hard-Shell Clam (*Pitar morrhuana*)	0.1195	USEPA 2010
		0.1657	USEPA 2010
		4.2120	USEPA 2010
		0.3363	USEPA 2010
		0.1275	USEPA 2010
		5.0744	USEPA 2010
		0.0293	USEPA 2010
		0.0225	USEPA 2010
		0.0218	USEPA 2010
	Little-Neck Clam (*Mercenaria mercenaria*)	0.0313	USEPA 2010
		0.0391	USEPA 2010
		0.1045	USEPA 2010
		0.2220	USEPA 2010
		2.2102	USEPA 2010
		0.8416	USEPA 2010
		0.2804	USEPA 2010
		0.4541	USEPA 2010
		0.5247	USEPA 2010
		0.4864	USEPA 2010
		0.2824	USEPA 2010
		0.0466	USEPA 2010
		0.0411	USEPA 2010
		0.0558	USEPA 2010
		0.0630	USEPA 2010
		0.0369	USEPA 2010
		0.0692	USEPA 2010
		0.0214	USEPA 2010
	Blue Mussel (*Mytilus edulis*)	0.4579	USEPA 2010
		0.2655	USEPA 2010
		0.2270	USEPA 2010
		0.3440	USEPA 2010
		0.1325	USEPA 2010
		0.0565	USEPA 2010
		0.1921	USEPA 2010

TABLE 5-11
LITERATURE-BASED BIOTA-SEDIMENT ACCUMULATION FACTORS USED TO DERIVE SEDIMENT-TO-INVERTEBRATE BIOACCUMULATION FACTORS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Organism	BSAF (wet weight)	Reference
PAHs:			
Acenaphthylene (continued)	Blue Mussel (*Mytilus edulis*) (continued)	1.2027	USEPA 2010
		0.9036	USEPA 2010
		4.8701	USEPA 2010
		0.1262	USEPA 2010
		0.2503	USEPA 2010
		0.1306	USEPA 2010
		1.0469	USEPA 2010
		0.0195	USEPA 2010
		0.0017	USEPA 2010
		0.0018	USEPA 2010
		0.0012	USEPA 2010
		0.0061	USEPA 2010
		0.2016	USEPA 2010
		0.0010	USEPA 2010
		0.0058	USEPA 2010
		0.0650	USACE 2010
		0.1090	USACE 2010
	Unidentified Crayfish	0.0149	USEPA 2010
		0.0375	USEPA 2010
		0.0085	USEPA 2010
	Acenaphthylene Statistics:		
	90th Percentile BSAF (wet weight)	1.0039	
	Median BSAF (wet weight)	0.1229	
Anthracene	Hard-Shell Clam (*Pitar morrhuana*)	0.2660	USEPA 2010
		1.0333	USEPA 2010
		0.2760	USEPA 2010
		0.1431	USEPA 2010
		0.0872	USEPA 2010
		0.6731	USEPA 2010
		0.3419	USEPA 2010
		0.2064	USEPA 2010
		0.1080	USEPA 2010
		0.2254	USEPA 2010
		0.1706	USEPA 2010
		0.5304	USEPA 2010
		0.0472	USEPA 2010
		0.0383	USEPA 2010
		0.0177	USEPA 2010
	Little-Neck Clam (*Mercenaria mercenaria*)	0.3669	USEPA 2010
		0.1215	USEPA 2010
		0.0590	USEPA 2010
		0.1199	USEPA 2010
		0.1914	USEPA 2010
		0.1641	USEPA 2010
		0.1068	USEPA 2010
		0.1420	USEPA 2010
		0.0776	USEPA 2010
		0.0495	USEPA 2010
		0.0068	USEPA 2010
		0.0575	USEPA 2010
		0.0206	USEPA 2010
		0.0178	USEPA 2010

TABLE 5-11
LITERATURE-BASED BIOTA-SEDIMENT ACCUMULATION FACTORS USED TO DERIVE SEDIMENT-TO-INVERTEBRATE BIOACCUMULATION FACTORS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Organism	BSAF (wet weight)	Reference
PAHs:			
Anthracene (continued)	Little-Neck Clam (*Mercenaria mercenaria*) (continued)	0.1260	USEPA 2010
		0.0132	USEPA 2010
		0.0078	USEPA 2010
		0.0282	USEPA 2010
		0.0367	USEPA 2010
	Blue Mussel (*Mytilus edulis*)	0.2516	USEPA 2010
		1.9053	USEPA 2010
		0.1195	USEPA 2010
		0.0348	USEPA 2010
		0.1005	USEPA 2010
		0.2459	USEPA 2010
		0.2491	USEPA 2010
		0.2744	USEPA 2010
		0.3097	USEPA 2010
		1.4894	USEPA 2010
		0.0353	USEPA 2010
		0.0976	USEPA 2010
		0.0914	USEPA 2010
		0.0012	USEPA 2010
		0.2030	USEPA 2010
		0.2265	USEPA 2010
		0.0089	USEPA 2010
		0.0006	USEPA 2010
		0.0011	USEPA 2010
		0.0003	USEPA 2010
		0.0020	USEPA 2010
		0.0066	USEPA 2010
		0.2131	USEPA 2010
		0.0060	USACE 2010
		0.0160	USACE 2010
	Bent-Nosed Clam (*Macoma nasuta*)	0.0500	USACE 2010
		0.0440	USACE 2010
	Unidentified Crayfish	0.0026	USEPA 2010
		0.0140	USEPA 2010
		0.0387	USEPA 2010
	Brackish Water Clam (*Rangia cuneata*)	4.4895	USEPA 2010
	Fiddler Crab (*Uca* sp.)	1.5155	USEPA 2010
	Anthracene Statistics:		
	90th Percentile BSAF (wet weight)	0.4487	
	Median BSAF (wet weight)	0.0991	
Benzo(a)anthracene	Hard-Shell Clam (*Pitar morrhuana*)	0.3950	USEPA 2010
		1.9526	USEPA 2010
		0.4332	USEPA 2010
		0.7700	USEPA 2010
		0.3152	USEPA 2010
		1.1428	USEPA 2010
		0.6938	USEPA 2010
		0.6447	USEPA 2010

TABLE 5-11
LITERATURE-BASED BIOTA-SEDIMENT ACCUMULATION FACTORS USED TO DERIVE SEDIMENT-TO-INVERTEBRATE BIOACCUMULATION FACTORS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Organism	BSAF (wet weight)	Reference
PAHs:			
Benzo(a)anthracene (continued)	Hard-Shell Clam (*Pitar morrhuana*) (continued)	0.2370	USEPA 2010
		0.3740	USEPA 2010
		0.0115	USEPA 2010
		0.0386	USEPA 2010
		0.0300	USEPA 2010
		0.0308	USEPA 2010
		0.0108	USEPA 2010
	Little-Neck Clam (*Mercenaria mercenaria*)	1.7028	USEPA 2010
		0.0992	USEPA 2010
		0.0160	USEPA 2010
		0.1860	USEPA 2010
		0.0588	USEPA 2010
		0.0549	USEPA 2010
		0.0234	USEPA 2010
		0.0336	USEPA 2010
		0.0217	USEPA 2010
		0.0314	USEPA 2010
		0.0076	USEPA 2010
		0.0325	USEPA 2010
		0.0044	USEPA 2010
		0.0197	USEPA 2010
		0.0365	USEPA 2010
		0.0061	USEPA 2010
		0.0056	USEPA 2010
		0.0386	USEPA 2010
		0.0087	USEPA 2010
	Blue Mussel (*Mytilus edulis*)	0.3752	USEPA 2010
		1.3486	USEPA 2010
		0.0887	USEPA 2010
		0.0252	USEPA 2010
		0.0633	USEPA 2010
		0.5590	USEPA 2010
		0.2063	USEPA 2010
		0.1802	USEPA 2010
		0.0288	USEPA 2010
		0.3608	USEPA 2010
		0.5301	USEPA 2010
		0.0811	USEPA 2010
		0.1268	USEPA 2010
		0.0739	USEPA 2010
		0.0100	USACE 2010
		0.0640	USACE 2010
		0.1750	USACE 2010
		0.2104	USEPA 2010
		0.2002	USEPA 2010
		0.0008	USEPA 2010
		0.0001	USEPA 2010
		0.0006	USEPA 2010
		0.0001	USEPA 2010
		0.0008	USEPA 2010
		0.0036	USEPA 2010
		0.1169	USEPA 2010

TABLE 5-11
LITERATURE-BASED BIOTA-SEDIMENT ACCUMULATION FACTORS USED TO DERIVE SEDIMENT-TO-INVERTEBRATE BIOACCUMULATION FACTORS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Organism	BSAF (wet weight)	Reference
PAHs:			
Benzo(a)anthracene (continued)	Fiddler Crab (*Uca* sp.)	3.1768	USEPA 2010
		0.4532	USEPA 2010
		5.0716	USEPA 2010
	Unidentified Crayfish	0.0009	USEPA 2010
		0.0020	USEPA 2010
		0.0115	USEPA 2010
	Brackish Water Clam (*Rangia cuneata*)	11.7785	USEPA 2010
		1.3275	USEPA 2010
	Bent-Nosed Clam (*Macoma nasuta*)	0.1028	USEPA 2010
		0.0280	USACE 2010
		0.0260	USACE 2010
		0.0700	USACE 2010
		0.0740	USACE 2010
	Benzo(a)anthracene Statistics:		
	90th Percentile BSAF (wet weight)	1.0682	
	Median BSAF (wet weight)	0.0640	
Benzo(a)pyrene	Hard-Shell Clam (*Pitar morrhuana*)	0.1313	USEPA 2010
		0.9764	USEPA 2010
		0.1467	USEPA 2010
		0.2808	USEPA 2010
		0.1327	USEPA 2010
		0.3552	USEPA 2010
		0.0621	USEPA 2010
		0.1503	USEPA 2010
		0.1455	USEPA 2010
		0.0930	USEPA 2010
		0.1736	USEPA 2010
		0.0167	USEPA 2010
		0.0163	USEPA 2010
		0.0068	USEPA 2010
	Little-Neck Clam (*Mercenaria mercenaria*)	0.5035	USEPA 2010
		0.2230	USEPA 2010
		0.0101	USEPA 2010
		0.0422	USEPA 2010
		0.0298	USEPA 2010
		0.0254	USEPA 2010
		0.0204	USEPA 2010
		0.0298	USEPA 2010
		0.0236	USEPA 2010
		0.0159	USEPA 2010
		0.0052	USEPA 2010
		0.0168	USEPA 2010
		0.0030	USEPA 2010
		0.0072	USEPA 2010
		0.0251	USEPA 2010
		0.0074	USEPA 2010
		0.0027	USEPA 2010
		0.0053	USEPA 2010
		0.0244	USEPA 2010
		0.0284	USEPA 2010

TABLE 5-11
LITERATURE-BASED BIOTA-SEDIMENT ACCUMULATION FACTORS USED TO DERIVE SEDIMENT-TO-INVERTEBRATE BIOACCUMULATION FACTORS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Organism	BSAF (wet weight)	Reference
PAHs:			
Benzo(a)pyrene (continued)	Blue Mussel (*Mytilus edulis*)	0.0400	USACE 2010
		0.0970	USACE 2010
		0.1237	USEPA 2010
		0.0255	USEPA 2010
		0.0047	USEPA 2010
		0.0224	USEPA 2010
		0.3513	USEPA 2010
		0.0453	USEPA 2010
		0.0662	USEPA 2010
		0.0741	USEPA 2010
		0.2383	USEPA 2010
		0.0084	USEPA 2010
		0.0315	USEPA 2010
		0.0191	USEPA 2010
		0.0433	USEPA 2010
		0.0313	USEPA 2010
		0.0028	USEPA 2010
		0.0006	USEPA 2010
		0.0002	USEPA 2010
		0.0004	USEPA 2010
		0.0002	USEPA 2010
		0.0009	USEPA 2010
		0.0017	USEPA 2010
		0.0491	USEPA 2010
	Bent-Nosed Clam (*Macoma nasuta*)	0.0150	USEPA 2010
		0.0210	USEPA 2010
		0.0280	USEPA 2010
		0.0320	USEPA 2010
	Brackish Water Clam (*Rangia cuneata*)	9.5120	USEPA 2010
		1.2660	USEPA 2010
	Ribbed Mussel (*Geukensia demissa*)	0.0195	USEPA 2010
	Eastern Oyster (*Crassostrea virginica*)	0.1051	USEPA 2010
	Amphipod (*Diporeia* spp.)	0.0500	USACE 2010
		0.0300	USACE 2010
		0.0400	USACE 2010
		0.0100	USACE 2010
		0.2200	USACE 2010
		0.0600	USACE 2010
		0.4000	USACE 2010
	Oligochaete (*Lumbriculus variegatus*)	1.0000	USACE 2010
		0.5000	USACE 2010
		1.3400	USACE 2010
	Unidentified Crayfish	0.0084	USEPA 2010
	Fiddler Crab (*Uca* sp.)	3.5792	USEPA 2010
		0.4317	USEPA 2010
		4.7011	USEPA 2010

TABLE 5-11
LITERATURE-BASED BIOTA-SEDIMENT ACCUMULATION FACTORS USED TO DERIVE SEDIMENT-TO-INVERTEBRATE BIOACCUMULATION FACTORS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Organism	BSAF (wet weight)	Reference
PAHs:			
Benzo(a)pyrene (continued)	**Benzo(a)pyrene Statistics:**		
	90th Percentile BSAF (wet weight)	0.5004	
	Median BSAF (wet weight)	0.0314	
Benzo(b)fluoranthene	Brackish Water Clam (*Rangia cuneata*)	8.0329	USEPA 2010
		1.0508	USEPA 2010
	Fiddler Crab (*Uca* sp.)	1.8679	USEPA 2010
		0.3598	USEPA 2010
		0.3136	USEPA 2010
	Unidentified Crayfish	0.0014	USEPA 2010
		0.0017	USEPA 2010
		0.0105	USEPA 2010
	Benzo(b)fluoranthene Statistics:		
	90th Percentile BSAF (wet weight)	3.7174	
	Median BSAF (wet weight)	0.3367	
Benzo(g,h,i)perylene	Hard-Shell Clam (*Pitar morrhuana*)	0.0991	USEPA 2010
		0.1087	USEPA 2010
		0.4162	USEPA 2010
		0.1043	USEPA 2010
		0.1634	USEPA 2010
		0.1296	USEPA 2010
		0.1397	USEPA 2010
		0.1354	USEPA 2010
		0.0193	USEPA 2010
		0.0169	USEPA 2010
	Little-Neck Clam (*Mercenaria mercenaria*)	0.1136	USEPA 2010
		0.0303	USEPA 2010
		0.0373	USEPA 2010
		0.0669	USEPA 2010
		0.0086	USEPA 2010
		0.0135	USEPA 2010
		0.0054	USEPA 2010
		0.0526	USEPA 2010
		0.0610	USEPA 2010
		0.0062	USEPA 2010
		0.0160	USEPA 2010
		0.0048	USEPA 2010
		0.0622	USEPA 2010
		0.0595	USEPA 2010
		0.0174	USEPA 2010
		0.0060	USEPA 2010
		0.0428	USEPA 2010
	Blue Mussel (*Mytilus edulis*)	0.0508	USEPA 2010
		0.4110	USEPA 2010
		0.0335	USEPA 2010
		0.2042	USEPA 2010
		0.0321	USEPA 2010
		0.1170	USEPA 2010
		0.6140	USEPA 2010
		0.0331	USEPA 2010
		0.0518	USEPA 2010
		0.0452	USEPA 2010

TABLE 5-11
LITERATURE-BASED BIOTA-SEDIMENT ACCUMULATION FACTORS USED TO DERIVE SEDIMENT-TO-INVERTEBRATE BIOACCUMULATION FACTORS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Organism	BSAF (wet weight)	Reference
PAHs:			
Benzo(g,h,i)perylene (continued)	Blue Mussel (*Mytilus edulis*) (continued)	0.0677	USEPA 2010
		0.0830	USEPA 2010
		0.0008	USEPA 2010
		0.0039	USEPA 2010
		0.0001	USEPA 2010
		0.0008	USEPA 2010
		0.0002	USEPA 2010
		0.0013	USEPA 2010
		0.0036	USEPA 2010
		0.0698	USEPA 2010
		0.0120	USACE 2010
		0.0170	USACE 2010
		0.0360	USEPA 2010
	Bent-Nosed Clam (*Macoma nasuta*)	0.0220	USACE 2010
		0.0350	USACE 2010
		0.0110	USACE 2010
		0.0130	USACE 2010
	Brackish Water Clam (*Rangia cuneata*)	16.7574	USEPA 2010
		3.7523	USEPA 2010
	Fiddler Crab (*Uca* sp.)	6.1502	USEPA 2010
		1.2775	USEPA 2010
		6.2611	USEPA 2010
	Unidentified Crayfish	0.0031	USEPA 2010
		0.0035	USEPA 2010
		0.0155	USEPA 2010
	Benzo(g,h,i)perylene Statistics:		
	90th Percentile BSAF (wet weight)	0.4157	
	Median BSAF (wet weight)	0.0367	
Benzo(k)fluoranthene	Brackish Water Clam (*Rangia cuneata*)	11.0245	USEPA 2010
		1.1277	USEPA 2010
	Unidentified Crayfish	0.0023	USEPA 2010
		0.0029	USEPA 2010
		0.0148	USEPA 2010
	Fiddler Crab (Uca sp.)	0.3851	USEPA 2010
	Benzo(k)fluoranthene Statistics:		
	90th Percentile BSAF (wet weight)	6.0761	
	Median BSAF (wet weight)	0.2000	
Chrysene	Hard-Shell Clam (*Pitar morrhuana*)	0.1651	USEPA 2010
		0.7712	USEPA 2010
		0.2586	USEPA 2010
		0.4849	USEPA 2010
		0.2009	USEPA 2010
		0.5775	USEPA 2010
		0.4125	USEPA 2010
		0.2299	USEPA 2010
		0.1392	USEPA 2010
		0.3818	USEPA 2010
		0.1705	USEPA 2010

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LITERATURE-BASED BIOTA-SEDIMENT ACCUMULATION FACTORS USED TO DERIVE SEDIMENT-TO-INVERTEBRATE BIOACCUMULATION FACTORS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Organism	BSAF (wet weight)	Reference
PAHs:			
Chrysene (continued)	Little-Neck Clam (*Mercenaria mercenaria*)	0.5615	USEPA 2010
		0.0832	USEPA 2010
		0.0305	USEPA 2010
		0.2276	USEPA 2010
		0.1447	USEPA 2010
		0.1179	USEPA 2010
		0.0853	USEPA 2010
		0.0985	USEPA 2010
		0.0712	USEPA 2010
	Blue Mussel (*Mytilus edulis*)	0.2475	USEPA 2010
		1.3264	USEPA 2010
		0.0916	USEPA 2010
		0.0158	USEPA 2010
		0.0613	USEPA 2010
		0.2944	USEPA 2010
		0.1960	USEPA 2010
		0.1743	USEPA 2010
		0.4230	USEPA 2010
		0.3013	USEPA 2010
		0.0245	USEPA 2010
		0.1426	USEPA 2010
		0.1050	USEPA 2010
		0.4085	USEPA 2010
		0.1720	USEPA 2010
		0.0100	USACE 2010
		0.0190	USACE 2010
		0.0840	USACE 2010
		0.1960	USACE 2010
	Bent-Nosed Clam (*Macoma nasuta*)	0.0507	USEPA 2010
		0.0250	USACE 2010
		0.0380	USACE 2010
		0.0730	USACE 2010
		0.0790	USACE 2010
	Brackish Water Clam (*Rangia cuneata*)	7.3039	USEPA 2010
		0.9933	USEPA 2010
	Fiddler Crab (*Uca* sp.)	1.6313	USEPA 2010
		0.3397	USEPA 2010
		3.4030	USEPA 2010
		0.9076	USEPA 2010
	Unidentified Crayfish	0.0071	USEPA 2010
	Chrysene Statistics:		
	90th Percentile BSAF (wet weight)	0.9076	
	Median BSAF (wet weight)	0.1720	
Dibenz(a,h)anthracene	Hard-Shell Clam (*Pitar morrhuana*)	0.0459	USEPA 2010
		0.0175	USEPA 2010
	Little-Neck Clam (*Mercenaria mercenaria*)	0.0291	USEPA 2010
		0.0961	USEPA 2010
		0.0518	USEPA 2010
		0.0073	USEPA 2010

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LITERATURE-BASED BIOTA-SEDIMENT ACCUMULATION FACTORS USED TO DERIVE SEDIMENT-TO-INVERTEBRATE BIOACCUMULATION FACTORS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Organism	BSAF (wet weight)	Reference
PAHs:			
Dibenz(a,h)anthracene (continued)	Little-Neck Clam (*Mercenaria mercenaria*) (continued)	0.0181	USEPA 2010
		0.0084	USEPA 2010
		0.0096	USEPA 2010
		0.0026	USEPA 2010
		0.0403	USEPA 2010
	Blue Mussel (*Mytilus edulis*)	0.1372	USEPA 2010
		0.2254	USEPA 2010
		0.1625	USEPA 2010
		0.6260	USEPA 2010
		0.0236	USEPA 2010
		0.0340	USEPA 2010
		0.0359	USEPA 2010
		0.0627	USEPA 2010
		0.0579	USEPA 2010
		0.0002	USEPA 2010
		0.0003	USEPA 2010
		0.00004	USEPA 2010
		0.0335	USEPA 2010
		0.0003	USEPA 2010
		0.0016	USEPA 2010
	Fiddler Crab (*Uca* sp.)	14.2575	USEPA 2010
	Dibenz(a,h)anthracene Statistics:		
	90th Percentile BSAF (wet weight)	0.1877	
	Median BSAF (wet weight)	0.0335	
Fluoranthene	Hard-Shell Clam (*Pitar morrhuana*)	0.3050	USEPA 2010
		2.4013	USEPA 2010
		0.5225	USEPA 2010
		0.5669	USEPA 2010
		0.1455	USEPA 2010
		0.8004	USEPA 2010
		0.3072	USEPA 2010
		0.6089	USEPA 2010
		0.3462	USEPA 2010
		0.3186	USEPA 2010
		0.0441	USEPA 2010
		0.1877	USEPA 2010
		0.0421	USEPA 2010
		0.0472	USEPA 2010
		0.0342	USEPA 2010
	Little-Neck Clam (*Mercenaria mercenaria*)	1.9672	USEPA 2010
		0.0925	USEPA 2010
		0.0570	USEPA 2010
		0.2326	USEPA 2010
		0.2878	USEPA 2010
		0.1482	USEPA 2010
		0.0709	USEPA 2010
		0.1046	USEPA 2010
		0.0602	USEPA 2010
		0.0846	USEPA 2010
		0.0163	USEPA 2010

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LITERATURE-BASED BIOTA-SEDIMENT ACCUMULATION FACTORS USED TO DERIVE SEDIMENT-TO-INVERTEBRATE BIOACCUMULATION FACTORS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Organism	BSAF (wet weight)	Reference
PAHs:			
Fluoranthene (continued)	Little-Neck Clam (*Mercenaria mercenaria*) (continued)	0.0714	USEPA 2010
		0.0199	USEPA 2010
		0.0332	USEPA 2010
		0.0730	USEPA 2010
		0.6760	USEPA 2010
		0.0178	USEPA 2010
		0.0719	USEPA 2010
		0.0132	USEPA 2010
		0.0365	USEPA 2010
	Blue Mussel (*Mytilus edulis*)	0.6400	USEPA 2010
		1.7373	USEPA 2010
		0.1978	USEPA 2010
		0.0323	USEPA 2010
		0.0842	USEPA 2010
		0.5312	USEPA 2010
		0.7834	USEPA 2010
		0.3955	USEPA 2010
		0.7712	USEPA 2010
		1.3857	USEPA 2010
		0.0825	USEPA 2010
		0.2052	USEPA 2010
		0.1899	USEPA 2010
		0.4089	USEPA 2010
		0.4969	USEPA 2010
		0.0012	USEPA 2010
		0.0005	USEPA 2010
		0.0012	USEPA 2010
		0.0004	USEPA 2010
		0.0019	USEPA 2010
		0.0085	USEPA 2010
		0.0116	USEPA 2010
		0.2727	USEPA 2010
		0.0320	USACE 2010
		0.1020	USACE 2010
	Bent-Nosed Clam (*Macoma nasuta*)	0.0230	USACE 2010
		0.0410	USACE 2010
		0.0930	USACE 2010
		0.0950	USACE 2010
		0.0090	USACE 2010
		0.2077	USEPA 2010
		0.1252	USEPA 2010
		0.1408	USEPA 2010
	Brackish Water Clam (*Rangia cuneata*)	4.5359	USEPA 2010
		0.6175	USEPA 2010
	Unidentified Crayfish	0.0014	USEPA 2010
		0.0029	USEPA 2010
		0.0095	USEPA 2010
		0.0888	USEPA 2010
	Fiddler Crab (*Uca* sp.)	2.4521	USEPA 2010
		0.2095	USEPA 2010
		2.7526	USEPA 2010

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LITERATURE-BASED BIOTA-SEDIMENT ACCUMULATION FACTORS USED TO DERIVE SEDIMENT-TO-INVERTEBRATE BIOACCUMULATION FACTORS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Organism	BSAF (wet weight)	Reference
PAHs:			
Fluoranthene (continued)	**Fluoranthene Statistics:**		
	90th Percentile BSAF (wet weight)	0.7902	
	Median BSAF (wet weight)	0.1020	
Fluorene	Hard-Shell Clam (*Pitar morrhuana*)	0.3233	USEPA 2010
		2.3704	USEPA 2010
		0.5678	USEPA 2010
		1.4454	USEPA 2010
		0.0715	USEPA 2010
		0.8249	USEPA 2010
		0.4195	USEPA 2010
		10.7313	USEPA 2010
		0.3695	USEPA 2010
		0.0496	USEPA 2010
		0.0485	USEPA 2010
	Little-Neck Clam (*Mercenaria mercenaria*)	1.4886	USEPA 2010
		0.6820	USEPA 2010
		0.3457	USEPA 2010
		0.1157	USEPA 2010
		0.1215	USEPA 2010
		0.1755	USEPA 2010
		0.2241	USEPA 2010
		0.2650	USEPA 2010
		0.3997	USEPA 2010
		0.0526	USEPA 2010
		0.0512	USEPA 2010
		0.0070	USEPA 2010
		0.0921	USEPA 2010
		0.0204	USEPA 2010
		0.0212	USEPA 2010
		0.0115	USEPA 2010
		0.0070	USEPA 2010
		0.0532	USEPA 2010
		0.0478	USEPA 2010
	Blue Mussel (*Mytilus edulis*)	0.2654	USEPA 2010
		2.3978	USEPA 2010
		0.1805	USEPA 2010
		0.1791	USEPA 2010
		0.2563	USEPA 2010
		0.1724	USEPA 2010
		0.3697	USEPA 2010
		0.5901	USEPA 2010
		0.6499	USEPA 2010
		7.1530	USEPA 2010
		0.0410	USEPA 2010
		0.1461	USEPA 2010
		0.1660	USEPA 2010
		0.3361	USEPA 2010
		0.2292	USEPA 2010
		0.0023	USEPA 2010
		0.0019	USEPA 2010
		0.0045	USEPA 2010
		0.0005	USEPA 2010

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LITERATURE-BASED BIOTA-SEDIMENT ACCUMULATION FACTORS USED TO DERIVE SEDIMENT-TO-INVERTEBRATE BIOACCUMULATION FACTORS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Organism	BSAF (wet weight)	Reference
PAHs:			
Fluorene (continued)	Blue Mussel (*Mytilus edulis*) (continued)	0.0048	USEPA 2010
		0.0275	USEPA 2010
		0.0123	USEPA 2010
		0.4877	USEPA 2010
	Unidentified Crayfish	0.0014	USEPA 2010
		0.0360	USEPA 2010
		0.0547	USEPA 2010
	Fluorene Statistics:		
	90th Percentile BSAF (wet weight)	1.1352	
	Median BSAF (wet weight)	0.1692	
Indeno(1,2,3-cd)pyrene	Hard-Shell Clam (*Pitar morrhuana*)	0.0731	USEPA 2010
		0.0889	USEPA 2010
		0.0877	USEPA 2010
		0.1276	USEPA 2010
		0.1102	USEPA 2010
		0.1028	USEPA 2010
		0.0327	USEPA 2010
		0.0202	USEPA 2010
		0.0166	USEPA 2010
	Little-Neck Clam (*Mercenaria mercenaria*)	0.0220	USEPA 2010
		0.0322	USEPA 2010
		0.0407	USEPA 2010
		0.0278	USEPA 2010
		0.0344	USEPA 2010
		0.0354	USEPA 2010
		0.0373	USEPA 2010
		0.0118	USEPA 2010
		0.0123	USEPA 2010
		0.0059	USEPA 2010
		0.0114	USEPA 2010
		0.0023	USEPA 2010
		0.0354	USEPA 2010
	Blue Mussel (*Mytilus edulis*)	0.0839	USEPA 2010
		0.3942	USEPA 2010
		0.0219	USEPA 2010
		0.1608	USEPA 2010
		0.0303	USEPA 2010
		0.1129	USEPA 2010
		0.6638	USEPA 2010
		0.0178	USEPA 2010
		0.0430	USEPA 2010
		0.0314	USEPA 2010
		0.0548	USEPA 2010
		0.0604	USEPA 2010
		0.0018	USEPA 2010
		0.0005	USEPA 2010
		0.0001	USEPA 2010
		0.0007	USEPA 2010
		0.0001	USEPA 2010
		0.0007	USEPA 2010
		0.0026	USEPA 2010
		0.0670	USEPA 2010

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LITERATURE-BASED BIOTA-SEDIMENT ACCUMULATION FACTORS USED TO DERIVE SEDIMENT-TO-INVERTEBRATE BIOACCUMULATION FACTORS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Organism	BSAF (wet weight)	Reference
PAHs:			
Indeno(1,2,3-cd)pyrene (continued)	Blue Mussel (*Mytilus edulis*) (continued)	0.8390	USACE 2010
		0.8270	USACE 2010
		0.0110	USACE 2010
		0.0260	USACE 2010
	Bent-Nosed Clam (*Macoma nasuta*)	0.0210	USACE 2010
		0.0250	USACE 2010
		0.0070	USACE 2010
	Brackish Water Clam (*Rangia cuneata*)	19.5522	USEPA 2010
		4.0446	USEPA 2010
	Fiddler Crab (*Uca* sp.)	11.4025	USEPA 2010
		1.3748	USEPA 2010
		9.0442	USEPA 2010
	Indeno(1,2,3-cd)pyrene Statistics:		
	90th Percentile BSAF (wet weight)	0.8354	
	Median BSAF (wet weight)	0.0336	
Naphthalene	Hard-Shell Clam (*Pitar morrhuana*)	0.7531	USEPA 2010
		0.5388	USEPA 2010
	Little-Neck Clam (*Mercenaria mercenaria*)	0.4400	USEPA 2010
		1.3412	USEPA 2010
		0.4154	USEPA 2010
		0.2182	USEPA 2010
		1.3221	USEPA 2010
	Blue Mussel (*Mytilus edulis*)	1.5619	USEPA 2010
		3.1543	USEPA 2010
		0.1713	USEPA 2010
		0.7555	USEPA 2010
		1.2388	USEPA 2010
		0.0369	USEPA 2010
		0.0949	USEPA 2010
		0.0805	USEPA 2010
		0.2660	USEPA 2010
		0.2862	USEPA 2010
		0.1906	USEPA 2010
		0.0046	USEPA 2010
		0.0046	USEPA 2010
		0.0900	USACE 2010
		0.1210	USACE 2010
		0.0790	USACE 2010
		0.0710	USACE 2010
	Bent-Nosed Clam (*Macoma nasuta*)	1.0600	USACE 2010
		0.4750	USACE 2010
		0.0440	USACE 2010
		0.0350	USACE 2010
	Unidentified Crayfish	0.0519	USEPA 2010
		0.0004	USEPA 2010
		0.0112	USEPA 2010
	Naphthalene Statistics:		
	90th Percentile BSAF (wet weight)	1.3221	
	Median BSAF (wet weight)	0.1906	

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LITERATURE-BASED BIOTA-SEDIMENT ACCUMULATION FACTORS USED TO DERIVE SEDIMENT-TO-INVERTEBRATE BIOACCUMULATION FACTORS
CMS WORK PLAN
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Chemical	Organism	BSAF (wet weight)	Reference
PAHs:			
Phenanthrene	Hard-Shell Clam (*Pitar morrhuana*)	0.2753	USEPA 2010
		1.9196	USEPA 2010
		0.3340	USEPA 2010
		0.6550	USEPA 2010
		0.1054	USEPA 2010
		0.3081	USEPA 2010
		0.2284	USEPA 2010
		0.1500	USEPA 2010
		0.1540	USEPA 2010
		0.1646	USEPA 2010
		0.3543	USEPA 2010
		0.2201	USEPA 2010
		0.0413	USEPA 2010
		0.0525	USEPA 2010
		0.0202	USEPA 2010
	Little-Neck Clam (*Mercenaria mercenaria*)	1.5031	USEPA 2010
		0.2465	USEPA 2010
		0.0572	USEPA 2010
		0.0419	USEPA 2010
		0.1137	USEPA 2010
		0.1174	USEPA 2010
		0.1191	USEPA 2010
		0.0401	USEPA 2010
		0.0718	USEPA 2010
		0.0308	USEPA 2010
		0.0409	USEPA 2010
		0.0044	USEPA 2010
		0.0501	USEPA 2010
		0.0098	USEPA 2010
		0.0158	USEPA 2010
		0.0930	USEPA 2010
		0.0082	USEPA 2010
		0.0042	USEPA 2010
		0.0290	USEPA 2010
	Blue Mussel (*Mytilus edulis*)	0.2205	USEPA 2010
		1.3525	USEPA 2010
		0.1336	USEPA 2010
		0.0466	USEPA 2010
		0.0734	USEPA 2010
		0.1991	USEPA 2010
		0.4570	USEPA 2010
		0.3817	USEPA 2010
		0.6770	USEPA 2010
		1.6889	USEPA 2010
		0.0405	USEPA 2010
		0.0907	USEPA 2010
		0.1265	USEPA 2010
		0.2125	USEPA 2010
		0.1642	USEPA 2010
		0.0006	USEPA 2010
		0.0002	USEPA 2010
		0.0007	USEPA 2010

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LITERATURE-BASED BIOTA-SEDIMENT ACCUMULATION FACTORS USED TO DERIVE SEDIMENT-TO-INVERTEBRATE BIOACCUMULATION FACTORS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Organism	BSAF (wet weight)	Reference
PAHs:			
Phenanthrene (continued)	Blue Mussel (*Mytilus edulis*) (continued)	0.0002	USEPA 2010
		0.0006	USEPA 2010
		0.0054	USEPA 2010
		0.2242	USEPA 2010
		0.0058	USEPA 2010
		0.0070	USACE 2010
		0.0180	USACE 2010
	Bent-Nosed Clam (*Macoma nasuta*)	0.1140	USACE 2010
		0.0600	USACE 2010
		0.0470	USACE 2010
		0.0440	USACE 2010
	Brackish Water Clam (*Rangia cuneata*)	8.8610	USEPA 2010
		1.6997	USEPA 2010
	Fiddler Crab (*Uca* sp.)	3.4472	USEPA 2010
		0.5813	USEPA 2010
		3.9180	USEPA 2010
	Unidentified Crayfish	0.0010	USEPA 2010
		0.0062	USEPA 2010
		0.0239	USEPA 2010
	Phenanthrene Statistics:		
	90th Percentile BSAF (wet weight)	1.3525	
	Median BSAF (wet weight)	0.0930	
Pyrene	Hard-Shell Clam (*Pitar morrhuana*)	0.2678	USEPA 2010
		2.1318	USEPA 2010
		0.3483	USEPA 2010
		0.4560	USEPA 2010
		0.1308	USEPA 2010
		0.6378	USEPA 2010
		0.2157	USEPA 2010
		0.0366	USEPA 2010
		0.0356	USEPA 2010
		0.0234	USEPA 2010
		0.3766	USEPA 2010
		0.3173	USEPA 2010
		0.2377	USEPA 2010
		0.2763	USEPA 2010
		0.2747	USEPA 2010
	Little-Neck Clam (*Mercenaria mercenaria*)	1.6478	USEPA 2010
		0.2613	USEPA 2010
		0.1493	USEPA 2010
		0.0628	USEPA 2010
		0.0903	USEPA 2010
		0.0517	USEPA 2010
		0.0607	USEPA 2010
		0.0140	USEPA 2010
		0.0480	USEPA 2010
		0.0200	USEPA 2010
		0.0301	USEPA 2010
		0.0624	USEPA 2010
		0.0162	USEPA 2010
		0.0110	USEPA 2010

TABLE 5-11
LITERATURE-BASED BIOTA-SEDIMENT ACCUMULATION FACTORS USED TO DERIVE SEDIMENT-TO-INVERTEBRATE BIOACCUMULATION FACTORS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Organism	BSAF (wet weight)	Reference
PAHs:			
Pyrene (continued)	Little-Neck Clam (*Mercenaria mercenaria*) (continued)	0.0555	USEPA 2010
		0.4934	USEPA 2010
		0.0310	USEPA 2010
		0.0935	USEPA 2010
		0.0603	USEPA 2010
		0.1758	USEPA 2010
	Blue Mussel (*Mytilus edulis*)	1.4573	USEPA 2010
		0.1150	USEPA 2010
		0.0163	USEPA 2010
		0.0646	USEPA 2010
		0.3914	USEPA 2010
		0.2275	USEPA 2010
		0.1992	USEPA 2010
		0.4155	USEPA 2010
		0.6368	USEPA 2010
		0.0606	USEPA 2010
		0.1156	USEPA 2010
		0.0816	USEPA 2010
		0.1549	USEPA 2010
		0.1978	USEPA 2010
		0.3675	USEPA 2010
		0.0012	USEPA 2010
		0.0004	USEPA 2010
		0.0010	USEPA 2010
		0.0004	USEPA 2010
		0.0017	USEPA 2010
		0.0105	USEPA 2010
		0.2093	USEPA 2010
		0.0068	USEPA 2010
		0.0120	USACE 2010
		0.0280	USACE 2010
		0.0300	USACE 2010
		0.1310	USACE 2010
	Bent-Nosed Clam (*Macoma nasuta*)	0.2304	USEPA 2010
		0.2362	USEPA 2010
		0.1935	USEPA 2010
		0.0220	USACE 2010
		0.0420	USACE 2010
		0.0890	USACE 2010
		0.0960	USACE 2010
	Brackish Water Clam (*Rangia cuneata*)	3.3315	USEPA 2010
		0.3575	USEPA 2010
	Amphipod (*Diporeia* spp.)	0.2200	USACE 2010
		0.2700	USACE 2010
		0.3700	USACE 2010
		0.1600	USACE 2010
		1.5700	USACE 2010
		0.4100	USACE 2010
		1.6200	USACE 2010
	Unidentified Crayfish	0.0026	USEPA 2010
		0.0089	USEPA 2010

TABLE 5-11
LITERATURE-BASED BIOTA-SEDIMENT ACCUMULATION FACTORS USED TO DERIVE SEDIMENT-TO-INVERTEBRATE BIOACCUMULATION FACTORS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Organism	BSAF (wet weight)	Reference
PAHs:			
Pyrene (continued)	Oligochaete (*Lumbriculus variegatus*)	0.5200	USACE 2010
		0.2900	USACE 2010
		0.7400	USACE 2010
		0.2900	USACE 2010
		1.3400	USACE 2010
		0.6600	USACE 2010
		2.0300	USACE 2010
	Fiddler Crab (*Uca* sp.)	0.1214	USEPA 2010
		2.4118	USEPA 2010
		1.0059	USEPA 2010
		0.4353	USEPA 2010
	Unidentified Penaeid Shrimp	0.0012	USEPA 2010
	Pyrene Statistics:		
	90th Percentile BSAF (wet weight)	1.0059	
	Median BSAF (wet weight)	0.1575	
Semi-Volatile Organics:			
1,1-Biphenyl	Hard-Shell Clam (*Pitar morrhuana*)	1.3216	USEPA 2010
		1.8343	USEPA 2010
		0.0493	USEPA 2010
	Little-Neck Clam (*Mercenaria mercenaria*)	0.1294	USEPA 2010
		0.4500	USEPA 2010
		0.9911	USEPA 2010
		0.4154	USEPA 2010
		0.4100	USEPA 2010
		0.1248	USEPA 2010
		0.5068	USEPA 2010
		0.0386	USEPA 2010
		0.0215	USEPA 2010
		0.0664	USEPA 2010
		0.1684	USEPA 2010
		0.0342	USEPA 2010
		0.0624	USEPA 2010
		0.0755	USEPA 2010
	Blue Mussel (*Mytilus edulis*)	0.5940	USEPA 2010
		0.4844	USEPA 2010
		1.1577	USEPA 2010
		1.3683	USEPA 2010
		0.0785	USEPA 2010
		0.0829	USEPA 2010
		0.0671	USEPA 2010
		0.4675	USEPA 2010
		0.5811	USEPA 2010
		0.1685	USEPA 2010
		0.0104	USEPA 2010
		0.0278	USEPA 2010
		0.0057	USEPA 2010
		0.4804	USEPA 2010
		0.0086	USEPA 2010
		0.0161	USEPA 2010

TABLE 5-11
LITERATURE-BASED BIOTA-SEDIMENT ACCUMULATION FACTORS USED TO DERIVE SEDIMENT-TO-INVERTEBRATE BIOACCUMULATION FACTORS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Organism	BSAF (wet weight)	Reference
Semi-Volatile Organics:			
1,1-Biphenyl (continued)	**1,1-Biphenyl Statistics:** 90th Percentile BSAF (wet weight)	1.1244	
	Median BSAF (wet weight)	0.1294	
Hexachlorobenzene	Blue Mussel (*Mytilus edulis*)	0.7313	USEPA 2010
		0.3029	USEPA 2010
		0.0800	USEPA 2010
		0.1837	USEPA 2010
		0.1154	USEPA 2010
		3.3973	USEPA 2010
		1.3486	USEPA 2010
	Bent-Nosed Clam (*Macoma nasuta)*	1.9700	USACE 2010
	Little-Neck Clam (*Mercenaria mercenaria*)	0.7369	USEPA 2010
		9.1426	USEPA 2010
		4.6511	USEPA 2010
		0.9457	USEPA 2010
	Hard-Shell Clam (*Pitar morrhuana*)	12.2301	USEPA 2010
		0.3128	USEPA 2010
	Mediterranean Mussel (*Mytilus galloprovincialis*)	0.6410	USACE 2010
	Hexachlorobenzene Statistics: 90th Percentile BSAF (wet weight)	7.3460	
	Median BSAF (wet weight)	0.7369	
Bis(2-ethylexyl)phthalate	Unidentified Crayfish	0.8100	USEPA 2010
		13.9641	USEPA 2010
		8.4739	USEPA 2010
	Bis (2-ethylhexyl)phthalate Statistics: 90th Percentile BSAF (wet weight)	12.8661	
	Median BSAF (wet weight)	8.4739	

Notes:

BSAF = Biota Sediment Accumulation Factor
USEPA = United States Environmental Protection Agency
USACE = United States Army Coprs of Engineers

Table References:

United States Army Corps of Engineers (USACE). 2010. BSAF Database. Engineering Research and Development Center, Engineering Laboratory. http://el.erdc.usace.army.mil/bsafnew/bsaf.html. Accessed May 30, 2010.

United States Environmental Protection Agency (USEPA). 2010. Biota-Sediment Accumulation Factor (BSAF) Database. http://www.epa.gov/med/Prods_Pubs/bsaf.htm. Accessed May 30, 2010.

TABLE 5-12
PERCENT LIPID CONTENT OF AQUATIC INVERTEBRATES
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Organism [(1)]	Percent Lipid (wet weight) [(2)]	Reference
Amphipod (*Diporeia* spp.)	7.73 [(3)]	USACE 2010
Amphipod (*Hyalella azteca*)	1.265 [(3)]	USACE 2010
Crayfish (*Orconectes* spp.)	0.86	USACE 2010
Crayfish (*Procambarus* spp.)	2.985 [(3)]	USACE 2010
Mysid shrimp (*Antarctomysis ohlinii*)	3.2	USACE 2010
Copepod (*Calanoides acutus*)	10.6	USACE 2010
Asian paddle crab (*Charybdis japonica*)	1.9	USACE 2010
Burrowing crab (*Chasmagnathus granulata*)	4.118 [(3)]	USACE 2010
Amphipod (*Corophium colo*)	0.54 [(3)]	USACE 2010
Amphipod (*Corophium volutator*)	0.81 [(3)]	USACE 2010
Amphipod (*Cyphocaris richardii*)	6.6	USACE 2010
Krill (*Euphausia superba*)	5.675	USACE 2010
Amphipod (*Eurythenes gryllus*)	13.8	USACE 2010
Amphipod (*Eusirus propaperdentatus*)	5.1	USACE 2010
Amphipod (*Leptocheirus plumulosus*)	1.21	USACE 2010

TABLE 5-12
PERCENT LIPID CONTENT OF AQUATIC INVERTEBRATES
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Organism [1]	Percent Lipid (wet weight) [2]	Reference
Indian brown shrimp (*Metapenaeus affinis*)	1.637 [3]	USACE 2010
Greasy-back shrimp (*Metapenaeus ensis*)	1.755 [3]	USACE 2010
Copepod (*Metridia gerlachei*)	5.0	USACE 2010
Mantis shrimp (*Oratosquilla oratoria*)	2.22 [3]	USACE 2010
Dager blade grass shrimp (*Palaemonetes pugio*)	1.7	USACE 2010
Amphpod (*Parandania boecki*)	4.6	USACE 2010
Arrow worm (*Pseudosagitta gazellae*)	4.1	USACE 2010
Copepod (*Rhincalanus gigas*)	1.9	USACE 2010
Chinese marsh crab (*Sesarma denaani*)	3.87 [3]	USACE 2010
Krill (*Thysanoessa macrura*)	4.1	USACE 2010
Asian clam (*Corbicula fluminea*)	2.11 [3]	USACE 2010
Asian clam (*Corbicula manilensis*)	1.504	USACE 2010
Asian clam (*Corbicula* spp.)	1.25	USACE 2010
Zebra musscle (*Dreissena polymorpha*)	2.37 [3]	USACE 2010
Clam (*Dreissena* spp.)	1.22	USACE 2010

TABLE 5-12
PERCENT LIPID CONTENT OF AQUATIC INVERTEBRATES
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Organism [1]	Percent Lipid (wet weight) [2]	Reference
Fatmucket (*Lampsilis siliquoidea*)	0.249 [3]	USACE 2010
Eastern oyster (*Crassostrea virginica*)	0.618 [3]	USACE 2010
Japanese cockel (*Fulvia mutica*)	0.5	USACE 2010
Bent nosed clam (*Macoma nasuta*)	1.663 [3]	USACE 2010
Hard clam (*Mercenaria* spp.)	0.88	USACE 2010
Blue muscle (*Mytilus edulis*)	3.634 [3]	USACE 2010
Asian clam (*Potamocorbula amurensis*)	0.40 [3]	USACE 2010
Razor clam (*Sinonovacula constricta*)	1.75 [3]	USACE 2010
Japanese littleneck clam (*Venerupis philippinarum*)	0.80 [3]	USACE 2010
Oligochaete (*Limnodrilus hoffmeisteri*)	13.0	USACE 2010
Oligochaete (*Lumbriculus variegatus*)	0.951 [3]	USACE 2010
Polychaete (*Abarenicola pacifica*)	20.9	USACE 2010
Milky ribbon worm (*Cerebratulus lacteus*)	3.696	USACE 2010
Polychaete (*Leitoscoloplos fragilis*)	1.52 [3]	USACE 2010
Polychaete (*Marenzelleria viridis*)	1.39 [3]	USACE 2010

TABLE 5-12
PERCENT LIPID CONTENT OF AQUATIC INVERTEBRATES
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Organism [(1)]	**Percent Lipid (wet weight)** [(2)]	**Reference**
Polychaete (*Nephtys* spp.)	2.86	USACE 2010
Polychaete (*Nereis diversicolor*)	1.29 [(3)]	USACE 2010

Notes:

USACE = United States Army Corps of Engineers

(1) The organisms listed include freshwater and marine species

(2) Arithmetic average of the listed percent lipid data was used to convert biota-sediment accumulation factors to bioaccumulation factors (arithmetic verage = 3.44 percent).

(3) The value shown represents an average of two or more percent lipid values.

Table References:

United States Army Corps of Engineers (USACE). 2010. BSAF Database. USACE Engineer Research and Development Center, Environmental Laboratory. Accessed May 30, 2010. http://el.erdc.usace.army.mil/bsafnew/bsaf.html.

TABLE 5-13
LITERATURE-BASED BIOTA-SEDIMENT ACCUMULATION FACTORS USED TO DERIVE SEDIMENT-TO-FISH BIOACCUMULATION FACTORS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Organism	BSAF (wet weight)	Reference	90th Percentile BSAF (wet weight)	Median BSAF (wet weight)
PAHs:					
2-Methylnaphthalene	American eel (*Anguilla rostrata*)	0.0284	USEPA 2010	0.1823	0.0788
		0.0109	USEPA 2010		
		0.0518	USEPA 2010		
	White sucker (*Catostomus commersoni*)	0.0721	USEPA 2010		
		0.0832	USEPA 2010		
		0.0703	USEPA 2010		
		0.0743	USEPA 2010		
		0.0267	USEPA 2010		
		0.1031	USEPA 2010		
		0.1190	USEPA 2010		
		0.0895	USEPA 2010		
	Killifish (*Fundulus* sp.)	0.9717	USEPA 2010		
		0.1935	USEPA 2010		
	Largemouth bass (*Micropterus salmoides*)	0.1561	USEPA 2010		
Acenaphthene	American eel (*Anguilla rostrata*)	0.0293	USEPA 2010	0.0428	0.0351
		0.0048	USEPA 2010		
		0.0145	USEPA 2010		
	White sucker (*Catostomus commersoni*)	0.0365	USEPA 2010		
		0.0428	USEPA 2010		
		0.0417	USEPA 2010		
		0.0602	USEPA 2010		
		0.0089	USEPA 2010		
		0.0306	USEPA 2010		
		0.0401	USEPA 2010		
		0.0351	USEPA 2010		
Acenaphthylene	American eel (*Anguilla rostrata*)	0.0037	USEPA 2010	0.0266	0.0138
		0.0024	USEPA 2010		
		0.0003	USEPA 2010		
	White sucker (*Catostomus commersoni*)	0.0150	USEPA 2010		
		0.0149	USEPA 2010		
		0.0136	USEPA 2010		
		0.0138	USEPA 2010		
		0.0085	USEPA 2010		
		0.0266	USEPA 2010		
		0.0287	USEPA 2010		
		0.0244	USEPA 2010		

TABLE 5-13
LITERATURE-BASED BIOTA-SEDIMENT ACCUMULATION FACTORS USED TO DERIVE SEDIMENT-TO-FISH BIOACCUMULATION FACTORS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Organism	BSAF (wet weight)	Reference	90th Percentile BSAF (wet weight)	Median BSAF (wet weight)
PAHs:					
Anthracene	American eel (*Anguilla rostrata*)	0.0031	USEPA 2010	0.0131	0.0084
		0.0008	USEPA 2010		
		0.0002	USEPA 2010		
	White sucker (*Catostomus commersoni*)	0.0119	USEPA 2010		
		0.0106	USEPA 2010		
		0.0099	USEPA 2010		
		0.0105	USEPA 2010		
		0.0032	USEPA 2010		
		0.0139	USEPA 2010		
		0.0109	USEPA 2010		
		0.0148	USEPA 2010		
	Largemouth bass (*Micropterus salmoides*)	0.0072	USEPA 2010		
		0.0062	USEPA 2010		
	Mummichog (*Fundulus heteroclitus*)	0.0084	USEPA 2010		
	Cunner (*Tautogolabrus adspersus*)	0.0061	USEPA 2010		
Benzo(a)anthracene	White sucker (*Catostomus commersoni*)	0.0021	USEPA 2010	0.0310	0.0024
		0.0040	USEPA 2010		
		0.0029	USEPA 2010		
		0.0026	USEPA 2010		
		0.0003	USEPA 2010		
		0.0014	USEPA 2010		
		0.0009	USEPA 2010		
	Killifish (*Fundulus* sp.)	0.0941	USEPA 2010		
Benzo(a)pyrene	White sucker (*Catostomus commersoni*)	0.0018	USEPA 2010	0.00353	0.0021
		0.0023	USEPA 2010		
		0.0040	USEPA 2010		
		0.0002	USEPA 2010		
Benzo(b)fluoranthene	White sucker (*Catostomus commersoni*)	0.0043	USEPA 2010	0.00395	0.0025
		0.0034	USEPA 2010		
		0.0019	USEPA 2010		
		0.0025	USEPA 2010		
		0.0002	USEPA 2010		

TABLE 5-13
LITERATURE-BASED BIOTA-SEDIMENT ACCUMULATION FACTORS USED TO DERIVE SEDIMENT-TO-FISH BIOACCUMULATION FACTORS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Organism	BSAF (wet weight)	Reference	90th Percentile BSAF (wet weight)	Median BSAF (wet weight)
PAHs:					
Benzo(g,h,i)perylene	White sucker (*Catostomus commersoni*)	0.0040	USEPA 2010	0.0567	0.0040
		0.0012	USEPA 2010		
		0.0699	USEPA 2010		
Benzo(k)fluoranthene	White sucker (*Catostomus commersoni*)	0.0018	USEPA 2010	0.0036	0.0024
		0.0024	USEPA 2010		
		0.0030	USEPA 2010		
		0.0041	USEPA 2010		
		0.0002	USEPA 2010		
Chrysene	White sucker (*Catostomus commersoni*)	0.0046	USEPA 2010	0.0223	0.0027
		0.0029	USEPA 2010		
		0.0024	USEPA 2010		
		0.0034	USEPA 2010		
		0.0003	USEPA 2010		
		0.0010	USEPA 2010		
		0.0017	USEPA 2010		
		0.0636	USEPA 2010		
Dibenzo(a,h)anthracene	White sucker (*Catostomus commersoni*)	0.0022	USEPA 2010	0.0036	0.0022
		0.0014	USEPA 2010		
		0.0027	USEPA 2010		
		0.0043	USEPA 2010		
		0.0003	USEPA 2010		
Fluoranthene	American eel (*Anguilla rostrata*)	0.0011	USEPA 2010	0.0096	0.0029
		0.0003	USEPA 2010		
		0.0001	USEPA 2010		
	White sucker (*Catostomus commersoni*)	0.0045	USEPA 2010		
		0.0048	USEPA 2010		
		0.0065	USEPA 2010		
		0.0040	USEPA 2010		
		0.0007	USEPA 2010		
		0.0027	USEPA 2010		
		0.0035	USEPA 2010		
		0.0026	USEPA 2010		
	Cunner (*Tautogolabrus adspersus*)	0.0117	USEPA 2010		
		0.0029	USEPA 2010		
		0.0001	USEPA 2010		
	Killifish (*Fundulus* sp.)	0.0383	USEPA 2010		

TABLE 5-13
LITERATURE-BASED BIOTA-SEDIMENT ACCUMULATION FACTORS USED TO DERIVE SEDIMENT-TO-FISH BIOACCUMULATION FACTORS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Organism	BSAF (wet weight)	Reference	90th Percentile BSAF (wet weight)	Median BSAF (wet weight)
PAHs:					
Fluorene	American eel (*Anguilla rostrata*)	0.0063	USEPA 2010	0.1244	0.0237
		0.0016	USEPA 2010		
		0.0006	USEPA 2010		
		0.0039	USEPA 2010		
	White sucker (*Catostomus commersoni*)	0.0415	USEPA 2010		
		0.0238	USEPA 2010		
		0.0236	USEPA 2010		
		0.0225	USEPA 2010		
		0.0081	USEPA 2010		
		0.0324	USEPA 2010		
		0.0280	USEPA 2010		
		0.0280	USEPA 2010		
	Largemouth bass (*Micropterus salmoides*)	0.0302	USEPA 2010		
		0.0189	USEPA 2010		
	Mummichog (*Fundulus heteroclitus*)	0.5256	USEPA 2010		
	Cunner (*Tautogolabrus adspersus*)	0.2073	USEPA 2010		
Naphthalene	American eel (*Anguilla rostrata*)	0.0265	USEPA 2010	0.2517	0.0408
		0.0123	USEPA 2010		
	White sucker (*Catostomus commersoni*)	0.0408	USEPA 2010		
		0.0430	USEPA 2010		
		0.0428	USEPA 2010		
		0.0387	USEPA 2010		
		0.0170	USEPA 2010		
	Killifish (*Fundulus* sp.)	0.8125	USEPA 2010		
		0.1575	USEPA 2010		
		0.0366	USEPA 2010		
	White perch (*Morone americana*)	0.2517	USEPA 2010		

TABLE 5-13
LITERATURE-BASED BIOTA-SEDIMENT ACCUMULATION FACTORS USED TO DERIVE SEDIMENT-TO-FISH BIOACCUMULATION FACTORS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Organism	BSAF (wet weight)	Reference	90th Percentile BSAF (wet weight)	Median BSAF (wet weight)
PAHs:					
Phenanthrene	American eel (*Anguilla rostrata*)	0.0027	USEPA 2010	0.0625	0.0083
		0.0006	USEPA 2010		
		0.0002	USEPA 2010		
	White sucker (*Catostomus commersoni*)	0.0055	USEPA 2010		
		0.0109	USEPA 2010		
		0.0068	USEPA 2010		
		0.0072	USEPA 2010		
		0.0016	USEPA 2010		
		0.0083	USEPA 2010		
		0.0099	USEPA 2010		
		0.0085	USEPA 2010		
	Killifish (*Fundulus* sp.)	0.1128	USEPA 2010		
		0.1611	USEPA 2010		
	Cunner (*Tautogolabrus adspersus*)	0.0289	USEPA 2010		
		0.0135	USEPA 2010		
	Largemouth bass (*Micropterus salmoides*)	0.0064	USEPA 2010		
	Mummichog (*Fundulus heteroclitus*)	0.0184	USEPA 2010		
Pyrene	White sucker (*Catostomus commersoni*)	0.0022	USEPA 2010	0.0462	0.0034
		0.0027	USEPA 2010		
		0.0041	USEPA 2010		
		0.0026	USEPA 2010		
		0.0003	USEPA 2010		
	Mummichog (*Fundulus heteroclitus*)	0.0387	USEPA 2010		
	Cunner (*Tautogolabrus adspersus*)	0.0122	USEPA 2010		
	Killifish (*Fundulus* sp.)	0.0638	USEPA 2010		

TABLE 5-13
LITERATURE-BASED BIOTA-SEDIMENT ACCUMULATION FACTORS USED TO DERIVE SEDIMENT-TO-FISH BIOACCUMULATION FACTORS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Organism	BSAF (wet weight)	Reference	90th Percentile BSAF (wet weight)	Median BSAF (wet weight)
PAHs:					
Indeno(1,2,3-cd)pyrene	White sucker (*Catostomus commersoni*)	0.0043	USEPA 2010	0.0400	0.0025
		0.0020	USEPA 2010		
		0.0013	USEPA 2010		
		0.0029	USEPA 2010		
		0.0002	USEPA 2010		
	Killifish (*Fundulus* sp.)	0.0756	USEPA 2010		
Semi-Volatile Organics:					
1,2,4-Trichlorobenzene	Killifish (*Fundulus* sp.)	0.0770	USEPA 2010	0.1752	0.1315
		0.1861	USEPA 2010		
1,2-Dichlorobenzene	killifish (*Fundulus* sp.)	0.1119	USEPA 2010	Not Applicable	Not Applicable
1,3-Dichlorobenzene	killifish (*Fundulus* sp.)	0.0202	USEPA 2010	Not Applicable	Not Applicable
1,4-Dichlorobenzene	killifish (*Fundulus* sp.)	0.0136	USEPA 2010	Not Applicable	Not Applicable
Hexachlorobenzene	Not reported	0.0900	USEPA 2004	Not Applicable	Not Applicable
Dibenzofuran	American eel (*Anguilla rostrata*)	0.0021	USEPA 2010	0.0357	0.0317
		0.0067	USEPA 2010		
	White sucker (*Catostomus commersoni*)	0.0093	USEPA 2010		
		0.0320	USEPA 2010		
		0.0359	USEPA 2010		
		0.0333	USEPA 2010		
		0.0305	USEPA 2010		
		0.0327	USEPA 2010		
		0.0338	USEPA 2010		
		0.0496	USEPA 2010		
	Largemouth bass (*Micropterus salmoides*)	0.0138	USEPA 2010		
		0.0315	USEPA 2010		

TABLE 5-13
LITERATURE-BASED BIOTA-SEDIMENT ACCUMULATION FACTORS USED TO DERIVE SEDIMENT-TO-FISH BIOACCUMULATION FACTORS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Organism	BSAF (wet weight)	Reference	90th Percentile BSAF (wet weight)	Median BSAF (wet weight)
Semi-Volatile Organics:					
Bis(2-ethylhexyl)phthalate	Killifish (*Fundulus* sp.)	2.8785	USEPA 2010	3.0859	1.1577
		3.2242	USEPA 2010		
		1.1577	USEPA 2010		
	Largescale sucker (*Catostomus macrocheilus*)	0.2988	USEPA 2010		
		0.1175	USEPA 2010		
Pentachlorobenzene	Not reported	0.0400	USEPA 2004	Not Applicable	Not Applicable
1,1-Biphenyl	White sucker (*Catostomus commersoni*)	0.0138	USEPA 2010	0.06459	0.0384
		0.0642	USEPA 2010		
		0.0681	USEPA 2010		
		0.0582	USEPA 2010		
		0.0337	USEPA 2010		
		0.0357	USEPA 2010		
		0.0347	USEPA 2010		
		0.0410	USEPA 2010		
	Largmouth Bass (*Micropterus salmoides*)	0.0519	USEPA 2010		
	Anerican eel (*Anguilla rostrata*)	0.0106	USEPA 2010		

Notes:

PAH = Polynuclear Aromatic Hydrocarbon
BSAF = Biota Sediment Accumulation Factor
USEPA = United States Environmental Protection Agency

Table References:

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TABLE 5-14
PERCENT LIPID CONTENT OF FISH
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Organism [1]	Percent Lipid (wet weight) [2]	Reference
Bridgelip sucker (*Catostomus columbianus*)	12.22	USACE 2010
White sucker (*Catostomus commersoni*)	5.995	USACE 2010
Largescale sucker (*Catostomus macrocheilus*)	6.95	USACE 2010
Speckled sanddab (*Citharichthys stigmaeus*)	1.682 [3]	USACE 2010
Paiute sculpin (*Cottus beldingii*)	2.6	USACE 2010
Sculpin (*Cottus* spp.)	5.35	USACE 2010
Common carp (*Cyprinus carpio*)	6.314	USACE 2010
Channel catfish (*Ictalurus punctatus*)	3.3	USACE 2010
Flathead mullet (*Mugil cephalus*)	0.46	USACE 2010
Round goby (*Neogobius melanstomus*)	2.825 [3]	USACE 2010
Silver perch (*Bairdiella chrysoura*)	3.7	USACE 2010
Popeye lampfish (*Bolinichthys longipes*)	4.4	USACE 2010
Dogtooth lampfish (*Ceratoscopelus townsendi*)	8.6 [3]	USACE 2010
California headlightfish (*Diaphus theta*)	7.8 [3]	USACE 2010
Lanternfish (*Electrona antarctica*)	18.9	USACE 2010

TABLE 5-14
PERCENT LIPID CONTENT OF FISH
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Organism [(1)]	Percent Lipid (wet weight) [(2)]	Reference
Lanternfish (*Electrona carlsbergi*)	11.2	USACE 2010
Eastern mosquitofish (*Gambusia holbrooki*)	4.367	USACE 2010
Slendertail lanternfish (*Gonichthys tenuiculus*)	2.6	USACE 2010
Thickhead lanternfish (*Hygophum atratum*)	1.8	USACE 2010
Sunbeam lampfish (*Lampadena urophaos*)	8.9 [(3)]	USACE 2010
Northern lampfish (*Lampanyctus ingens*)	1.2	USACE 2010
Slimtail lampfish (*Lampanyctus parvicauda*)	12.3	USACE 2010
Pinpoint lanternfish (*Lampanyctus regalis*)	1.7	USACE 2010
Broadfin lampfish (*Lampanyctus ritteri*)	8.85 [(3)]	USACE 2010
Smallmouth bass (*Micropterus dolomieu*)	1.9	USACE 2010
Lanternfish (*Nannobrachium idostigma*)	5.8	USACE 2010
Patchwork lampfish (*Notoscopelus resplendens*)	5.6	USACE 2010
Columbia River redband trout (*Oncorhynchus mykiss gairdnerii*)	4.203 [(3)]	USACE 2010
Antarctic silverfish (*Pleuragramma antarcticum*)	4.3	USACE 2010
Japanese ricefish (*Oryzias latipes*)	4.765 [(3)]	USACE 2010

TABLE 5-14
PERCENT LIPID CONTENT OF FISH
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Organism [(1)]	**Percent Lipid (wet weight)** [(2)]	**Reference**
Rainbow smelt (*Osmerus mordax*)	7.0 [(3)]	USACE 2010
Fathead minnow (*Pimephales promelas*)	2.05 [(3)]	USACE 2010
Guppy (*Poecilia reticulata*)	9.7	USACE 2010
Bluefish (*Pomatomus saltatrix*)	1.8 [(3)]	USACE 2010
Lanternfish (*Protomyctophum bolini*)	8.5	USACE 2010
California flashlightfish (*Protomyctophum crockeri*)	5.2	USACE 2010
Brown trout (*Salmo trutta*)	4.8	USACE 2010
Deepwater lanternfish (*Taaningichthys bathyphilus*)	3.8	USACE 2010
Blue lanternfish (*Tarletonbeania crenularis*)	2.6	USACE 2010
Lake trout (*Salvelinus namaycush*)	13.60 [(3)]	USACE 2010
Pacific blackchin (*Scopelengys tristis*)	3.8	USACE 2010
California lanternfish (*Symbolophorus californiensis*)	5.76 [(3)]	USACE 2010
Mexican lampfish (*Triphoturus mexicanus*)	11.7 [(3)]	USACE 2010
Atlantic herring (*Clupea harengus*)	8.75	USACE 2010

TABLE 5-14
PERCENT LIPID CONTENT OF FISH
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Notes:

(1) The organisms listed include freshwater and marine species.

(2) Arithmetic average of the listed percent lipid data was used to convert biota-sediment accumulation factors to bioaccumulation factors (arithmetic average = 5.90 percent).

(3) The value shown represents an average of two or more percent lipid values.

Table References:

United States Army Corps of Engineers (USACE). 2010. BSAF Database. USACE Engineer Research and Development Center, Environmental Laboratory. Accessed May 30, 2010. http://el.erdc.usace.army.mil/bsafnew/bsaf.html.

TABLE 5-15
EXPOSURE PARAMETERS FOR UPPER TROPHIC LEVEL RECEPTORS: STEP 2 SCREENING LEVEL RISK CALCULATION
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Receptor	Habitat	Body Weight (kg)		Food Ingestion Rate (kg/day - dry)		Water Ingestion Rate (L/day)		Area Use Factor
		Value	Reference	Value	Reference	Value	Reference	
Birds:								
American robin	Terrestrial	0.056 (1)	Dunning 2008	0.01503	Allometric equation from Nagy (2001) for insectivorous birds(7): $[0.540((BW*1000)^{0.705})]/1000$	0.01361	Allometric equation from Calder and Braun (1983) for all birds(7): $0.059(BW)^{0.67}$	1.00
Mourning dove	Terrestrial	0.115 (2)	Dunning 2008	0.01723	Allometric equation from Nagy (2001) for all birds(7): $[0.638((BW*1000)^{0.685})]/1000$	0.01449	Allometric equation from Calder and Braun (1983) for all birds(7): $0.059(BW)^{0.67}$	1.00
Red-tailed hawk	Terrestrial	0.923 (3)	Dunning 2008	0.09679	Allometric equation from Nagy (2001) for carnivorous birds(7): $[0.849((BW*1000)^{0.663})]/1000$	0.06910	Allometric equation from Calder and Braun (1983) for all birds(7): $0.059(BW)^{0.67}$	1.00
Green heron	Aquatic	0.138 (4)	Dunning 2008	0.02567	Allometric equation from Nagy (2001) for all birds(7): $[0.638((BW*1000)^{0.685})]/1000$	0.02139	Allometric equation from Calder and Braun (1983) for all birds(7): $0.059(BW)^{0.67}$	1.00
Spotted sandpiper	Aquatic	0.0294 (5)	Dunning 2008	0.01052	Allometric equation from Nagy (2001) for all birds(7): $[0.638((BW*1000)^{0.685})]/1000$	0.00894	Allometric equation from Calder and Braun (1983) for all birds(7): $0.059(BW)^{0.67}$	1.00

TABLE 5-15
EXPOSURE PARAMETERS FOR UPPER TROPHIC LEVEL RECEPTORS: STEP 2 SCREENING LEVEL RISK CALCULATION
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Receptor	Habitat	Body Weight (kg)		Food Ingestion Rate (kg/day - dry)		Water Ingestion Rate (L/day)		Area Use Factor
		Value	Reference	Value	Reference	Value	Reference	
Mammals:								
Norway rat (prey item for red-tailed hawk)	Terrestrial	0.200 [6]	Jackson 1992	0.04075	Allometric equation from Nagy (2001) for rodents[8]: $[0.332((BW*1000)^{0.774})]/1000$	0.05305	Allometric equation from Calder and Braun (1983) for all mammals[8]: $0.099(BW)^{0.90}$	1.00

Notes:

BW = Body Weight
kg = kilogram
L/day = liter per day
kg/day - dry = kilogram per day - dry weight basis
USEPA = United States Environmental Protection Agency

(1) Minimum body weight for males and females from the western United States (n = 255).
(2) Minimum mean body weight for females from Illinois (n = 95)
(3) Minimum mean body weight for males from the western United States (n = 26)
(4) Minimum body weight for males and females in the Caribbean (n = 70)
(5) Minimum body weight for unknown gender in Pennsylvania (n = 56)
(6) Minimum body weight within the range of reported values (sex and location not specified).
(7) Food and drinking water ingestion rates for avian receptors were calculated using maximum body weights: 0.123 kg for the mourning dove, 0.112 kg for the American robin, 1.266 kg for the red-tailed hawk, 0.220 kg for the green heron, and 0.0598 kg for the spotted sandpiper (Dunning, 2008).
(8) Food ingestion rate and drinking water ingestion rate for the Norway rat were calculated using the maximum body weight within the range of reported values: 0.500 kg (Jackson, 1992).

Table References:

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Dunning, J.B., Jr. (ed.). 2008. CRC Handbook of Avian Body Masses, Second Edition. CRC Press, Boca Raton, FL. 655 pp.

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Nagy, K. A. 2001. Food Requirements of Wild Animals: Predictive Equations for Free-Living Mammals, Reptiles, and Birds. Nutr. Abstr. Rev. Series B. 71:21R-31R.

TABLE 5-16
DIETARY COMPOSITION FOR UPPER TROPHIC LEVEL RECEPTORS: SCREENING LEVEL RISK CALCULATION
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Receptor	Dietary Composition (percent)						Soil/Sediment Ingestion (percent)	
	Terrestrial Plants	Soil Invertebrates	Small Mammals	Aquatic Invertebrates	Fish	Reference	Value	Reference
Birds:								
American robin	0	89.5	0	0	0	Assumed [(1)]	10.5 [(4)]	Sample and Suter II 1994
Mourning dove	95.0	0	0	0	0	Tomlinson et al. 1994	5.0	Assumed
Red-tailed hawk	0	0	100	0	0	USEPA 1993; Sample and Suter II 1994	0	Sample and Suter II 1994
Green heron	0	0	0	0	100	Assumed [(2)]	0	Sample et al. 1997
Spotted sandpiper	0	0	0	81.9	0	USEPA 1993	18.1	Beyer et al. 1994
Mammals:								
Norway rat (prey item for red-tailed hawk)	0	98.0	0	0	0	Assumed [(3)]	2.0	Assumed

Notes:

USEPA = United States Environmental Protection Agency

(1) Although the American robin is omnivorous (USEPA, 1993, Sample et al., 1997, Wheelwright et al., 1986, and Martin et al., 1951), an exclusive diet of terrestrial invertebrates (i.e., earthworms) is assumed for the screening level risk calculation.

(2) Although the green heron consumes aquatic invertebrates and fish (Sample et al., 1997), an exclusive diet of fish is assumed for the screening level risk calculation.

(3) Although the Norway rat is omnivorous (Jackson, 1992), an exclusive diet of terrestrial invertebrates (i.e., earthworms) is assumed for the screening level risk calculation.

(4) The percentage of soil in the diet of the American robin was estimated using the relationship presented in Sample and Sutter II (1994). An exclusive diet of earthworms extrapolates to a soil contribution of 10.5 percent to the total diet.

Table References:

Beyer, N., E. Connor, and S. Gerould. 1994. Estimates of Soil Ingestion by Wildlife. Patuxent Wildlife Research Center, Lauren, MD.

Jackson, W.B. 1992. Norway Rat and Allies. Chapter 54 *In* Chapman, J.A. and G.A. Feldhamer (eds.), Wild Mammals of North America: Biology, Management, and Economics. The John Hopkins University Press, Baltimore, MD. pp. 1077-1088.

TABLE 5-16
DIETARY COMPOSITION FOR UPPER TROPHIC LEVEL RECEPTORS: SCREENING LEVEL RISK CALCULATION
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Table References (continued):

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TABLE 5-17
SOIL TO PLANT AND SOIL TO EARTHWORM BIOACCUMULATION FACTORS AND BIOACCUMULATION UPTAKE EQUATIONS FOR THE ESTIMATION OF CHEMICAL CONCENTRATIONS IN TERRESTRIAL PLANT AND INVERTEBRATE TISSUE: STEP 3A RISK CALCULATION
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

	Soil-Plant BAF (dry weight)			Soil-Invertebrate BAF (dry weight)		
Chemical	**BAF Value/Uptake Equation**	**Source Document**	**Description**	**BAF Value/Uptake Equation**	**Source Document**	**Description**
Volatile Organics:						
1,1,1,2-Tetrachloroethane	5.176	USEPA 2007	Regression-based BAF (1)	3.151	USEPA 2007	Modeled BAF (10)
Carbon tetrachloride	4.715	USEPA 2007	Regression-based BAF (1)	3.070	USEPA 2007	Modeled BAF (10)
Chlorobenzene	4.175	USEPA 2007	Regression-based BAF (1)	2.968	USEPA 2007	Modeled BAF (10)
Chloroform	10.047	USEPA 2007	Regression-based BAF (1)	3.790	USEPA 2007	Modeled BAF (10)
Ethylbenzene	3.214	USEPA 2007	Regression-based BAF (1)	2.759	USEPA 2007	Modeled BAF (10)
Pentachloroethane	3.464	USEPA 2007	Regression-based BAF (1)	2.818	USEPA 2007	Modeled BAF (10)
Styrene	3.875	USEPA 2007	Regression-based BAF (1)	2.907	USEPA 2007	Modeled BAF (10)
Toluene	4.627	USEPA 2007	Regression-based BAF (1)	3.054	USEPA 2007	Modeled BAF (10)
Trichloroethene	4.803	USEPA 2007	Regression-based BAF (1)	3.086	USEPA 2007	Modeled BAF (10)
Xylene, total	3.245	USEPA 2007	Regression-based BAF (1)	2.766	USEPA 2007	Modeled BAF (10)
Semi-Volatile Organics:						
1,1-Biphenyl	1.467	USEPA 2007	Regression-based BAF (1)	2.218	USEPA 2007	Modeled BAF (10)
1,2,4,5-Tetrachlorobenzene	0.792	USEPA 2007	Regression-based BAF (1)	0.50	Beyer 1996	Mean BAF
1,2,4-Trichlorobenzene	1.426	USEPA 2007	Regression-based BAF (1)	0.56	Beyer 1996	Mean BAF
1,2-Dichlorobenzene	2.452	USEPA 2007	Regression-based BAF (1)	2.559	USEPA 2007	Modeled BAF (10)
1,3-Dichlorobenzene	2.092	USEPA 2007	Regression-based BAF (1)	2.448	USEPA 2007	Modeled BAF (10)
1,4,-Dichlorobenzene	2.475	USEPA 2007	Regression-based BAF (1)	2.565	USEPA 2007	Modeled BAF (10)
2,3,4,6-Tetrachlorophenol	0.945	USEPA 2007	Regression-based BAF (1)	1.962	USEPA 2007	Modeled BAF (10)
2,4,5-Trichlorophenol	1.870	USEPA 2007	Regression-based BAF (1)	2.373	USEPA 2007	Modeled BAF (10)
2,4,6-Trichlorophenol	1.905	USEPA 2007	Regression-based BAF (1)	2.385	USEPA 2007	Modeled BAF (10)
2,4-Dichlorophenol	3.400	USEPA 2007	Regression-based BAF (1)	2.803	USEPA 2007	Modeled BAF (10)
2-Acetylaminofluorene	3.275	USEPA 2007	Regression-based BAF (1)	2.774	USEPA 2007	Modeled BAF (10)
2-Chloronaphthalene	2.569	USEPA 2007	Regression-based BAF (1)	2.592	USEPA 2007	Modeled BAF (10)
3,3'-Dichlorobenzidine	2.275	USEPA 2007	Regression-based BAF (1)	2.506	USEPA 2007	Modeled BAF (10)
3,3'-Dimethylbenzidine	4.940	USEPA 2007	Regression-based BAF (1)	3.110	USEPA 2007	Modeled BAF (10)
3-Methylcholanthrene	0.150	USEPA 2007	Regression-based BAF (1)	1.175	USEPA 2007	Modeled BAF (10)
4-Bromophenyl phenyl ether	0.566	USEPA 2007	Regression-based BAF (1)	1.701	USEPA 2007	Modeled BAF (10)
4-Chloro-3-methylphenol	3.337	USEPA 2007	Regression-based BAF (1)	2.788	USEPA 2007	Modeled BAF (10)
4-Chlorophenyl phenyl ether	0.593	USEPA 2007	Regression-based BAF (1)	1.723	USEPA 2007	Modeled BAF (10)
7,12-Dimethylbenz(a)anthracene	0.125	USEPA 2007	Regression-based BAF (1)	1.116	USEPA 2007	Modeled BAF (10)
Aramite, total	0.669	USEPA 2007	Regression-based BAF (1)	1.782	USEPA 2007	Modeled BAF (10)
Bis(2-ethylhexyl)phthalate	0.066	USEPA 2007	Regression-based BAF (1)	0.935	USEPA 2007	Modeled BAF (10)
Butyl benzyl phthalate	0.657	USEPA 2007	Regression-based BAF (1)	1.773	USEPA 2007	Modeled BAF (10)

TABLE 5-17
SOIL TO PLANT AND SOIL TO EARTHWORM BIOACCUMULATION FACTORS AND BIOACCUMULATION UPTAKE EQUATIONS FOR THE ESTIMATION OF CHEMICAL CONCENTRATIONS IN TERRESTRIAL PLANT AND INVERTEBRATE TISSUE: STEP 3A RISK CALCULATION
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

	Soil-Plant BAF (dry weight)			Soil-Invertebrate BAF (dry weight)		
Chemical	**BAF Value/Uptake Equation**	**Source Document**	**Description**	**BAF Value/Uptake Equation**	**Source Document**	**Description**
Semi-Volatile Organics:						
Diallate	0.911	USEPA 2007	Regression-based BAF [1]	1.942	USEPA 2007	Modeled BAF [10]
Dibenzofuran	1.194	USEPA 2007	Regression-based BAF [1]	2.094	USEPA 2007	Modeled BAF [10]
Diethyl phthalate	5.845	USEPA 2007	Regression-based BAF [1]	3.259	USEPA 2007	Modeled BAF [10]
Di-n-butyl phthalate	0.814	USEPA 2007	Regression-based BAF [1]	1.882	USEPA 2007	Modeled BAF [10]
Di-n-octyl phthalate	0.032	USEPA 2007	Regression-based BAF [1]	0.767	USEPA 2007	Modeled BAF [10]
Dinoseb	1.923	USEPA 2007	Regression-based BAF [1]	2.391	USEPA 2007	Modeled BAF [10]
Hexachlorobenzene	0.246	USEPA 2007	Regression-based BAF [1]	1.69	Beyer 1996	Mean BAF
Hexachlorobutadiene	0.675	USEPA 2007	Regression-based BAF [1]	1.787	USEPA 2007	Modeled BAF [10]
Hexachlorocyclopentadiene	0.393	USEPA 2007	Regression-based BAF [1]	1.536	USEPA 2007	Modeled BAF [10]
Hexachloroethane	1.439	USEPA 2007	Regression-based BAF [1]	2.206	USEPA 2007	Modeled BAF [10]
Hexachlorophene	0.053	USEPA 2007	Regression-based BAF [1]	0.878	USEPA 2007	Modeled BAF [10]
Hexachloropropene	1.009	USEPA 2007	Regression-based BAF [1]	1.998	USEPA 2007	Modeled BAF [10]
Isosafrole	2.593	USEPA 2007	Regression-based BAF [1]	2.599	USEPA 2007	Modeled BAF [10]
n-Nitrosodiphenylamine	3.155	USEPA 2007	Regression-based BAF [1]	2.745	USEPA 2007	Modeled BAF [10]
p-Dimethylamino azobenzene	0.837	USEPA 2007	Regression-based BAF [1]	1.897	USEPA 2007	Modeled BAF [10]
Pentachlorobenzene	0.444	USEPA 2007	Regression-based BAF [1]	1.589	USEPA 2007	Modeled BAF [10]
Pentachloronitrobenzene	0.792	USEPA 2007	Regression-based BAF [1]	1.868	USEPA 2007	Modeled BAF [10]
Pentachlorophenol	5.93	USEPA 2007	Median BAF [2]	16.15	USEPA 2007	Median BAF [11]
Pronamide	2.275	USEPA 2007	Regression-based BAF [1]	2.506	USEPA 2007	Modeled BAF [10]
PAHs:						
2-Methylnaphthalene	1.580	USEPA 2007	Regression-based BAF [1]	0.20	Beyer and Stafford 1993	Median value
Acenaphthene	$In(C_p) = -0.8556[In(C_s)] - 5.562$	USEPA 2007	Uptake equation [3]	0.30	Beyer and Stafford 1993	Median value
Acenaphthylene	1.311	USEPA 2007	Regression-based BAF [1]	0.22	Beyer and Stafford 1993	Median value
Anthracene	$\ln(C_p) = 0.7784[\ln(C_s)] - 0.9887$	USEPA 2007	Uptake equation [3]	0.32	Beyer and Stafford 1993	Median value
Benzo(a)anthracene	$In(C_p) = 0.5944[In(C_s)] - 2.7078$	USEPA 2007	Uptake equation [3]	0.27	Beyer and Stafford 1993	Median value
Benzo(a)pyrene	$\ln(C_p) = 0.975[\ln(C_s)] - 2.0615$	USEPA 2007	Uptake equation [3]	0.34	Beyer and Stafford 1993	Median value
Benzo(b)fluoranthene	0.31	USEPA 2007	Median BAF [4]	0.21	Beyer and Stafford 1993	Median value
Benzo(g,h,i)perylene	$\ln(C_p) = 1.1829[\ln(C_s)] - 0.9313$	USEPA 2007	Uptake equation [3]	0.15	Beyer and Stafford 1993	Median value
Benzo(k)fluoranthene	$\ln(C_p) = 0.8595[\ln(C_s)] - 2.1579$	USEPA 2007	Uptake equation [3]	0.21	Beyer and Stafford 1993	Median value
Chrysene	$In(C_p) = 0.5944[In(C_s)] - 2.7078$	USEPA 2007	Uptake equation [3]	0.44	Beyer and Stafford 1993	Median value
Dibenzo(a,h)anthracene	0.13	USEPA 2007	Median BAF [4]	0.49	Beyer and Stafford 1993	Median value
Fluoranthene	0.50	USEPA 2007	Median BAF [4]	0.37	Beyer and Stafford 1993	Median value
Fluorene	$In(C_p) = -0.8556[In(C_s)] - 5.562$	USEPA 2007	Uptake equation [3]	0.20	Beyer and Stafford 1993	Median value

TABLE 5-17
SOIL TO PLANT AND SOIL TO EARTHWORM BIOACCUMULATION FACTORS AND BIOACCUMULATION UPTAKE EQUATIONS FOR THE ESTIMATION OF CHEMICAL CONCENTRATIONS IN TERRESTRIAL PLANT AND INVERTEBRATE TISSUE: STEP 3A RISK CALCULATION
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

	Soil-Plant BAF (dry weight)			Soil-Invertebrate BAF (dry weight)		
Chemical	**BAF Value/Uptake Equation**	**Source Document**	**Description**	**BAF Value/Uptake Equation**	**Source Document**	**Description**
PAHs:						
Indeno(1,2,3-cd)pyrene	0.11	USEPA 2007	Median BAF [4]	0.41	Beyer and Stafford 1993	Median value
Naphthalene	12.2	USEPA 2007	Median BAF [4]	0.21	Beyer and Stafford 1993	Median value
Phenanthrene	$ln(C_p) = 0.6203[ln(C_s)] - 0.1665$	USEPA 2007	Uptake equation [3]	0.28	Beyer and Stafford 1993	Median value
Pyrene	0.72	USEPA 2007	Median BAF [4]	0.39	Beyer and Stafford 1993	Median value
PCBs (ug/kg):						
Aroclor-1016	0.317	USEPA 2007	Regression-based BAF [1]	6.667	Sample et al. 1998	Median value [12]
Aroclor-1221	0.877	USEPA 2007	Regression-based BAF [1]	6.667	Sample et al. 1998	Median value [12]
Aroclor-1232	0.877	USEPA 2007	Regression-based BAF [1]	6.667	Sample et al. 1998	Median value [12]
Aroclor-1242	0.169	USEPA 2007	Regression-based BAF [1]	6.667	Sample et al. 1998	Median value [12]
Aroclor-1248	0.162	USEPA 2007	Regression-based BAF [1]	6.667	Sample et al. 1998	Median value [12]
Aroclor-1254	0.106	USEPA 2007	Regression-based BAF [1]	6.667	Sample et al. 1998	Median value [12]
Aroclor-1260	0.027	USEPA 2007	Regression-based BAF [1]	6.667	Sample et al. 1998	Median value [12]
Metals:						
Antimony	$ln(C_p) = 0.938[ln(C_s)] - 3.233$	USEPA 2007	Uptake equation [5]	1.00	USEPA 2007	Assumed BAF
Arsenic	$In(C_p) = 0.564[ln(C_{s)]} - 1.992$	Bechtel Jacobs 1998	Uptake equation [6]	$ln(C_e) = 0.706[ln(C_s)] - 1.421$	USEPA 2007	Uptake equation [13]
Barium	0.156	USEPA 2007	Median BAF [7]	0.091	USEPA 2007	Median BAF [14]
Beryllium	$In(C_p) = 0.7345[ln(C_s)] - 0.5361$	USEPA 2007	Uptake equation [8]	0.045	USEPA 2007	Median BAF [14]
Cadmium	$ln(C_p) = 0.546[ln(C_s)] - 0.475$	USEPA 2007	Uptake equation [9]	$ln(C_e) = 0.795[ln(C_s)] + 2.114$	USEPA 2007	Uptake equation [13]
Chromium, total	0.041	USEPA 2007	Median BAF [7]	0.306	USEPA 2007	Median BAF [15]
Cobalt	0.0075	USEPA 2007	Median BAF [7]	0.122	USEPA 2007	Median BAF [14]
Copper	$ln(C_p) = 0.394[ln(C_s)] + 0.668$	USEPA 2007	Uptake equation [9]	$ln(C_e) = 0.264[ln(C_s)] + 1.675$	Sample et al. 1998	Median BAF [16]
Lead	$ln(C_p) = 0.561[ln(C_s)] - 1.328$	USEPA 2007	Uptake equation [9]	$ln(C_e) = 0.807[ln(C_s)] - 2.18$	USEPA 2007	Uptake equation [13]
Mercury	$In(C_p) = 0.544[ln[C_s]) - 0.996$	Bechtel Jacobs 1998	Uptake equation [6]	1.693	Sample et al. 1998	Median BAF [12]
Nickel	$ln(C_p) = 0.748[ln(C_s)] - 2.224$	USEPA 2007	Uptake equation [9]	1.059	Sample et al. 1998	Median BAF [12]
Selenium	$ln(C_p) = 0.1.104[ln(C_s)] - 0.678$	USEPA 2007	Uptake equation [9]	$ln(C_e) = 0.733[ln(C_s)] - 0.075$	USEPA 2007	Uptake equation [13]
Silver	0.014	USEPA 2007	Median BAF [7]	2.045	USEPA 2007	Median BAF [14]
Thallium	0.004	Baes et al. 1984	Geometric mean	1.00	---	Assumed BAF
Tin	0.03	Baes et al. 1984	Geometric mean	1.00	---	Assumed BAF
Vanadium	0.00485	USEPA 2007	Median BAF [7]	0.042	USEPA 2007	Median BAF [14]
Zinc	$ln(C_p) = 0.554[ln(C_s)] + 1.575$	USEPA 2007	Uptake equation [9]	$ln(C_e) = 0.328[ln(C_s)] + 4.449$	USEPA 2007	Uptake equation [13]

TABLE 5-17
SOIL TO PLANT AND SOIL TO EARTHWORM BIOACCUMULATION FACTORS AND BIOACCUMULATION UPTAKE EQUATIONS FOR THE ESTIMATION OF CHEMICAL CONCENTRATIONS IN TERRESTRIAL PLANT AND INVERTEBRATE TISSUE: STEP 3A RISK CALCULATION
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Notes:

USEPA = United States Environmental Protection Agency
BAF = Bioaccumulation Factor (unitless)
PAH = Polynuclear Aromatic Hydrocarbon
PCB = Polychlorinated Biphenyl
ln = natural logarithm
C_e = Concentration in earthworm tissue (mg/kg - dry weight)
C_p = Concentration in plant tissue (mg/kg - dry weight)
C_s = 95 percent UCL of the mean concentration in soil (mg/kg - dry weight) - maximum concentration is used if 95 percent UCL of the mean concentration exceeds the maximum concentration

(1) BAF value was estimated using an inter-chemical regression equation for non-ionic organics based on rinsed plant foliage BAF data: logBAF = -0.4057(logK_{ow}) + 1.781, where BAF is the bioaccumulation factor and K_{ow} is the octanol-water partition coefficient (see Figure 5, Panel B in USEPA, 2007). The K_{ow} value used in the estimation of the BAF value is listed in Table 7-3.

Notes (continued):

(2) Median BAF value listed in Appendix F, Table F-1 of USEPA (2007).

(3) The concentration in plant tissue was estimated using a chemical-specific bioaccumulation uptake equation (i.e., regression equation) based on rinsed plant foliage BAF data (see Appendix C in USEPA, 2007).

(4) Median BAF value for rinsed plant foliage BAF data listed in Appendix C of USEPA (2007).

(5) The concentration in plant tissue was estimated using a chemical-specific bioaccumulation uptake equation (i.e., regression equation; see Table 4a of USEPA[2007]) derived from measured BAF data (see Appendix A, Table A-1 of USEPA, 2007).

(6) The concentration in plant tissue was estimated using a chemical-specific bioaccumulation uptake equation (i.e., regression equation) listed in Table 7 of Bechtel Jacobs (1998).

(7) Median BAF value listed in Table 4a of USEPA (2007). The value corresponds to the median BAF value listed in Appendix D, Table D-1 of Bechtel Jacobs (1998).

(8) The concentration in plant tissue was estimated using a chemical-specific bioaccumulation uptake equation (i.e., regression equation; see Table 4a of USEPA, 2007) derived from measured BAF data (see Appendix A, Table A-2 of USEPA, 2007).

(9) The concentration in plant tissue was estimated using a chemical-specific bioaccumulation uptake equation (i.e., regression equation; see Table 4a of USEPA[2007]) developed by Bechtel Jacobs (1998) and cited in Table 4a of USEPA (2007).

(10) BAF value was estimated using the relationship BAF = K_{ww}/K_d where K_{ww} is the biota to soil pore water partition coefficient (L soil pore water/kg ww tissue; converted to L soil pore water/kg dw tissue by assuming 16 percent soilds [USEPA, 1993] and dividing by 0.16) and K_d is the soil to pore water partition coefficient (L soil pore water/kg dw soil) (relationship developed by Jager, 1998 and cited in USEPA, 2007). Chemical-specific values for K_{ww} and K_d were derived using the following relationships:

log(K_{ww}) = 0.87(logK_{ow}) - 2.0 where K_{ow} is the ocantol-water partition coefficient (K_{ow} value listed in Table 7-3)

K_d = (f_{oc})(K_{oc}) where f_{oc} is the fraction of organic carbon in soil (assumed to be 0.01 [one percent]) and K_{oc} is the organic carbon patition coefficient (K_{oc} value listed in Table 7-3)

(11) Median BAF value calculated from individual earthworm BAF values listed in Appendix F-2 of USEPA (2007).

(12) Median BAF value listed in Table 11 of Sample et al. (1998).

(13) The concentration in earthworm tissue was estimated using a chemical-specific bioaccumulation uptake equation (i.e., regression equation) developed by Sample et al. (1998 and 1999) and cited in Table 4a of USEPA (2007).

(14) Median BAF value listed in Table 4a of USEPA (2007). The value corresponds to the median BAF value listed in Appendix C, Table C-1 of Sample et al. (1998).

(15) Median BAF value listed in Table 4a of USEPA (2007). The value corresponds to the median BAF value listed in Table 11 of Sample et al. (1998).

(16) The concentration in earthworm tissue was estimated using a chemical-specific bioaccumulation uptake equation (i.e., regression equation) listed in Table 12 of Sample et al. (1998).

TABLE 5-17
SOIL TO PLANT AND SOIL TO EARTHWORM BIOACCUMULATION FACTORS AND BIOACCUMULATION UPTAKE EQUATIONS FOR THE ESTIMATION OF CHEMICAL CONCENTRATIONS IN TERRESTRIAL PLANT AND INVERTEBRATE TISSUE: STEP 3A RISK CALCULATION
CMS WORK PLAN
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TABLE 5-18
SOIL BIOACCUMULATION FACTORS AND BIOACCUMULATION UPTAKE EQUATIONS USED TO ESTIMATE CHEMICAL CONCENTRATIONS IN SMALL MAMMAL TISSUE: STEP 3A RISK CALCULATION
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	Soil-Small Mammal BAF (dry weight)		
Chemical	**BAF Value/Uptake Equation**	**Source Document**	**Description**
Volatile Organics:			
1,1,1,2-Tetrachloroethane	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Carbon tetrachloride	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Chlorobenzene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Chloroform	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Ethylbenzene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Pentachloroethane	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Styrene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Toluene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Trichloroethene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Xylenes, total	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Semi-Volatile Organics:			
1,2,4,5-Tetrachlorobenzene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
1,2,4-Trichlorobenzene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
1,2-Dichlorobenzene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
1,3-Dichlorobenzene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
1,4,-Dichlorobenzene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
2,3,4,6-Tetrachlorophenol	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
2,4,5-Trichlorophenol	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
2,4,6-Trichlorophenol	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
2,4-Dichlorophenol	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
2-Acetylaminofluorene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
2-Chloronaphthalene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
3,3'-Dichlorobenzidine	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
3,3'-Dimethylbenzidine	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
3-Methylcholanthrene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
4-Bromophenyl phenyl ether	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
4-Chloro-3-methylphenol	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)

TABLE 5-18
SOIL BIOACCUMULATION FACTORS AND BIOACCUMULATION UPTAKE EQUATIONS USED TO ESTIMATE CHEMICAL CONCENTRATIONS IN SMALL MAMMAL TISSUE: STEP 3A RISK CALCULATION
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Chemical	Soil-Small Mammal BAF (dry weight)		
	BAF Value/Uptake Equation	**Source Document**	**Description**
Semi-Volatile Organics:			
4-Chlorophenyl phenyl ether	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
7,12-Dimethylbenz(a)anthracene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Aramite, total	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Bis(2-ethylhexyl)phthalate	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Butyl benzyl phthalate	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Diallate	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Dibenzofuran	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Diethyl phthalate	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Di-n-butyl phthalate	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Di-n-octyl phthalate	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Dinoseb	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Hexachlorobenzene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Hexachlorobutadiene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Hexachlorocyclopentadiene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Hexachloroethane	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Hexachlorophene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Hexachloropropene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Isosafrole	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
n-Nitrosodiphenylamine	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
p-Dimethylamino azobenzene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Pentachlorobenzene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Pentachloronitrobenzene	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Pentachlorophenol	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Pronamide	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
PAHs:			
2-Methylnaphthalene	0.000	---	Value for other PAH compounds used as a surrogate
Acenaphthene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
Acenaphthylene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible

TABLE 5-18
SOIL BIOACCUMULATION FACTORS AND BIOACCUMULATION UPTAKE EQUATIONS USED TO ESTIMATE CHEMICAL CONCENTRATIONS IN SMALL MAMMAL TISSUE: STEP 3A RISK CALCULATION
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Chemical	Soil-Small Mammal BAF (dry weight)		
	BAF Value/Uptake Equation	**Source Document**	**Description**
PAHs:			
Anthracene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
Benzo(a)anthracene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
Benzo(a)pyrene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
Benzo(b)fluoranthene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
Benzo(g,h,i)perylene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
Benzo(k)fluoranthene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
Chrysene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
Dibenzo(a,h)anthracene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
Fluoranthene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
Fluorene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
Indeno(1,2,3-cd)pyrene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
Naphthalene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
Phenanthrene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
Pyrene	0.000	USEPA 2007	Bioaccumulation is assumed to be negligible
PCBs:			
Aroclor-1016	---	---	See Section 5.5.2.2.1
Aroclor-1221	---	---	See Section 5.5.2.2.1
Aroclor-1232	---	---	See Section 5.5.2.2.1
Aroclor-1242	---	---	See Section 5.5.2.2.1
Aroclor-1248	---	---	See Section 5.5.2.2.1
Aroclor-1254	---	---	See Section 5.5.2.2.1
Aroclor-1260	---	---	See Section 5.5.2.2.1
Metals:			
Antimony	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Arsenic	$\ln(C_m) = 0.7354[\ln(C_s)] - 4.5796$	Sample et al. 1998	Regression-based uptake equation for omnivores (2)
Barium	0.0463	Sample et al. 1998	Median BAF for omnivores (3)
Beryllium	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Cadmium	$\ln(C_m) = 0.566[In(C_s)] - 1.5383$	Sample et al. 1998	Regression-based uptake equation for omnivores (2)
Chromium, total	$\ln(C_m) = 0.7326[\ln(C_s)] - 1.4945$	Sample et al. 1998	Regression-based uptake equation for omnivores (1)
Cobalt	0.021	Sample et al. 1998	Median BAF for omnivores (3)
Copper	$\ln(C_m) = 0.2681[\ln(C_s)] + 1.4592$	Sample et al. 1998	Regression-based uptake equation for omnivores (2)

TABLE 5-18
SOIL BIOACCUMULATION FACTORS AND BIOACCUMULATION UPTAKE EQUATIONS USED TO ESTIMATE CHEMICAL CONCENTRATIONS IN SMALL MAMMAL TISSUE: STEP 3A RISK CALCULATION
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Chemical	Soil-Small Mammal BAF (dry weight)		
	BAF Value/Uptake Equation	**Source Document**	**Description**
Metals:			
Lead	0.0659	Sample et al. 1998	Median BAF for omnivores (3)
Mercury	0.0543	Sample et al. 1998	Median BAF for omnivores (3)
Nickel	$\ln(C_m) = 0.4780[\ln(C_s)] - 0.4140$	Sample et al. 1998	Regression-based uptake equation for omnivores (2)
Selenium	$\ln(C_m) = 0.3786[\ln(C_s)] - 0.4260$	Sample et al. 1998	Regression-based uptake equation for omnivores (2)
Silver	0.1513	Sample et al. 1998	Median BAF for omnivores (4)
Thallium	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Tin	$C_m = [(BAF_d)(DI)]/0.32$	---	See Section 5.5.2.2.1 (1)
Vanadium	0.01037	Sample et al. 1998	Median BAF for omnivores (4)
Zinc	0.55772	Sample et al. 1998	Median BAF for omnivores (3)

Notes:

USEPA = United States Environmental Protection Agency
PAH = Polynuclear Aromatic Hydrocarbon
BAF = Bioaccumulation Factor
PCB = Polychlorinated Biphenyl
C_m = Concentration in small mammal tissue (mg/kg - dry weight)
C_s = 95 percent UCL of the mean concentration in soil (mg/kg - dry weight) - maximum concentration is used if 95 percent UCL of the mean concentration exceeds the maximum concentration
BAF_d = diet-to-small mammal bioaccumulation factor (wet weight)
DI = Small mammal dietary intake (mg/kg-BW/day)

(1) Most chemical exposure for small mammals is via the diet. Therefore, it is assumed that the concentration of the chemical in the small mammal's tissues is equal to the chemical concentration in its diet multiplied by a diet-to-whole body BAF (BAF_d - wet weight basis). In the absence of literature-based diet-to whole-body BAF, a value of 1.0 was assumed. The resulting tissue concentration was converted to a dry weight basis using an estimated solids content for small mammals of 0.32 (USEPA, 1993). Additional explaination if provided in Section 5.5.2.2.1.

(2) The concentration in plant tissue was estimated using a chemical-specific bioaccumulation uptake equation for omnivores (i.e., regression equation) listed in Table 8 of Sample et al. (1998).

(3) Median BAF value for omnivores listed in Table 7 of Sample et al. (1998).

(4) Median BAF value for omnivores listed in Appendix C, Table C-1 of Sample et al. (1998).

TABLE 5-18
SOIL BIOACCUMULATION FACTORS AND BIOACCUMULATION UPTAKE EQUATIONS USED TO ESTIMATE CHEMICAL CONCENTRATIONS IN SMALL MAMMAL TISSUE: STEP 3A RISK CALCULATION
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Table References:

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United States Environmental Protection Agency (USEPA). 2007. Attachemnt 4-1 of Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs): Exposure Factors and Bioaccumulation Models for Derivation of Wildlife Eco-SSLs. Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.7-55.

TABLE 5-19
BIOACCUMULATION FACTORS FOR THE ESTIMATION OF CHEMICAL CONCENTRATIONS IN AQUATIC INVERTEBRATES AND FISH: STEP 3A RISK CALCULATION
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Chemical	Sediment-Invertebrate BAF (dry weight)			Sediment-Fish BAF (dry weight)		
	Value	Source Document	Description	Value	Source Document	Description
Volatile Organics:						
1,1,1,2-Tetrachloroethane	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Carbon tetrachloride	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Chlorobenzene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Chloroform	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Ethylbenzene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Pentachloroethane	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Styrene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Toluene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Trichloroethene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Xylene, total	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Semi-Volatile Organics:						
1,1-Biphenyl	2.120	---	BAF derived from median BSAF value listed in Table 5-11 [(1)]	0.904		BAF derived from median BSAF value listed in Table 5-13 [(5)]
1,2,4,5-Tetrachlorobenzene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
1,2,4-Trichlorobenzene	1.00	---	Assumed BAF	4.134	---	BAF derived from the single BSAF value listed in Table 5-13 [(5)]
1,2-Dichlorobenzene	1.00	---	Assumed BAF	2.641	---	BAF derived from the single BSAF value listed in Table 5-13 [(5)]
1,3-Dichlorobenzene	1.00	---	Assumed BAF	0.477	---	BAF derived from the single BSAF value listed in Table 5-13 [(5)]
1,4,-Dichlorobenzene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
2,3,4,6-Tetrachlorophenol	1.00	---	Assumed BAF	1.00	---	Assumed BAF
2,4,5-Trichlorophenol	1.00	---	Assumed BAF	1.00	---	Assumed BAF
2,4,6-Trichlorophenol	1.00	---	Assumed BAF	1.00	---	Assumed BAF
2,4-Dichlorophenol	1.00	---	Assumed BAF	1.00	---	Assumed BAF
2-Acetylaminofluorene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
2-Chloronaphthalene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
3,3'-Dichlorobenzidine	1.00	---	Assumed BAF	1.00	---	Assumed BAF
3,3'-Dimethylbenzidine	1.00	---	Assumed BAF	1.00	---	Assumed BAF
3-Methylcholanthrene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
4-Bromophenyl phenyl ether	1.00	---	Assumed BAF	1.00	---	Assumed BAF
4-Chloro-3-methylphenol	1.00	---	Assumed BAF	1.00	---	Assumed BAF
4-Chlorophenyl phenyl ether	1.00	---	Assumed BAF	1.00	---	Assumed BAF
7,12-Dimethylbenz(a)anthracene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Aramite, total	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Bis(2-ethylhexyl)phthalate	138.811	---	BAF derived from median BSAF value listed in Table 5-11 [(1)]	27.322	---	BAF derived from median BSAF value listed in Table 5-13 [(5)]
Butyl benzyl phthalate	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Diallate	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Dibenzofuran	1.00	---	Assumed BAF	0.748	---	BAF derived from median BSAF value listed in Table 5-13 [(5)]
Diethyl phthalate	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Di-n-butyl phthalate	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Di-n-octyl phthalate	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Dinoseb	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Hexachlorobenzene	12.071	---	BAF derived from median BSAF value listed in Table 5-11 [(1)]	2.124	---	BAF derived from the single BSAF value listed in Table 5-13 [(5)]
Hexachlorobutadiene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Hexachlorocyclopentadiene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Hexachloroethane	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Hexachlorophene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Hexachloropropene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Isosafrole	1.00	---	Assumed BAF	1.00	---	Assumed BAF
n-Nitrosodiphenylamine	1.00	---	Assumed BAF	1.00	---	Assumed BAF
p-Dimethylamino azobenzene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Pentachlorobenzene	1.00	---	Assumed BAF	0.944	---	BAF derived from the single BSAF value listed in Table 5-13 [(5)]

TABLE 5-19
BIOACCUMULATION FACTORS FOR THE ESTIMATION OF CHEMICAL CONCENTRATIONS IN AQUATIC INVERTEBRATES AND FISH: STEP 3A RISK CALCULATION
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Sediment-Invertebrate BAF (dry weight)			Sediment-Fish BAF (dry weight)		
	Value	Source Document	Description	Value	Source Document	Description
Semi-Volatile Organics:						
Pentachloronitrobenzene	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Pentachlorophenol	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Pronamide	1.00	---	Assumed BAF	1.00	---	Assumed BAF
PAHs:						
2-Methylnaphthalene	10.078	---	BAF derived from median BSAF value listed in Table 5-11 (1)	1.860	---	BAF derived from median BSAF value listed in Table 5-13 (5)
Acenaphthene	0.849	---	BAF derived from median BSAF value listed in Table 5-11 (1)	0.828	---	BAF derived from median BSAF value listed in Table 5-13 (5)
Acenaphthylene	2.013	---	BAF derived from median BSAF value listed in Table 5-11 (1)	0.326	---	BAF derived from median BSAF value listed in Table 5-13 (5)
Anthracene	1.623	---	BAF derived from median BSAF value listed in Table 5-11 (1)	0.198	---	BAF derived from median BSAF value listed in Table 5-13 (5)
Benzo(a)anthracene	1.048	---	BAF derived from median BSAF value listed in Table 5-11 (1)	0.057	---	BAF derived from median BSAF value listed in Table 5-13 (5)
Benzo(a)pyrene	0.514	---	BAF derived from median BSAF value listed in Table 5-11 (1)	0.050	---	BAF derived from median BSAF value listed in Table 5-13 (5)
Benzo(b)fluoranthene	5.515	---	BAF derived from median BSAF value listed in Table 5-11 (1)	0.059	---	BAF derived from median BSAF value listed in Table 5-13 (5)
Benzo(g,h,i)perylene	0.601	---	BAF derived from median BSAF value listed in Table 5-11 (1)	0.094	---	BAF derived from median BSAF value listed in Table 5-13 (5)
Benzo(k)fluoranthene	3.276	---	BAF derived from median BSAF value listed in Table 5-11 (1)	0.057	---	BAF derived from median BSAF value listed in Table 5-13 (5)
Chrysene	2.818	---	BAF derived from median BSAF value listed in Table 5-11 (1)	0.064	---	BAF derived from median BSAF value listed in Table 5-13 (5)
Dibenzo(a,h)anthracene	0.549	---	BAF derived from median BSAF value listed in Table 5-11 (1)	0.052	---	BAF derived from median BSAF value listed in Table 5-13 (5)
Fluoranthene	1.671	---	BAF derived from median BSAF value listed in Table 5-11 (1)	0.068	---	BAF derived from median BSAF value listed in Table 5-13 (5)
Fluorene	2.772	---	BAF derived from median BSAF value listed in Table 5-11 (1)	0.559	---	BAF derived from median BSAF value listed in Table 5-13 (5)
Indeno(1,2,3-cd)pyrene	0.550	---	BAF derived from median BSAF value listed in Table 5-11 (1)	0.059	---	BAF derived from median BSAF value listed in Table 5-13 (5)
Naphthalene	3.122	---	BAF derived from median BSAF value listed in Table 5-11 (1)	0.963	---	BAF derived from median BSAF value listed in Table 5-13 (5)
Phenanthrene	1.523	---	BAF derived from median BSAF value listed in Table 5-11 (1)	0.196	---	BAF derived from median BSAF value listed in Table 5-13 (5)
Pyrene	2.580	---	BAF derived from median BSAF value listed in Table 5-11 (1)	0.080	---	BAF derived from median BSAF value listed in Table 5-13 (5)
PCBs (ug/kg):						
Aroclor-1016	4.670	Bechtel Jacobs 1998	Median BAF (2)	8.64	Oliver and Niimi 1988	Mean BAF
Aroclor-1221	4.670	Bechtel Jacobs 1998	Median BAF (2)	8.64	Oliver and Niimi 1988	Mean BAF
Aroclor-1232	4.670	Bechtel Jacobs 1998	Median BAF (2)	8.64	Oliver and Niimi 1988	Mean BAF
Aroclor-1242	4.670	Bechtel Jacobs 1998	Median BAF (2)	8.64	Oliver and Niimi 1988	Mean BAF
Aroclor-1248	4.670	Bechtel Jacobs 1998	Median BAF (2)	8.64	Oliver and Niimi 1988	Mean BAF
Aroclor-1254	4.670	Bechtel Jacobs 1998	Median BAF (2)	8.64	Oliver and Niimi 1988	Mean BAF
Aroclor-1260	4.670	Bechtel Jacobs 1998	Median BAF (2)	8.64	Oliver and Niimi 1988	Mean BAF
Metals:						
Antimony	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Arsenic	0.329	Bechtel Jacobs 1998	Median BAF (3)	0.126	Pascoe et al. 1996	Mean BAF
Barium	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Beryllium	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Cadmium	0.459	Bechtel Jacobs 1998	Median BAF (2)	0.164	Pascoe et al. 1996	Mean BAF
Chromium, total	0.100	Bechtel Jacobs 1998	Median BAF (3)	0.038	Krantzberg and Boyd 1992	Mean BAF
Cobalt	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Copper	0.661	Bechtel Jacobs 1998	Median BAF (2)	0.10	Krantzberg and Boyd 1992	Mean BAF
Lead	0.080	Bechtel Jacobs 1998	Median BAF (2)	0.07	Krantzberg and Boyd 1992	Mean BAF
Mercury	1.136	Bechtel Jacobs 1998	Median BAF (3)	3.25	Cope et al. 1990	Mean BAF
Nickel	0.134	Bechtel Jacobs 1998	Median BAF (2)	1.00	---	Assumed BAF
Selenium	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Silver	0.18	Hirsch 1998	Mean BAF (4)	1.00	---	Assumed BAF
Thallium	1.00	---	Assumed BAF	1.00	---	Assumed BAF

TABLE 5-19
BIOACCUMULATION FACTORS FOR THE ESTIMATION OF CHEMICAL CONCENTRATIONS IN AQUATIC INVERTEBRATES AND FISH: STEP 3A RISK CALCULATION
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Sediment-Invertebrate BAF (dry weight)			Sediment-Fish BAF (dry weight)		
	Value	Source Document	Description	Value	Source Document	Description
Metals:						
Tin	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Vanadium	1.00	---	Assumed BAF	1.00	---	Assumed BAF
Zinc	0.840	Bechtel Jacobs 1998	Median BAF (2)	0.147	Pascoe et al. 1996	Mean BAF

Notes:

BAF = Bioaccumulation Factor
PAH = Polynuclear Aromatic Hydrocarbon
PCB = Polychlorinated Biphenyl
BSAF = Biota-Sediment Accumulation Factor

(1) Median BSAF values (wet weight) listed in Table 5-11 were converted to BAF values (dry weight) using a lipid content of 3.44 percent, solids content of 21 percent, and a sediment organic carbon content of 1.0 percent (default value).
(2) Median BAF value listed in Table 2 of Bechtel Jacobs (1998) for depurated organisms.
(3) Median BAF value listed in Table 2 of Bechtel Jacobs (1998) for depurated and non-depurated organisms. A combined depurated/non-depurated data set was used as the source of the 90th percentile BAF value due to the low number of data points for the depurated data set.
(4) Mean BAF value for depurated oligochates (*Lumbriculus variegatus*).
(5) Median/single value BSAF values (wet weight) listed in Table 5-13 were converted to BAF values (dry weight) using a lipid content of 5.90 percent, solids content of 25 percent, and a sediment organic carbon content of 1.0 percent (default value).

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TABLE 5-20
EXPOSURE PARAMETERS FOR UPPER TROPHIC LEVEL RECEPTORS: STEP 3A RISK CALCULATION
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Receptor	Habitat	Body Weight (kg)		Food Ingestion Rate (kg/day - dry)		Water Ingestion Rate (L/day)		Area Use Factor
		Value	Reference	Value	Reference	Value	Reference	
Birds:								
American robin	Terrestrial	0.0785 (1)	Dunning 2008	0.01033	Allometric equation from Nagy (2001) for omnivorous birds(7): $[0.67((BW*1000)^{0.627})]/1000$	0.01073	Allometric equation from Calder and Braun (1983) for all birds(7): $0.059(BW)^{0.67}$	1.00
Mourning dove	Terrestrial	0.115 (2)	Dunning 2008	0.01646	Allometric equation from Nagy (2001) for all birds(7): $[0.638((BW*1000)^{0.685})]/1000$	0.01385	Allometric equation from Calder and Braun (1983) for all birds(7): $0.059(BW)^{0.67}$	1.00
Red-tailed hawk	Terrestrial	1.0945 (3)	Dunning 2008	0.08788	Allometric equation from Nagy (2001) for carnivorous birds(7): $[0.849((BW*1000)^{0.663})]/1000$	0.06268	Allometric equation from Calder and Braun (1983) for all birds(7): $0.059(BW)^{0.67}$	1.00
Green heron	Aquatic	0.187 (4)	Dunning 2008	0.02296	Allometric equation from Nagy (2001) for all birds(7): $[0.638((BW*1000)^{0.685})]/1000$	0.01919	Allometric equation from Calder and Braun (1983) for all birds(7): $0.059(BW)^{0.67}$	1.00
Spotted sandpiper	Aquatic (estuarine wetland)	0.0404 (5)	Dunning 2008	0.00804	Allometric equation from Nagy (2001) for all birds(7): $[0.638((BW*1000)^{0.685})]/1000$	0.00687	Allometric equation from Calder and Braun (1983) for all birds(7): $0.059(BW)^{0.67}$	1.00

TABLE 5-20
EXPOSURE PARAMETERS FOR UPPER TROPHIC LEVEL RECEPTORS: STEP 3A RISK CALCULATION
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Receptor	Habitat	Body Weight (kg)		Food Ingestion Rate (kg/day - dry)		Water Ingestion Rate (L/day)		Area Use Factor
		Value	Reference	Value	Reference	Value	Reference	
Mammals:								
Norway rat (prey item for red-tailed hawk)	Terrestrial	0.350 [6]	Jackson 1992	0.03092	Allometric equation from Nagy (2001) for rodents[8]: $[0.332((BW*1000)^{0.774})]/1000$	0.03849	Allometric equation from Calder and Braun (1983) for all mammals[8]: $0.099(BW)^{0.90}$	1.00

Notes:

BW = Body Weight
kg = kilogram
L/day = liter per day
kg/day - dry = kilogram per day - dry weight basis
USEPA = United States Environmental Protection Agency

(1) Mean body weight for males and females from the western United States (n = 255).
(2) Mean mean body weight for males and females from Illinois (n = 95)
(3) Mean body weight for males and females from the western United States (n = 50)
(4) Mean body weight for males and femals in the Caribbean (n = 70)
(5) Mean body weight for unknown gender in Pennsylvania (n = 56)
(6) The body weight shown represents the midpoint within the range of reported values (sex and location not specified).
(7) Food and drinking water ingestion rates for avian receptors were calculated using mean body weights: 0.115 kg for the mourning dove, 0.0785 kg for the American robin, 1.0945 kg for the red-tailed hawk, 0.187 kg for the green heron, and 0.0404kg for the spotted sandpiper (Dunning, 2008).
(8) Food ingestion rate and drinking water ingestion rate for the Norway rat were calculated using the midpoint within the range of reported values: 0.350 kg (Jackson, 1992).

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TABLE 5-21
DIETARY COMPOSITION FOR UPPER TROPHIC LEVEL RECEPTORS: STEP 3A RISK CALCULATION
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Receptor	Dietary Composition (percent)						Soil/Sediment Ingestion (percent)	
	Terrestrial Plants	Soil Invertebrates	Small Mammals	Aquatic Invertebrates	Fish	Reference	Value	Reference
Birds:								
American robin	7.3	83.0 [(1)]	0	0	0	Wheelwright et al. 1986	8.7 [(2)]	Sample and Suter II 1994
Mourning dove	95.0	0	0	0	0	Tomlinson et al. 1994	5.0	Assumed
Red-tailed hawk	0	0	100	0	0	USEPA 1993; Sample and Suter II 1994	0	Sample and Suter II 1994
Green heron	0	0	0	29.0	71.0	Sample et al. 1997	0	Sample et al. 1997
Spotted sandpiper	0	0	0	81.9	0	USEPA 1993	18.1	Beyer et al. 1994
Mammals:								
Norway rat (prey item for red-tailed hawk)	49.0	49.0	0	0	0	Assumed	2.0	Assumed

Notes:

USEPA = United States Environmental Protection Agency

(1) The value shown represents the highest seasonal percentage of invertebrates in the diet of the American robin as reported by Wheelwright et al. (1986).

(2) The percentage of soil in the diet of the American robin was estimated using the relationship presented in Sample and Sutter II (1994). A diet of 83 percent earthworms extrapolates to a soil contribution of 8.7 percent to the total diet.

Table References:

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TABLE 6-1

HUMAN HEALTH SCREENING VALUES
FOR SWMU 28 - BUNDY WWTP SLUDGE DRYING BEDS
CMS 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)	(units)	USEPA MCLs/ PR WQS (7)	(units)
Polychlorinated Biphenyls (PCBs)								
Aroclor-1016	390 (3)	ug/kg	3,720 (3)	ug/kg	0.256 (3)	ug/L	0.00064 (8)	ug/L
Aroclor-1221	140	ug/kg	540	ug/kg	0.007	ug/L	0.00064 (8)	ug/L
Aroclor-1232	140	ug/kg	540	ug/kg	0.007	ug/L	0.00064 (8)	ug/L
Aroclor-1242	220	ug/kg	740	ug/kg	0.034	ug/L	0.00064 (8)	ug/L
Aroclor-1248	220	ug/kg	740	ug/kg	0.034	ug/L	0.00064 (8)	ug/L
Aroclor-1254	112 (3)	ug/kg	740	ug/kg	0.034	ug/L	0.00064 (8)	ug/L
Aroclor-1260	220	ug/kg	740	ug/kg	0.034	ug/L	0.00064 (8)	ug/L
Metals								
Antimony	3 (3)	mg/kg	41 (3)	mg/kg	2 (3)	ug/L	5.6 (8)	ug/L
Arsenic	0.39	mg/kg	2	mg/kg	0.045	ug/L	10	ug/L
Barium	1,500 (3)	mg/kg	19,000 (3)	mg/kg	730 (3)	ug/L	2,000	ug/L
Beryllium	16 (3)	mg/kg	200 (3)	mg/kg	7 (3)	ug/L	4	ug/L
Cadmium	7 (3)	mg/kg	80 (3)	mg/kg	2 (3)	ug/L	5	ug/L
Chromium	12,000 (3)(4)	mg/kg	150,000 (3)(4)	mg/kg	5,500 (3)(4)	ug/L	100	ug/L
Cobalt	2 (3)	mg/kg	30 (3)	mg/kg	1 (3)	ug/L	NE	
Copper	310 (3)	mg/kg	4,100 (3)	mg/kg	150 (3)	ug/L	1,300	ug/L
Lead	400 (5)	mg/kg	800	mg/kg	15 (6)	ug/L	15	ug/L
Mercury	1 (3)	mg/kg	3 (3)	mg/kg	0.057 (3)	ug/L	0.05 (8)	ug/L
Nickel	150 (3)	mg/kg	2,000 (3)	mg/kg	73 (3)	ug/L	610 (8)	
Selenium	39 (3)	mg/kg	510 (3)	mg/kg	18 (3)	ug/L	50	ug/L
Silver	39 (3)	mg/kg	510 (3)	mg/kg	18 (3)	ug/L	NE	
Thallium	NE		NE		2 (6)	ug/L	0.24 (8)	ug/L
Tin	4,700 (3)	mg/kg	61,000 (3)	mg/kg	2,200 (3)	ug/L	NE	
Vanadium	1 (3)	mg/kg	7 (3)	mg/kg	0.26 (3)	ug/L	NE	
Zinc	2,300 (3)	mg/kg	31,000 (3)	mg/kg	1,100 (3)	ug/L	NE	

TABLE 6-1

HUMAN HEALTH SCREENING VALUES
FOR SWMU 28 - BUNDY WWTP SLUDGE DRYING BEDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Notes:

ug/L - microgram per liter
ug/kg - microgram per kilogram
mg/L - milligram per liter
mg/kg - milligram per kilogram
USEPA - United States Environmental Protection Agency
MCL - USEPA Maximum Contaminant Level (http://water.epa.gov/drink/contaminants/index.cfm)
NE - Not established
PR WQS - Puerto Rico Water Quality Standards Regulation. Regulation No. 7837. March 31, 2010.

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

(4) Value for chromium III used as a surrogate.

(5) USEPA Action Level for lead in soil.

(6) Value for MCL used as surrogate.

(7) The more stringent of the USEPA MCL or PR WQS is listed.

(8) Value designated by PR WQS for protection of water body for reasons of human health (Class SG).

TABLE 6-2

SUMMARY OF EXPOSURE PARAMETERS
FOR SWMU 28 - BUNDY WWTP SLUDGE DRYING BEDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Parameter	Units	Current and Future Adult Trespassers	Current and Future Youth Trespassers	Future Adult Residents	Future Young Child Residents	Future Adult Industrial / Commercial Workers	Future Adult Construction Workers
		RME	RME	RME	RME	RME	RME
Soil							
Ingestion Rate of Soil (IR-S)	mg/day	100 USEPA, 1991	100 USEPA, 1991	100 USEPA, 1991	200 USEPA, 1991	100 USEPA, 2002	330 USEPA, 2002
Fraction Ingested from Source (FI)	NA	1 Prof Judge (1)	1 Prof Judge (1)	1 Prof Judge (1)	1 Prof Judge (1)	1 Prof Judge (1)	1 Prof Judge (1)
Exposure Frequency (EF)	days/year	52 Prof Judge (2)	52 Prof Judge (2)	350 USEPA, 2004	350 USEPA, 2004	250 USEPA, 2004	250 USEPA, 2004
Exposure Duration (ED)	years	24 USEPA, 1991	11 Prof Judge (3)	24 USEPA, 1991	6 USEPA, 1991	25 USEPA, 2004	1 Prof Judge (4)
Exposure Time (ET)	hours/day	2 USEPA, 1997 (5)	2 USEPA, 1997 (5)	24 Prof Judge (6)	24 Prof Judge (6)	8 Prof Judge (7)	8 Prof Judge (7)
Surface Area Available for Contact (SA)	cm2/day	5,700 USEPA, 2004	3,200 USEPA, 1997	5,700 USEPA, 2004	2,800 USEPA, 2004	3,300 USEPA, 2004	3,300 USEPA, 2004
Conversion Factor (CF)	kg/mg	1.00E-06 USEPA, 1989	1.00E-06 USEPA, 1989	1.00E-06 USEPA, 1989	1.00E-06 USEPA, 1989	1.00E-06 USEPA, 1989	1.00E-06 USEPA, 1989
Averaging Time (Non-Cancer) (AT-N)	days	8,760 USEPA, 1989	4,015 USEPA, 1989	8,760 USEPA, 1989	2,190 USEPA, 1989	9,125 USEPA, 1989	365 USEPA, 1989
Groundwater							
Ingestion Rate of Groundwater (IR-W)	L/day	--	--	2 USEPA, 1991	1 USEPA, 1989	--	0.02 VDEQ, 2009
Exposure Frequency (EF)	days/year	--	--	350 USEPA, 2004	350 USEPA, 2004	--	50 Prof Judge (8)
Exposure Duration (ED)	years	--	--	24 USEPA, 1991	6 USEPA, 1991	--	1 Prof Judge (4)
Exposure Time (ET)	hours/day	--	--	0.58 USEPA, 2004	1 USEPA, 2004	--	2 Prof Judge (9)
Surface Area Available for Contact (SA)	cm2	--	--	18,000 USEPA, 2004	6,600 USEPA, 2004	--	3,300 USEPA, 2004
Conversion Factor (CF)	L/cm3	--	--	1.00E-03 USEPA, 1989	1.00E-03 USEPA, 1989	--	1.00E-03 USEPA, 1989
Averaging Time (Non-Cancer) (AT-N)	days	--	--	8,760 USEPA, 1989	2,190 USEPA, 1989	--	365 USEPA, 1989
Surface Water							
Ingestion Rate of Surface Water (IR-W)	L/hour	0.05 USEPA, 1989 (10)	0.05 USEPA, 1989 (10)	0.05 USEPA, 1989 (10)	0.05 USEPA, 1989 (10)	--	--
Exposure Frequency (EF)	days/year	52 Prof Judge (2)	52 Prof Judge (2)	52 Prof Judge (2)	52 Prof Judge (2)	--	--
Exposure Duration (ED)	years	24 USEPA, 1991	11 Prof Judge (3)	24 USEPA, 1991	6 USEPA, 1991	--	--
Exposure Time (ET)	hours/day	2 USEPA, 1997 (5)	2 USEPA, 1997 (5)	2 USEPA, 1997 (5)	2 USEPA, 1997 (5)	--	--
Surface Area Available for Contact (SA)	cm2	5,700 USEPA, 2004	3,200 USEPA, 1997	5,700 USEPA, 2004	2,800 USEPA, 2004	--	--
Conversion Factor (CF)	L/cm3	1.00E-03 USEPA, 1989	1.00E-03 USEPA, 1989	1.00E-03 USEPA, 1989	1.00E-03 USEPA, 1989	--	--
Averaging Time (Non-Cancer) (AT-N)	days	8,760 USEPA, 1989	4,015 USEPA, 1989	8,760 USEPA, 1989	2,190 USEPA, 1989	--	--

TABLE 6-2

SUMMARY OF EXPOSURE PARAMETERS
FOR SWMU 28 - BUNDY WWTP SLUDGE DRYING BEDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Parameter	Units	Current and Future Adult Trespassers RME	Current and Future Youth Trespassers RME	Future Adult Residents RME	Future Young Child Residents RME	Future Adult Industrial / Commercial Workers RME	Future Adult Construction Workers RME
Ingestion Rate of Surface Water (IR-W)	L/hour	USEPA, 1989 (10)	USEPA, 1989 (10)	USEPA, 1989 (10)	USEPA, 1989 (10)		
Sediment							
Ingestion Rate of Sediment (IR-S)	mg/day	100 USEPA, 1991	100 USEPA, 1991	100 USEPA, 1991	200 USEPA, 1991	--	--
Fraction Ingested from Source (Fi)	NA	1 Prof Judge (1)	1 Prof Judge (1)	1 Prof Judge (1)	1 Prof Judge (1)	--	--
Exposure Frequency (EF)	days/year	52 Prof Judge (2)	52 Prof Judge (2)	52 Prof Judge (2)	52 Prof Judge (2)	--	--
Exposure Duration (ED)	years	24 USEPA, 1991	11 Prof Judge (3)	24 USEPA, 1991	6 USEPA, 1991	--	--
Surface Area Available for Contact (SA)	cm2/day	5,700 USEPA, 2004	3,200 USEPA, 1997	5,700 USEPA, 2004	2,800 USEPA, 2004	--	--
Conversion Factor (CF)	kg/mg	1.00E-06 USEPA, 1989	1.00E-06 USEPA, 1989	1.00E-06 USEPA, 1989	1.00E-06 USEPA, 1989	--	--
Averaging Time (Non-Cancer) (AT-N)	days	8,760 USEPA, 1989	4,015 USEPA, 1989	8,760 USEPA, 1989	2,190 USEPA, 1989	--	--
Other Parameters							
Body Weight (BW)	kg	70 USEPA, 1997	45 USEPA, 1997	70 USEPA, 1997	15 USEPA, 1997	70 USEPA, 1997	70 USEPA, 1997
Soil to Skin Adherence Factor (AF)	mg/cm2	0.07 USEPA, 2004	0.2 USEPA, 2004	0.07 USEPA, 2004	0.2 USEPA, 2004	0.2 USEPA, 2004	0.3 USEPA, 2002
Sediment to Skin Adherence Factor (AF)	mg/cm2	0.3 VDEQ, 2010	0.3 VDEQ, 2010	0.3 VDEQ, 2010	0.3 VDEQ, 2010	--	--
Particulate Emission Factor (PEF)	m3/kg	1.36E+09 USEPA, 2002	1.36E+09 USEPA, 2002	1.36E+09 USEPA, 2002	1.36E+09 USEPA, 2002	1.36E+09 USEPA, 2002	Site Specific USEPA, 2002 (11)
Averaging Time (Cancer) (AT-C)	days	25,550 USEPA, 1989	25,550 USEPA, 1989	25,550 USEPA, 1989	25,550 USEPA, 1989	25,550 USEPA, 1989	25,550 USEPA, 1989

Notes:

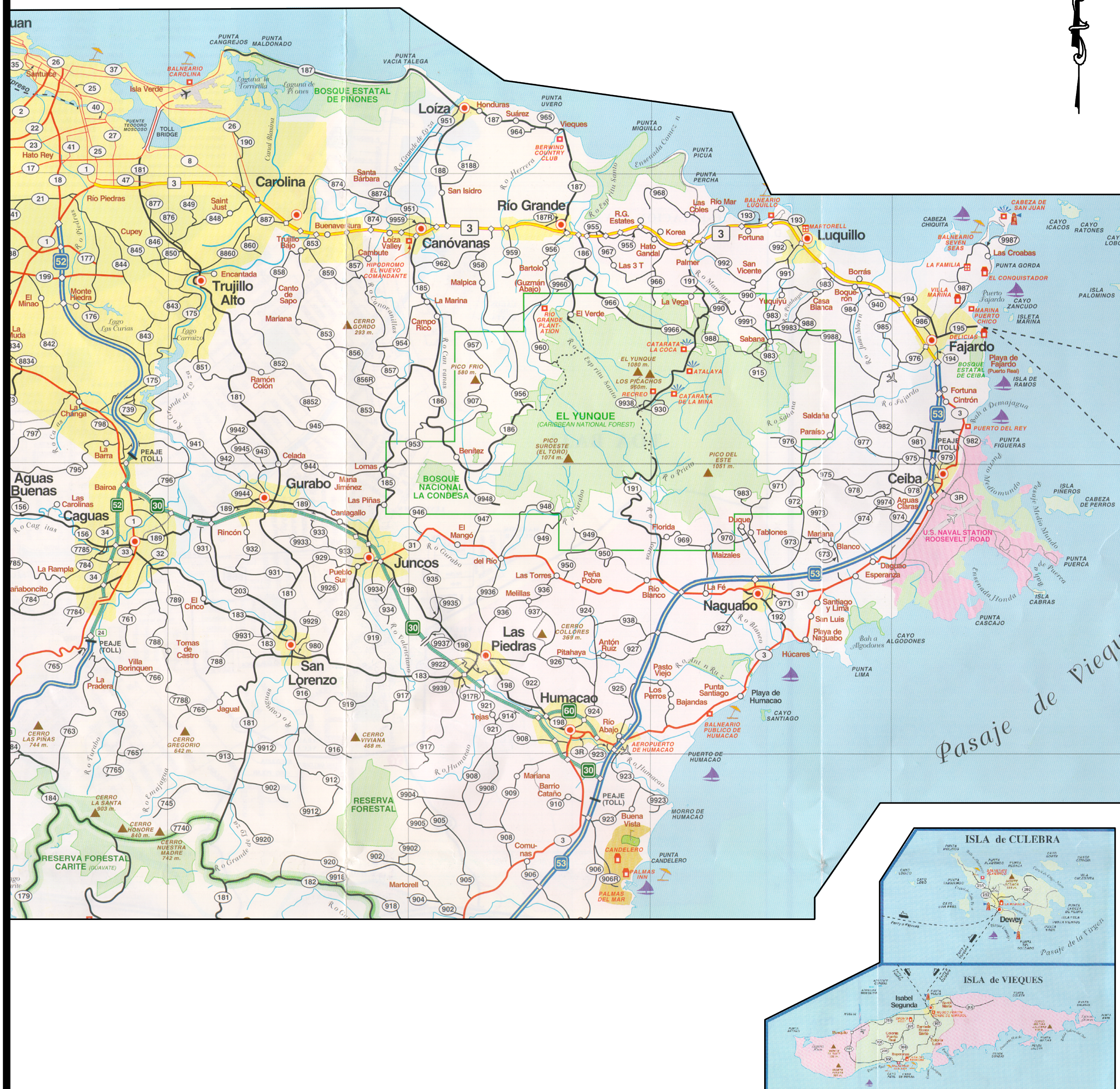
RME - Reasonalble Maximum Exposure
Prof Judge - Professional Judgment
Gastrointestinal absorption efficiencies (GIABS), dermal absorption factors (ABS), and permeability constants (Kp) obtained from RAGS Part E (USEPA, 2004).

(1) Conservative assumption of 100% ingested from source.
(2) Assumes individuals trespass on site 1 day/week based on status of SWMU 56 as an inactive airfield.
(3) Represents youths from 6 to 16 years of age.
(4) Assumes a construction period of 1 year.
(5) Recommended outdoor activity factor for adults.
(6) Conservatively assumes receptor remains at residence 24 hours/day.
(7) Assumes an 8 hour work day.
(8) Assumes 20% of time spent in trench.
(9) Assumes 2 hours/event in trench.
(10) Ingestion rate for swimming.
(11) PEF to be calculated as part of HHRA based on emissions from truck traffic on unpaved roads.

USEPA, 1989: Risk Assessment Guidance for Superfund Vol 1, Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.
USEPA, 1991: Risk Assessment Guidance for Superfund Vol 1, Human Health Evaluation Manual Supplemental Guidance: Standard Default Exposure Factors.
USEPA, 1997: Exposure Factors Handbook. Vol. 1: General Factors. ORD. EPA/600/P-95/002Fa.
USEPA, 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.
USEPA, 2004: Risk Assessment Guidance for Superfund Vol 1, Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). EPA/540/R-99/005.
Virginia Department of Environmental Quality (VDEQ), 2010. Virginia Voluntary Remediation Program Risk Assessment Guidance, Section 3.2.2 (http://www.deq.state.va.us/vrprisk/raguide.html). Accessed February 2010.

FIGURES

K:_SOUTHNAVFAC\119197 JM01\SWMUs 27 28 29\CADD\111626_61_00.dwg



4 0 2 4 8

1 inch = 4 miles

Baker

FIGURE 1-1
REGIONAL LOCATION MAP
SWMUs 27, 28, AND 29
CMS WORK PLAN

SOURCE: METRODATA, INC., 1999.

NAVAL ACTIVITY PUERTO RICO

LEGEND

SWMUs

AOC D – AOCs

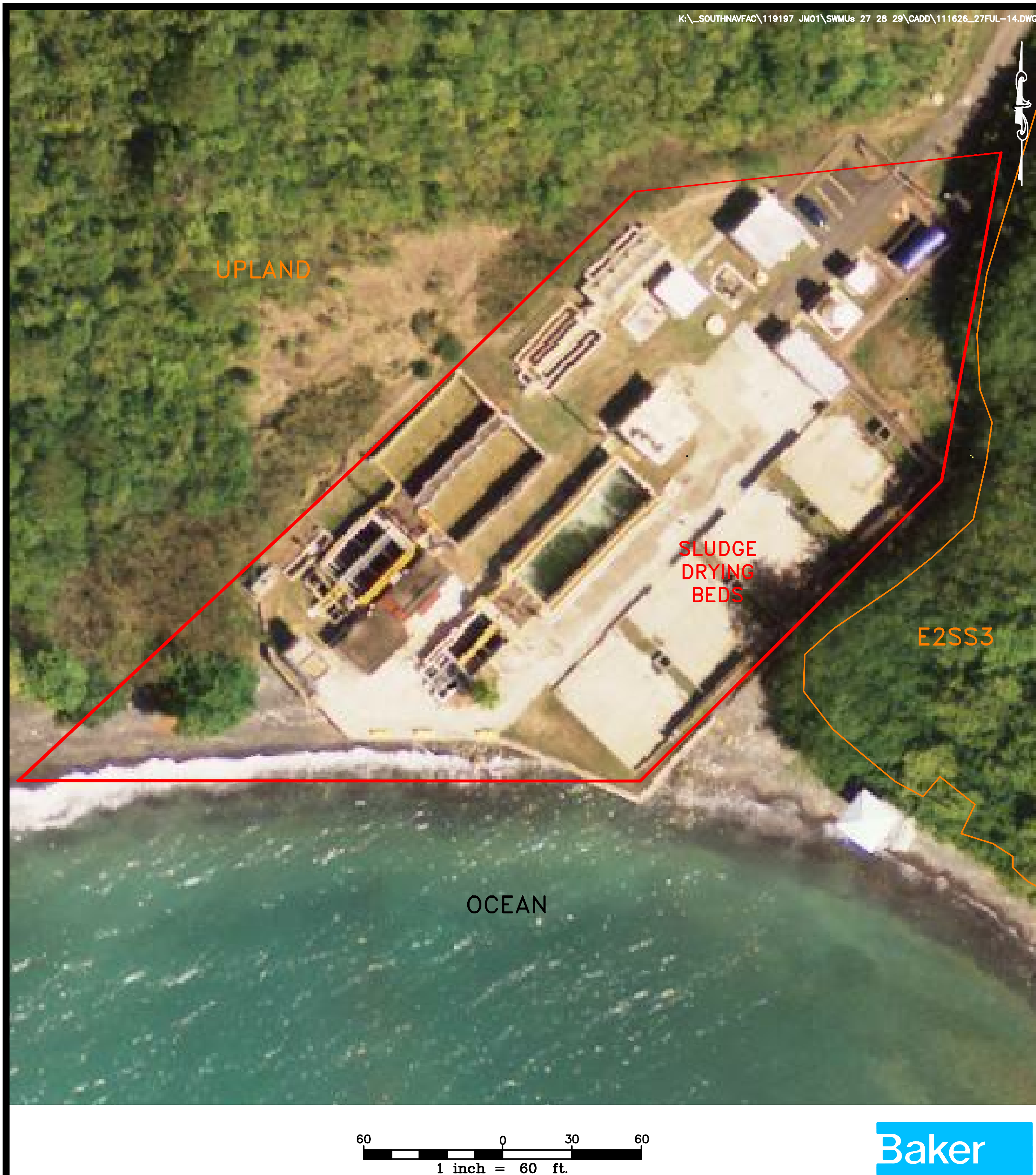
AREAS TO WHICH THIS CORRECTIVE MEASURES STUDY PERTAINS

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

3000 0 1500 3000
1 inch = 3000 ft.

FIGURE 1-2
SWMU/AOC LOCATION MAP
SWMU 27, 28, AND 29 WWTP SLUDGE DRYING BEDS
CMS WORK PLAN

NAVAL ACTIVITY PUERTO RICO



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LEGEND

– SITE BOUNDARY

– WETLAND DELINEATION

NOTE
INFORMATION ON E2SS3 IS ON FIGURE 5-7 THE COWARDIN WETLAND CLASSIFICATION SYSTEM

FIGURE 1-3
SWMU 27 LOCATION MAP
CAPEHART WWTP SLUDGE DRYING BEDS
CMS WORK PLAN

NAVAL ACTIVITY PUERTO RICO

Baker

LEGEND

- SITE BOUNDARY
- WETLAND DELINEATION

NOTE
INFORMATION ON E2FO3 IS ON FIGURE 5-7 THE COWARDIN WETLAND CLASSIFICATION SYSTEM

FIGURE 1-4
SWMU 28 LOCATION MAP
BUNDY WWTP SLUDGE DRYING BEDS
CMS WORK PLAN

NAVAL ACTIVITY PUERTO RICO

100 0 50 100

1 inch = 100 ft.

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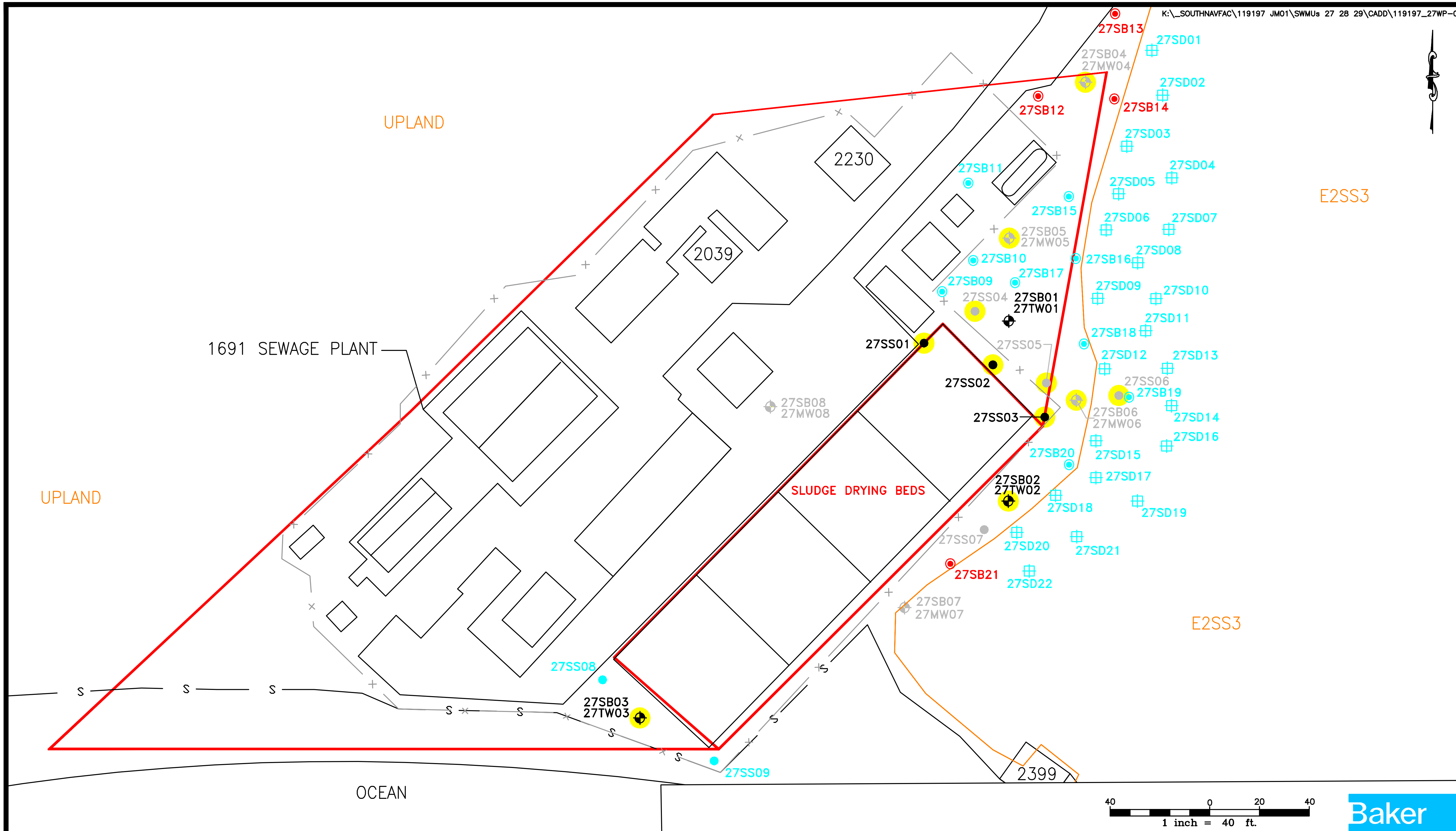
LEGEND

— SWMU BOUNDARY

FIGURE 1-5
SWMU 29 LOCATION MAP
INDUSTRIAL AREA WWTP SLUDGE DRYING BEDS
CMS WORK PLAN

NAVAL ACTIVITY PUERTO RICO



NOTE
INFORMATION ON E2SS3 IS ON FIGURE 5-7 THE COWARDIN WETLAND CLASSIFICATION SYSTEM

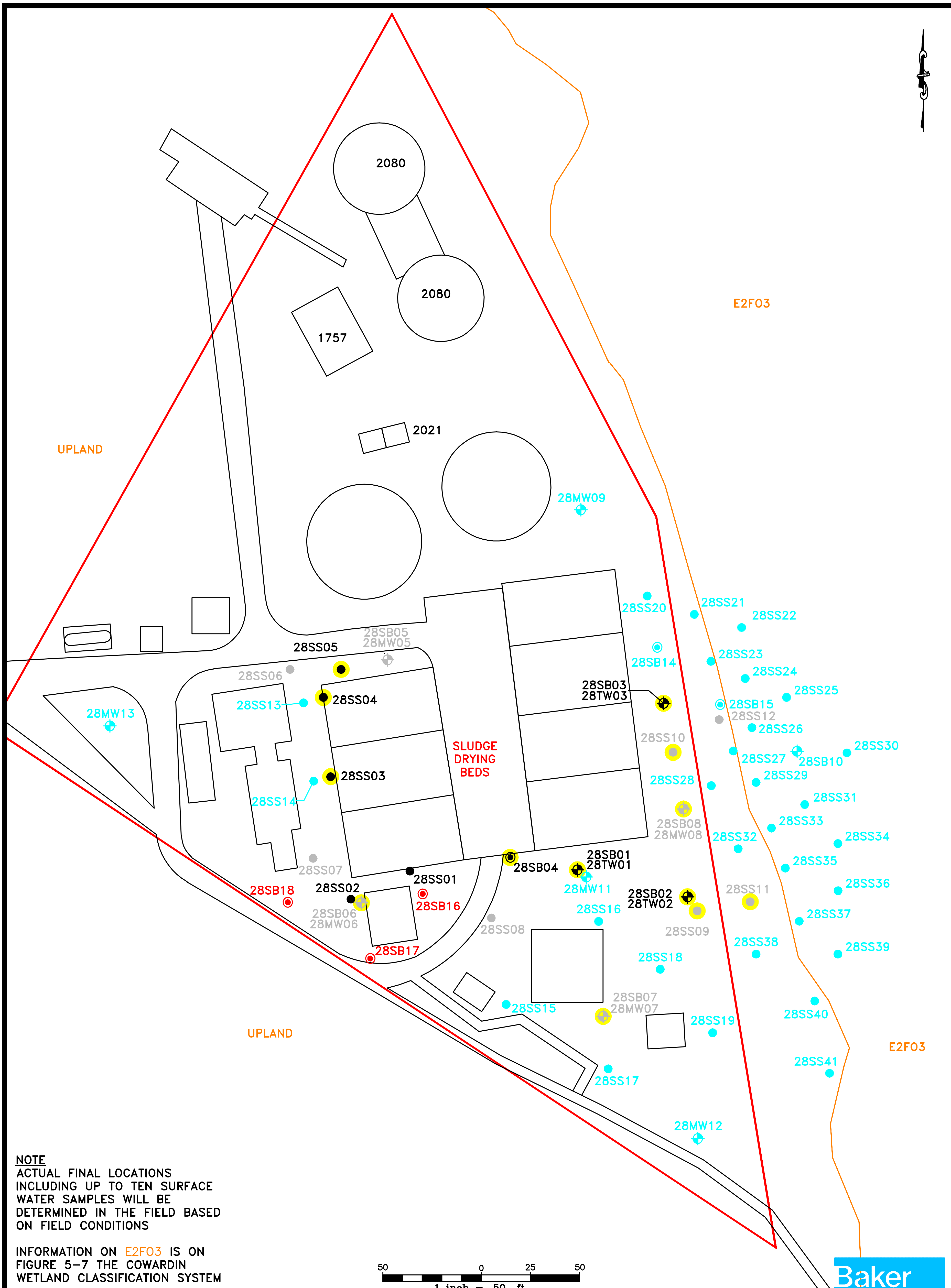
ACTUAL FINAL LOCATIONS INCLUDING TEN SURFACE WATER SAMPLES WILL BE DETERMINED IN THE FIELD BASED ON FIELD CONDITIONS

LEGEND

- PROPOSED SURFACE SOIL SAMPLE LOCATION
- PROPOSED SURFACE/SUBSURFACE SOIL SAMPLE LOCATION
- PROPOSED SUBSURFACE SOIL SAMPLE LOCATION
- PROPOSED SEDIMENT SAMPLE LOCATION
- LOCATIONS WITH SAMPLES THAT EXCEED ECOLOGICAL SCREENING CRITERIA AND BACKGROUND
- SITE BOUNDARY
- APPROXIMATE WETLAND LOCATION
- EXISTING SURFACE SOIL LOCATION (NOVEMBER 2006)
- EXISTING SUBSURFACE SOIL BORING/TEMPORARY MONITORING WELL LOCATION (NOVEMBER 2006)
- EXISTING SURFACE SOIL LOCATION (MARCH 2008)
- EXISTING SUBSURFACE SOIL BORING/MONITORING WELL LOCATION (MARCH 2008)
- FENCE
- S — SHEETPILE SEAWALL

FIGURE 3-1
PROPOSED SAMPLE LOCATIONS
SWMU 27-CAPEHART
WWTP SLUDGE DRYING BEDS
CMS WORK PLAN

NAVAL ACTIVITY PUERTO RICO

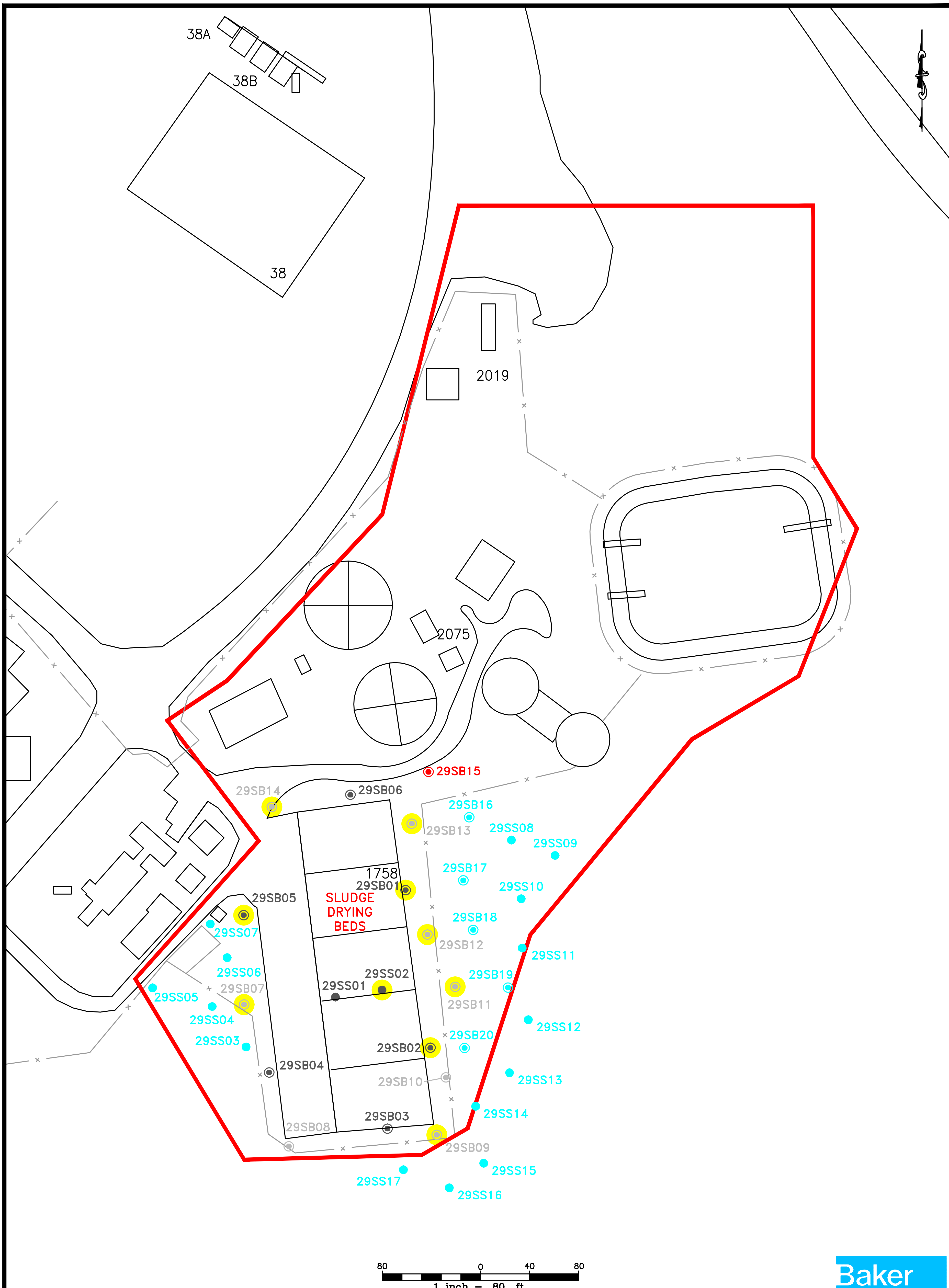


LEGEND

- SITE BOUNDARY
- APPROXIMATE WETLAND DELINEATION
- EXISTING SURFACE SOIL LOCATION (NOVEMBER 2006)
- EXISTING SUBSURFACE SOIL BORING/TEMPORARY MONITORING WELL LOCATION (NOVEMBER 2006)
- EXISTING SUBSURFACE SOIL BORING LOCATION (NOVEMBER 2006)
- EXISTING SURFACE SOIL SAMPLE LOCATION (MARCH 2008)
- EXISTING SOIL BORING/MONITORING WELL LOCATION (MARCH 2008)
- PROPOSED SURFACE SOIL SAMPLE LOCATION
- PROPOSED SURFACE AND SUBSURFACE SOIL SAMPLE LOCATION
- PROPOSED SUBSURFACE SOIL SAMPLE LOCATION
- PROPOSED GROUNDWATER SAMPLE LOCATION
- PROPOSED GROUNDWATER, SURFACE SOIL AND SUBSURFACE SOIL SAMPLE LOCATION
- LOCATIONS WITH SAMPLES THAT EXCEED SCREENING CRITERIA AND BACKGROUNDS

FIGURE 3-2
PROPOSED SAMPLE LOCATIONS
SWMU 28-BUNDY WWTP SLUDGE
DRYING BEDS
CMS WORK PLAN

NAVAL ACTIVITY PUERTO RICO



LEGEND

- SWMU BOUNDARY
- EXISTING SURFACE, SUBSURFACE AND GROUNDWATER SOIL SAMPLE LOCATION (NOVEMBER 2006)
- EXISTING SURFACE SOIL SAMPLE LOCATION (NOVEMBER 2006)
- SURFACE AND SUBSURFACE SOIL SAMPLING LOCATIONS (MARCH 2008)
- PROPOSED SURFACE AND SUBSURFACE SOIL SAMPLE
- PROPOSED SUBSURFACE SOIL SAMPLE LOCATION
- PROPOSED SURFACE SOIL SAMPLE
- EXISTING BORINGS THAT EXCEED SCREENING CRITERIA AND BACKGROUND

FIGURE 3-3
PROPOSED SAMPLE LOCATIONS
SWMU 29-INDUSTRIAL AREA WWTP
SLUDGE DRYING BEDS
CMS WORK PLAN

NAVAL ACTIVITY PUERTO RICO

Figure 5-1
Navy Ecological Risk Assessment Tiered Approach

Remedial Project Manager Input and Risk Management Consideration[3]

Tier 1. Screening-Level Ecological Risk Assessment (SERA): Identify pathways and compare exposure point concentrations to bench marks.

Step 1: Site visit; Pathway Identification/Problem Formulation; Toxicity Evaluation

Step 2: Exposure Estimate; Risk Calculation (SMDP) [1]

Proceed to Exit Criteria for SERA

Exit Criteria for the Screening-Level Ecological Risk Assessment: Decision for exiting or continuing the ecological risk assessment.

1) Site passes screening-level risk assessment: A determination is made that the site poses acceptable risk and shall be closed out for ecological concerns.

2) Site fails screening-level risk assessment: The site must have both complete pathway and unacceptable risk. As a result the site will either have an interim cleanup or moves to the second tier.

Tier 2. Baseline Ecological Risk Assessment (BERA): Detailed assessment of exposure and hazard to "assessment endpoints" (ecological qualities to be protected). Develop site specific values that are protective of the environment.

Step 3a: Refinement of Conservative Exposure Assumptions[2]
Proceed to Exit Criteria for Step 3a

Step 3b: Problem Formulation - Toxicity Evaluation; Assessment Endpoints; Conceptual Model; Risk Hypothesis (SMDP)

Step 4: Study Design/Data Quality Objectives - Lines of Evidence; Measurement Endpoints; Work Plan and Sampling & Analysis Plan (SMDP)

Step 5: Verification of Field Sampling Design (SMDP)

Step 6: Site Investigation and Data Analysis (SMDP)

Step 7: Risk Characterization

Proceed to Exit Criteria for BERA

Exit Criteria Step 3a Refinement

1) If re-evaluation of the conservative exposure assumptions support an acceptable risk determination then the site exits the ecological risk assessment process.

2) If re-evaluation of the conservative exposure assumptions do not support an acceptable risk determination then the site continues in the Baseline Ecological Risk Assessment process.

Proceed to Step 3b.

Exit Criteria Baseline Ecological Risk Assessment

1) If the site poses acceptable risk then no further evaluation and no remediation from an ecological perspective is warranted.

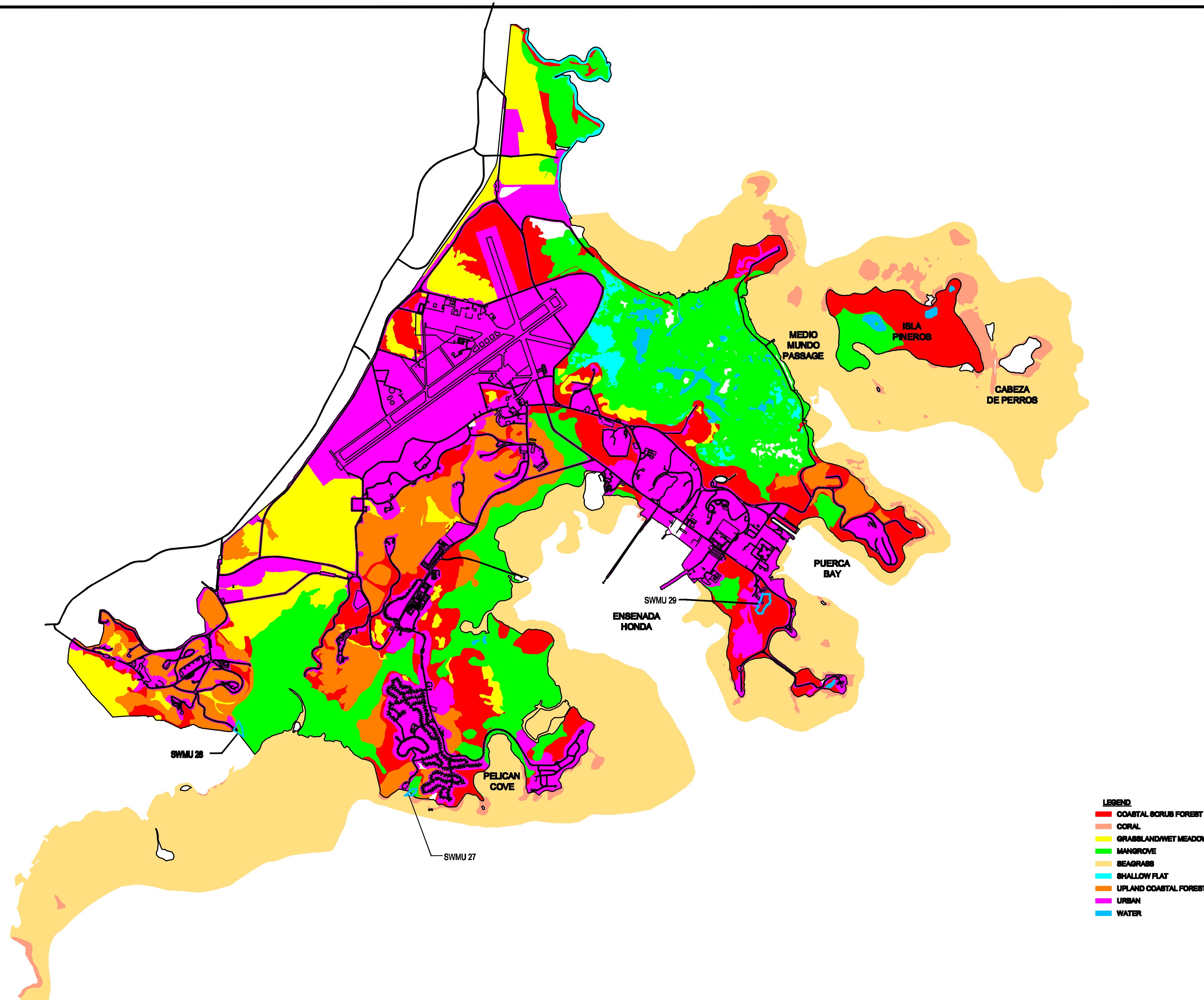
2) If the site poses unacceptable ecological risk and additional evaluation in the form of remedy development and evaluation is appropriate, proceed to third tier.

Tier 3. Evaluation of Remedial Alternative (RAGs C)

a. Develop site specific risk based cleanup values.

b. Qualitatively evaluate risk posed to the environment by implementation of each alternative (short term) impacts and estimate risk reduction provided by each (long-term) impacts; provide quantitative evaluation where appropriate. Weigh alternative using the remaining CERCLA 9 Evaluation Criteria. Plan for monitoring and site closeout.

Notes: 1) See USEPA's 8 Step ERA Process for requirements for each Scientific Management Decision Point (SMDP).
2) Refinement includes but is not limited to background, bioavailability, etc.
3) Risk management is incorporated throughout the tiered approach.



SOURCE: GEO-MARINE, INC.

REVISIONS

DRAWN /RRR
REVIEWED MEK
S.O.# 119197
CADD# 119197_CMS272829_01.DWG

NORTH

CMS WORK PLAN

NAVAL ACTIVITY PUERTO RICO

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker

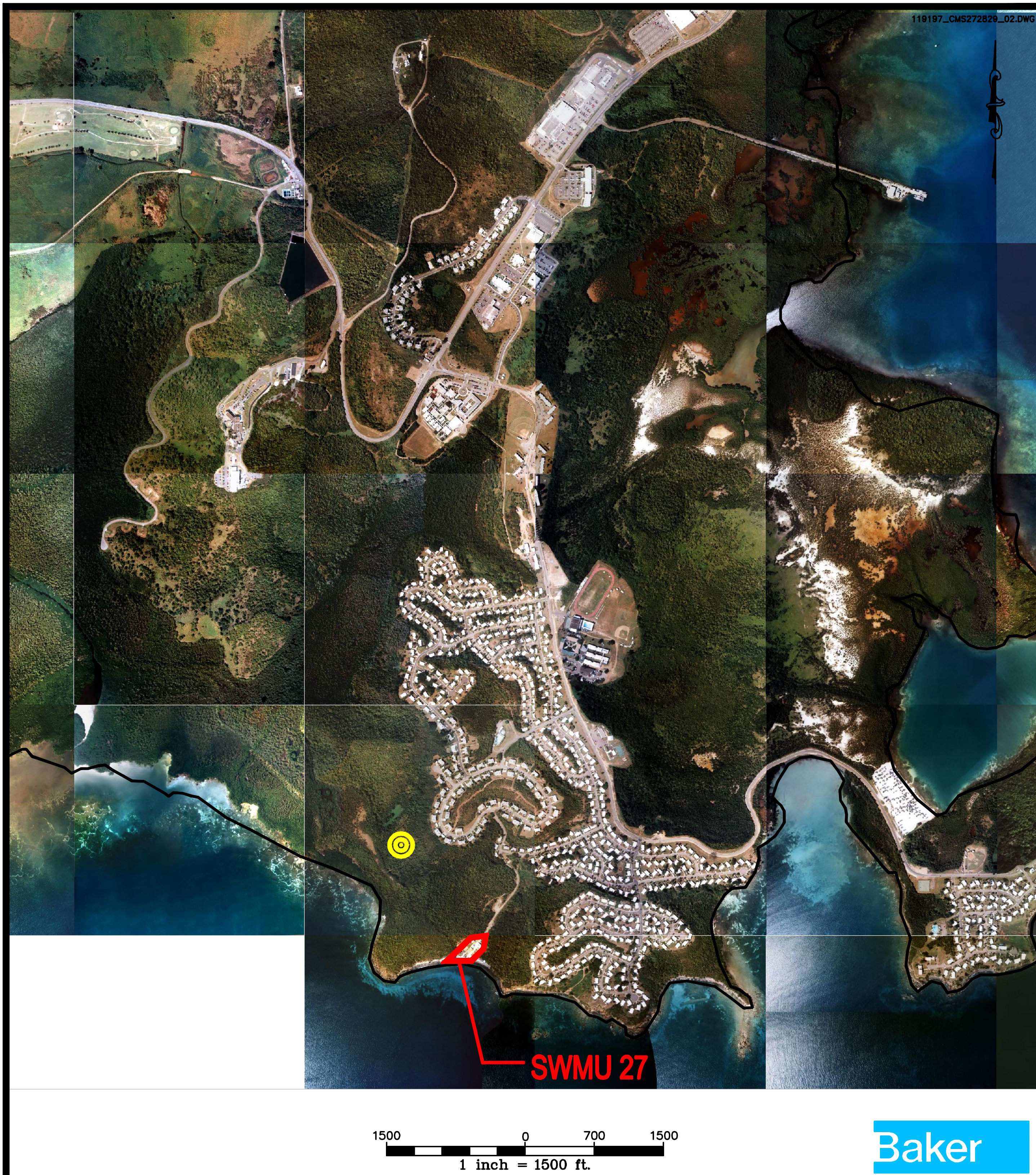
TERRESTRIAL AND AQUATIC HABITAT OCCURRING AT NAVAL ACTIVITY PUERTO RICO

SCALE 1" = 2000'

DATE SEPTEMBER 2010

FIGURE

5-2



LEGEND

- APPROX. LOCATION OF COBANA NEGRA
- SWMU 27 BOUNDARY

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

FIGURE 5-3
APPROXIMATE LOCATION OF
COBANA NEGRA IN RELATION TO SWMU 27
CAPEHART WWTP SLUDGE
DRYING BEDS
CMS WORK PLAN

NAVAL ACTIVITY PUERTO RICO

Baker

LEGEND

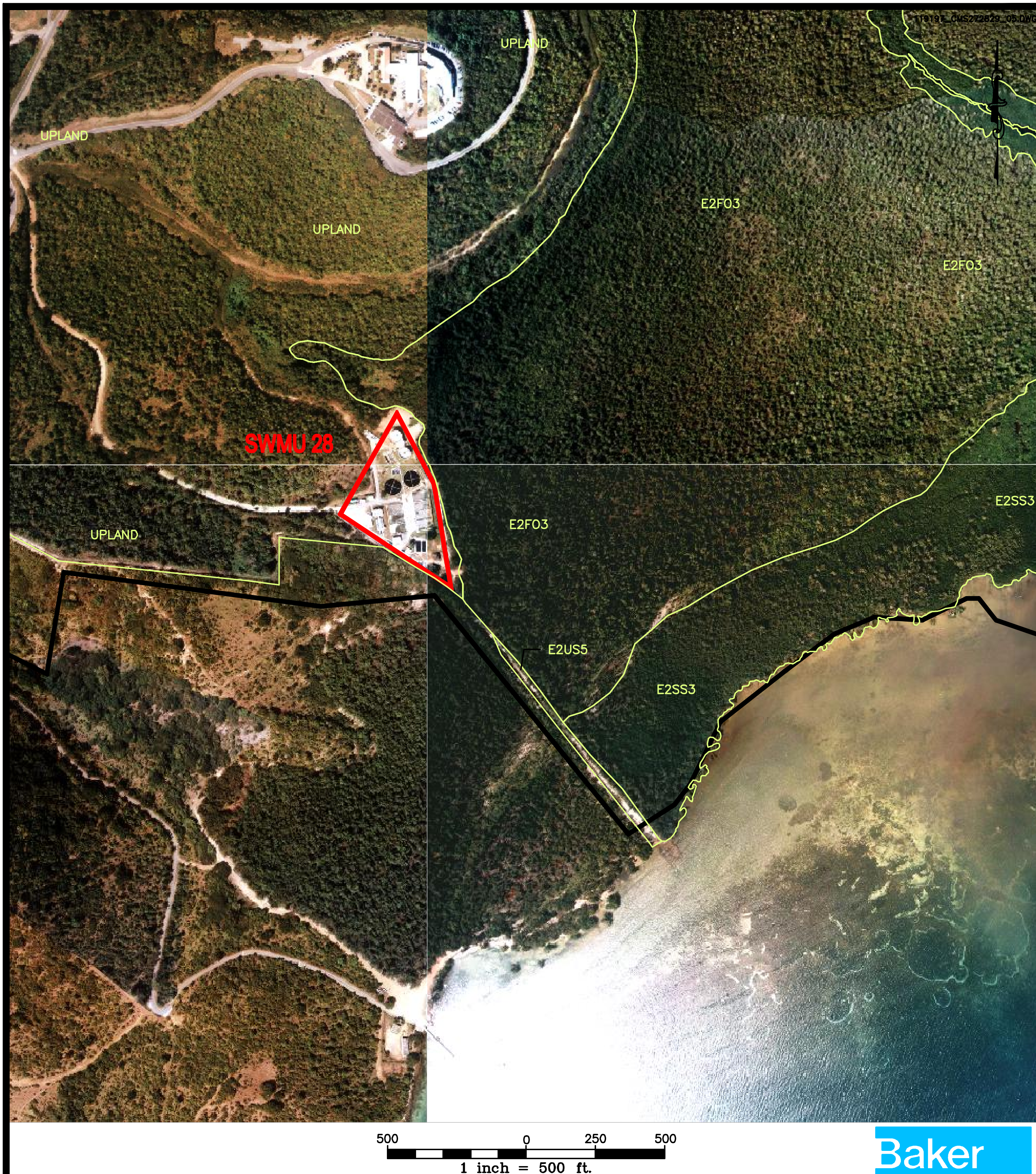
– SWMU 27 BOUNDARY

E2SS3 – E2SS3 WETLANDS BOUNDARIES (SEE FIGURE 5-7 FOR CLASSIFICATIONS)

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

FIGURE 5-4
AQUATIC HABITAT LOCATION MAP
SWMU 27 – CAPEHART WWTP SLUDGE DRYING BEDS
CMS WORK PLAN

NAVAL ACTIVITY PUERTO RICO



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LEGEND

– SWMU 28 BOUNDARY

E2SS3 – E2SS3 WETLANDS BOUNDARIES (SEE FIGURE 5-7 FOR CLASSIFICATIONS)

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

FIGURE 5-5
AQUATIC HABITAT LOCATION MAP
SWMU 28 – BUNDY WWTP SLUDGE DRYING BEDS
CMS WORK PLAN

NAVAL ACTIVITY PUERTO RICO

500 0 250 500

1 inch = 500 ft.

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LEGEND

– SWMU 29 BOUNDARY

E2SS3 – E2SS3 WETLANDS BOUNDARIES (SEE FIGURE 5–7 FOR CLASSIFICATIONS)

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

FIGURE 5–6
AQUATIC HABITAT LOCATION MAP
SWMU 29 – INDUSTRIAL AREA WWTP
SLUDGE DRYING BEDS
CMS WORK PLAN

NAVAL ACTIVITY PUERTO RICO

119197_CMS272829_03.DWG

SYSTEM: M - MARINE

SUBSYSTEM: 1 - SUBTIDAL

CLASS	Subclass
RB - Rock Bottom	1 Bedrock 2 Rubble
UB - Uncon-solidated Bottom	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic
AB - Aquatic Bed	1 Algal 3 Rooted Vasc 5 Unknown
RF - Reef	1 Coral 3 Worm
OW - Open Water (unknown bottom)	

SUBSYSTEM: 2 - INTERTIDAL

CLASS	Subclass
AB - Aquatic Bed	1 Algal 3 Rooted Vasc 5 Unknown
RF - Reef	1 Coral 3 Worm
RS - Rocky Shore	1 Bedrock 2 Rubble
US - Uncon-solidated Shore	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic

SYSTEM: E - ESTUARINE

SUBSYSTEM: 1 - SUBTIDAL

CLASS	Subclass
RB - Rock Bottom	1 Bedrock 2 Rubble
UB - Uncon-solidated Bottom	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic
AB - Aquatic Bed	1 Algal 3 Rooted Vasc 4 Floating Vasc 5 *Unknown Submerg.* 6 *Unknown Surface*
RF - Reef	2 Mollusk 3 Worm
OW - Open Water *(unknown bottom)*	

SUBSYSTEM: 2 - INTERTIDAL

CLASS	Subclass
AB - Aquatic Bed	1 Algal 3 Rooted Vasc 4 Floating Vasc 5 *Unknown Submerg.* 6 *Unknown Surface*
RF - Reef	2 Mollusk 3 Worm
SB - Streambed	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic
RS - Rocky Shore	1 Bedrock 2 Rubble
US - Uncon-solidated Shore	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic 5 Dead
EM - Emergent	1 Persistent 2 Nonpersistent
SS - Scrub-Shrub	1 Broad-leaved Decid. 2 Needle-leaved Decid. 3 Broad-leaved Everg. 4 Needle-leaved Everg. 5 Dead 6 *Deciduous* 7 *Evergreen*
FO - Forested	1 Broad-leaved Decid. 2 Needle-leaved Decid. 3 Broad-leaved Everg. 4 Needle-leaved Everg. 5 Dead 6 *Deciduous* 7 *Evergreen*

SYSTEM: R - RIVERINE

SUBSYSTEM: 1 - TIDAL; 2 - LOWER PERENNIAL; 3 - UPPER PERENNIAL; 4 INTERMITTENT; 5 - UNKNOWN PERENNIAL

CLASS	Subclass
RB - Rock	1 Bedrock 2 Rubble
UB - Uncon-solidated Bottom	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic
SB - Streambed	1 Bedrock 2 Rubble 3 Cobble - Gravel 4 Sand 5 Mud 6 Organic 7 Vegetated
AB - Aquatic Bed	1 Algal 2 Aquatic Moss 3 Rooted Vasc 4 Floating Vasc 5 *Unknown Submerg.* 6 *Unknown Surface*
RS - Rocky Shore	1 Bedrock 2 Rubble
US - Uncon-solidated Shore	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic
OW - Open Water *(unknown bottom)*	
**EM - Emergent	2 Nonpersistent

SYSTEM: L - LACUSTRINE

SUBSYSTEM: 1 - LIMNETIC

CLASS	Subclass
RB - Rock Bottom	1 Bedrock 2 Rubble
UB - Uncon-solidated Bottom	1 Cobble - Gravel 2 Sand 3 Mud 4 Organic
AB - Aquatic Bed	1 Algal 2 Aquatic Moss 3 Rooted Vasc 4 Floating Vasc 5 *Unknown Submerg.* 6 *Unknown Surface*
OW - Open Water *(unknown bottom)*	

SUBSYSTEM: 2 - LITTORAL

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

SYSTEM: P - PALUSTRINE

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

MODIFIERS

WATER REGIME

	Non-Tidal		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	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	Inland Salinity	pH (fresh water)
1 Hyperhaline 2 Euhaline 3 Mixohaline 4 Polyhaline 5 Mesohaline 6 Oligohaline 0 Fresh	7 Hypersaline 8 Eusaline 9 Mixosaline 0 Fresh	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

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FIGURE 5-7
THE COWARDIN WETLAND CLASSIFICATION SYSTEM
CMS WORK PLAN

NAVAL ACTIVITY PUERTO RICO

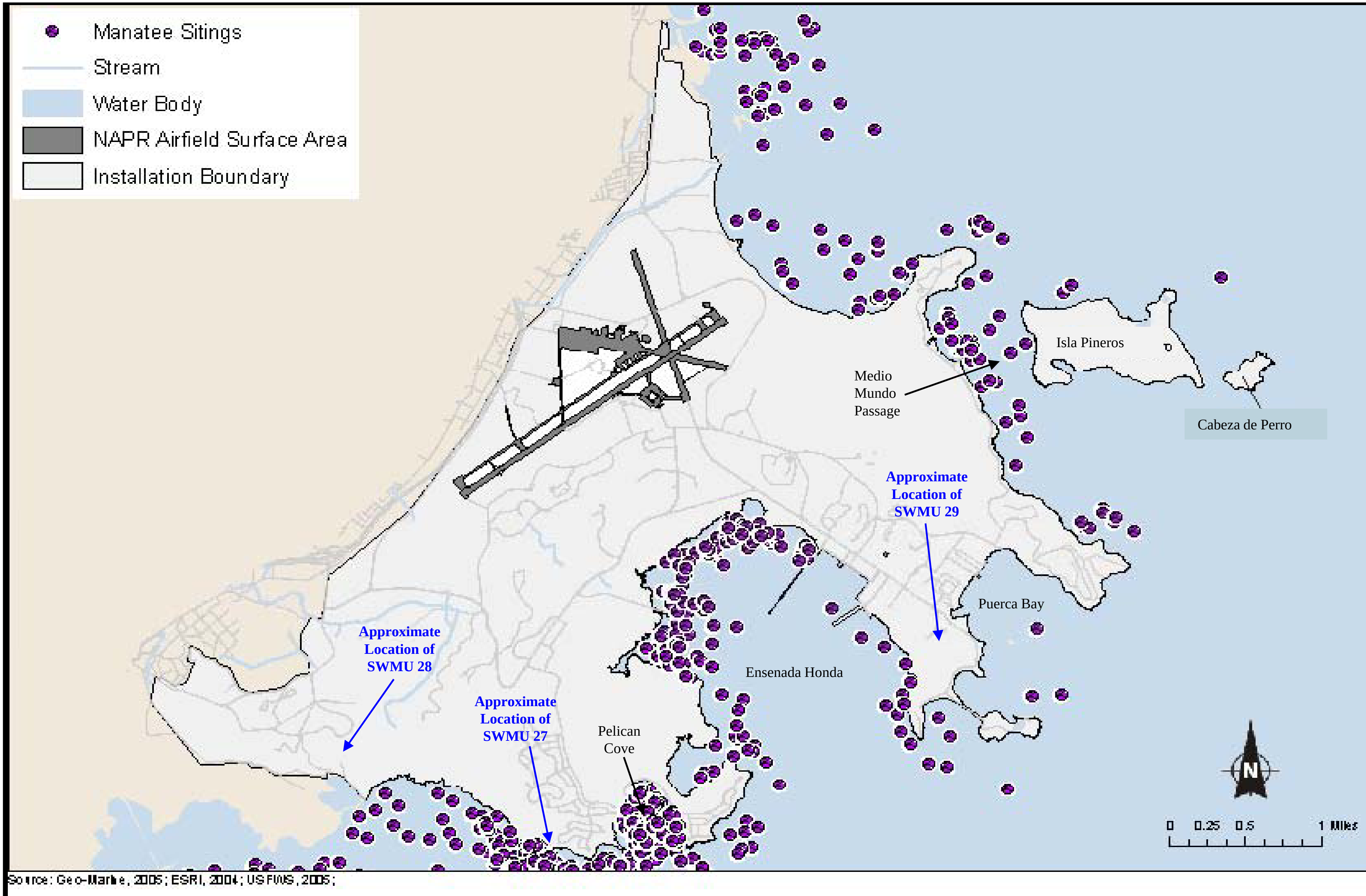
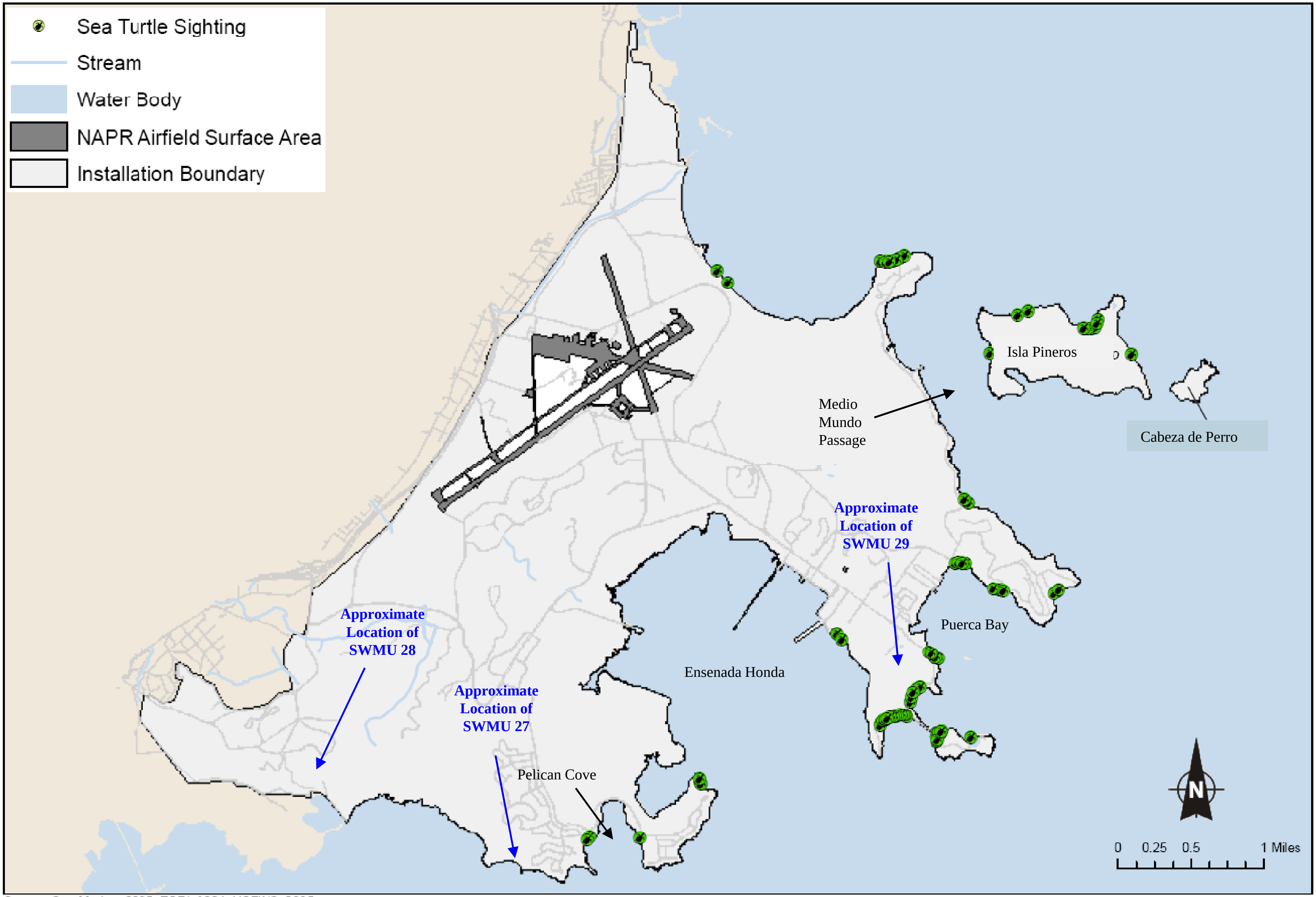


Figure from: Department of the Navy (DoN). 2007. *Environmental Assessment for the Disposal of Naval Activity Puerto Rico (formerly Naval Station Roosevelt Roads).* April 2007.

FIGURE 5-8
HISTORICAL MANATEE SIGHTINGS IN EASTERN PUERTO RICO
CMS WORKPLAN
NAVAL ACTIVITY PUERTO RICO

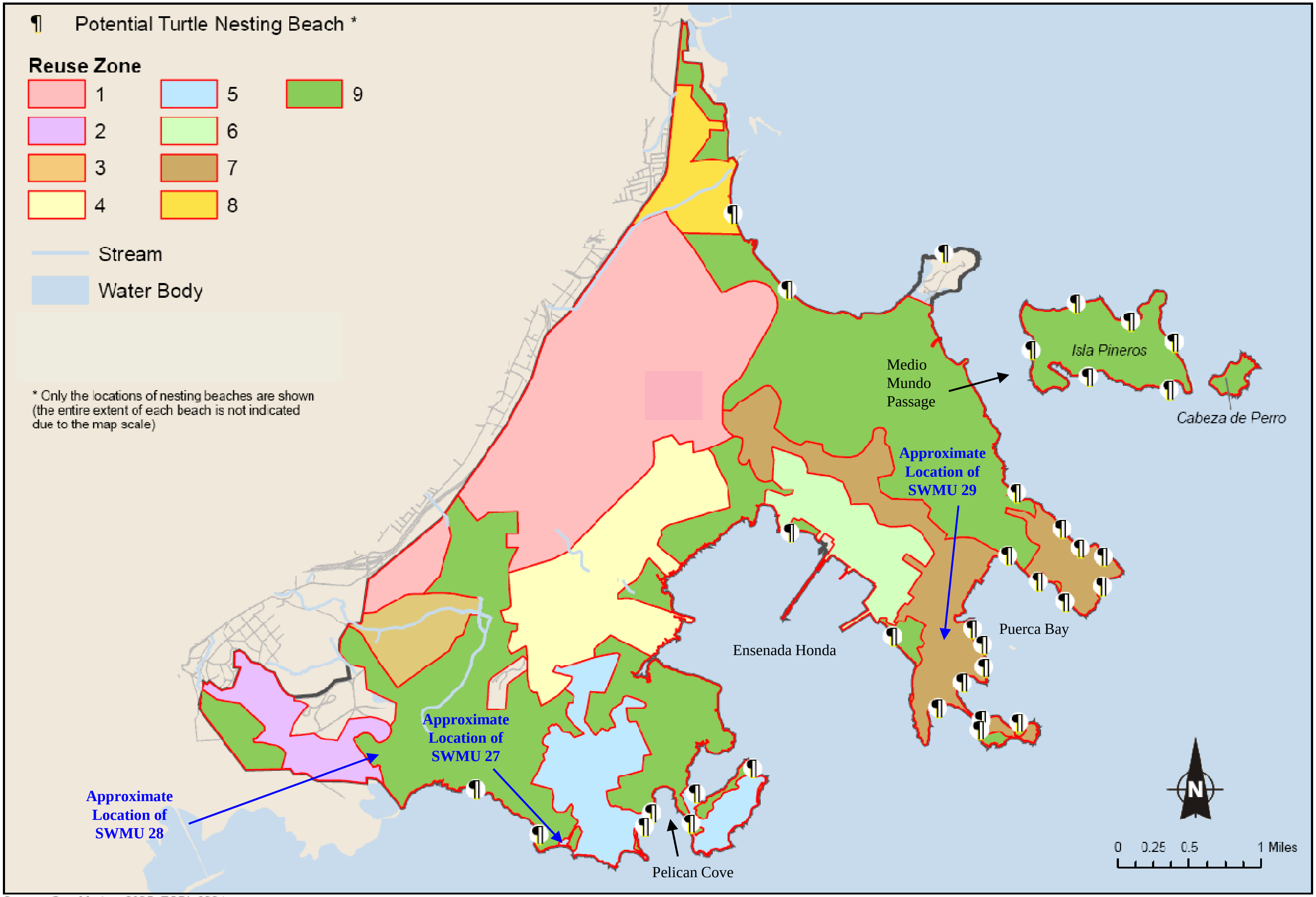


Source: Geo-Marine, 2005; ESRI, 2004; USFWS, 2005;

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.

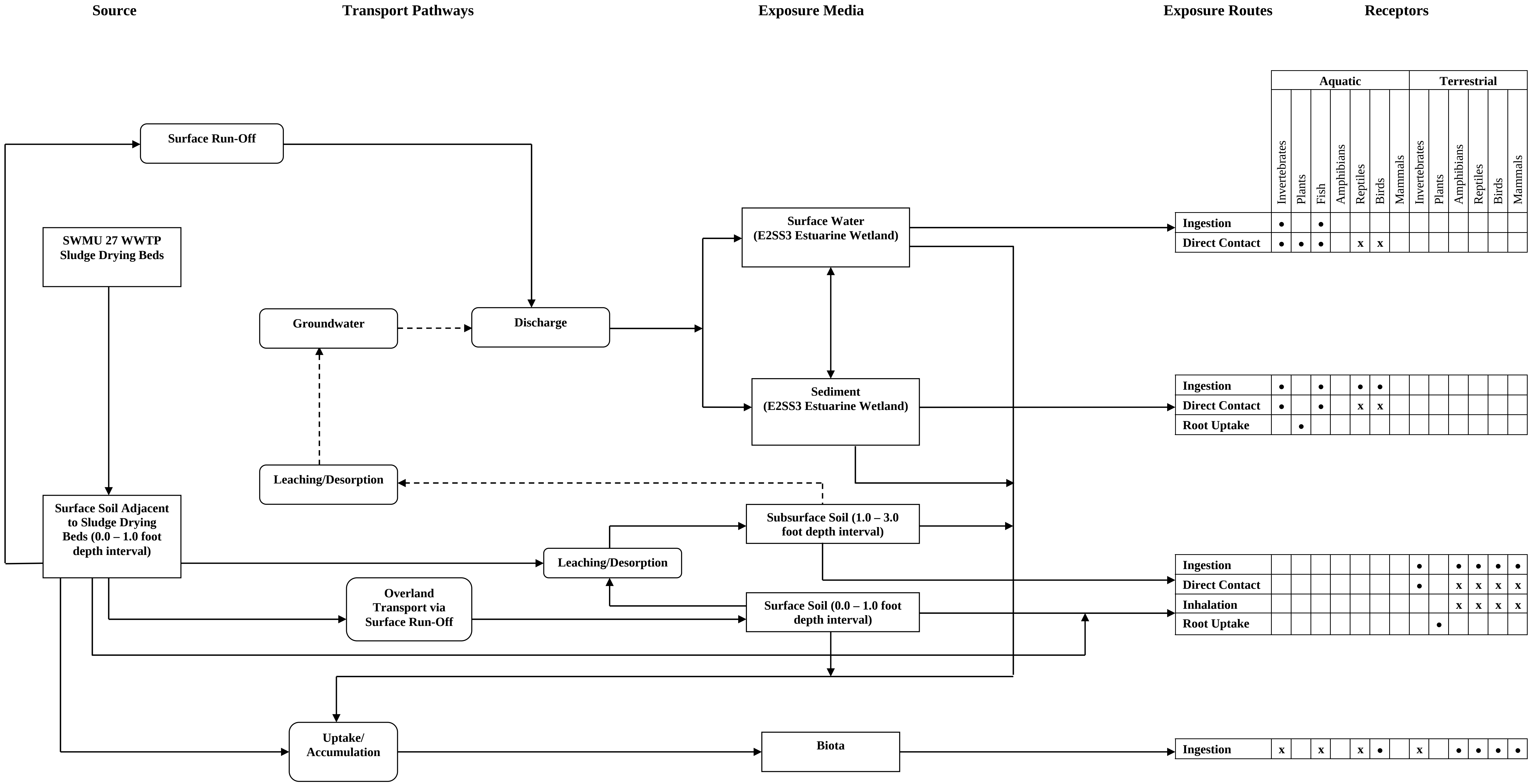
FIGURE 5-9
SEA TURTLE SIGHTINGS AT NAVAL ACTIVITY PUERTO RICO
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO



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 5-10
POTENTIAL TURTLE NESTING SITES
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO



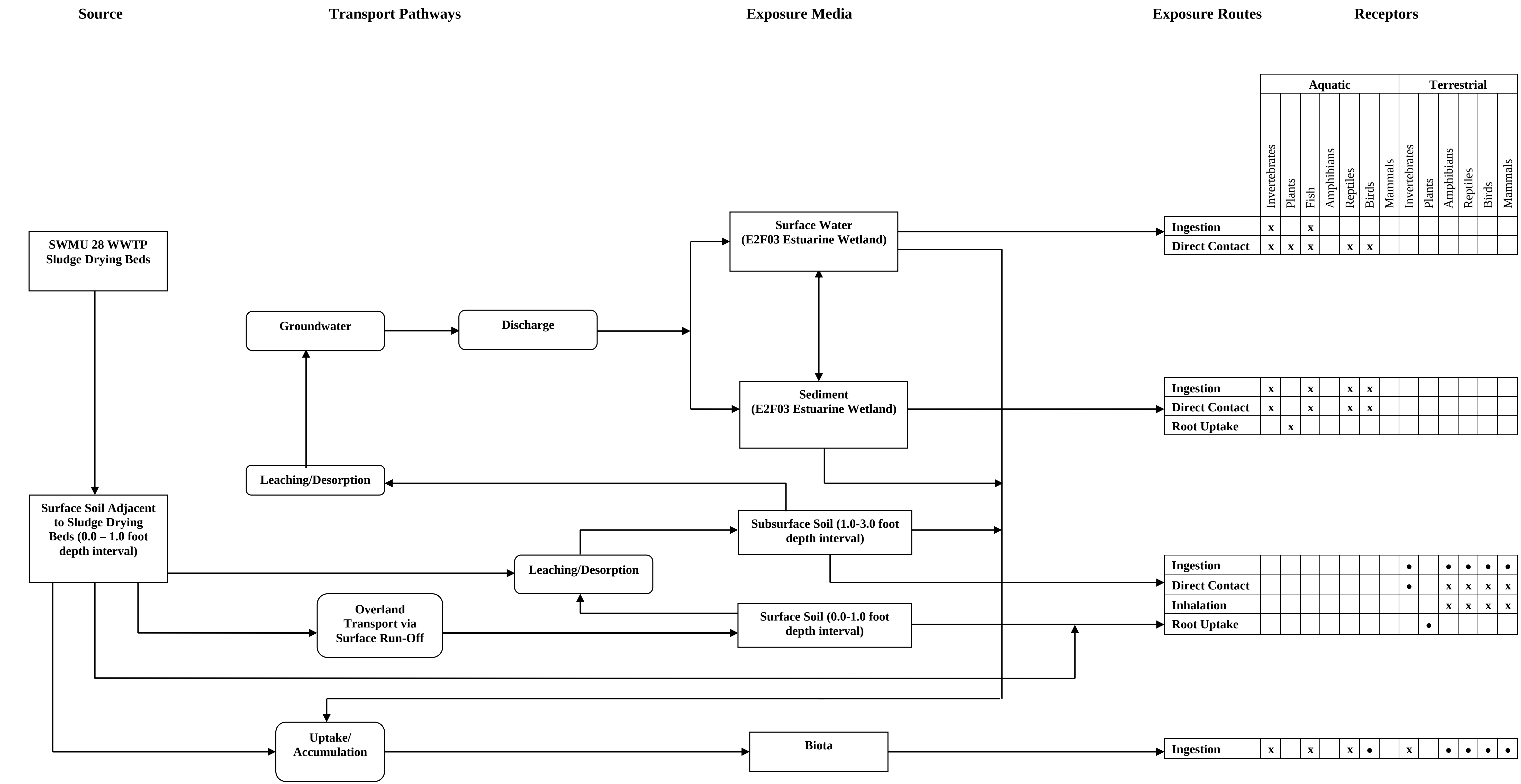
Exposure Medium	Exposure Route	Aquatic Invertebrates	Aquatic Plants	Aquatic Fish	Aquatic Amphibians	Aquatic Reptiles	Aquatic Birds	Aquatic Mammals	Terrestrial Invertebrates	Terrestrial Plants	Terrestrial Amphibians	Terrestrial Reptiles	Terrestrial Birds	Terrestrial Mammals
Surface Water	Ingestion	•		•										
Surface Water	Direct Contact	•	•	•		x	x							
Sediment	Ingestion	•		•		•	•							
Sediment	Direct Contact	•		•		x	x							
Sediment	Root Uptake		•											
Soil	Ingestion								•		•	•	•	•
Soil	Direct Contact								•		x	x	x	x
Soil	Inhalation										x	x	x	x
Soil	Root Uptake									•				
Biota	Ingestion	x		x		x	•		x		•	•	•	•

FIGURE 5-11
PRELIMINARY CONCEPTUAL MODEL
SWMU 27 – CAPEHART WWTP SLUDGE DRYING BEDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

—— Potentially complete and significant pathway
- - - Potentially complete and insignificant pathway

• - Receptor/pathway will be evaluated quantitatively or qualitatively
x - Receptor/pathway will be not be evaluated

K:_SOUTHNAVFAC\119197 JM01\SWMUs 27 28 29\CMS Work Plan\Draft\ERA Files\Non-CAD Figures\Figure 5-11 (SWMU 27 CMS).doc



Exposure Media	Exposure Route	Aquatic Invertebrates	Aquatic Plants	Aquatic Fish	Aquatic Amphibians	Aquatic Reptiles	Aquatic Birds	Aquatic Mammals	Terrestrial Invertebrates	Terrestrial Plants	Terrestrial Amphibians	Terrestrial Reptiles	Terrestrial Birds	Terrestrial Mammals
Surface Water	Ingestion	x		x										
	Direct Contact	x	x	x		x	x							
Sediment	Ingestion	x		x		x	x							
	Direct Contact	x		x		x	x							
	Root Uptake		x											
Subsurface Soil / Surface Soil	Ingestion								•		•	•	•	•
	Direct Contact								•		x	x	x	x
	Inhalation										x	x	x	x
	Root Uptake									•				
Biota	Ingestion	x		x		x	•		x		•	•	•	•

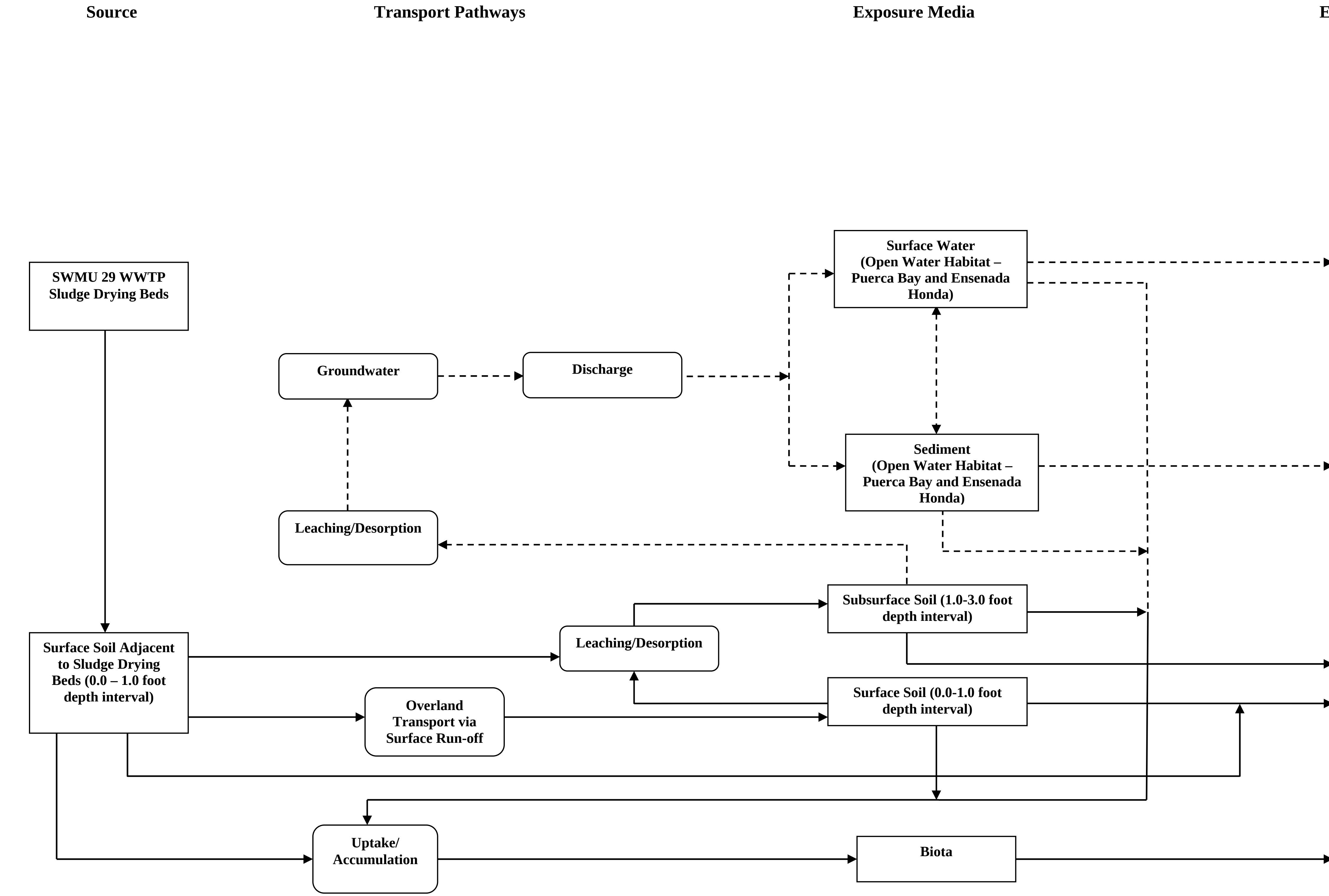
→ Potentially complete and significant pathway

FIGURE 5-12
PRELIMINARY CONCEPTUAL MODEL
SWMU 28 – BUNDY WWTP SLUDGE DRYING BEDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

• - Receptor/pathway will be evaluated quantitatively or qualitatively
x - Receptor/pathway will be not be evaluated

Groundwater data will be screened against the marine/estuarine surface water screening values listed in Table 5-5

FIGURE 5-13
PRELIMINARY CONCEPTUAL MODEL
SWMU 29 – INDUSTRIAL AREA WWTP SLUDGE DRYING BEDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO



Exposure Routes / Receptors

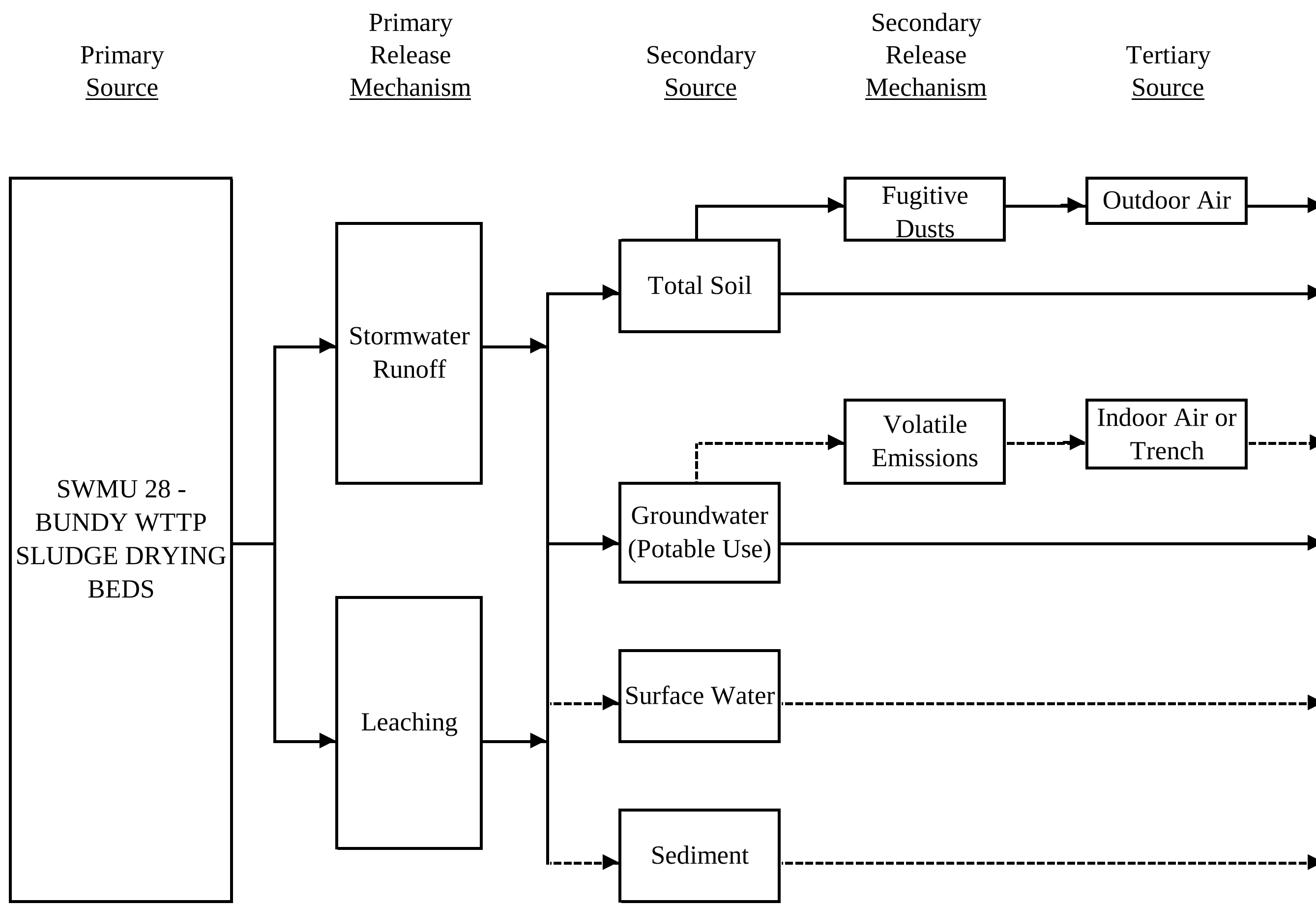
Exposure Media	Exposure Route	Aquatic: Invertebrates	Aquatic: Plants	Aquatic: Fish	Aquatic: Amphibians	Aquatic: Reptiles	Aquatic: Birds	Aquatic: Mammals	Terrestrial: Invertebrates	Terrestrial: Plants	Terrestrial: Amphibians	Terrestrial: Reptiles	Terrestrial: Birds	Terrestrial: Mammals
Surface Water	Ingestion	x		x										
Surface Water	Direct Contact	x	x	x		x	x	x						
Sediment	Ingestion	x		x		x	x	x						
Sediment	Direct Contact	x		x		x	x	x						
Sediment	Root Uptake		x											
Subsurface Soil / Surface Soil	Ingestion								•		•	•	•	•
Subsurface Soil / Surface Soil	Direct Contact								•		x	x	x	x
Subsurface Soil / Surface Soil	Inhalation										x	x	x	x
Subsurface Soil / Surface Soil	Root Uptake									•				
Biota	Ingestion	x		x		x	x	x	x		•	•	•	•

Potentially complete and significant pathway (solid arrow)
Potentially complete and insignificant pathway (dashed arrow)

• - Receptor/pathway will be evaluated quantitatively or qualitatively
x - Receptor/pathway will be not be evaluated

FIGURE 6 -1

CONCEPTUAL SITE MODEL
FOR SWMU 28 - BUNDY WTTP SLUDGE DRYING BEDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO



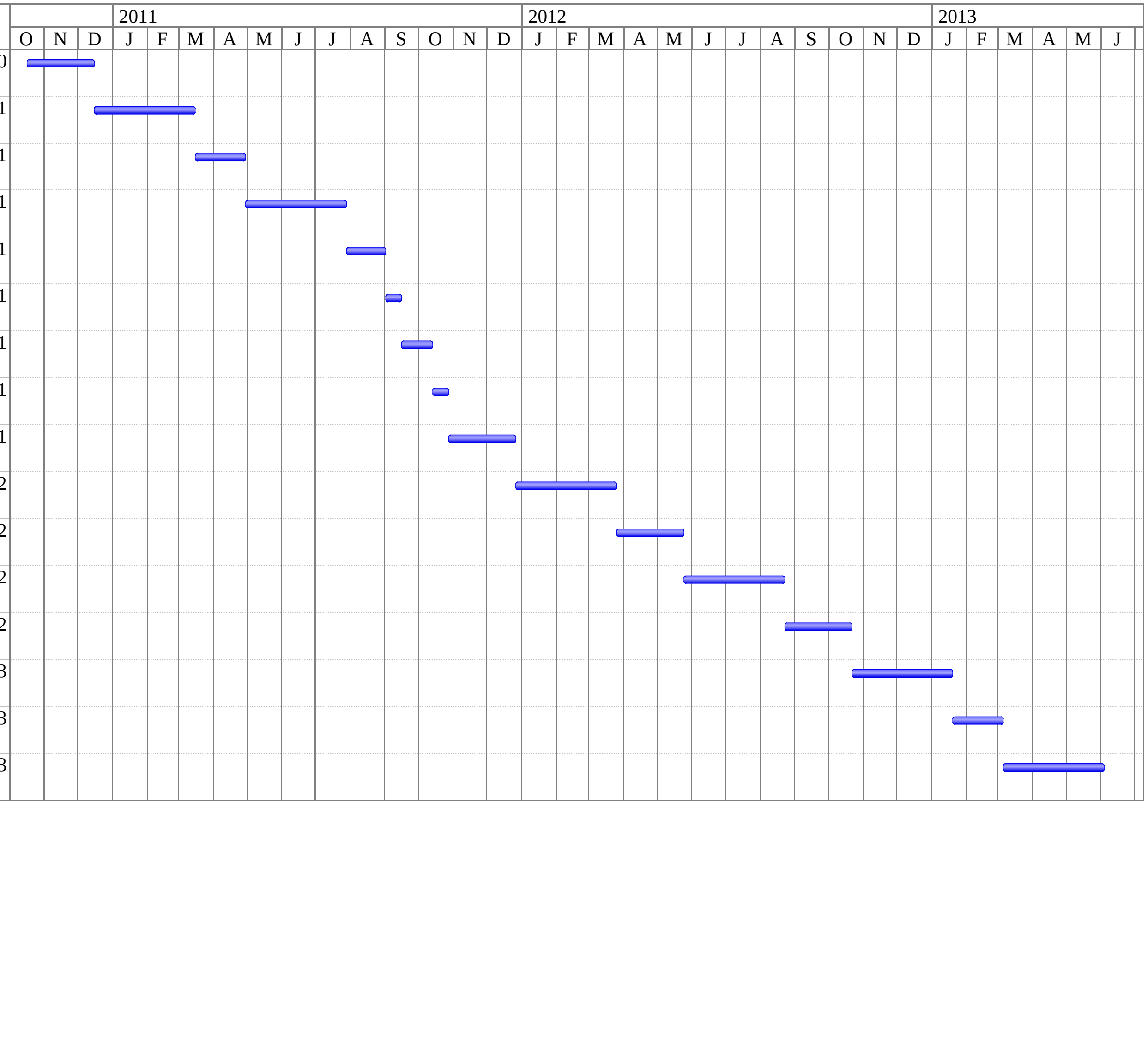
Exposure Route	Potential Human Receptors: Current and Future Adult Trespassers	Current and Future Youth Trespassers	Future Adult Residents	Future Young Child Residents	Future Adult Industrial / Commercial Workers	Future Adult Construction Workers
Inhalation	***CF***	***CF***	**F**	**F**	**F**	**F**
Ingestion	***CF***	***CF***	**F**	**F**	**F**	**F**
Dermal Contact	***CF***	***CF***	**F**	**F**	**F**	**F**
Inhalation			**F**	**F**	**F**	**F**
Ingestion			**F**	**F**		**F**
Dermal Contact			**F**	**F**		**F**
Ingestion	***CF***	***CF***	**F**	**F**		
Dermal Contact	***CF***	***CF***	**F**	**F**		
Ingestion	***CF***	***CF***	**F**	**F**		
Dermal Contact	***CF***	***CF***	**F**	**F**		

Legend

F	Future Exposure Pathway
CF	Current and Future Exposure Pathway
→ (solid arrow)	Complete Exposure Pathway
- · - →	Potentially Complete and Insignificant Exposure Pathway

FIGURE 9-1
PROPOSED PROJECT SCHEDULE
SWMU 27 - CAPEHART WWTP SLUDGE DRYING BEDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

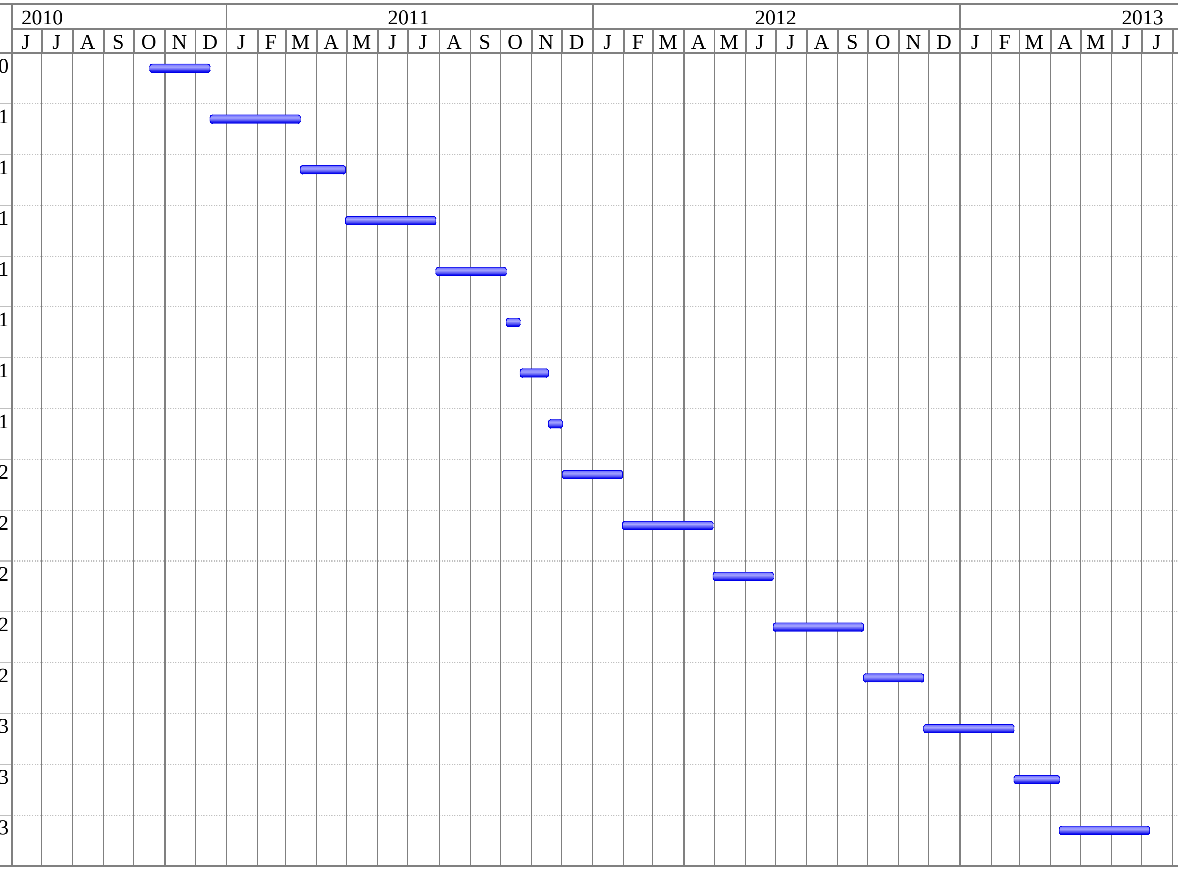
ID	Task Name	Duration	Start	Finish
1	Draft CMS Work Plan for SWMUs 27, 28 and 29 to the EPA	60 edays	10/16/10	12/15/10
2	EPA Review	90 edays	12/15/10	3/15/11
3	Final CMS Work Plan for SWMUs 27, 28 and 29 to the EPA	45 edays	3/15/11	4/29/11
4	EPA Review & Approval	90 edays	4/29/11	7/28/11
5	Initiate Field Work for SWMU 27	25 days	7/29/11	9/1/11
6	Field Investigation	14 edays	9/1/11	9/15/11
7	Laboratory Analysis	28 edays	9/15/11	10/13/11
8	Data Validation	14 edays	10/13/11	10/27/11
9	Draft CMS Task I or CMS Report for SWMU 27 to EPA	60 edays	10/27/11	12/26/11
10	EPA Review	90 edays	12/26/11	3/25/12
11	Final CMS Task I or CMS Report for SWMU 27 to EPA	60 edays	3/25/12	5/24/12
12	EPA Review & Approval	90 edays	5/24/12	8/22/12
13	Draft CMS Final Report for SWMU 27 to EPA	60 edays	8/22/12	10/21/12
14	EPA Review	90 edays	10/21/12	1/19/13
15	Final CMS Final Report for SWMU 27 to EPA	45 edays	1/19/13	3/5/13
16	EPA Review & Approval	90 edays	3/5/13	6/3/13



Project: CMS Work Plan
Date: 11/29/10

FIGURE 9-2
PROPOSED PROJECT SCHEDULE
SWMU 28 - BUNDY WWTP SLUDGE DRYING BEDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

ID	Task Name	Duration	Start	Finish
1	Draft CMS Work Plan for SWMUs 27, 28 and 29 to the EPA	60 edays	10/16/10	12/15/10
2	EPA Review	90 edays	12/15/10	3/15/11
3	Final CMS Work Plan for SWMUs 27, 28 and 29 to the EPA	45 edays	3/15/11	4/29/11
4	EPA Review & Approval	90 edays	4/29/11	7/28/11
5	Initiate Field Work for SWMU 28	50 days	7/29/11	10/6/11
6	Field Investigation	14 edays	10/6/11	10/20/11
7	Laboratory Analysis	28 edays	10/20/11	11/17/11
8	Data Validation	14 edays	11/17/11	12/1/11
9	Draft CMS Task I or CMS Report for SWMU 28 to EPA	60 edays	12/1/11	1/30/12
10	EPA Review	90 edays	1/30/12	4/29/12
11	Final CMS Task I or CMS Report for SWMUs 28 to EPA	60 edays	4/29/12	6/28/12
12	EPA Review & Approval	90 edays	6/28/12	9/26/12
13	Draft CMS Final Report for SWMUs 28 to EPA	60 edays	9/26/12	11/25/12
14	EPA Review	90 edays	11/25/12	2/23/13
15	Final CMS Final Report for SWMU 28 to EPA	45 edays	2/23/13	4/9/13
16	EPA Review & Approval	90 edays	4/9/13	7/8/13

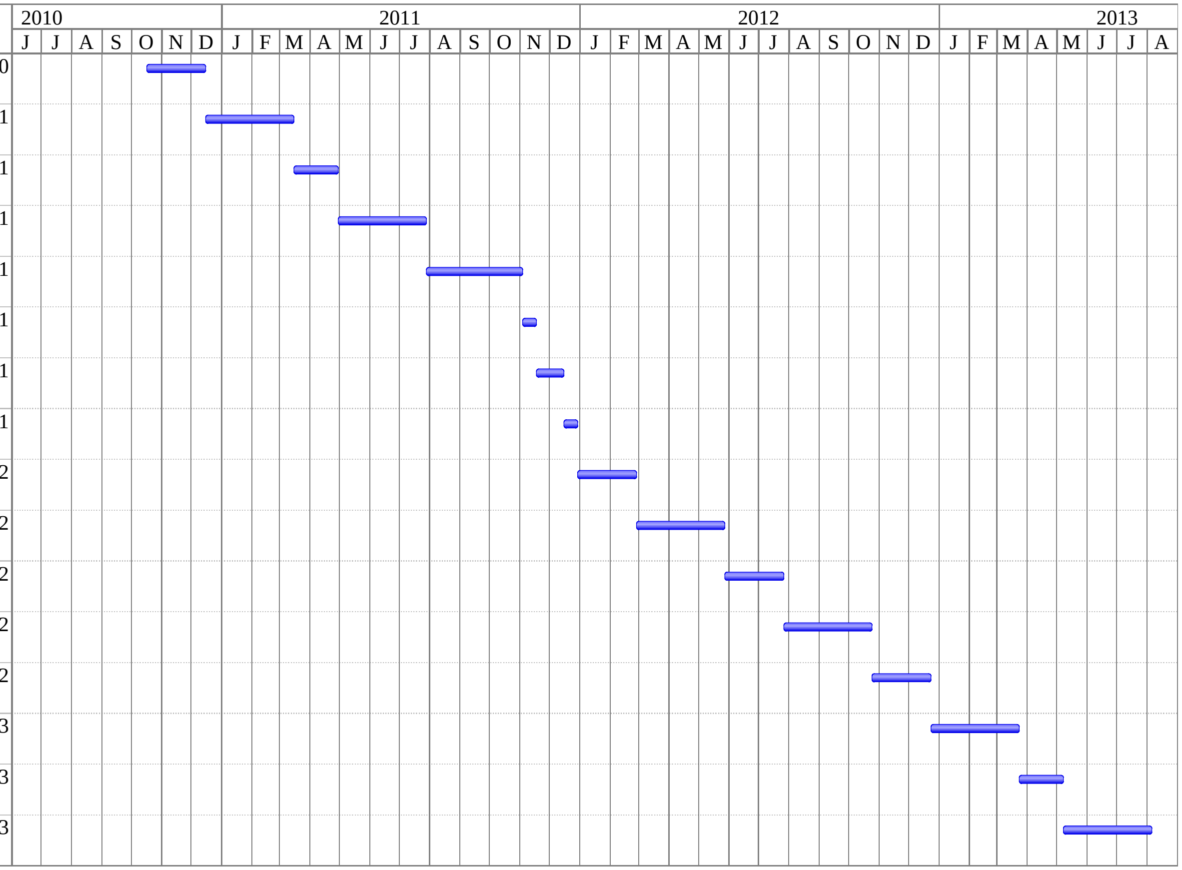


Task

Project: CMS Work Plan
Date: 11/29/10

FIGURE 9-3
PROPOSED PROJECT SCHEDULE
SWMU 29 - INDUSTRIAL AREA WWTP SLUDGE DRYING BEDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

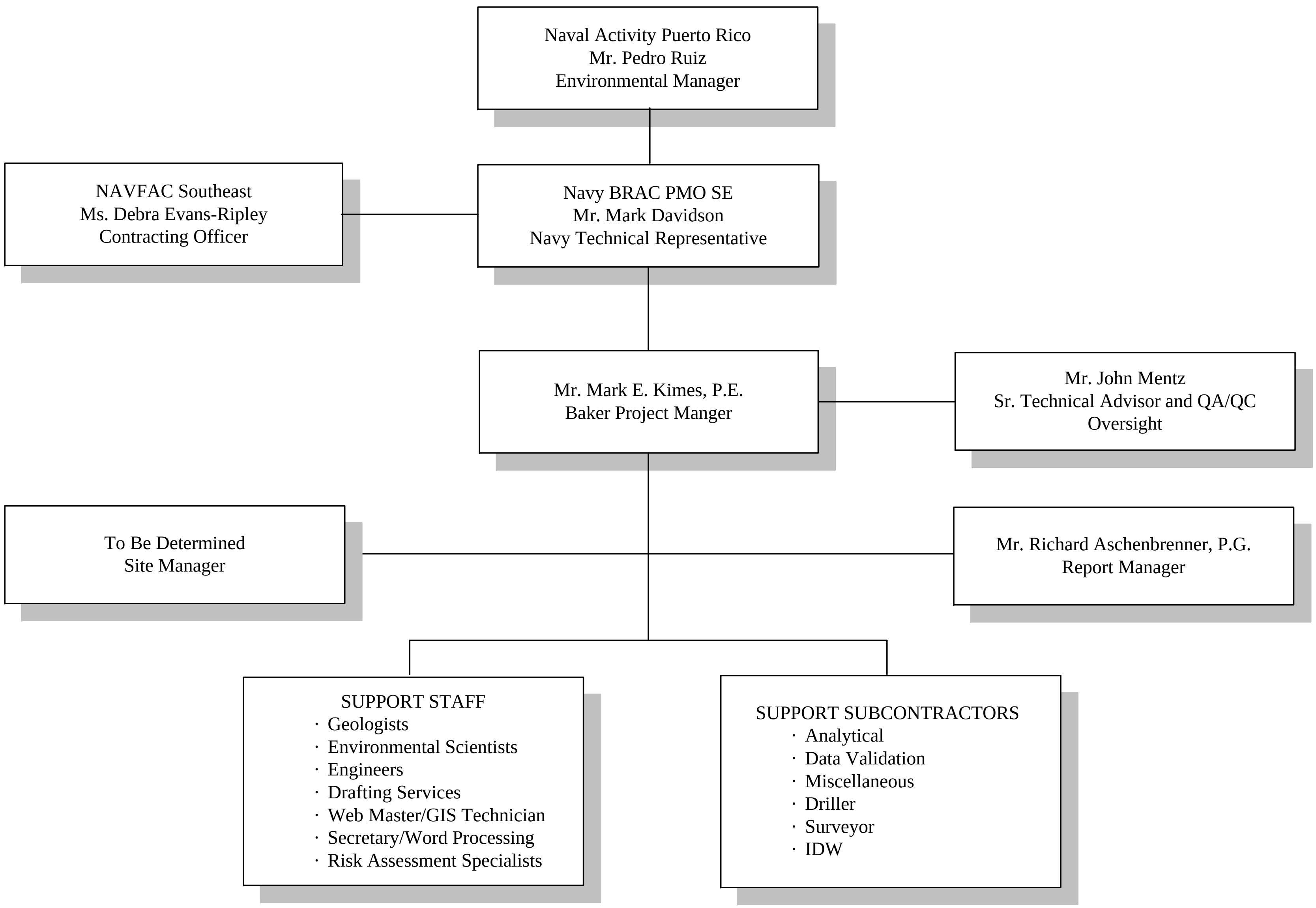
ID	Task Name	Duration	Start	Finish
1	Draft CMS Work Plan for SWMUs 27, 28 and 29 to the EPA	60 edays	10/16/10	12/15/10
2	EPA Review	90 edays	12/15/10	3/15/11
3	Final CMS Work Plan for SWMUs 27, 28 and 29 to the EPA	45 edays	3/15/11	4/29/11
4	EPA Review & Approval	90 edays	4/29/11	7/28/11
5	Initiate Field Work SWMU 29	70 days	7/29/11	11/3/11
6	Field Investigation	14 edays	11/3/11	11/17/11
7	Laboratory Analysis	28 edays	11/17/11	12/15/11
8	Data Validation	14 edays	12/15/11	12/29/11
9	Draft CMS Task I or CMS Report for SWMU 29 to EPA	60 edays	12/29/11	2/27/12
10	EPA Review	90 edays	2/27/12	5/27/12
11	Final CMS Task I or CMS Report for SWMU 29 to EPA	60 edays	5/27/12	7/26/12
12	EPA Review & Approval	90 edays	7/26/12	10/24/12
13	Draft CMS Final Report for SWMU 29 to EPA	60 edays	10/24/12	12/23/12
14	EPA Review	90 edays	12/23/12	3/23/13
15	Final CMS Final Report for SWMU 29 to EPA	45 edays	3/23/13	5/7/13
16	EPA Review & Approval	90 edays	5/7/13	8/5/13



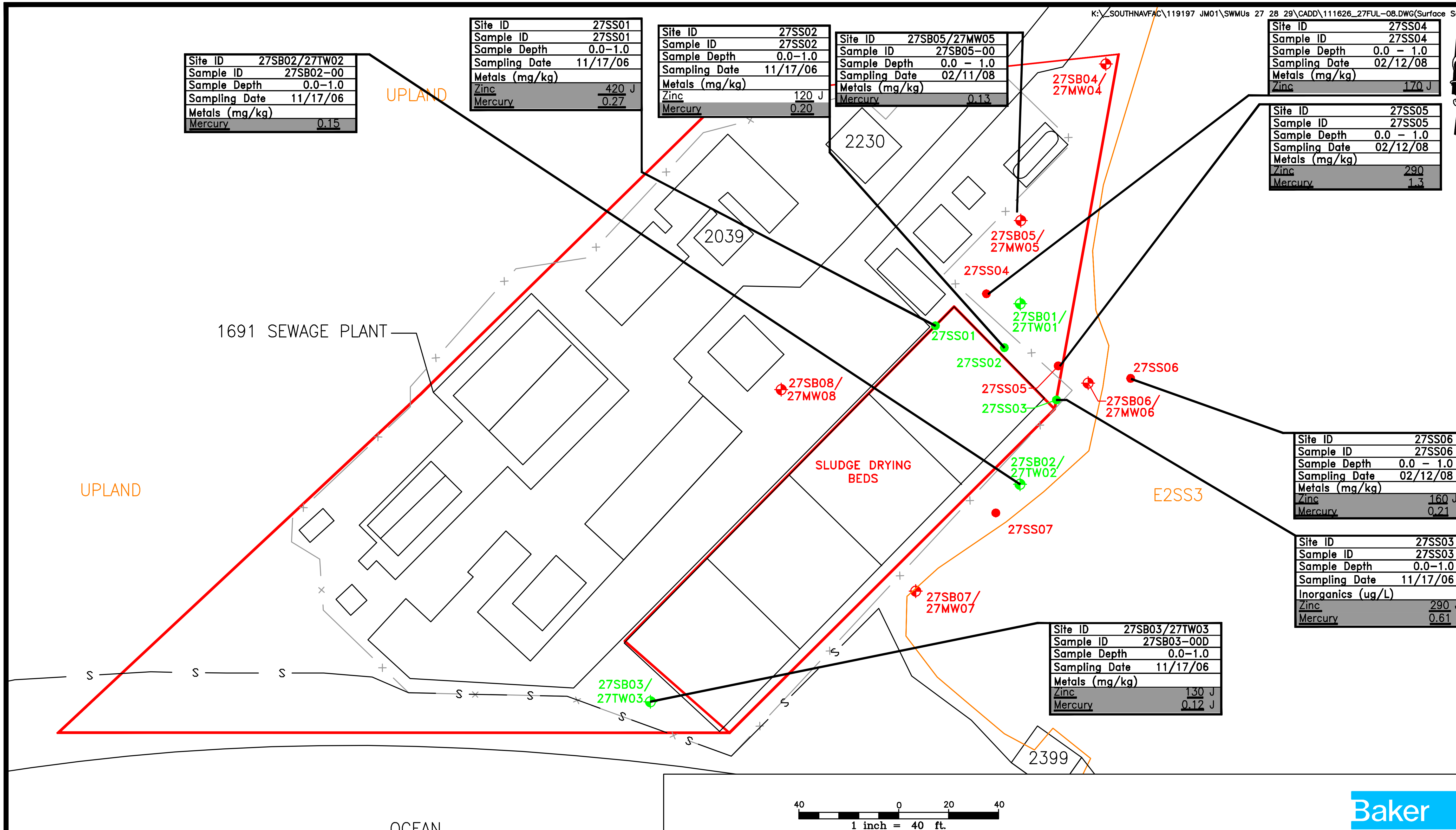
Task

Project: CMS Work Plan
Date: 11/29/10

FIGURE 10-1
PROJECT ORGANIZATION
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO



APPENDIX A
SELECT FIGURES FROM THE FINAL FULL RFI REPORT SWMU 27



Baker

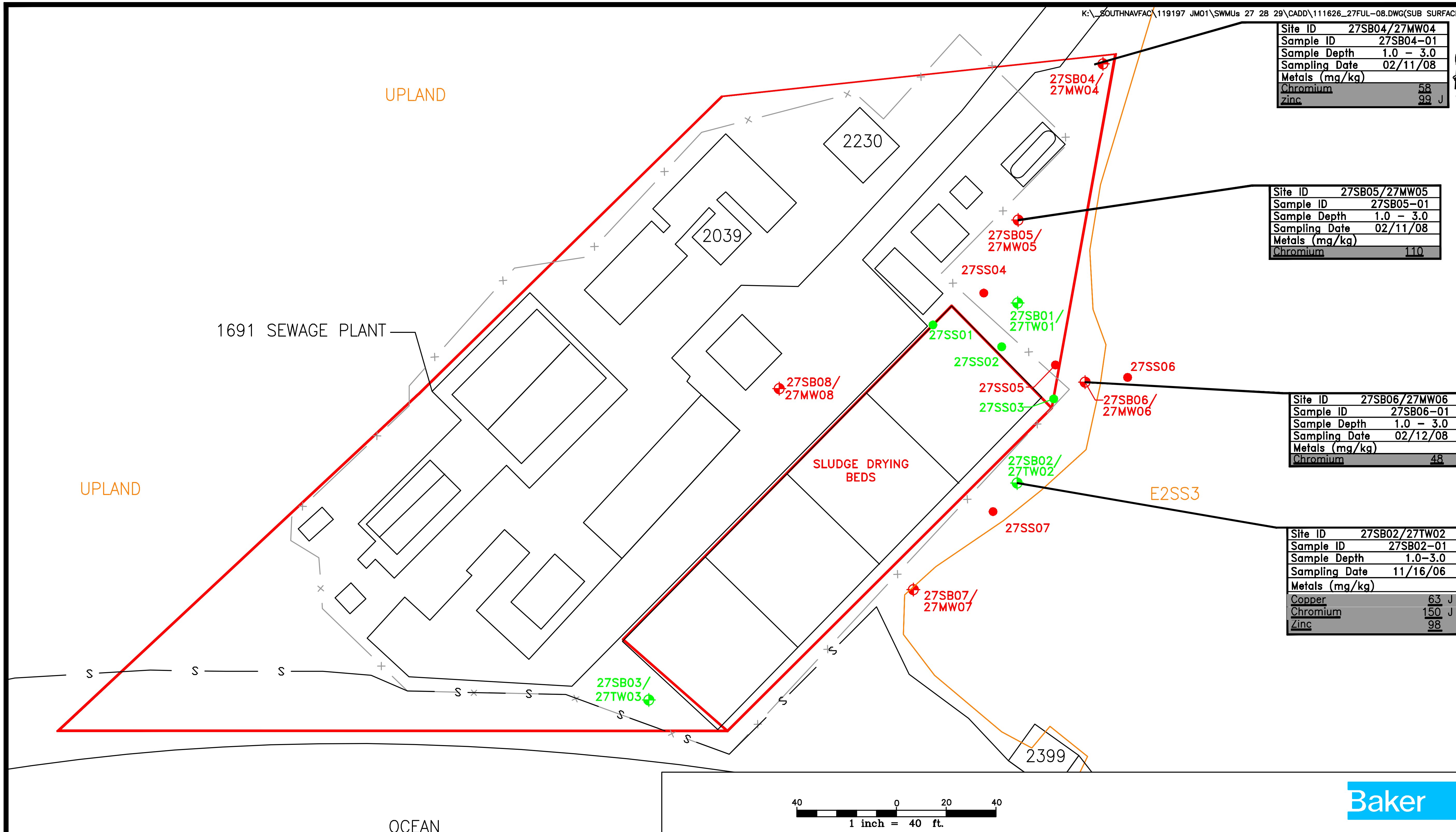
NOTE
INFORMATION ON E2SS3 IS ON FIGURE 5-7 THE COWARDIN WETLAND CLASSIFICATION SYSTEM

J:	Estimated: The analyte was positively identified; the quantitation is an estimation
U:	Undetected at the Limit of Detection.
BOLD	Exceeds USEPA Region IX Residential Soil PRGs
ITALIC	Exceeds Region IX Industrial Soil PRGs
SHADE	Exceeds Selected Ecological Surface Soil Screening Values
UNDERLINE	NAPR Basewide Background
Sample Depth	Feet Below Ground Surface

LEGEND

- SITE BOUNDARY
- FENCE
- EXISTING SURFACE SOIL LOCATION (NOVEMBER 2006)
- SUBSURFACE SOIL BORING/TEMPORARY MONITORING WELL LOCATION (NOVEMBER 2006)
- SUBSURFACE SOIL BORING/MONITORING WELL LOCATION (MARCH 2008)
- SURFACE SOIL LOCATION (MARCH 2008)
- SHEETPILE SEAWALL
- WETLAND DELINEATION

FIGURE A1
EXCEEDANCES OF ECOLOGICAL SCREENING CRITERIA AND BACKGROUND FOR SURFACE SOIL
SWMU 27-CAPEHART
WWTP SLUDGE DRYING BEDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO



NOTE
INFORMATION ON E2SS3 IS ON FIGURE 5-7 THE COWARDIN WETLAND CLASSIFICATION SYSTEM

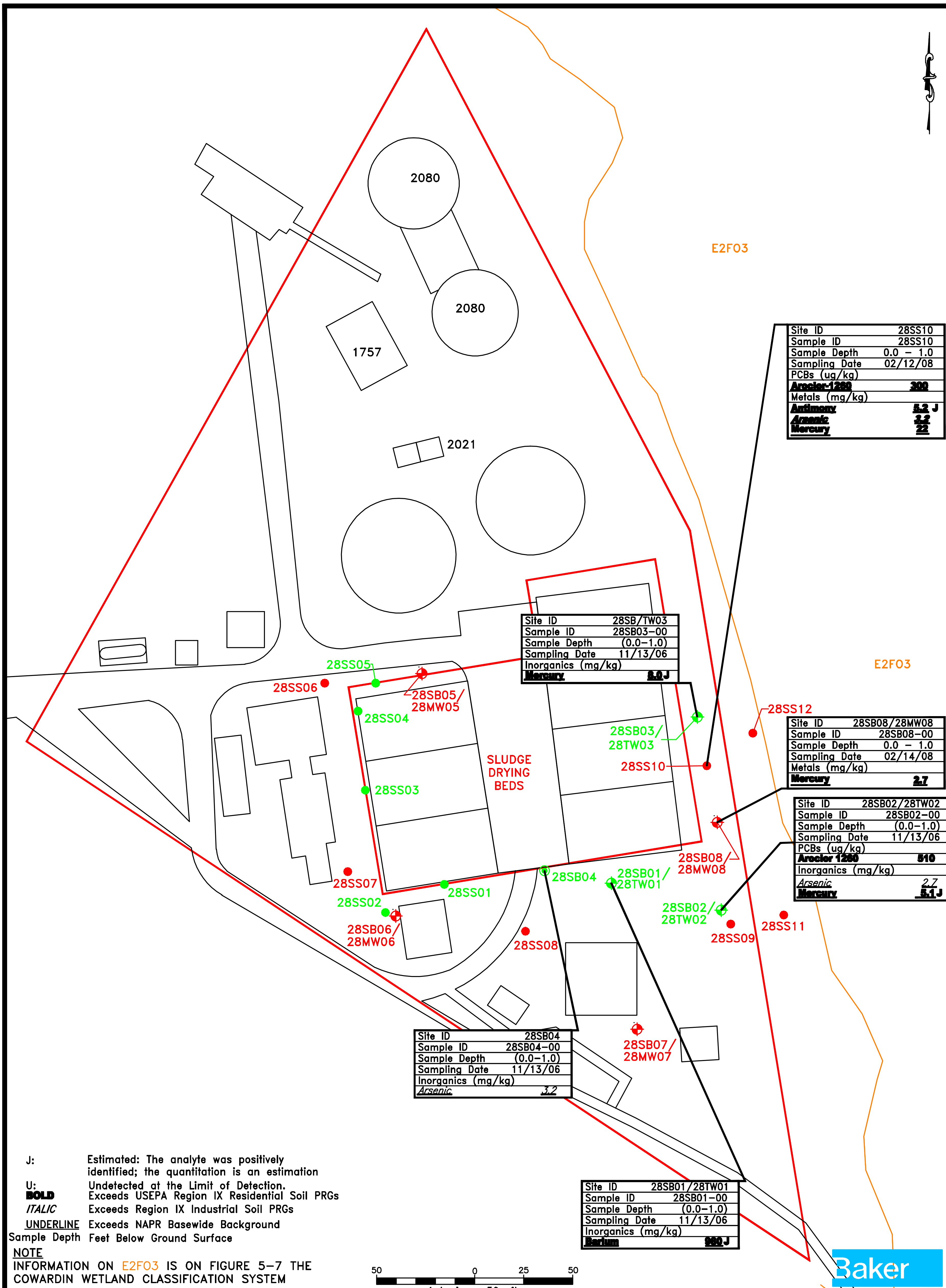
J: Estimated: The analyte was positively identified; the quantitation is an estimation
U: Undetected at the Limit of Detection.
BOLD Exceeds USEPA Region IX Residential Soil PRGs
ITALIC Exceeds Region IX Industrial Soil PRGs
SHADE Exceeds Selected Ecological Surface Soil Screening Values
UNDERLINE Exceeds NAPR Basewide Background
Sample Depth Feet Below Ground Surface

LEGEND

- SITE BOUNDARY
- FENCE
- EXISTING SURFACE SOIL LOCATION (NOVEMBER 2006)
- SUBSURFACE SOIL BORING/TEMPORARY MONITORING WELL LOCATION (NOVEMBER 2006)
- SUBSURFACE SOIL BORING/MONITORING WELL LOCATION (MARCH 2008)
- SURFACE SOIL LOCATION (MARCH 2008)
- SHEETPILE SEAWALL
- WETLAND DELINEATION

FIGURE A2
EXCEEDANCES OF ECOLOGICAL SCREENING CRITERIA AND BACKGROUND FOR SUBSURFACE SOIL
SWMU 27-CAPEHART
WWTP SLUDGE DRYING BEDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO

APPENDIX B
SELECT FIGURES FROM THE FINAL FULL RFI REPORT SWMU 28



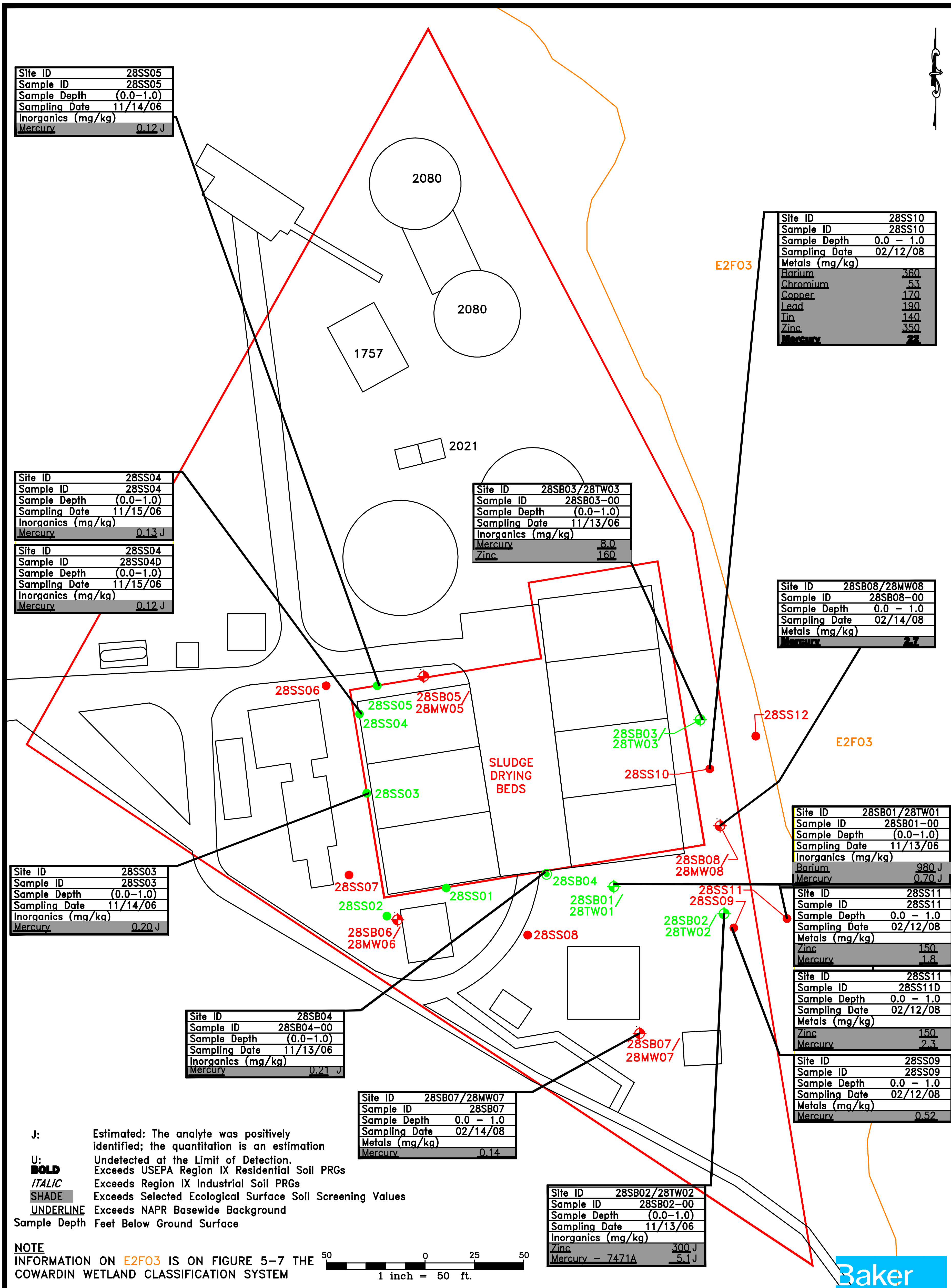
J: Estimated: The analyte was positively identified; the quantitation is an estimation
U: Undetected at the Limit of Detection.
BOLD Exceeds USEPA Region IX Residential Soil PRGs
ITALIC Exceeds Region IX Industrial Soil PRGs
UNDERLINE Exceeds NAPR Basewide Background
Sample Depth Feet Below Ground Surface

NOTE
INFORMATION ON E2FO3 IS ON FIGURE 5–7 THE COWARDIN WETLAND CLASSIFICATION SYSTEM

K:_SOUTHNAVFAC\119197 JM01\SWMUs 27 28 29\CADD\111626_28FUL–08.DWF

LEGEND
– SITE BOUNDARY
– FENCE
– EXISTING SURFACE SOIL LOCATION (NOVEMBER 2006)
– SUBSURFACE SOIL BORING/TEMPORARY MONITORING WELL LOCATION (NOVEMBER 2006)
– SUBSURFACE SOIL BORING LOCATION (NOVEMBER 2006)
– SUBSURFACE SOIL BORING/MONITORING WELL LOCATION (MARCH 2008)
– SURFACE SOIL LOCATION (MARCH 2008)
– WETLAND DELINEATION

FIGURE B1
EXCEEDANCES OF HUMAN HEALTH SCREENING CRITERIA AND BACKGROUND FOR SURFACE SOIL
SWMU 28–BUNDY
WWTP SLUDGE DRYING BEDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO



J: Estimated: The analyte was positively identified; the quantitation is an estimation
U: Undetected at the Limit of Detection.
BOLD Exceeds USEPA Region IX Residential Soil PRGs
ITALIC Exceeds Region IX Industrial Soil PRGs
SHADE Exceeds Selected Ecological Surface Soil Screening Values
UNDERLINE Exceeds NAPR Basewide Background
Sample Depth Feet Below Ground Surface

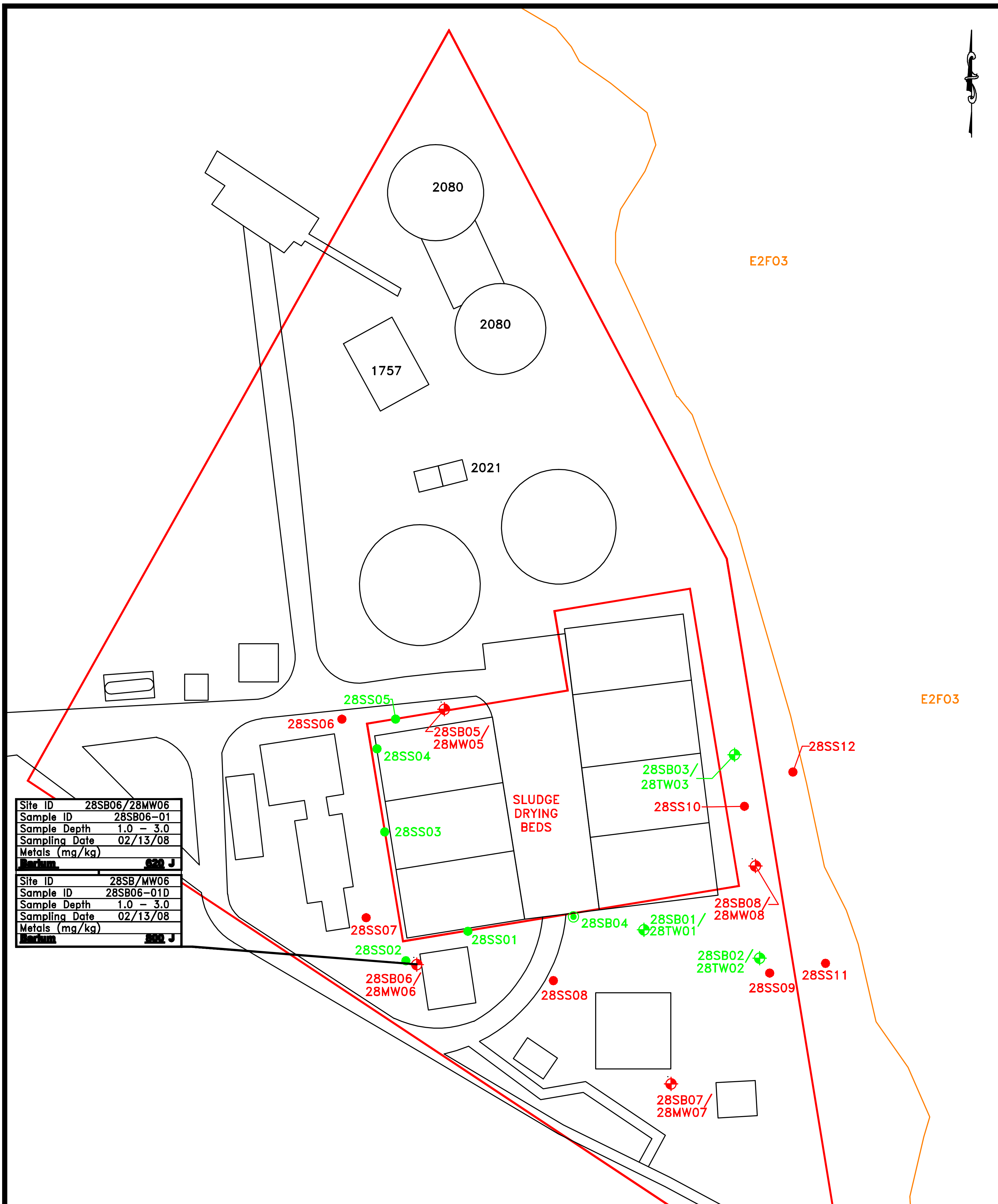
NOTE
INFORMATION ON E2FO3 IS ON FIGURE 5–7 THE COWARDIN WETLAND CLASSIFICATION SYSTEM

K:_SOUTHNAVFAC\119197 JM01\SWMUs 27 28 29\CADD\111626_28FUL–07.DWG

LEGEND

- – SITE BOUNDARY
- – FENCE
- – EXISTING SURFACE SOIL LOCATION (NOVEMBER 2006)
- – SUBSURFACE SOIL BORING/TEMPORARY MONITORING WELL LOCATION (NOVEMBER 2006)
- – SUBSURFACE SOIL BORING LOCATION (NOVEMBER 2006)
- – SUBSURFACE SOIL BORING/MONITORING WELL LOCATION (MARCH 2008)
- – SURFACE SOIL LOCATION (MARCH 2008)
- – WETLAND DELINEATION

FIGURE B2
EXCEEDANCES OF ECOLOGICAL SCREENING CRITERIA AND BACKGROUND FOR SURFACE SOIL
SWMU 28–BUNDY
WWTP SLUDGE DRYING BEDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO



J: Estimated: The analyte was positively identified; the quantitation is an estimation

U: Undetected at the Limit of Detection.

BOLD Exceeds USEPA Region IX Residential Soil PRGs

ITALIC Exceeds Region IX Industrial Soil PRGs

UNDERLINE Exceeds NAPR Basewide Background

Sample Depth Feet Below Ground Surface

NOTE

INFORMATION ON E2FO3 IS ON FIGURE 5-7 THE COWARDIN WETLAND CLASSIFICATION SYSTEM

K:_SOUTHNAVFAC\119197 JM01\SWMUs 27 28 29\CADD\111626_28FUL-08.DWG

50 0 25 50

1 inch = 50 ft.

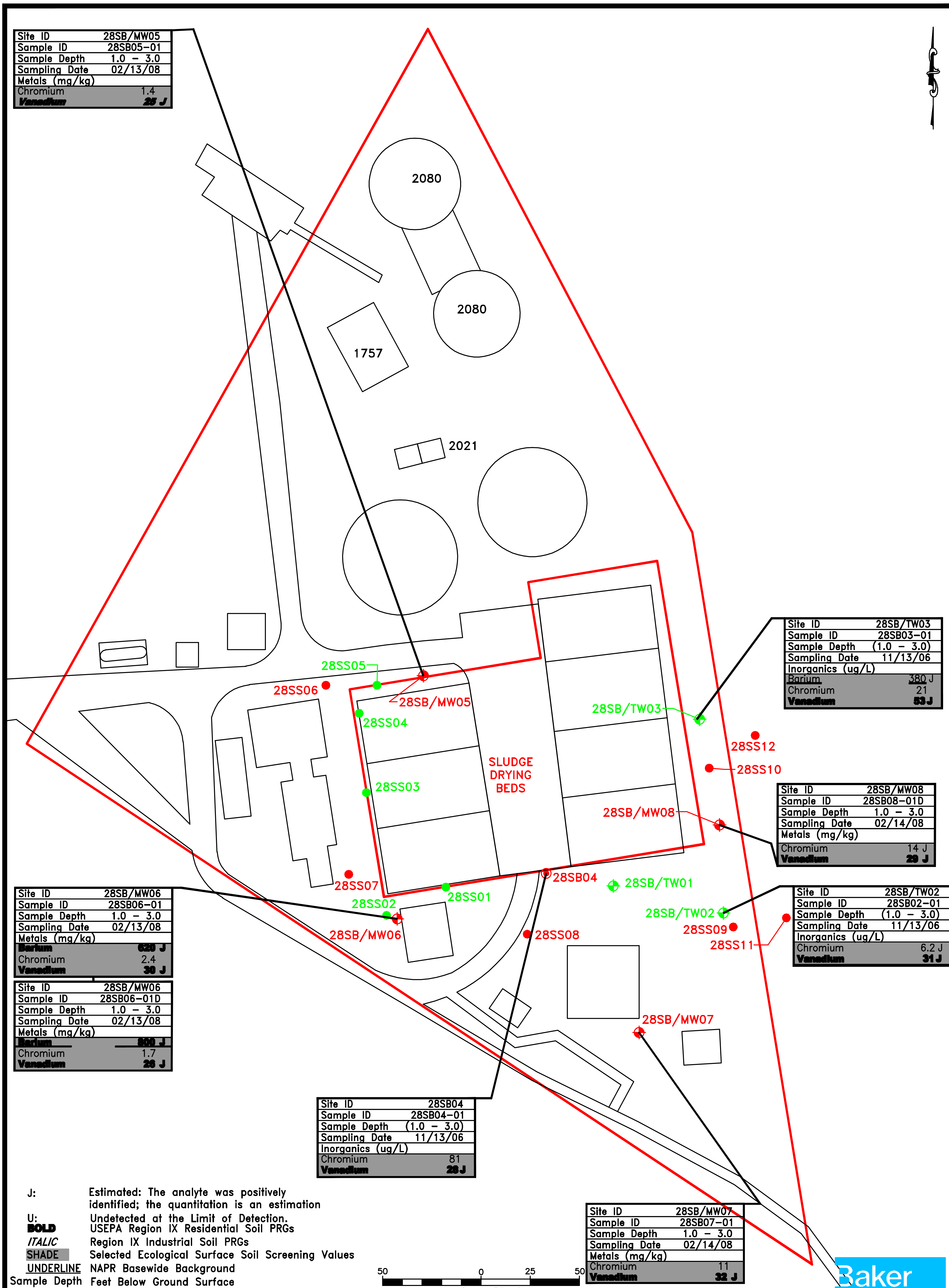
Baker

LEGEND

- SITE BOUNDARY
- FENCE
- EXISTING SURFACE SOIL LOCATION (NOVEMBER 2006)
- SUBSURFACE SOIL BORING/TEMPORARY MONITORING WELL LOCATION (NOVEMBER 2006)
- SUBSURFACE SOIL BORING LOCATION (NOVEMBER 2006)
- SUBSURFACE SOIL BORING/MONITORING WELL LOCATION (MARCH 2008)
- SURFACE SOIL LOCATION (MARCH 2008)
- WETLAND DELINEATION

FIGURE B3
EXCEEDANCES OF HUMAN HEALTH SCREENING CRITERIA AND BACKGROUND FOR SUBSURFACE SOIL
SWMU 28-BUNDY
WWTP SLUDGE DRYING BEDS
CMS WORK PLAN

NAVAL ACTIVITY PUERTO RICO



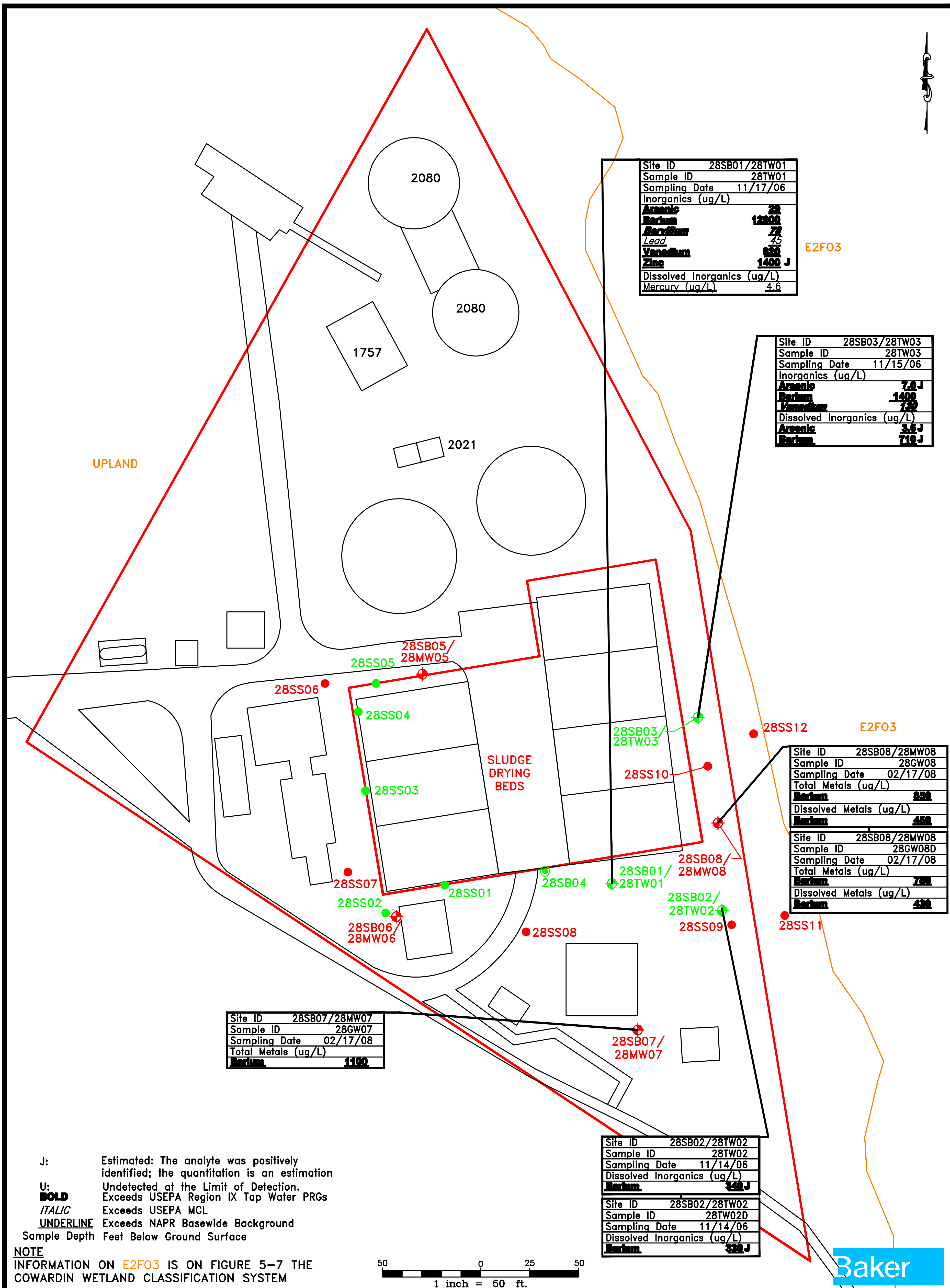
J: Estimated: The analyte was positively identified; the quantitation is an estimation
U: Undetected at the Limit of Detection.
BOLD USEPA Region IX Residential Soil PRGs
ITALIC Region IX Industrial Soil PRGs
SHADE Selected Ecological Surface Soil Screening Values
UNDERLINE NAPR Basewide Background
Sample Depth Feet Below Ground Surface

K:_SOUTHNAVFAC\119197 JM01\SWMUs 27 28 29\CADD\111626_28FUL-04.DWG

LEGEND

- SITE BOUNDARY
- EXISTING SURFACE SOIL LOCATION (NOVEMBER 2006)
- SUBSURFACE SOIL BORING/TEMPORARY MONITORING WELL LOCATION (NOVEMBER 2006)
- SUBSURFACE SOIL BORING/MONITORING WELL LOCATION (MARCH 2008)
- SURFACE SOIL LOCATION (MARCH 2008)
- FENCE

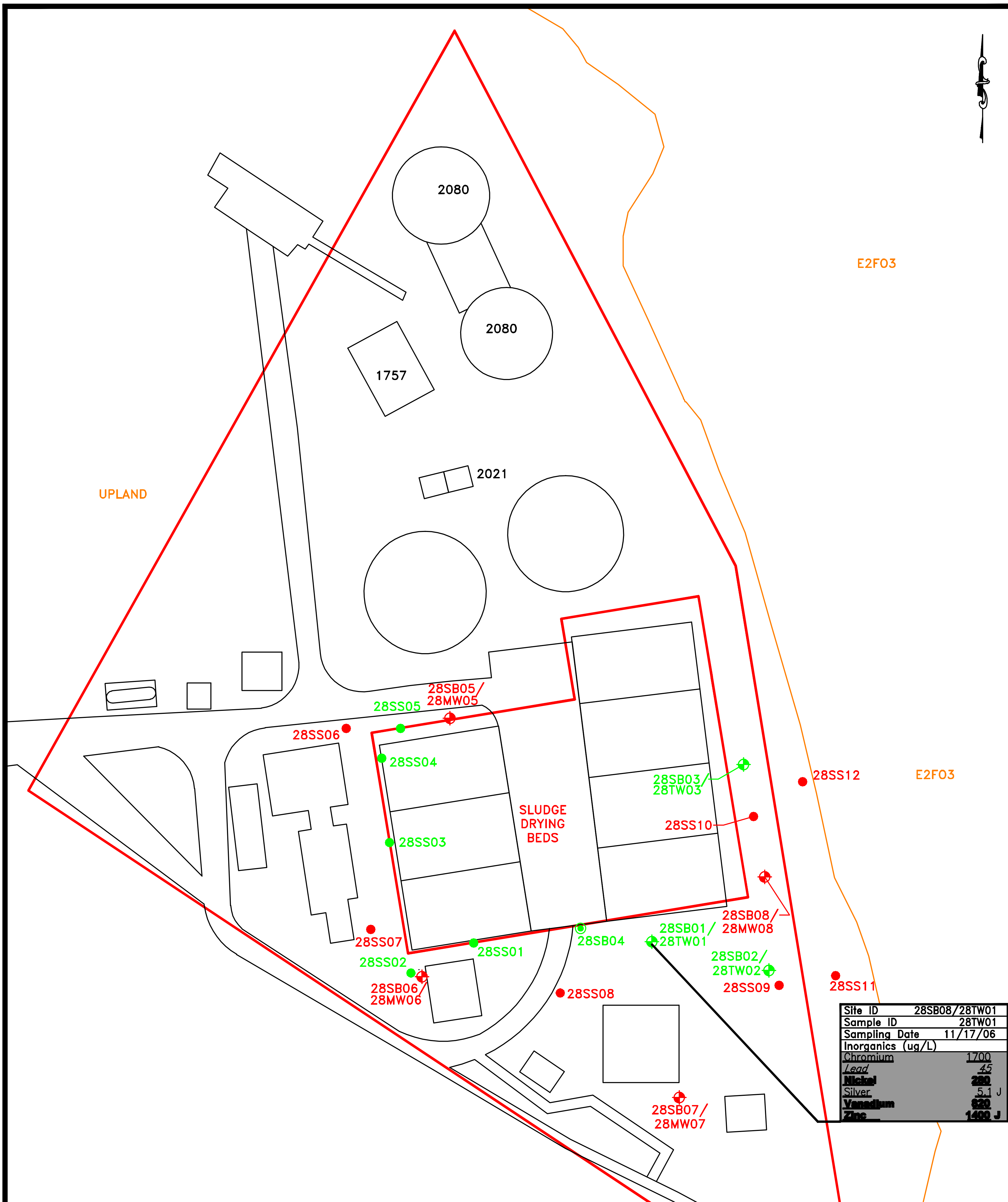
FIGURE B4
EXCEEDANCES OF ECOLOGICAL SCREENING CRITERIA FOR SUBSURFACE SOIL
SWMU 28–BUNDY
WWTP SLUDGE DRYING BEDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO



LEGEND

- SITE BOUNDARY
- FENCE
- EXISTING SURFACE SOIL LOCATION (NOVEMBER 2006)
- SUBSURFACE SOIL BORING/TEMPORARY MONITORING WELL LOCATION (NOVEMBER 2006)
- SUBSURFACE SOIL BORING LOCATION (NOVEMBER 2006)
- SUBSURFACE SOIL BORING/MONITORING WELL LOCATION (MARCH 2008)
- SURFACE SOIL LOCATION (MARCH 2008)
- WETLAND DELINEATION

FIGURE B5
EXCEEDANCES OF HUMAN HEALTH SCREENING CRITERIA AND BACKGROUND FOR GROUNDWATER
SWMU 28-BUNDY
WWTP SLUDGE DRYING BEDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO



J: Estimated: The analyte was positively identified; the quantitation is an estimation
U: Undetected at the Limit of Detection.
BOLD Exceeds USEPA Region IX Tap Water PRGs
ITALIC Exceeds USEPA MCL
SHADE Exceeds Selected Ecological Surface Soil Screening Values
UNDERLINE Exceeds NAPR Basewide Background
Sample Depth Feet Below Ground Surface

NOTE
INFORMATION ON E2FO3 IS ON FIGURE 5-7 THE COWARDIN WETLAND CLASSIFICATION SYSTEM

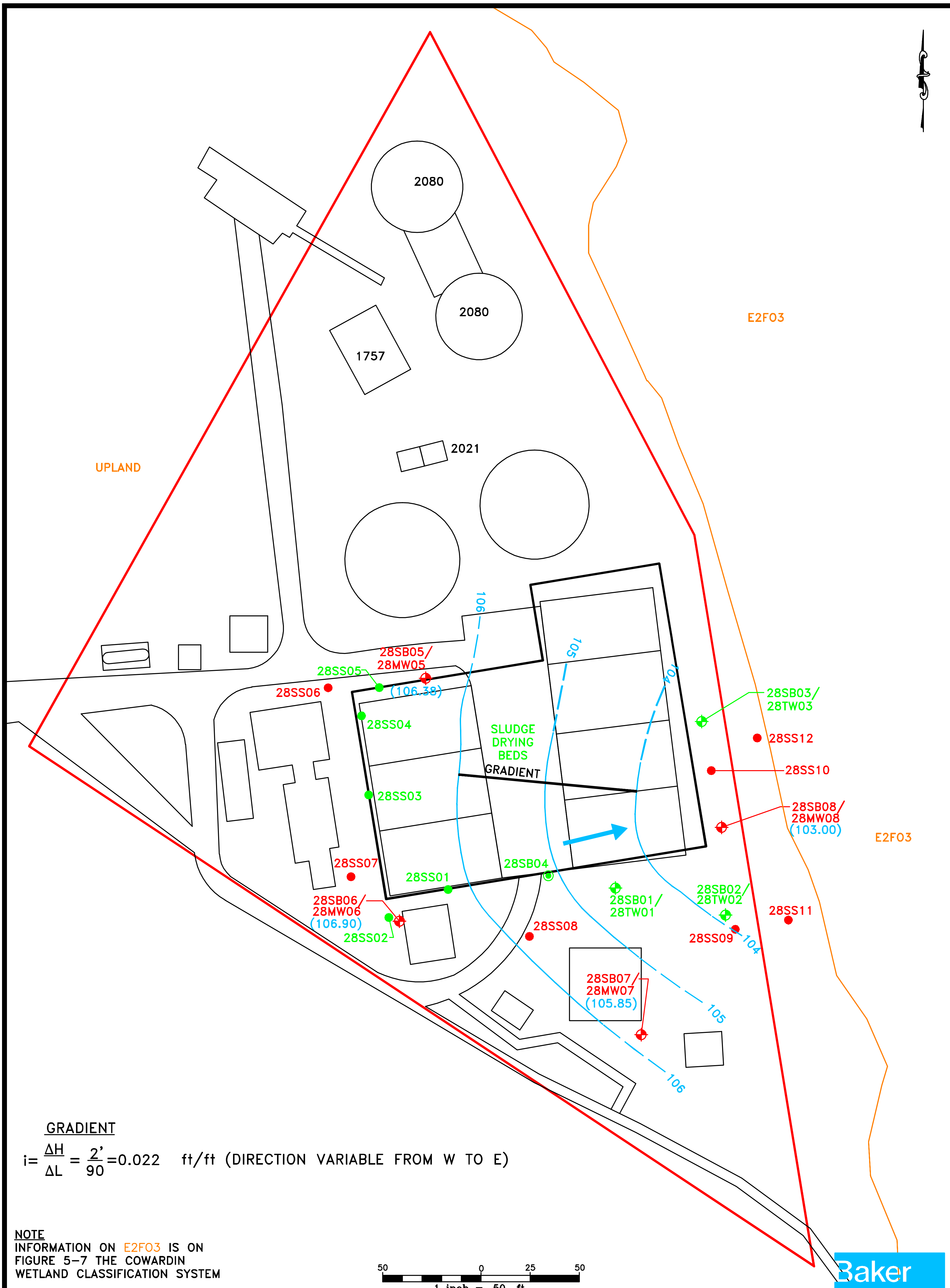
50 0 25 50
1 inch = 50 ft.

Baker

K:_SOUTHNAVFAC\119197 JM01\SWMUs 27 28 29\CADD\111626_28FUL-09.DWG

LEGEND
- SITE BOUNDARY
- FENCE
- EXISTING SURFACE SOIL LOCATION (NOVEMBER 2006)
- SUBSURFACE SOIL BORING/TEMPORARY MONITORING WELL LOCATION (NOVEMBER 2006)
- SUBSURFACE SOIL BORING LOCATION (NOVEMBER 2006)
- SUBSURFACE SOIL BORING/MONITORING WELL LOCATION (MARCH 2008)
- SURFACE SOIL LOCATION (MARCH 2008)
- WETLAND DELINEATION

FIGURE B6
EXCEEDANCES OF ECOLOGICAL SCREENING CRITERIA AND BACKGROUND FOR GROUNDWATER
SWMU 28-BUNDY
WWTP SLUDGE DRYING BEDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO



GRADIENT

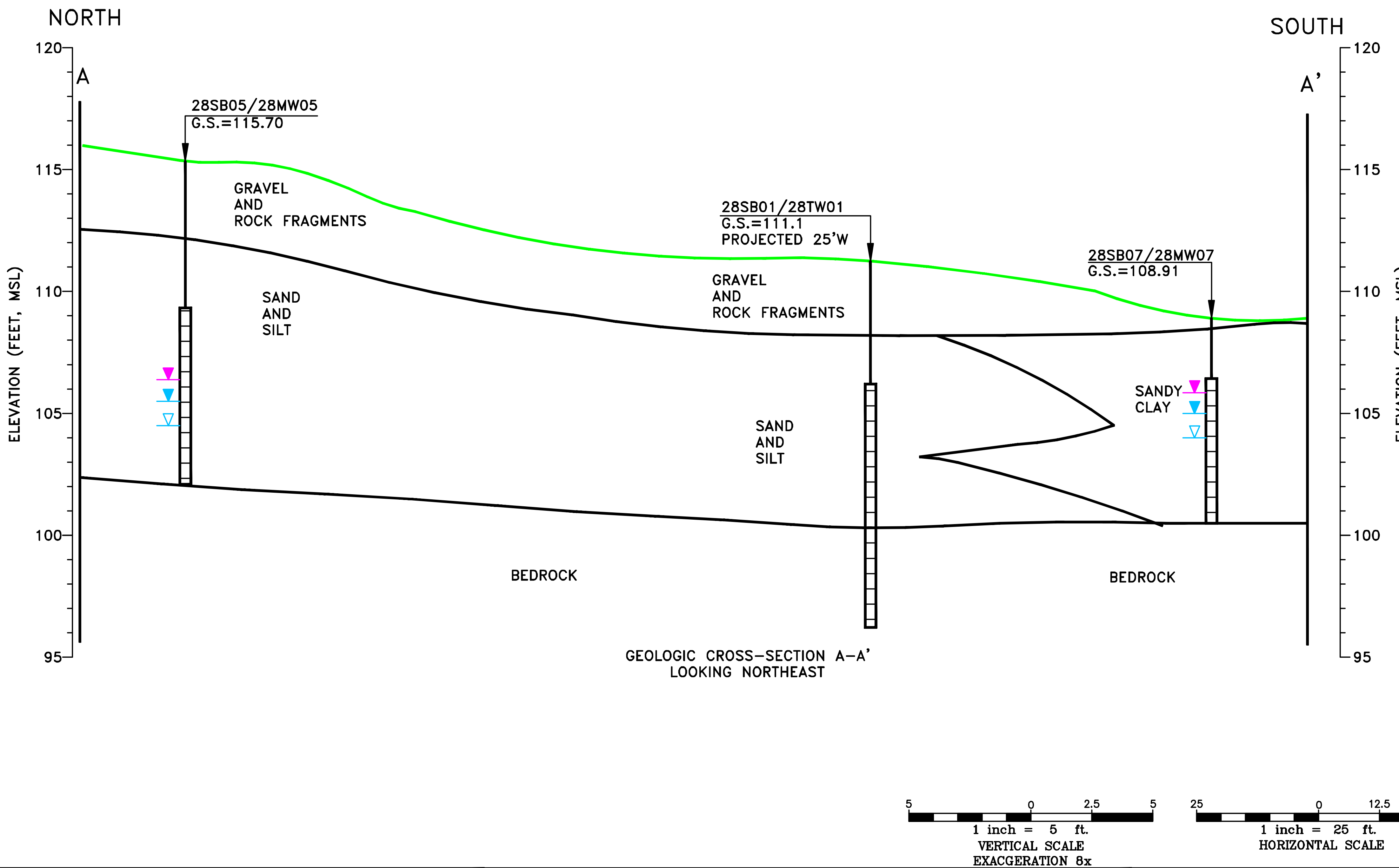
$$i = \frac{\Delta H}{\Delta L} = \frac{2'}{90} = 0.022 \quad \text{ft/ft (DIRECTION VARIABLE FROM W TO E)}$$

NOTE
INFORMATION ON E2FO3 IS ON FIGURE 5-7 THE COWARDIN WETLAND CLASSIFICATION SYSTEM

LEGEND

- SITE BOUNDARY
- WETLAND DELINEATION
- EXISTING SURFACE SOIL LOCATION (NOVEMBER 2006)
- SUBSURFACE SOIL BORING/TEMPORARY MONITORING WELL LOCATION (NOVEMBER 2006)
- SUBSURFACE SOIL BORING LOCATION (NOVEMBER 2006)
- SUBSURFACE SOIL BORING/MONITORING WELL LOCATION (MARCH 2008)
- SURFACE SOIL LOCATION (MARCH 2008)
- (103.00) – GROUNDWATER ELEVATION, ft. msl
- GROUNDWATER FLOW
- 103 – GROUNDWATER ELEVATION CONTOUR, FEET MSL (ELEVATIONS ARE MEAN SEA LEVEL PLUS 100 FEET)

FIGURE B7
GROUNDWATER CONTOUR MAP
(JUNE 12, 2008)
SWMU 28-BUNDY
WWTP SLUDGE DRYING BEDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO



GEOLOGIC CROSS-SECTION A-A'
LOOKING NORTHEAST

Baker

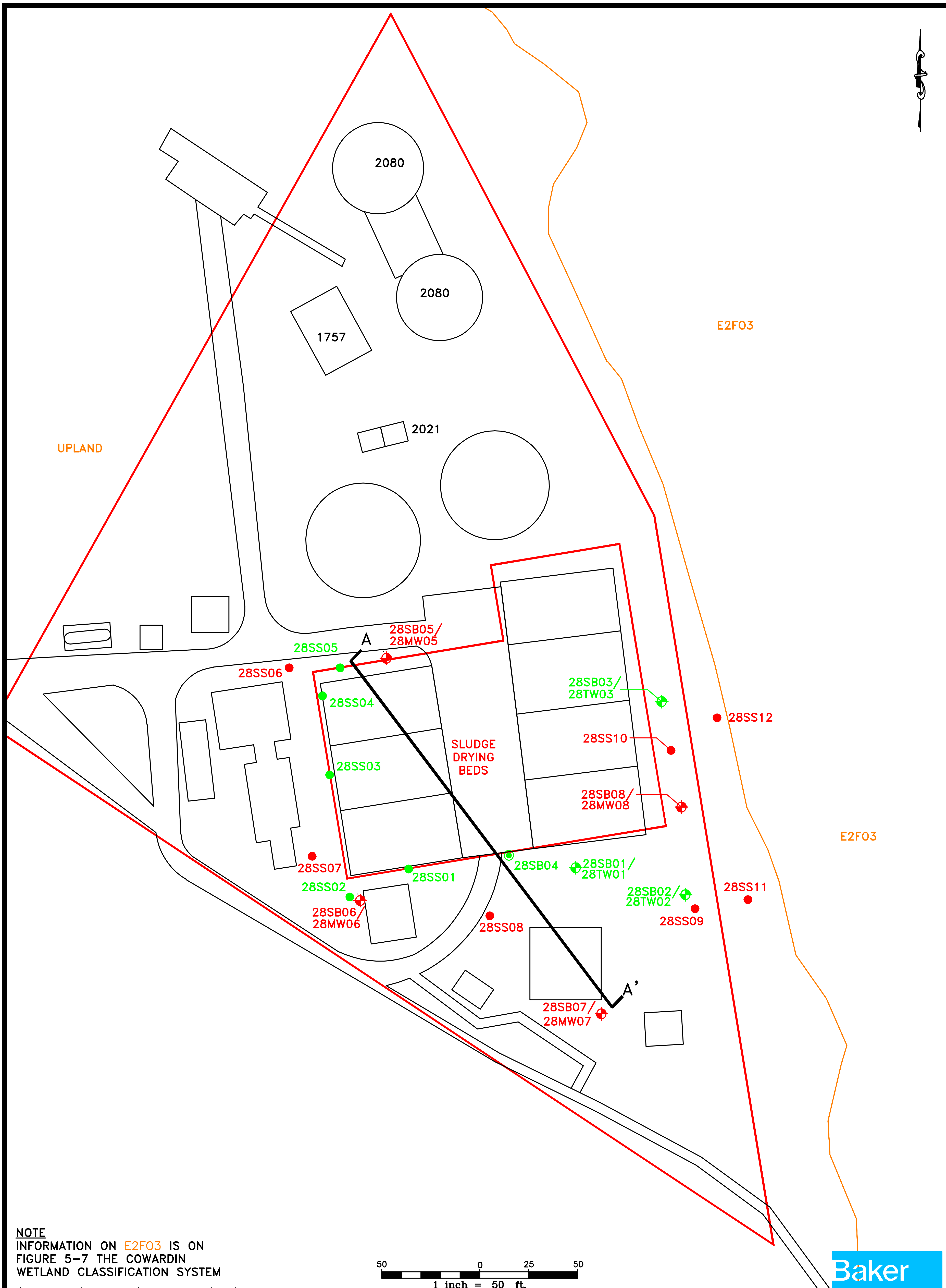
LEGEND

ft.	FEET
msl	MEAN SEA LEVEL
———	ESTIMATED
G.S.	GROUND SURFACE, ft. msl
▼	GROUNDWATER SURFACE (FEBRUARY 15, 2008)
▼	GROUNDWATER SURFACE (JUNE 12, 2008)
▽	GROUNDWATER ENCOUNTERED DURING DRILLING
I	WELL RISER
▯	WELL SCREEN INTERVAL
— —	PROJECTED

ALL ELEVATIONS SHOWN ARE MEAN SEA LEVEL PLUS 100 FEET

THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

FIGURE B8
GEOLOGIC CROSS-SECTION A-A'
SWMU 28-BUNDY
WWTP SLUDGE DRYING BEDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO

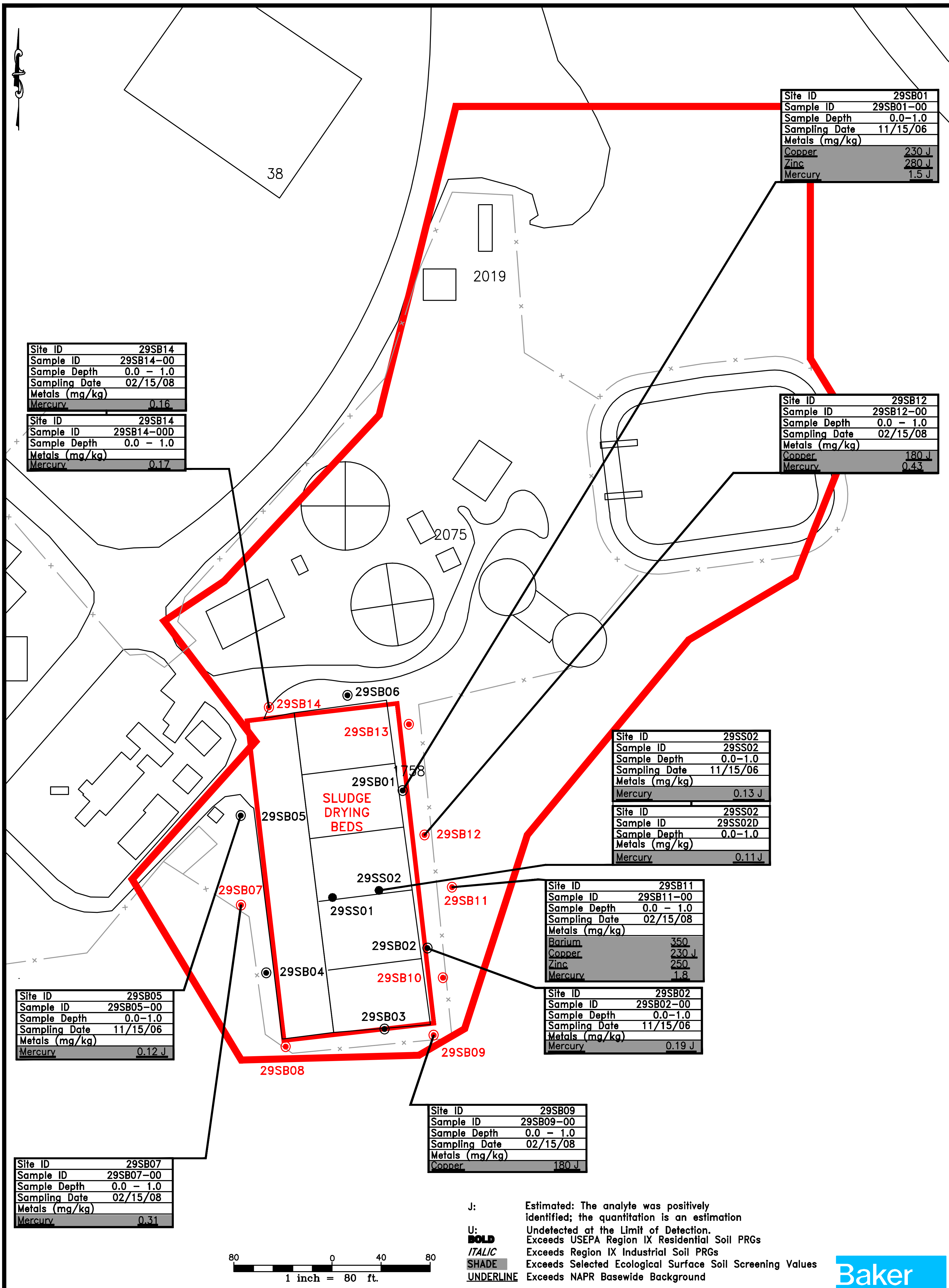


LEGEND

- SITE BOUNDARY
- FENCE
- EXISTING SURFACE SOIL LOCATION (NOVEMBER 2006)
- SUBSURFACE SOIL BORING/TEMPORARY MONITORING WELL LOCATION (NOVEMBER 2006)
- SUBSURFACE SOIL BORING LOCATION (NOVEMBER 2006)
- SUBSURFACE SOIL BORING/MONITORING WELL LOCATION (MARCH 2008)
- SURFACE SOIL LOCATION (MARCH 2008)
- WETLAND DELINEATION
- A A' CROSS SECTION

FIGURE B9
SITE PLAN AND CROSS SECTION LOCATION MAP
SWMU 28-BUNDY WWTP SLUDGE DRYING BEDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO

APPENDIX C
SELECT FIGURES FROM THE FINAL FULL RFI REPORT SWMU 29

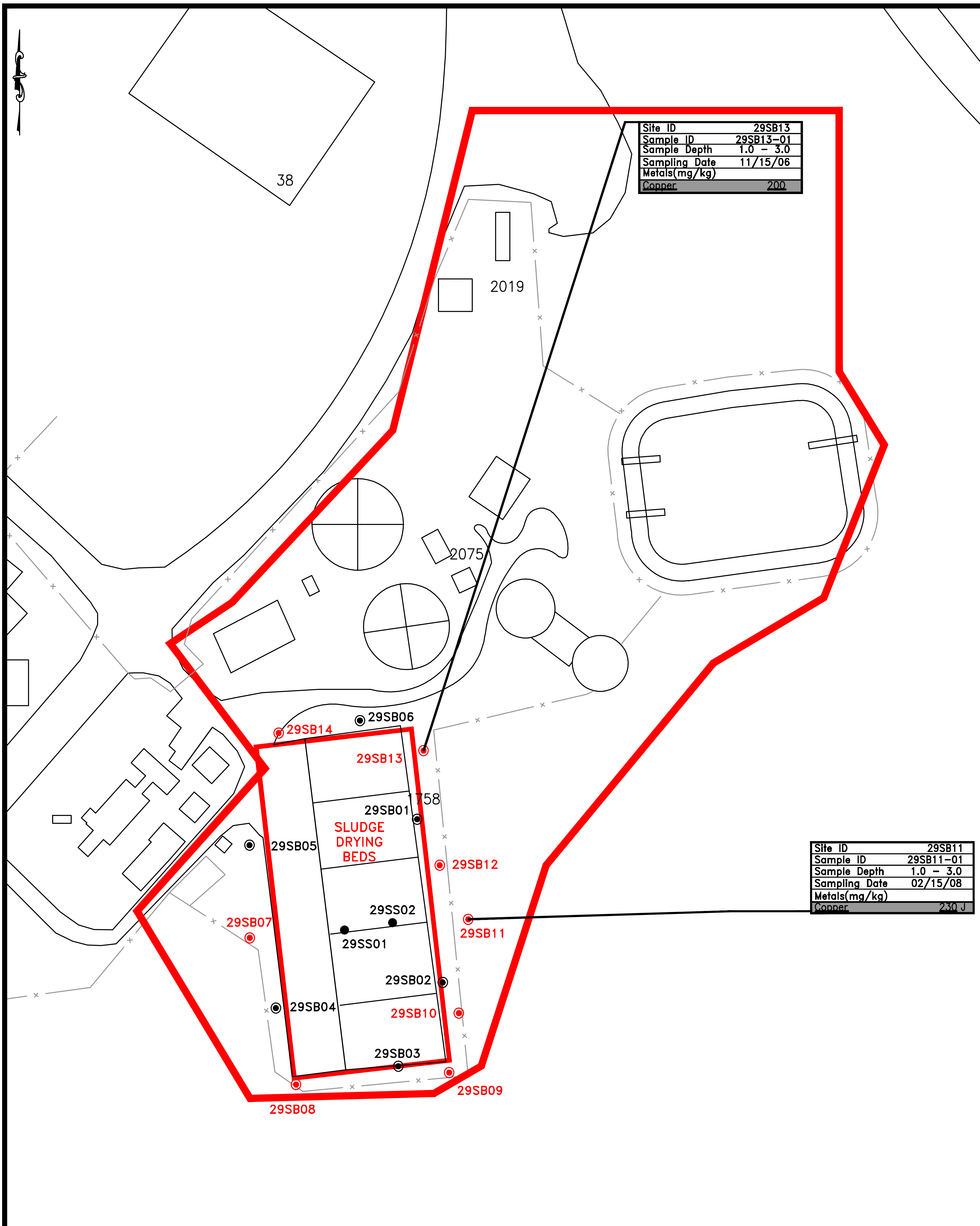


LEGEND

- SWMU BOUNDARY
- EXISTING SURFACE, SUBSURFACE AND GROUNDWATER SOIL SAMPLE LOCATION (NOVEMBER 2006)
- EXISTING SURFACE SOIL SAMPLE LOCATION (NOVEMBER 2006)
- SURFACE AND SUBSURFACE SOIL SAMPLING LOCATIONS (MARCH 2008)

FIGURE C1
EXCEEDANCES OF ECOLOGICAL SCREENING CRITERIA AND BACKGROUND FOR SURFACE SOIL

SWMU 29-INDUSTRIAL AREA WWTP SLUDGE DRYING BEDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO



J: Estimated: The analyte was positively identified; the quantitation is an estimation

U: Undetected at the Limit of Detection.

BOLD Exceeds USEPA Region IX Residential Soil PRGs

ITALIC Exceeds Region IX Industrial Soil PRGs

SHADE Exceeds Selected Ecological Surface Soil Screening Values

UNDERLINE Exceeds NAPR Basewide Background

80 0 40 80

1 inch = 80 ft.

Baker

K:_SOUTHNAVFAC\119197 JM01\SWMUs 27 28 29\CADD\111626_29FUL-07.DWG(SUBSURFACE SOIL)

LEGEND

- SWMU BOUNDARY
- EXISTING SURFACE, SUBSURFACE AND GROUNDWATER SOIL SAMPLE LOCATION (NOVEMBER 2006)
- EXISTING SURFACE SOIL SAMPLE LOCATION (NOVEMBER 2006)
- SURFACE AND SUBSURFACE SOIL SAMPLING LOCATIONS (MARCH 2008)

FIGURE C2
EXCEEDANCES OF ECOLOGICAL SCREENING CRITERIA AND BACKGROUND FOR SUBSURFACE SOIL

SWMU 29-INDUSTRIAL AREA WWTP SLUDGE DRYING BEDS
CMS WORK PLAN
NAVAL ACTIVITY PUERTO RICO

APPENDIX D
USEPA REGION II – GROUNDWATER 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 four 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 Adaily@ 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 (Adaily decon@) and after each well is sampled (Abetween-well decon@). Dedicated, in-place pumps and tubing must be thoroughly decontaminated using Adaily 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 (Adaily 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 (Abetween-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. **<u>Between-Well Decon</u>**

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 PARTITIONING 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 will be used in the screening level ecological risk assessment (SERA) for SWMU 27 and if sediment is present for SWMU 28 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 documented in the literature (USEPA, 1996 and Jones et al., 1997).

Sediment screening values derived using EqP (see Table 5-6) are based on a default f_{oc} of 0.01. As discussed in Section 5.4.1.3, sediment samples collected within the E2SS3 wetland unit adjacent to SWMU 27 will be analyzed for total organic carbon (TOC). For the SERA, the minimum f_{oc} measured in SWMU 27 sediment will be used to adjust the EqP-based sediment screening values presented in Table 5-6. K_{oc} values used in the derivation of EqP-based sediment screening values are those listed in Table 5-3. The K_{oc} values listed in Table 5-3 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. The surface water screening values used to derive EqP-based sediment screening values for organic chemicals lacking bulk sediment screening values are those listed in Table 5-5. It is noted that EqP-based sediment screening values could not be calculated for those organic chemicals lacking a surface water screening value.

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.

APPENDIX F
IDENTIFICATION OF BIOACCUMULATIVE CHEMICALS

APPENDIX F

IDENTIFICATION OF BIOACCUMULATIVE CHEMICALS

Only those organic chemicals with a log octanol-water partition coefficient (K_{ow}) value greater than or equal to 3.0 will be considered a bioaccumulative chemical. Justification for defining bioaccumulative organic chemicals as those with log K_{ow} values greater than or equal to 3.0 is provided below.

- The potential for organic chemicals to accumulate in organisms has been shown to correlate well with the K_{ow}. USEPA (1985), as sited in USEPA/ACOE (1998), recommends that only chemicals for which the log K_{ow} is greater than 3.5 be considered for evaluation of bioaccumulation potential since chemicals with log K_{ow} values less than 3.5 are not likely to bioaccumulate to a significant degree.

- Although organic chemicals with log K_{ow} values in the 2 to 7 range have at least some potential to bioconcentrate (Connell, 1990), significant bioconcentration does not generally occur for chemicals with log K_{ow} values less than 3.0 (Maki and Duthie, 1978) to 5.0 (Gobas and Mackay, 1990). Most work with bioconcentration (uptake from the surrounding medium, such as water) and bioaccumulation (uptake from all exposure routes, including via food) of organic chemicals has concerned chemicals with log K_{ow} values of 3.0 or more (USEPA, 1995a), since organic chemicals with lower log K_{ow} values generally have little potential for significant bioaccumulation.

- The USEPA has developed a number of scoring algorithms to evaluate the relative hazard of chemicals to human or ecological receptors. All of these algorithms have a component that addresses bioaccumulation potential. The evaluation of bioaccumulation potential is generally based on measured or estimated (using log K_{ow} values) BCFs or BAFs, or less commonly using log K_{ow} itself. For example, USEPA (1980) developed a bioaccumulation potential scoring system that considered organics with BCF values of less than 100 (equivalent to a log K_{ow} of approximately 3.0) to have negligible potential to bioaccumulate in aquatic food webs, while organic chemicals with BCFs in the 100 to 1,000 range (equivalent to log K_{ow} values of about 3.0 to 4.3) are considered to have low bioaccumulation potential. The more recent Scoring and Ranking Assessment Model (SCRAM), developed by EPA Region 5 for the Great Lakes, has similar bioaccumulation scoring cut-offs (USEPA, 2000).

- The proposed categorization of persistent, bioaccumulative, and toxic (PBT) chemicals under the Toxic Substances Control Act (TSCA) defines chemicals with a tendency to accumulate in organisms as those with a BCF or BAF of greater than 1,000 (Federal Register 63(192):53417; 10/5/98). Using the equation listed below (USEPA, 1995b), a BCF/BAF of 1,000 equates to a log K_{ow} value of approximately 4.3.

$$Log\ BCF = [(0.79)(log\ K_{ow}) - 0.40] \qquad \text{(Equation F-1)}$$

- The Beta Test Version 1.0 of the EPA Waste Minimization Prioritization Tool (WMPT), used to develop a list of PBTs for the Resource Conservation and Recovery Act (RCRA) program, defined organic chemicals with a low potential to bioaccumulate as those with log K_{ow} values of less than 3.5 and those with a high potential to bioaccumulate as those with log K_{ow} values greater than 5.0 (USEPA, 1998). The 1998 version of the EPA WMPT defines bioaccumulation potential based on BCF or BAF values (rather than on log K_{ow} values directly), with a scoring "fenceline" for organic chemicals with a low bioaccumulation potential defined as a BCF or BAF of less than 250. Although the tool no longer uses log K_{ow} directly, log K_{ow} values can be used to estimate a BCF or BAF value. Using Equation G-1, a BCF/BAF of 250 equates to a log K_{ow} value of approximately 3.5.

- Garten and Trabalka (1983) have reviewed terrestrial food web data and concluded that only organic chemicals with log K_{ow} values greater than 3.5 have the potential to significantly bioaccumulate from food to birds to mammals.

The information listed above indicates that a log K_{ow} of 3.0 to 3.5 is a reasonable, non-arbitrary parameter value to use in defining an organic chemical with the potential to bioaccumulate. For conservatism, the low end (3.0) of this log K_{ow} range will be used to define a bioaccumulative organic chemical. Table 5-3 lists log K_{ow} values (range and recommended value) for volatile and semi-volatile organic chemicals. Log K_{ow} values were primarily obtained from the USEPA (1995c and 1996). The recommended value from these sources generally represents a "high-end" or best estimate from empirical data. The organic chemicals that will be evaluated in the dietary intake models are those with a log K_{ow} value of greater than or equal to 3.0. For conservatism, the maximum value in the log K_{ow} range is used for this determination, not the recommended value.

Inorganic chemicals were not quantitatively screened for bioaccumulation potential since log K_{ow} values are not available for these chemicals. Although all Appendix IX metals are retained for evaluation in the upper trophic level food chain models, only mercury and selenium are known to biomagnify in food chains (in organic forms [Suter, 1993]) and only cadmium, copper, and zinc generally have the potential to bioaccumulate significantly. The other metals are retained by default.

Appendix G References

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