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Final

Corrective Measures Study Work Plan
SWMU 9

Naval Station Roosevelt Roads

RCRA/HSWA Permit No. PR2170027203

Ceiba, Puerto Rico

Prepared For

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TABLE OF CONTENTS

Page

LIST OF ACRONYMS AND ABBREVIATIONS iv

1.0 INTRODUCTION 1-1
1.1 Basis for the Work Plan 1-1
1.2 Site Status Summary 1-2
1.2.1 Findings of the Investigations 1-2
1.3 Organization of the CMS Work Plan 1-4

2.0 CMS OBJECTIVES AND CORRECTIVE MEASURE STANDARDS 2-1
2.1 Objectives 2-1
2.2 Corrective Measures Standards 2-1

3.0 CMS INVESTIGATION 3-1
3.1 Surface Water and Sediment Sample Locations 3-2
3.2 Surface Soil Sample Locations 3-2
3.3 Laboratory Analyses 3-3
3.4 Data Validation 3-3
3.5 Field QA/QC 3-4

4.0 CMS INVESTIGATION REPORT 4-1
4.1 Introduction 4-1
4.2 Investigation Methodologies 4-1
4.3 Background Data Set Evaluation 4-1
4.4 Nature and Extent of Contamination 4-2
4.5 Screening Level Ecological Risk Assessment 4-2
4.6 Conclusions and Recommendations 4-2

5.0 SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT (STEP 1 AND STEP 2) AND REFINEMENT OF EXPOSURE ASSUMPTIONS (STEP 3A) 5-1
5.1 Ecological Risk Assessment Methodology 5-3
5.1.1 Identification of Chemicals Selected for Evaluation 5-4
5.1.2 Estimation of Prey Exposure Point Concentrations for Avian Piscivores 5-5
5.1.3 Surface Water Threshold Screening Values for Metals 5-9
5.1.4 Bioavailability of Chemicals in Sediment 5-10
5.2 Decision Points 5-14
5.3 Baseline Risk Assessment Problem Formulation 5-15

6.0 POTENTIAL CORRECTIVE MEASURES 6-1
6.1 Task I - Identification and Development of the Corrective Measure Alternative or Alternatives 6-1
6.1.1 Description of the Current Situation 6-1
6.1.2 Establishment of Corrective Action Objectives 6-1
6.1.3 Screening of Corrective Measure Technologies 6-2
6.1.4 Identification of the Corrective Measure Alternative or Alternatives 6-2
6.2 Task II - Evaluation of the Corrective Measure Alternative or Alternatives 6-2
6.2.1 Technical/Environmental/Human Health/Institutional 6-2
6.2.2 Cost Estimate 6-3

TABLE OF CONTENTS
(Continued)

Page

6.3 Task III - Justification and Recommendation of the Corrective Measure or Measures 6-4
6.3.1 Technical 6-4
6.3.2 Human Health 6-5
6.3.3 Environmental 6-5
6.4 Task IV – Reports 6-5
6.4.1 Progress 6-5
6.4.2 Corrective Measures Study (CMS) Final Report 6-5

7.0 SCHEDULE 7-1

8.0 REFERENCES 8-1

LIST OF TABLES

3-1 Summary of Sampling and Analytical Program - Tanks 212-217
3-2 Method Performance Limits

5-1 List of Birds Reported from Naval Station Roosevelt Roads - Tanks 212-217
5-2 Ecological COPCs Identified During the Revised Final RCRA RFI Screening-Level Ecological Risk Assessment - Tanks 212-217
5-3 Identification of Chemicals Selected for Ecological Risk Evaluation in the Corrective Measures Study Investigation - Tanks 212-217
5-4 LOG K_{ow} Values for Organic Chemicals Retained for Evaluation in the CMS Investigation

LIST OF FIGURES

1-1 SWMU/AOC Location Map

3-1 Surface Water and Sediment Sample Locations – SWMU 9 – Background
3-2 Surface Water and Sediment Sample Locations – SWMU 9 – Areas A and B
3-3 Surface Water and Sediment Sample Locations – SWMU 9 – Area C
3-4 Surface Soil Sampling Locations – SWMU 9 – Area B

5-1 Screening-Level ERA Preliminary Conceptual Model for SWMU 9 – Areas A, B, and C

7-1 Corrective Measures Study - Proposed Schedule

LIST OF ACRONYMS AND ABBREVIATIONS

AVS	Acid Volatile Sulfide
Baker	Baker Environmental, Inc.
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
CCC	Criteria Continuous Concentration
CFR	Code of Federal Regulations
CMC	Criteria Maximum Concentration
CMS	Corrective Measures Study
CNO	Chief of Naval Operators
COPCs	Chemicals of Potential Concern
CTO	Contract Task Order
DRO	Diesel Range Organics
ERA	Ecological Risk Assessment
FDEP	Florida Department of Environmental Protection
GPS	Global Positioning System
GRO	Gasoline Range Organics
HI	Hazard Index
HHRA	Human Health Risk Assessment
LANTDIV	United States Navy, Atlantic Division
MCLs	Maximum Contaminant Levels
mg/kg	milligrams per kilogram
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NAWQC	National Ambient Water Quality Criteria
NSRR	Naval Station Roosevelt Roads
PAHs	Polynuclear Aromatic Hydrocarbons
PEL	Probable Effects Level
PREQB	Puerto Rico Environmental Quality Board
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
SDWA	Safe Drinking Water Act
SEM	Simultaneously Extracted Metals
SS	Surface Soil
SSI	Supplemental Site Investigation
SWMU	Solid Waste Management Unit
SVOC	Semivolatile Organic Compounds

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

TEL	Threshold Effects Level
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons gasoline and diesel range organics
TSCA	Toxic Substance Control Act
UST	Underground Storage Tank
USEPA	United States Environmental Protection Agency
USGS	United State Geological Survey
VOCs	Volatile Organic Compounds

1.0 INTRODUCTION

This work plan presents the technical approach for conducting a Corrective Measures Study (CMS) for Solid Waste Management Unit (SWMU) 9, Tanks 212-217 located at Naval Station Roosevelt Roads (NSRR), Ceiba, Puerto Rico. This CMS work plan has been prepared under contract to the Atlantic Division, Naval Facilities Engineering Command (LANTDIV), Contract Number N62470-95-6007, Contract Task Order (CTO) 033.

1.1 Basis for the Work Plan

SWMU 9 is located at NSRR as shown on Figure 1-1, and is comprised of six fuel storage tanks, pipelines, and ancillary facilities. The SWMU was divided into three separate areas for investigation purposes. Area A, located along Forestall Drive consists of Tanks 212 and 213. Area B, also located along Forestall Drive consists of Tanks 214 and 215. Area C, located along Antietam Road consists of Tanks 216 and 217. Previous reports indicate that the tanks were constructed in 1948 for the storage of aviation gasoline, and that the tanks were cleaned every five years until 1978. This facility was included as a Solid Waste Management Unit in the RCRA Part B Permit, as a result of petroleum sludge generated and disposed of onsite in unlined earthen pits. According to base personnel, Tanks 212 and 213 are now used for the storage of diesel fuel and unleaded gasoline, respectively. Tanks 214 and 215 were later changed from aviation gasoline storage to marine diesel fuel and are currently out of service. Tank 216 was most recently used for storage of gasoline but is currently out of service. Previous investigations indicate that Tank 217 was used for the storage of marine diesel fuel and JP-5. The Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) conducted at the site indicated that various environmental media were impacted by past site operations. These impacts are discussed further in Section 1.2. This CMS work plan is designed to fill identified data gaps and to provide a guide for selecting corrective measures to mitigate human health and ecological risks associated with contamination related to site operations. The CMS work plan also will address background data, by describing how a statistical evaluation of the SWMU 9 site-specific background samples to the NSRR base-wide background samples and to United States Geological Service (USGS) data from the island of Puerto Rico will be conducted in the CMS.

1.2 Site Status Summary

Roosevelt Roads submitted a RCRA Part B Permit application for the storage of hazardous waste on the Base. Recognizing that corrective action would apply to unpermitted waste management units, the Navy performed a Supplemental Site Investigation (SSI) at a variety of units (including SWMU 9) to provide additional site characterization information to the United States Environmental Protection Agency (USEPA) to assist in their permitting decisions.

The RCRA corrective action portion of the facility's permit (RCRA/HSWA Permit No. PR2170027203) contained specific requirements for investigation and, potentially, remediation at the site. To accomplish the goals of the permit, a RFI work plan (Baker, 1995) was submitted to, and subsequently approved by, the USEPA. The work plan provided the framework for site characterization activities; its scope was guided by the results of the SSI.

The RFI at SWMU 9 was conducted as a series of three phases of investigation, Phase I was conducted on April 1996; Phase II in September/October 1997; and Phase III in June 1999. The first phase RFI field activities (April 1996) included a geophysical investigation, test pit excavations, surface and subsurface soil sampling, monitoring well installation, groundwater sampling, wellhead testing, and surveying. The second phase RFI field activities (September/October 1997) were conducted to address USEPA comments on the first phase RFI Report and consisted of test pit excavations at Areas A and B and the installation of additional monitoring wells, including soil and groundwater sampling. The third phase RFI field activities (June 1999) were conducted to address USEPA comments on the second phase RFI Report and included specific areas of additional soil and groundwater investigation, surface water, sediment, and site-specific background sampling, and the completion of an ecological study.

1.2.1 Findings of the Investigations

Each phase of RFI presented various analytical results from the different areas within SWMU 9. The data from each investigation were combined and evaluated under the Revised Draft RFI (Baker, 2000). The paragraphs that follow provide a summary of the investigation findings of each of the three areas.

1.2.1.1 Area A

There is evidence of the impact of past site operations on the environmental media sampled, particularly subsurface soil and groundwater. Benzene, toluene, ethylbenzene, and xylenes (BTEX), as well as total petroleum hydrocarbons (TPH) were the primary contaminants. Several inorganic compounds, such as lead and chromium also exceeded screening criteria in various media.

The Human Health Risk Assessment (HHRA) did not identify a cancer risk greater than the acceptable USEPA limits in Area A. Non-carcinogenic risk may exist for future, young-child military residents, mostly attributable to exposures to benzene and chromium in groundwater (HI=1.06). Additionally, future construction workers in Area A may potentially be at risk due to chromium in subsurface soil and groundwater and benzene in groundwater (HI=1.11). The Hazard Index (HI) is primarily the result of exposures to potential hexavalent chromium in subsurface soil and groundwater and benzene in groundwater. A HI value of 1.0 or higher indicates the potential for adverse health effects.

The screening-level ecological risk assessment (screening-level ERA) identified a potential for an unacceptable risk to aquatic life receptors and piscovore-bird receptors for certain metals in surface water and sediment. However, there is insufficient data to address bioavailability of these metals. Additionally, there is an unacceptable uncertainty due to the limited number of samples collected.

1.2.1.2 Area B

There is evidence of the impact of past site operations on the environmental media sampled, particularly subsurface soil and groundwater. BTEX and TPH were the primary contaminants. Several inorganic compounds, such as lead and chromium also exceeded screening criteria in various media. Lead concentrations in surface soil samples 9SS03 and 9SS04 exceeded the background screening criteria with concentrations of 30 mg/kg and 258 mg/kg, respectively. Lead concentrations did not exceed the residential or industrial RBCs.

The HHRA did not identify a cancer risk greater than the acceptable USEPA limits. There were no unacceptable non-carcinogenic risks associated with exposures to contaminants detected in Area B as estimated in the HHRA. However, results indicated that untreated groundwater is not suitable for human use because of odor, color, and staining problems.

The screening-level ERA identified a potential for an unacceptable risk to aquatic life receptors and piscovore-bird receptors for certain metals in surface water and sediment. However, there is insufficient data to address bioavailability of these metals. Additionally, there is an unacceptable uncertainty due to the limited number of samples collected.

1.2.1.3 Area C

There is limited evidence of the impact of past site operations on the environmental media sampled, particularly surface and subsurface soil. Semi-volatile organic compounds and several inorganic compounds such as lead were the primary contaminants.

The HHRA did not identify a cancer risk greater than the acceptable USEPA limits. The HHRA concludes that a minimal non-carcinogenic risk may potentially exist for future, young-child military resident due to chromium and vanadium in surface water and sediment (HI=1.29). Also the results indicated that untreated groundwater is not suitable for human use because of odor, color, and staining problems.

The screening-level ERA identified a potential for an unacceptable risk to aquatic life receptors and piscovore-bird receptors for certain metals in surface water and sediment. However, there is insufficient data to address bioavailability of these metals. Additionally, there is an unacceptable uncertainty due to the limited number of samples collected.

1.3 Organization of the CMS Work Plan

This CMS Work Plan is organized into eight 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, goals, and the corrective measure standards being utilized for this project. The CMS Investigation to be performed is discussed in Section 3.0, with CMS Investigation reporting discussed in Section 4.0. The Screening Level Ecological Risk Assessment (ERA) is discussed in Section 5.0. The tasks to be accomplished as part of the Corrective Measure Study

are described in Section 6.0. The project schedule is provided in Section 7.0. Section 8.0 provides the references cited in this report.

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.

2.1 Objectives

The objectives of this CMS work plan are as follows:

- To identify those tasks required for refining the screening-level ecological risk assessment (ERA) and Step 3a of the baseline ERA presented in the RFI Report for SWMU 9 (Baker, 2000).

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

This work plan documents the scope and objectives of the full CMS, and the activities required to implement the program. The Work Plan serves as a tool for assigning responsibilities and establishing the project schedule and costs.

2.2 Corrective Measures Standards

Corrective measure standards that may be applicable to SWMU 9 will be developed as part of the CMS "Task I" reporting effort, which will include the results of the ecological evaluation to be performed. Once the possible corrective measures are selected for applicability to this site, the appropriate standards will be developed.

The corrective measure standards to be considered will include the applicable Federal Maximum Contaminant Levels (MCLs) established under the Safe Drinking Water Act (SDWA) and Toxic Substance Control Act (TSCA) regulations and the Puerto Rico Environmental Quality Bond (PREQB) standards. The Code of Federal Regulations (CFR) (40 CFR 264.100) will also be reviewed for applicability to the site. In addition, ecological risks will be considered in the development of corrective measures standards by incorporating standards that are determined to be protective of ecological receptors by the risk assessment process described in Section 5.0.

3.0 CMS INVESTIGATION

This section of the work plan describes the technical elements of the investigation. The USEPA has approved a RFI Work Plan for the initial work at Roosevelt Roads under the Corrective Action Program (Baker, 1995). The RFI Work Plan addressed all the necessary technical elements including provisions of the following separate plans:

- Project Management Plan
- Data Collection Quality Assurance Plan
- Data Management Plan, and
- Health and Safety Plan

Together, these plans provided all the details regarding field investigation techniques, laboratory analyses, data validation and data evaluation needed to fulfill the requirements of the RFI program. Since the above-mentioned document is in place and approved, it will form the basis of this plan. All the investigation tasks described in subsequent sections of this plan will be performed in accordance with the techniques and methodologies provided in the original USEPA approved work plan. Therefore, only the work elements themselves are discussed in the sections that follow.

The objectives of this CMS Investigation are as follows:

- To provide more site-specific information related to the bioavailability of inorganic compounds detected in surface water and sediment samples to ecological receptors.

- To refine the screening-level ERA and Step 3a of the baseline ERA using additional medium-specific data and more realistic exposure assumptions.

- To reduce the uncertainty of the screening-level ERA and Step 3a of the baseline ERA associated with the limited number of samples that were previously collected.

3.1 Surface Water and Sediment Sample Locations

Five background surface water and sediment samples will be collected in an area between Areas B and C, as shown on Figure 3-1. The sample locations shown are approximate and may change based on observed site conditions (e.g., evidence of contamination and location access). Samples will be collected approximately 10 feet from the edge of the mangrove swamp. The locations were selected because they are sufficiently far from Areas B and C (the closest location being approximately 1,500 feet away), yet representative of site-specific background conditions. These locations have been chosen due to their locations being unimpacted by base operations. The area chosen is approximately 250 to 750 feet away from Forrestal Drive and Antietam Road. The area between the roadway and sampling locations is heavily vegetated with secondary growth vegetation which would prevent any overland flow to reach these locations. In addition, the raised roadway with drainage culverts discharging to the Ensenada Honda separates these locations from all the other SWMUs throughout NSRR. Also, based on the contamination extent delineation of the Revised Draft RFI Report (Baker 2000), these locations are unaffected by contamination related to site operations.

Five surface water and sediment samples (9SW13/9SD13 through 9SW17/9SD17) will be collected downgradient from Area A as shown on Figure 3-2. Six surface water and sediment samples (9SW18/9SD18 through 9SW23/9SD23) will be collected downgradient from Area B also shown on Figure 3-2. Five surface water/sediment samples (9SW24/9SD24 through 9SW28 /9SD28) will be collected downgradient from Area C as shown on Figure 3-3. Based on groundwater flow directions determined in the Revised Draft RFI Report (Baker 2000), samples were placed in areas located downgradient of site operations. The sample locations shown are approximate and may change based on observed site conditions (e.g., evidence of contamination and location access). Samples will be collected 10 to 20 feet from shore (edge of the mangrove).

All surface water/sediment sampling locations will be flagged in the field and will be surveyed for horizontal location. Due to the remote location of these samples relative to site control, the survey will be accomplished using global positioning system (GPS) tools.

3.2 Surface Soil Sample Locations

An additional three surface soil samples will be collected from Area B in the vicinity of 9SS04 to address the high detection of lead in the sample. These samples will be analyzed for metals,

PAHs, and TPH (Diesel Range Organics (DRO) and Gasoline Range Organics (GRO)). It is believed that the high level of lead in this sample is from suspected lead based paint flaking from the adjacent valve pit box. This additional sampling will assist in determining whether or not the lead in surface soil sample 9SS04 (collected during the initial RCRA Facility Investigation April 1996) is related to site activities. The additional samples to be obtained during the CMS investigation are 9SS07, 9SS08 and 9SS09, as depicted on Figure 3-4.

All surface soil sampling locations will be flagged in the field and will be surveyed for horizontal and vertical location.

3.3 Laboratory Analyses

Surface water samples from background and Areas A, B, and C will be submitted to a mainland laboratory for analysis of total and dissolved Appendix IX metals, and BTEX, as presented in Table 3-1. The same firm will be retained for this investigation that performed the laboratory analysis for the previous RFI investigation. This will ensure a consistency of techniques for analysis of the samples. Sediment samples from the same locations will also be submitted to a mainland laboratory. Analysis will include Appendix IX metals, low-level polynuclear aromatic hydrocarbons (PAHs), total organic carbon (TOC), and acid volatile sulfide/simultaneously extracted metals (AVS/SEM), as presented in Table 3-1. Specific analytical methods are presented on Table 3-2.

Surface soil samples from Area B will be submitted to a mainland laboratory for analysis of Appendix IX metals, PAHs, and TPH (DRO and GRO) as presented in Table 3-1. Specific analytical methods are presented in Table 3-2.

3.4 Data Validation

All mainland laboratory data generated by the investigation will be subjected to independent, third party, validation. The USEPA Region II Data Validation Standard Operating Procedures will be followed. The same firm will be retained for this investigation that performed data validation for the previous RFI reports. This will ensure a consistency of techniques and that an equivalent review of the data is performed.

3.5 Field QA/QC

The collection of Quality Assurance/Quality Control (QA/QC) samples will be obtained during these investigations. These will include the collection of equipment rinsates, field blanks, field duplicates, and matrix spike/matrix spike duplicate (MS/MSD).

Equipment rinsate blanks will be collected daily during the sampling event. Initially, samples from every other day should be analyzed. If analytes pertinent to the project are detected in any rinsate blank, the remaining rinsate blanks will be analyzed. The results from the blanks will be used to evaluate the decontamination methods. This comparison is made during data validation and the rinsates are analyzed for the same parameters as the related samples. One equipment rinsate will be collected per day of field sampling.

Field blanks will consist of the source water used in equipment decontamination procedures and in equipment rinsate samples. One field blank per source per event will be collected.

Field duplicates for surface water, sediment and surface soil sample duplicates will be collected at a frequency of ten percent. Sediment and surface soil sample duplicates will be homogenized and split. Surface water sample duplicates will be collected simultaneously.

Analysis of duplicates and blanks associated with surface water sampling will include total Appendix IX Metals and BTEX. Analysis of duplicates and blanks associated with sediment sampling will include total Appendix IX Metals and PAHs. Analysis of duplicate and blanks associated with surface soil sampling will include Appendix IX Metals, PAHs, and TPH (DRO and GRO).

MS/MSD samples are collected to evaluate the matrix effect of the sample upon the analytical methodology. An MS and MSD must be performed for each group of samples of a similar matrix (e.g., surface water). MS/MSD samples will be collected at a frequency of five percent per media.

4.0 CMS INVESTIGATION REPORT

A report will be prepared on the methodologies and findings of the surface water, sediment, and surface soil sampling at SWMU 9. The report will also include a refined screening level ecological risk assessment. A draft report will be submitted to the USEPA 111 days upon completion of the field investigation. The main elements of the document will consist of the following:

- Introduction
- Investigation Methodologies
- Background Data Set Evaluation
- Nature and Extent of Contamination
- Screening Level ERA and Step 3a of the Baseline ERA
- Conclusions and Recommendations

4.1 Introduction

The introduction will consist of a discussion of the historical background of the investigations conducted at SWMU 9 and incorporate this CMS Investigation in that context. The introduction will also provide a regulatory framework for Roosevelt Roads and SWMU 9, as well as a discussion of current conditions.

4.2 Investigation Methodologies

The investigation methodologies section will detail the investigation. The section will discuss sample locations, sample collection and handling procedures, QA/QC procedures, and analytical methods used. This section will also discuss problems encountered and problem resolution.

4.3 Background Data Set Evaluation

The background data set evaluation will include an evaluation of base-wide background, site specific, and island wide soil samples. This evaluation of background will include a statistical evaluation of the SWMU 9 site-specific background samples to the NSRR base-wide background samples and to USGS data from across the island of Puerto Rico. This statistical evaluation will

include comparison of such things as minimum, maximum, average, mean, standard variation and variance. The USGS data will compare data on the concentrations of metals in the area surrounding the base.

If the comparison of the SWMU 9 background data indicates that they are statistically representative of background (i.e., concentrations are statistically representative of each other) then they will be considered representative of background. If the site specific SWMU 9 background samples are determined to be representative of background then an evaluation will be conducted to determine if the site specific surface soil samples have been impacted by site operations at SWMU 9. If this evaluation determines that the site samples are similar to the background samples then it will not be necessary to obtain additional surface soil samples other than the samples indicated in the vicinity of 9SS04 (Figure 3-4).

4.4 Nature and Extent of Contamination

The Nature and Extent of Contamination section will present analytical results and interpretation of the data. Data will be presented on tables and figures with textual explanation. Results of QA/QC procedures will also be presented.

4.5 Screening Level Ecological Risk Assessment and Step 3a of the Baseline Ecological Risk Assessment

The analytical data from the surface water and sediment sampling program will be incorporated into the screening-level ERA and Step 3a of the baseline ERA, as detailed in Section 5.0 of this document. The purpose of screening-level ERA and Step 3a of the baseline ERA is to refine the risk assessment presented in the Revised Draft RFI Report for SWMU 9 (Baker, 2000).

4.6 Conclusions and Recommendations

Information from the nature and extent of contamination and the refined ecological risk assessment screening will be synthesized into conclusions regarding site conditions. Recommendation will be made from these conclusions which will then be incorporated into the SWMU 9 CMS as appropriate.

5.0 SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT (STEP 1 AND STEP 2) AND STEP 3A OF THE BASELINE RISK ASSESSMENT

A screening-level ERA was conducted at SWMU 9 using the process outlined in the USEPA document entitled Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final (USEPA 1997a) and the Chief of Naval Operations (CNO) document entitled Navy Policy for Conducting Ecological Risk Assessments (CNO 1999). The results of the screening-level ERA were presented in the document entitled Revised Draft RCRA Facility Investigation Report for SWMU 9, Naval Station Roosevelt Roads, Ceiba, Puerto Rico (Baker 2000), henceforth referred as the Revised Draft RFI Report. The screening-level ERA for SWMU 9 covered the first two steps of the USEPA and CNO guidance (screening-level problem formulation and ecological effects evaluation and screening-level exposure estimate and risk calculation). The Revised Draft RFI Report also included Step 3a of the CNO guidance. In the CNO guidance, Step 3a precedes the baseline ERA problem formulation (Step 3 of the USEPA guidance and Step 3b of the CNO guidance) and is conducted to determine if risks detected in Step 2 are a result of overly conservative exposure assumptions.

The specific ecological receptors evaluated by the screening-level ERA and Step 3a of the CNO guidance were sediment-associated biota (marine), aquatic life (marine), terrestrial plants, soil invertebrates (earthworms), and four bird species (belted kingfisher, great blue heron, American robin, and red-tailed hawk). The selection of ecological receptors took into consideration the following factors:

- The receptors are known to occur or are likely to occur at the site.
- The ecological receptors are representative of species known to occur at the site (see Table 5-1 for a list of birds known to occur at NSRR).
- Life history information is available from the literature.
- Ecological receptors are represented by a complete exposure pathway (see Figure 5-1 for the screening-level ERA conceptual site model).
- The ecological receptors are valued by society.

Additional rational for the selection of the ecological receptors evaluated by the screening-level ERA and Step 3a of the CNO guidance is presented in the Revised Draft RFI Report for SWMU 9.

Based on the results of the screening-level ERA and Step 3a of the CNO guidance, it was concluded that there is potential for ecological risks resulting from receptor exposures to chemicals detected in sediment, surface water, and surface soil. Specific chemicals retained as ecological chemicals of potential concern (COPCs) following completion of Step 2 of the screening-level ERA for the sediment, surface water, and surface soil exposure pathways are summarized in Table 5-2. Uncertainties associated with the analytical data utilized in the screening-level ERA were also deemed to be unacceptable. These uncertainties, which may have resulted in an overestimation and/or underestimation of risks to ecological receptors, included the following:

- Sediment sample quantitation limits for several chemicals (e.g., PAHs) exceeded conservative threshold screening values for sediment-associated biota.

- The number of sediment and surface water samples collected from the mangrove forest adjacent to SWMU 9 was low, ranging from one to three samples per area.

- The number of surface soil samples collected from SWMU 9 was low, ranging from three to four samples per area.

- The sediment samples were not analyzed for characteristics that can influence the bioavailability and toxicity of chemicals (e.g., TOC and AVS). As such, the screening-level ERA and Step 3a of the CNO guidance assumed that the bioavailability of chemicals to sediment-associated biota was 100 percent.

- The surface water samples were not analyzed for dissolved metals (bioavailable fraction). As such, the screening-level ERA and Step 3a of the CNO guidance assumed that the bioavailability of metals to saltwater aquatic life was 100 percent.

To address the uncertainties associated with the sediment and surface water analytical data, a sampling and analytical program will be conducted within the mangrove forest adjacent to SWMU 9 as part of the CMS investigation (see Section 3.0 of this Work Plan). Surface soil samples will also be collected within Area B, downgradient from sample location 9SS04 to further characterize surface soil quality. Lead was detected in this sample at a concentration of

258 milligrams per kilogram (mg/kg). Additional surface soil samples may also be collected from SWMU 9 if a comparison of site data to basewide and site background data indicate that activities at SWMU 9 have potentially impacted surface soil quality. The analytical data generated by the sampling event described in Section 3.0 of this Work Plan will be combined with the existing data into a unified database. The screening-level ERA and Step 3a of the CNO guidance will then be repeated as part of the CMS investigation using the unified database and the same conceptual site model presented in the revised draft RFI report (see Figure 5-1). Repeating the screening-level ERA and Step 3a of the CNO guidance with the unified database will reduce uncertainties and increase the amount of information available for a determination of whether the ecological risk assessment process should proceed to the baseline ecological risk assessment problem formulation (Step 3 of the USEPA guidance and Step 3b of the CNO guidance).

5.1 Ecological Risk Assessment Methodology

The methodology that will be used to repeat the screening-level ERA and Step 3a of the CNO guidance will be identical to the methodology presented in the Revised Draft RFI Report. Exceptions are identified below and described in the sections that follow.

- Specific chemicals evaluated in the Revised Draft RFI Report were limited to those chemicals detected in abiotic environmental media (surface water, sediment, and surface soil). The CMS risk assessment process will include an evaluation of potentially site-related chemicals that were not detected in environmental media.

- The methodology used in the Revised Draft RFI Report to estimate the concentration of chemicals in the prey of the belted kingfisher and great blue heron only took into consideration bioaccumulation of chemicals in surface water. The methodology will be revised in the CMS investigation to include bioaccumulation of chemicals in sediment.

- The dietary intake models used in the Revised Draft RFI Report assumed that the diet of the great blue heron and American robin was 100 percent fish and earthworms, respectively. The diet of the great blue heron will be revised to include aquatic invertebrates (i.e., benthic invertebrates), while the diet of the American robin will be revised to include terrestrial vegetation as discussed in the EPA comment letter dated December 5, 2000 to the Navy (USEPA 2000a). The diet of the belted kingfisher (100 percent fish) and the diet of the red-tailed hawk (100 percent small mammals) used to estimate dietary intakes within the Revised Draft RFI Report will not be changed.

- Threshold screening values for several metals (arsenic, cadmium, copper, chromium, lead, mercury, nickel, selenium, silver, zinc) used in the Revised Draft RFI Report were USEPA Saltwater National Ambient Water Quality Criteria (NAWQC) expressed as total recoverable concentrations. In place of total recoverable criteria, dissolved metals criteria will be used as threshold screening values for these ten metals in the CMS investigation.

- The CMS risk assessment process will take into consideration the bioavailability of organic and inorganic chemicals detected in sediment.

If methodology used in the CMS investigation differs from methodology used in the Revised Draft RFI Report not listed above, a detailed discussion (with supporting documentation) will be included in the CMS risk assessment report.

5.1.1 Identification of Chemicals Selected for Evaluation

For a given environmental medium (sediment, surface water, or surface soil), the screening-level ERA and Step 3a of the CNO guidance presented in the Revised Draft RFI Report only evaluated those chemicals detected in at least one sample. The medium-specific screening evaluation that will be conducted as part of the CMS investigation (i.e., Step 2 of the USEPA and CNO guidance and Step 3a of the CNO guidance) will also include an evaluation of non-detected chemicals that are potentially site-related. The data that will be evaluated in the CMS investigation are summarized below. Specific chemicals retained for screening against medium-specific threshold screening values are identified in Table 5-3:

- Detected and non-detected data for Appendix IX metals.

- Detected and non-detected data for Appendix IX PAHs.

- Detected and non-detected data for benzene, toluene, ethylbenzene, and xylenes (BTEX).

- Non-detected data for Appendix IX Volatile Organic Compounds (VOCs) and Semivolatile Organic Compounds (SVOCs) not listed above that are components of crude oil or refined petroleum products, used in the refinement of crude oil, or used as refined petroleum product additives.

- Data for Appendix IX VOCs and SVOCs not listed above but detected in environmental media (sediment, surface water, and surface soil) collected during Phase I, II, or III of the RFI investigation.

- Data for Appendix IX VOCs and SVOCs not listed above but detected in environmental media (sediment, surface water and surface soil) collected during the CMS investigation.

- Non-detected data for Appendix IX VOCs and SVOCs not listed above for which use information could not be identified from the literature.

Chemicals described by the fourth bullet item above were identified by reviewing information available from the literature, including Spectrum Laboratory Inc. chemical fact sheets (Spectrum Laboratories, Inc, 2000). It is noted that many of the Appendix IX metals are not associated with crude oil or refined petroleum products. Furthermore, many Appendix IX PAHs are generated from the combustion of refined petroleum products, not their storage. All Appendix IX metals and PAHs have been retained for evaluation in the CMS investigation as a measure of conservatism.

The dietary intake evaluation for upper trophic level receptors will be limited to the detected and non-detected metals and the detected and non-detected bioaccumulative organic chemicals listed above. The process used to identify bioaccumulative organic chemicals is discussed within Section 5.1.2.

When data for a non-detected chemical are evaluated in the CMS investigation during Step 2 of the USEPA and CNO guidance, one-half of the maximum detection limit for that chemical will be used as the exposure point concentration for direct comparison to threshold screening values. One-half the maximum detection limit will also be used as the exposure point concentration for upper trophic level receptor dietary exposures from ingestion of surface water, sediment, and surface soil. Finally, one-half of the maximum detection limit will be used to estimate the concentration of a non-detected chemical in the prey of upper trophic level receptors. For Step 3a, exposure point concentrations for a given non-detected chemical will be based on an arithmatic mean of the one-half detection limit values.

5.1.2 Estimation of Exposure Point Concentrations in Upper Trophic Level Receptor Prey Items

The sections that follow describe the methodology that will be used to estimate the concentration of chemicals in prey items consumed by upper trophic level avian receptors (i.e., belted kingfisher, great blue heron, American robin, and red-tailed hawk).

5.1.2.1 Belted Kingfisher and Great Blue Heron

The methodology used in the Revised Draft RFI Report to estimate the concentration of chemicals in the prey of the belted kingfisher and great blue heron (i.e., fish) only took into consideration surface water bioaccumulation:

$$C_f = (C_{sw})(BCF_{sw\text{-}f})(FCM) \qquad \text{(Equation 5-1)}$$

Where C_f is the chemical concentration in fish (mg/kg), C_{sw} is the chemical concentration in surface water (mg/L), $BCF_{sw\text{-}f}$ is the surface water to fish bioconcentration factor (L/kg), and FCM is the food chain multiplier (unitless).

The methodology will be revised in the CMS investigation to take into consideration bioaccumulation from surface water and sediment:

$$C_f = [(C_{sw})(BCF_{sw\text{-}f})(FCM) + (C_{sed})(BAF_{sed\text{-}f})] \qquad \text{(Equation 5-2)}$$

Where C_{sed} is the chemical concentration in sediment (mg/kg), $BAF_{sed\text{-}f}$ is the sediment to fish bioaccumulation factor (unitless), and C_f, C_{sw}, $BCF_{sw\text{-}f}$, and FCM are as previously described.

The surface water concentration (C_{sw}) used for metals will be based on the dissolved fraction in the water column (i.e., dissolved metals concentrations). Dissolved metals data will be used in place of total recoverable data since the dissolved fraction more closely approximates the bioavailable fraction of metals in the water column (USEPA 1995a and 1999). Furthermore, based on the information summarized below, only those detected and non-detected organic chemicals retained for evaluation (see Table 5-3) with a log octanol-water partition coefficient (log K_{ow}) value greater than 3.0 will be evaluated in the upper trophic level dietary intake models.

- 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 (e.g., Maki and Duthie 1978) to 5.0 (e.g., 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 or more (USEPA 1995b), 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) to have low bioaccumulation potential. The more recent Scoring and Ranking Assessment Model (SCRAM), developed by USEPA Region 5 for the Great Lakes, has similar bioaccumulation scoring cut-offs (USEPA 1997b).

- The proposed categorization of persistent, bioaccumulative, and toxic (PBT) chemicals under 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 5-3 below (USEPA 1995a), a BCF/BAF of 1,000 equates to a log K_{ow} value of approximately 4.3.

$$\text{Log BCF} = [(0.79)(\log K_{ow}) - 0.40] \quad \text{(Equation 5-3)}$$

- The Beta Test Version 1.0 (1997b) of the USEPA Waste Minimization Prioritization Tool (WMPT), used to develop a list of PBTs for the 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 this tool now 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 5-3, 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. Log K_{ow} values for the Appendix IX VOCs and SVOCs retained for evaluation in the CMS investigation (see Table 5-3) are summarized in Table 5-4. As evidenced by the table, log K_{ow} values were primarily obtained from USEPA documents (1995c and USEPA 1996a). 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 that is 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.

For a given chemical (metals and bioaccumulative organic chemicals), Equation 5-2 will be modified to eliminate surface water bioaccumulation if that chemical is not detected in surface water. However, metals and bioaccumulative organic chemicals not detected in sediment will be evaluated in the belted kingfisher and great blue heron dietary exposure models. Under this scenario, fish tissue concentrations would be estimated by the following equation:

$$C_f = (C_{sed})(BAF_{sed\text{-}f}) \qquad \text{(Equation 5-4)}$$

Where C_f, C_{sed}, and BAF_{sed-f} are as previously described. If a situation is encountered where a chemical (metal or bioaccumulative organic) was detected in surface water but not in sediment, bioaccumulation from surface water and sediment will be considered in the estimation of fish tissue concentrations (See equation 5-1). For sediment, this will be accomplished by using one-half the maximum detection limit (Step 1 and Step 2) or the arithmatic mean of the one-half detection limit values (Step 3a).

For the great blue heron, the diet assumptions used in the Revised Draft RFI Report (100 percent fish) will be modified to include benthic invertebrates. The concentration of chemicals in the tissue of benthic invertebrates will be calculated from the following equation:

$$C_{bi} = (C_{sed})\ (BAF_{sed-bi}) \qquad \text{(Equation 5-5)}$$

where C_{bi} is the chemical concentration in benthic invertebrates (mg/kg), BAF_{sed-bi} is the sediment to benthic invertebrate bioaccumulation factor (unitless), and C_{sed} is as previously described.

5.1.2.2 <u>American Robin and Red-Tailed Hawk</u>

Identical to the avian piscivore dietary intake models, chemicals evaluated by the terrestrial dietary intake models for the American robin and red-tailed hawk will be limited to the detected and non-detected metals, detected organics, and the non-detected bioaccumulative organic chemicals (i.e., organic chemicals listed in Table 5-4 with log K_{ow} values greater than or equal to 3.0).

The methodology that will be used to estimate the concentration of chemicals in the prey of the red-tailed hawk (small mammals) will be identical to the methodology presented in the Revised Draft FRI Report. Specifically, the concentration of chemicals in the tissue of small mammals will be estimated by the following equation:

$$C_{sm} = (C_{ss})\ (BAF_{ss-sm}) \qquad \text{(Equation 5-6)}$$

where C_{sm} is the chemical concentration in small mammals (mg/kg), C_{ss} is the chemical concentration in surface soil (mg/kg), and BAF_{ss-sm} is the surface soil to small mammal bioaccumulation factor (unitless).

The diet assumption used in the Revised Draft RFI Report for the American robin (100 percent earthworms) will be revised to include terrestrial vegetation. The methodology that will be used to estimate the concentration of chemicals in the tissue of earthworms will be identical to the methodology presented in the Revised Draft RFI Report. Specifically, the chemical concentration in earthworms will be estimated from the following equation:

$$C_{worm} = (C_{ss})\ (BAF_{ss\text{-}worm}) \qquad \text{(Equation 5-7)}$$

where C_{worm} is the chemical concentration in earthworms (mg/kg), $BAF_{ss\text{-}worm}$ is the surface soil to earthworm bioaccumulation factor (unitless), and C_{ss} is as previously described. The concentration of chemicals in the tissue of terrestrial vegetation will be estimated from the following equation:

$$C_p = (C_{ss})\ (BCF_{ss\text{-}p}) \qquad \text{(Equation 5-8)}$$

where C_p is the chemical concentration in plants (mg/kg), $BCF_{ss\text{-}p}$ is the surface soil to plant bioconcentration factor (unitless), and C_{ss} is as previously described.

5.1.3 Dietary Intake Equation

The preceding sections presented the methodology that will be used to estimate the concentration of chemicals in the prey items of the belted kingfisher, great blue heron, American robin, and red-tailed hawk. Dietary intakes for each receptor species will be calculated using Equation 5-9 below (modified from USEPA [1993]).

$$DI_x = \left[\left[\sum_i (IR_f)\ (C_{xi})\ (PDF_i)\right] + \left[(IR_{sed/ss})\ (C_{sed/ss})\ (PDF_{sed/ss})\right] + \left[(IR_{sw})\ (C_{swx})\right]\right]$$

where D_{ix} is the dietary intake for chemical x (mg/kg body weight/day) IR_f is the food ingestion rate (kg/day, dry weight), C_{xi} is the concentration of chemical x in food item i (mg/kg, dry weight), PDF_i is the proportion of diet composed of food item i (dry weight basis), $IR_{sed/ss}$ is the sediment/surface soil ingestion rate (mg/kg, dry weight), $C_{sed/ss}$ is the concentration of chemical x in sediment/surface soil (mg/kg, dry weight), $PDF_{sed/ss}$ is the proportion of diet composed of sediment/surface soil (dry weight basis), IR_{sw} is the surface water ingestion rate (L/day), C_{sw} is the concentration of chemical x in surface water (mg/L), and BW is the receptor body weight (kg, wet weight).

For those receptors with a diet comprised of more than one prey item (i.e., great blue heron and American robin), the proportion of diet for a given prey item will be determined by reviewing information contained in the document entitled Wildlife Exposure Factors Handbook (USEPA 1993a).

It is noted that the conservative assumptions identified in the Revised Draft RFI report and applied to the dietary intake models with regard to mercury and selenium will also be applied to the CMS investigation. Specifically, modeled dietary intakes will be screened against No Observable Adverse Effect Levels (NOAELs) based on organic forms (i.e., methylated mercury and selenium). Furthermore, if dissolved mercury and selenium are detected in surface water, the surface water to fish bioaccumulation factors used in the estimation of fish tissue concentrations will be based on methylated forms.

The sediment to fish, sediment to benthic invertebrates, surface soil to earthworm, surface soil to plant, and surface soil to small mammal BCF/BAF values for mercury will be taken from Cope et. al. (1990), Bechtel Jacobs (1998a), Sample et al. (1998a), Betchel Jacobs (1998b), and Sample el al. (1998b), respectively. Surface soil to earthworm, surface soil to plant, and surface soil to small mammal BCF/BAF values for selenium will be taken from Sample et al. (1998a), Bechtel Jacobs (1998b), and Sample et. al. (1998b), respectively. There are no sediment to invertebrate or sediment to fish BAF values for selenium available from the literature. As such, an assumed BAF of 1.0 will be used to estimate the concentration of selenium in the tissue of invertebrates and fish.

It is not known if the BCF/BAF values from the sources listed above are based on organic forms of mercury and selenium. However, given that the BCF/BAF values were derived from field studies that measured chemical concentrations in co-located tissue and sediment/surface soil samples, they represent realistic bioaccumulation values for the various forms of mercury and selenium (inorganic and organic) that occur concurrently in the environment.

5.1.4 Surface Water Threshold Screening Values for Metals

The Revised Draft RFI Report used USEPA saltwater NAWQC as surface water threshold screening values for arsenic, cadmium, copper, chromium, lead, mercury, nickel, selenium, silver, zinc. Current USEPA policy is to express saltwater NAWQC for these metals as dissolved metals

concentrations (USEPA 1999). Because dissolved metals data were not available for use in the Revised Draft RFI Report, the dissolved criteria were converted to total recoverable criteria by dividing the dissolved criteria by default conversion factors (USEPA 1999). This allowed for a direct comparison of total recoverable metals data to threshold screening values expressed as total recoverable concentrations. However, given that the default conversion factors do not take into consideration site-specific factors that can affect the distribution of the metals among the total recoverable and dissolved fraction, their use may have resulted in the derivation of total recoverable criteria that overestimate or underestimate threshold concentrations.

Surface water samples collected as part of the CMS investigation will be analyzed for dissolved metals. As such, USEPA saltwater NAWQC expressed as dissolved concentrations will be used as surface water threshold screening values for arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc in the CMS investigation.

5.1.5 Bioavailability of Chemicals in Sediment

There are a number of physical, chemical, and biological factors that have the potential to influence the bioavailability and toxicity of sediment contaminants. Some of the more important factors are identified below (USEPA 2000b).

Physical Factors	Chemical Factors	Biological Factors
Rate of mixing Rate of sedimentation Diffusion Resuspension	Redox conditions pH Acid volatile sulfides Sediment organic carbon Dissolved organic carbon	Biotransformation Bioturbation Size and age of receptors Lipid content of receptors Diet/feeding habit of receptors

The screening values used in the Revised Draft RFI Report do not reflect site-specific factors that can influence bioavailability and toxicity. As such, they may not have represented threshold concentrations above which adverse effects would be expected to occur. The sections that follow present an evaluation that will be conducted as part of the CMS investigation (Step 3a of the CNO guidance) to determine what effect site-specific chemical factors have on the bioavailability and toxicity of organic and inorganic sediment contaminants. Specifically, an evaluation will be conducted to determine what effect particulate organic carbon has on the bioavailability and toxicity of organic chemicals and the effect that acid volatile sulfides (AVS) has on the

bioavailability and toxicity of several divalent metals (i.e., cadmium, copper, lead, nickel, and zinc).

It is noted that bulk sediment screening values will still be used in Step 2 and Step 3a of the ERA process conducted as part of the CMS investigation. Only those organic and inorganic chemicals evaluated in the CMS investigation with detected or one-half non-detected concentrations exceeding bulk sediment threshold screening values will be evaluated by the methodology presented in Sections 5.1.4.1 and 5.1.4.2, respectively. As stated, the evaluation of bioavailability will be conducted in Step 3a of the CNO guidance.

5.1.5.1 Bioavailability of Organic Chemicals in Sediment

The USEPA has chosen the equilibrium partitioning (EqP) approach for developing sediment quality criteria for nonionic organic chemicals (USEPA 1993b). This approach will be used to derive site-specific sediment screening values for nonionic organic chemicals detected in the mangrove forest sediment samples.

There are three underlying assumptions to the derivation of sediment quality criteria (in the case of the CMS investigation, sediment screening values) using the EqP method. First, it is assumed sediment toxicity correlates with the concentration of the chemical in the sediment pore water and not to the bulk sediment concentration (i.e., the pore water concentration represents the bioavailable fraction). Secondly, partitioning between sediment pore water and bulk sediment is assumed to be dependent on the particulate organic content of the sediment with little dependence upon other chemical or physical properties. Finally, the EqP approach assumes that an 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 1993b):

$$K_p = (C_{sed})/(C_{pw}) \qquad \text{(Equation 5-10)}$$

where C_{sed} is the concentration in bulk sediment and C_{pw} is the concentration in sediment pore water. The partition coefficient can be derived for a given nonionic organic chemical by

multiplying the fraction of organic carbon (f_{oc}) present in the sediment by the chemical's organic carbon partition coefficient (K_{oc}) (USEPA 1993b):

$$K_p = (f_{oc})(k_{oc}) \qquad \text{(Equation 5-11)}$$

Combining Equations 5-10 and 5-11 yields the following:

$$C_{sed} = (k_{oc})(f_{oc})(C_{pw}) \qquad \text{(Equation 5-12)}$$

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

$$TSV_{sed} = (K_{oc})(f_{oc})(TSV_{sw}) \qquad \text{(Equation 5-13)}$$

In this equation, TSV_{sed} 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. Bulk sediment concentrations less than TSV_{sed} would be protective of sediment-associated biota. The use of surface water screening values in Equation 5-13 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 f_{oc} is greater than 0.2 percent. At f_{oc} values less than 0.2 percent, other factors (e.g., particle size, sorption to nonorganic mineral fractions) become relatively more important (USEPA 1993b).

Although the EqP approach was developed by the USEPA for nonionic organic chemicals, this method will also be used to derive sediment screening values for ionic organic chemicals detected in the mangrove forest sediment samples. 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 and Suter II 1997). Regardless, application of the EqP approach to the development of sediment screening values for ionic chemicals is documented in the literature (USEPA 1996b and Jones and Suter II 1997).

The chemical-specific K_{oc} values that will be used in the derivation of EqP-based sediment threshold screening values will be calculated from the following equation (USEPA 1993b and 1996b):

$$\text{Log}K_{oc} = 0.00028 + (0.983)(\log K_{ow}) \qquad \text{(Equation 5-14)}$$

Where K_{ow} is the octanol-water partition coefficient. Surface water threshold screening values will be identical to those used in the surface water screening evaluation. It is noted that derivation of EqP-based sediment threshold screening values will require the availability of surface water screening values. For those organic chemicals lacking a surface water screening value, an evaluation of bioavailability using the EqP approach can not be conducted.

5.1.5.2 Bioavailability of Metals in Sediment

Total sediment concentrations are usually not predictive of the bioavailability and toxicity of metals (Luoma 1983). However, similar to nonionic chemicals, metal concentrations in sediment pore water have been correlated with toxicity (Adams et al. 1985, Swartz et al. 1985, and Kemp and Swartz 1988). An important partitioning phase controlling the bioavailability and toxicity of cadmium, copper, lead, nickel, and zinc is AVS. AVS represents a reactive pool of solid-phase sulfide that is available to bind these metals, rendering them biologically unavailable and nontoxic to sediment-associated biota. Cadmium, copper, lead, nickel, and zinc, collectively termed simultaneously extracted metals (SEM), represent those metals that form a more stable complex with sulfide than does iron. Theoretically, mercury is also an SEM. However, the bioavailability of mercury appears to be controlled more by methylation than be AVS (USEPA 2000b).

SEM and AVS measurements can be made on sediments to assess the potential bioavailability of the SEM. The SEM/AVS model states that if the AVS concentration is less than the concentration of SEM, toxicity will be observed. That is, if the ratio SEM/AVS is greater than 1.0, sufficient AVS is not available to bind all the SEM and sediment-associated biota may be exposed to toxic concentrations of these metals in the sediment pore water. Conversely, if the ratio SEM/AVS is less than 1.0, sufficient AVS is present to bind all SEM. The SEM theory has successfully predicted the toxicity of sediments containing cadmium and nickel (Ankley et al. 1991, Carlson et al. 1991, and Di Toro et al. 1992) and zinc and lead (Cases and Crecelius 1994). Results with copper have been mixed (Ankley et al. 1993). It is noted that the SEM/AVS theory

can only be used to predict if sediments are or are not acutely toxic. The SEM/AVS theory has not been adapted to predict chronic toxicity.

5.2 Decision Points

Two decision points will be reached during the screening-level ERA and Sub-Step 3a of the CNO guidance. The first decision point will be reached following completion of Step 2, where four possible decision points may be reached. These decision points are as follows:

1. **No further action is warranted** – This decision is appropriate if the screening-level ERA indicates that sufficient data are available on which to base a conclusion of no unacceptable risk.

2. **Further evaluation is warranted**. This decision is appropriate if the screening-level ERA indicates that there is the potential for unacceptable risks for some pathways, receptors, and chemicals. In this instance, the ERA process will proceed to Step 3a wherein the risk estimates would be refined based on more realistic and site-specific assumptions and data (i.e., mean body weights, mean ingestion rates, etc.).

3. **Further data are required**. This decision is appropriate if the screening-level ERA 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 to refine these estimates are needed for Step 3.

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

Decision Point No. 3 is unlikely since additional sampling will be conducted to fill data gaps and reduce uncertainties identified during the original screening-level ERA conducted as part of the Revised Draft RFI Report. The likely decision point reached following completion of Step 2 in the CMS Investigation is Decision Point No. 2. This conclusion is based on the original screening-level ERA presented in the Revised Draft RFI Report. Given that Sub-Step 3a is likely, the preceding sections included a discussion of this sub-step.

If risk estimates based on more realistic and site-specific exposure assumptions indicate the potential for unacceptable risk in Step 3a, a recommendation will be made to move the ERA process to the baseline risk assessment problem formulation (Step 3 of the USEPA guidance and Step 3b of the CNO guidance). The decision to proceed to the baseline risk assessment problem formulation will also be based on the evaluation of bioavailability and a comparison of site data to background data.

5.3 Baseline Risk Assessment Problem Formulation

If the CMS investigation refinement of the screening-level ERA and Sub-Step 3a of the CNO guidance indicates that ecological receptors may be adversely affected by chemicals detected in site media, the risk assessment process will proceed to the baseline risk assessment problem formulation (Step 3 of the USEPA guidance and Step 3b of the CNO guidance). As part of the baseline risk assessment problem formulation, the preliminary conceptual model developed during the screening-level ERA, including receptors, exposure pathways, and measurement and assessment endpoints, will be refined. The product of this step will be a refined problem formulation that focuses the ERA on specific habitats/areas, receptors, pathways, and chemicals where there is a reasonable potential for ecological risk.

If the baseline risk assessment is warranted because there is evidence of potential risk or there is an unacceptable level of uncertainty, Step 4 of the EPA and CNO guidance will be implemented (study design and data quality objectives). Depending on site-specific circumstances and data requirements, the following studies may be proposed:

- Acute or chronic media-specific toxicity tests
- Biological field studies/surveys
- Tissue residual studies

If site-specific studies are necessary, they will be identified in a work plan and Sampling and Analysis Plan (SAP). Any field sampling activities and studies conducted within site habitats will be duplicated within the USEPA approved site-specific background stations discussed in this CMS Work Plan.

6.0 POTENTIAL CORRECTIVE MEASURES

Following completion of the ecological risk assessment process, the CMS will be implemented. This section of the CMS work plan describes the stepwise approach to be taken in performing the CMS. The CMS consists of four tasks, which are described in the sections that follow. The identification and development of the corrective measure alternative or alternatives described below in Section 6.1, will take into consideration the results of the ecological risk assessment process.

6.1 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 measure. The analysis will be based on the results of the all previous investigations at SWMU 9 as well as the CMS investigation described in Sections 3.0 and 4.0 of this document.

6.1.1 Description of the Current Situation

The current situation and the known nature and extent of contamination at SWMU 9 will be described in this section. A statement of the purpose for the response, based on the results of the RFI investigations will be provided, as will the actual or potential exposure pathways that will be addressed by the corrective measures.

6.1.2 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 corrective action objectives will be consistent with 40 CFR '264.100 as applicable.

6.1.3 Screening of Corrective Measure Technologies

The preliminary corrective measure technologies screened in the Pre-Investigative Measures Screening Report (Baker, 1994), and any additional technologies which are applicable at the facility, will be reviewed based on all the available data and information at SWMU 9. 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. The screening of the technologies will look in detail at the site and waste characteristics as well as the technology limitations.

6.1.4 Identification of the Corrective Measure Alternative or Alternatives

The corrective measure alternative or alternatives will be developed based on the corrective action objectives 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.

6.2 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.

6.2.1 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:

6.2.1.1 Technical

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

6.2.1.2 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.

6.2.1.3 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.

6.2.1.4 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.

6.2.2 Cost Estimate

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

6.3 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.

6.3.1 Technical

6.3.1.1 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.

6.3.1.2 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.

6.3.1.3 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.

6.3.1.4 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.

6.3.2 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.

6.3.3 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.

6.4 Task IV - Reports

6.4.1 Progress

The USEPA will be provided with signed progress reports as required by Condition B.8.(a) of Module III of the Permit.

6.4.2 Corrective Measures Study (CMS) Final Report

A CMS Final Report will be developed which includes all the information gathered under the approved CMS Work Plan. At a minimum the report will include a description of the facility, a summary of the corrective measure or measures, a summary of the previous investigations impact on the selected corrective measure or measures, design and implementation precautions, cost estimates and schedules.

7.0 SCHEDULE

The schedule for implementation of this work plan commenced upon receipt of an USEPA notification letter dated May 4, 2000 and received May 15, 2000 (Figure 7-1). Initiation of the CMS and CMS Investigation will be based on USEPA approval of the Final CMS Work Plan. The schedule of events included in this Work Plan is presented in Figure 7-1. 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, funding is delayed by the Navy, consensus cannot be reached on how the USEPA's comments are incorporated.

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TABLES

TABLE 3-1

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM
SWMU 9 - TANKS 212-217
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Sample Media	Sample Designation	Sample Depth (ft bgs) (1)	Analytical Parameters
Surface Water	9SW08	Water Surface	App. IX Metals (total and diss.), BTEX
	9SW09	Water Surface	App. IX Metals (total and diss.), BTEX
	9SW10	Water Surface	App. IX Metals (total and diss.), BTEX
	9SW11	Water Surface	App. IX Metals (total and diss.), BTEX
	9SW12	Water Surface	App. IX Metals (total and diss.), BTEX
	9SW13	Water Surface	App. IX Metals (total and diss.), BTEX
	9SW14	Water Surface	App. IX Metals (total and diss.), BTEX
	9SW15	Water Surface	App. IX Metals (total and diss.), BTEX
	9SW16	Water Surface	App. IX Metals (total and diss.), BTEX
	9SW17	Water Surface	App. IX Metals (total and diss.), BTEX
	9SW18	Water Surface	App. IX Metals (total and diss.), BTEX
	9SW19	Water Surface	App. IX Metals (total and diss.), BTEX
	9SW20	Water Surface	App. IX Metals (total and diss.), BTEX
	9SW21	Water Surface	App. IX Metals (total and diss.), BTEX
	9SW22	Water Surface	App. IX Metals (total and diss.), BTEX
	9SW23	Water Surface	App. IX Metals (total and diss.), BTEX
	9SW24	Water Surface	App. IX Metals (total and diss.), BTEX
	9SW25	Water Surface	App. IX Metals (total and diss.), BTEX
	9SW26	Water Surface	App. IX Metals (total and diss.), BTEX
	9SW27	Water Surface	App. IX Metals (total and diss.), BTEX
	9SW28	Water Surface	App. IX Metals (total and diss.), BTEX
Sediment	9SD08	0.0 - 0.5 ft bgs	App. IX Metals, PAH, TOC, AVS/SEM
	9SD09	0.0 - 0.5 ft bgs	App. IX Metals, PAH, TOC, AVS/SEM
	9SD10	0.0 - 0.5 ft bgs	App. IX Metals, PAH, TOC, AVS/SEM
	9SD11	0.0 - 0.5 ft bgs	App. IX Metals, PAH, TOC, AVS/SEM
	9SD12	0.0 - 0.5 ft bgs	App. IX Metals, PAH, TOC, AVS/SEM
	9SD13	0.0 - 0.5 ft bgs	App. IX Metals, PAH, TOC, AVS/SEM
	9SD14	0.0 - 0.5 ft bgs	App. IX Metals, PAH, TOC, AVS/SEM
	9SD15	0.0 - 0.5 ft bgs	App. IX Metals, PAH, TOC, AVS/SEM
	9SD16	0.0 - 0.5 ft bgs	App. IX Metals, PAH, TOC, AVS/SEM
	9SD17	0.0 - 0.5 ft bgs	App. IX Metals, PAH, TOC, AVS/SEM
	9SD18	0.0 - 0.5 ft bgs	App. IX Metals, PAH, TOC, AVS/SEM
	9SD19	0.0 - 0.5 ft bgs	App. IX Metals, PAH, TOC, AVS/SEM
	9SD20	0.0 - 0.5 ft bgs	App. IX Metals, PAH, TOC, AVS/SEM
	9SD21	0.0 - 0.5 ft bgs	App. IX Metals, PAH, TOC, AVS/SEM
	9SD22	0.0 - 0.5 ft bgs	App. IX Metals, PAH, TOC, AVS/SEM
	9SD23	0.0 - 0.5 ft bgs	App. IX Metals, PAH, TOC, AVS/SEM
	9SD24	0.0 - 0.5 ft bgs	App. IX Metals, PAH, TOC, AVS/SEM
	9SD25	0.0 - 0.5 ft bgs	App. IX Metals, PAH, TOC, AVS/SEM
	9SD26	0.0 - 0.5 ft bgs	App. IX Metals, PAH, TOC, AVS/SEM
	9SD27	0.0 - 0.5 ft bgs	App. IX Metals, PAH, TOC, AVS/SEM
	9SD28	0.0 - 0.5 ft bgs	App. IX Metals, PAH, TOC, AVS/SEM
Surface Soil	9SS07	0.0 - 0.5 ft bgs	App. IX Metals, PAH, TPH (DRO/GRO)
	9SS08	0.0 - 0.5 ft bgs	App. IX Metals, PAH, TPH (DRO/GRO)
	9SS09	0.0 - 0.5 ft bgs	App. IX Metals, PAH, TPH (DRO/GRO)

Note: (ft bgs) - feet below ground surface

App IX - Appendix IX Metals
TOC - Total Organic Compounds
PAH - Polyaromatic Hydrocarbons
AVS - Acid Volatile Sulfide
BTEX - Benzene, toluene, ethylenebenzene, and xylenes
DRO - Diesel Range Organics
GRO - Gasoline Range Organics
SEM - Simultaneously Extracted Metals

TABLE 3-2

METHOD PERFORMANCE LIMITS
APPENDIX IX COMPOUND LIST AND CONTRACT
REQUIRED QUANTITATION LIMITS (CRQL)
SWMU 9 - TANKS 212-217
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Volatiles and other Organic Analysis	Quantitation Limits*		Method Number
	Water (mg/L)	Soil (mg/kg)	
Benzene	5.0	--	8260
Ethyl benzene	5.0	--	8260
Toluene	5.0	--	8260
Xylene (total)	10.0	--	8260
Total Organic Carbon (TOC)	--	500,000	415.1(soil) /9060(water)

Polynuclear Aromatic Hydrocarbons	Quantitation Limits*		Method Number
	Low Water (mg/L)	Low Soil (mg/kg)	
Acenaphthene	--	6.7	8270-PAH
Acenaphthylene	--	6.7	8270-PAH
Anthracene	--	6.7	8270-PAH
Benzo(a)anthracene	--	6.7	8270-PAH
Benzo(b)fluoranthene	--	6.7	8270-PAH
Benzo(k)fluoranthene	--	6.7	8270-PAH
Benzo(g,h,i)perylene	--	6.7	8270-PAH
Benzo(a)pyrene	--	6.7	8270-PAH
Chrysene	--	6.7	8270-PAH
Dibenzo(a,h)anthracene	--	6.7	8270-PAH
Fluoranthene	--	6.7	8270-PAH
Fluorene	--	6.7	8270-PAH
Indeno(1,2,3-cd)pyrene	--	6.7	8270-PAH
2-Methylnaphthalene	--	6.7	8270-PAH
Naphthalene	--	6.7	8270-PAH
Phenanthrene	--	6.7	8270-PAH
Pyrene	--	6.7	8270-PAH

* 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.

TABLE 3-2 (Continued)

METHOD PERFORMANCE LIMITS
APPENDIX IX COMPOUND LIST AND CONTRACT
REQUIRED QUANTITATION LIMITS (CRQL)

Inorganics	Method Number	Quantitation Limits*		Method Description
		Low Water (mg/L)	Low Soil (mg/kg)	
Antimony	6010	20	2.0	Inductively Coupled Plasma
Arsenic	6010	10	1.0	Inductively Coupled Plasma
Barium	6010	10	1.0	Inductively Coupled Plasma
Beryllium	6010	4.0	0.4	Inductively Coupled Plasma
Cadmium	6010	5.0	0.5	Inductively Coupled Plasma
Chromium	6010	10	1.0	Inductively Coupled Plasma
Cobalt	6010	10	1.0	Inductively Coupled Plasma
Copper	6010	20	2.0	Inductively Coupled Plasma
Lead	6010	5.0	0.5	Inductively Coupled Plasma
Mercury	7470/7471	0.2	0.02	Cold Vapor AA
Nickel	6010	40	4.0	Inductively Coupled Plasma
Selenium	6010	10	1.0	Inductively Coupled Plasma
Silver	6010	10	1.0	Inductively Coupled Plasma
Thallium	6010	10	1.0	Inductively Coupled Plasma
Tin	6010	10	5.0	Inductively Coupled Plasma
Vanadium	6010	10	1.0	Inductively Coupled Plasma
Cyanide	9012	0.010	1.0	Colorimetric
Sulfide	9030	1.0	25	Titrimetric, Iodine
Zinc	6010	20	2.0	Inductively Coupled Plasma
AVS/SEM [(1)]	SL-SOP	N/A	N/A	Laboratory Procedure

* 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.

[(1)] AVS/SEM - Acid Volatile Sulfide/Simultaneously Extracted Metals

N/A - Not Available

TABLE 5-1

LIST OF BIRDS REPORTED FROM NAVAL STATION ROOSEVELT ROADS
SMWU 9 – TANKS 212-217
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Common Name [1]		
Pied-billed grebe	Red-billed tropicbird	Brown pelican [2]
Brown booby	Magnificent frigatebird	Great blue heron
Louisiana heron	Snowy egret	Great egret
Striated heron	Little blue heron	Cattle egret
Least bittern	Yellow-crowned night heron	Black-crowned night heron
White-cheeked pintail	Blue-winged teal	American widgeon
Red-tailed hawk	Osprey	Merlin
Clapper rail	American coot	Caribbean coot
Common gallinule	Piping plover [3]	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 cockoo	Short-eared owl
Chuck-will's-widow	Common nighthawk	Antillean crested hummingbird
Green-throated carib	Antillean mango	Belted kingfisher

TABLE 5-1 (Continued)

LIST OF BIRDS REPORTED FROM NAVAL STATION ROOSEVELT ROADS
SWMU 9 – TANKS 212-217
NAVAL STATION ROOSEVELT ROADS, 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 mannikin
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]

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 Station Roosevelt Roads.

TABLE 5-2

ECOLOGICAL COPCS IDENTIFIED DURING THE REVISED FINAL RCRA RFI SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT
SWMU 9 - TANKS 212-217
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

	Area A		Area B		Area C	
Receptor	**Ecological COPC**	**Reason**	**Ecological COPC**	**Reason**	**Ecological COPC**	**Reason**
Sediment Associated Biota	Copper	HQ > 1.0	Cobalt	HQ > 1.0	Barium	HQ > 1.0
	Vanadium	HQ > 1.0	Copper	HQ > 1.0	Cobalt	HQ > 1.0
	Beryllium	No Threshold Value	Lead	HQ > 1.0	Copper	HQ > 1.0
	Tin	No Threshold Value	Vanadium	HQ > 1.0	Vanadium	HQ > 1.0
	Acetone	No Threshold Value	Beryllium	No Threshold Value	Beryllium	No Threshold Value
			Tin	No Threshold Value	Tin	No Threshold Value
			Acetone	No Threshold Value	Acetone	No Threshold Value
			2-Butanone	No Threshold Value	2-Butanone	No Threshold Value
			Carbon disulfide	No Threshold Value	Carbon disulfide	No Threshold Value
Saltwater Aquatic Life	Arsenic	HQ > 1.0	Arsenic	HQ > 1.0	Arsenic	HQ > 1.0
	Barium	Limited Effect Data	Copper	HQ > 1.0	Chromium	HQ > 1.0
	Cobalt	Limited Effect Data	Cyanide	HQ > 1.0	Copper	HQ > 1.0
	Vanadium	Limited Effect Data	Nickel	HQ > 1.0	Lead	HQ > 1.0
	Tin	No Threshold Value	Barium	Limited Effect Data	Nickel	HQ > 1.0
			Cobalt	Limited Effect Data	Zinc	HQ > 1.0
			Vanadium	Limited Effect Data	Barium [(1)]	Limited Effect Data
			Beryllium	No Threshold Value	Cobalt	Limited Effect Data
			Tin	No Threshold Value	Vanadium [(1)]	Limited Effect Data
					Beryllium	No Threshold Value
					Tin	No Threshold Value
Plants	Chromium	HQ > 1.0	Chromium	HQ > 1.0	Chromium	HQ > 1.0
	Selenium	HQ > 1.0	Lead	HQ > 1.0	Lead	HQ > 1.0
	Acetone	No Threshold Value	Selenium	HQ > 1.0	Benzo(b)fluoranthene	No Threshold Value
	Benzyl Alcohol	No Threshold Value	Acetone	No Threshold Value	Crysene	No Threshold Value
					Pyrene	No Threshold Value
Earthworms	Chromium	HQ > 1.0	Chromium	HQ > 1.0	Chromium	HQ > 1.0
	Barium	No Threshold Value	Barium	No Threshold Value	Barium	No Threshold Value
	Silver	No Threshold Value	Acetone	No Threshold Value	Benzo(b)fluoranthene	No Threshold Value
	Acetone	No Threshold Value	Di-n-butylphthalate	No Threshold Value	Chrysene	No Threshold Value
	Benzyl alcohol	No Threshold Value			Di-n-butylphthalate	No Threshold Value
	Diethylphthalate	No Threshold Value			Pyrene	No Threshold Value

TABLE 5-2 (Continued)

ECOLOGICAL COPCS IDENTIFIED DURING THE REVISED FINAL RCRA RFI SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT
SWMU 9 - TANKS 212-217
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

	Area A		Area B		Area C	
Receptor	**Ecological COPC**	**Reason**	**Ecological COPC**	**Reason**	**Ecological COPC**	**Reason**
Belted Kingfisher	Chromium	HQ > 1.0	Cadmium	HQ > 1.0	Barium	HQ > 1.0
	Mercury	HQ > 1.0	Chromium	HQ > 1.0	Cadmium	HQ > 1.0
	Selenium	HQ > 1.0	Lead	HQ > 1.0	Chromium	HQ > 1.0
	Vanadium	HQ > 1.0	Mercury	HQ > 1.0	Copper	HQ > 1.0
	Beryllium	No Threshold Value	Vanadium	HQ > 1.0	Lead	HQ > 1.0
	Cobalt	No Threshold Value	Zinc	HQ > 1.0	Mercury	HQ > 1.0
	Acetone	No Threshold Value	Antimony	No Threshold Value	Vanadium	HQ > 1.0
			Beryllium	No Threshold Value	Zinc	HQ > 1.0
			Cobalt	No Threshold Value	Beryllium	No Threshold Value
			Cyanide	No Threshold Value	Cobalt	No Threshold Value
			Acetone	No Threshold Value	Acetone	No Threshold Value
			2-Butanone	No Threshold Value	2-Butanone	No Threshold Value
			Carbon disulfide	No Threshold Value	Carbon disulfide	No Threshold Value
					Methylene chloride	No Threshold Value
Great Blue Heron	Selenium	HQ > 1.0	Antimony	No Threshold Value	Cadmium	HQ > 1.0
	Beryllium	No Threshold Value	Beryllium	No Threshold Value	Lead	HQ > 1.0
	Cobalt	No Threshold Value	Cobalt	No Threshold Value	Mercury	HQ > 1.0
	Acetone	No Threshold Value	Cyanide	No Threshold Value	Vanadium	HQ > 1.0
			Acetone	No Threshold Value	Zinc	HQ > 1.0
			2-Butanone	No Threshold Value	Beryllium	No Threshold Value
			Carbon disulfide	No Threshold Value	Cobalt	No Threshold Value
					Acetone	No Threshold Value
					2-Butanone	No Threshold Value
					Carbon disulfide	No Threshold Value
					Methylene chloride	No Threshold Value
American Robin	Barium	HQ > 1.0	Barium	HQ > 1.0	Barium	HQ > 1.0
	Chromium	HQ > 1.0	Cadmium	HQ > 1.0	Chromium	HQ > 1.0
	Lead	HQ > 1.0	Chromium	HQ > 1.0	Lead	HQ > 1.0
	Selenium	HQ > 1.0	Lead	HQ > 1.0	Benzo(b)fluoranthene	No Threshold Value
	Silver	No Threshold Value	Selenium	HQ > 1.0	Crysene	No Threshold Value
	Acetone	No Threshold Value	Acetone	No Threshold Value	Pyrene	No Threshold Value
	Benzyl Alcohol	No Threshold Value				
	Diethylphthalate	No Threshold Value				

TABLE 5-2 (Continued)

ECOLOGICAL COPCS IDENTIFIED DURING THE REVISED FINAL RCRA RFI SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT
SWMU 9 - TANKS 212-217
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

	Area A		Area B		Area C	
Receptor	**Ecological COPC**	**Reason**	**Ecological COPC**	**Reason**	**Ecological COPC**	**Reason**
Red-Tailed Hawk	Chromium	HQ > 1.0	Lead	HQ > 1.0	Chromium	HQ > 1.0
	Silver	No Threshold Value	Acetone	No Threshold Value	Lead	HQ > 1.0
	Acetone	No Threshold Value			Benzo(b)fluoranthene	No Threshold Value
	Benzyl Alcohol	No Threshold Value			Crysene	No Threshold Value
	Diethylphthalate	No Threshold Value			Pyrene	No Threshold Value

Notes:

HQ = Hazard Quotient

(1) In addition to lacking a conservative effect concentration, the maximum detected concentration exceeded the minimum literature-based acute effect concentration.

TABLE 5-3

IDENTIFICATION OF CHEMICALS SELECTED FOR ECOLOGICAL RISK EVALUATION IN THE CORRECTIVE MEASURES STUDY INVESTIGATION
SWMU 9 - TANKS 212-217
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical [1]	Selected for Evaluation (Yes/No)	Reason for Selection or Elimination From Evaluation
Appendix IX Volatiles:		
Acetone	YES	Detected in environmental media
Acetonitrile	NO	[2]
Acrolein	NO	[2]
Acrylonitrile	NO	[2]
Benzene	YES	Component of gasoline; Detected in environmental media
Bromodichloromethane	YES	Detected in environmental media
Bromoform	YES	Detected in environmental media
Bromomethane	NO	[2]
Carbon Disulfide	YES	Detected in environmental media
Carbon Tetrachloride	NO	[2]
Chlorobenzene	NO	[2]
Chloroethane	NO	[2]
Chloroform	YES	Detected in environmental media
Chloromethane	NO	[2]
Chloroprene	NO	[2]
3-Chloropropene	NO	[2]
1,2-Dibromo-3-chloropropane	NO	[2]
Dibromochloromethane	YES	Detected in environmental media
1,2-Dibromoethane	YES	Component of gasoline
Dibromomethane	NO	[2]
trans-1,4-Dichloro-2-butene	NO	[2]
Dichlorodifluoromethane	NO	[2]
1,1-Dichloroethane	YES	Component of gasoline
1,2-Dichloroethane	YES	Component of gasoline
trans-1,2-Dichloroethylene	NO	[2]
1,1-Dichloroethylene	NO	[2]
Dichloromethane	NO	[2]
1,2-Dichloropropane	YES	Component of gasoline; Detected in environmental media
cis-1,3-Dichloropropene	NO	[2]
trans-1,3-Dichloropropene	NO	[2]
Ethyl benzene	YES	Detected in environmental media
Ethyl methacrylate	NO	[2]
2-Hexanone	NO	[2]
Iodomethane	NO	[2]

TABLE 5-3 (Continued)

IDENTIFICATION OF CHEMICALS SELECTED FOR ECOLOGICAL RISK EVALUATION IN THE CORRECTIVE MEASURES STUDY INVESTIGATION
SWMU 9 - TANKS 212-217
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical [1]	Selected for Evaluation (Yes/No)	Reason for Selection or Elimination From Evaluation
Appendix IX Volatiles (continued):		
Isobutyl alcohol	NO	[2]
Methacrylonitrile	NO	[2]
Methyl ethyl ketone	NO	[2]
Methyl methacrylate	NO	[2]
4-Methyl-2-pentanone	NO	[2]
Pentachloroethane	NO	[2]
Propionitrile	NO	[2]
Stryene	NO	[2]
1,1,1,2-Tetrachloroethane	NO	[2]
1,1,2,2-Tetrachloroethane	NO	[2]
Tetrachloroethene	NO	[2]
Toluene	YES	Gasoline additive; detected in environmental media
1,1,1-Trichloroethane	NO	[2]
1,1,2-Trichloroethane	NO	[2]
Trichloroethene	NO	[2]
Trichlorofluoromethane	NO	[2]
1,2,3-Trichloropropane	NO	[2]
Vinyl Acetate	NO	[2]
Vinyl Chloride	NO	[2]
Xylenes	YES	Component of gasoline; Detected in environmental media
Appendix IX Semivolatiles:		
Acenaphthene	YES	Component of crude oil and/or by default
Acenaphthylene	YES	Component of crude oil and/or by default
Acetophenone	YES	Detected in environmental media
2-Acetylaminofluorene	NO	[2]
4-Aminobiphenyl	NO	[2]
Aniline	NO	[2]
Anthracene	YES	Component of crude oil and/or by default
Aramite	NO	[2]
Benzo(a)anthracene	YES	Component of crude oil and/or by default
Benzo(b)fluoranthene	YES	Component of crude oil and/or by default
Benzo(k)fluoranthene	YES	Component of crude oil and/or by default
Benzo(g,h,i)perylene	YES	Component of crude oil and/or by default

TABLE 5-3 (Continued)

IDENTIFICATION OF CHEMICALS SELECTED FOR ECOLOGICAL RISK EVALUATION IN THE CORRECTIVE MEASURES STUDY INVESTIGATION
SWMU 9 - TANKS 212-217
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical [1]	Selected for Evaluation (Yes/No)	Reason for Selection or Elimination From Evaluation
Appendix IX Semivolatiles (continued):		
Benzo(a)pyrene	YES	Component of crude oil and/or by default
Benzoic Acid	YES	Detected in environmental media
Benzyl alcohol	YES	Detected in environmental media
Bis(2-chloroethoxyl)methane	NO	[2]
Bis(2-chloroethyl)ether	NO	[2]
Bis(2-ethylhexyl)phthalate	YES	Detected in environmental media
4-Bromophenyl phenyl ether	NO	[2]
Butyl benzyl phthalate	YES	Detected in environmental media
p-Chloroaniline	NO	[2]
p-Chloro-m-cresol	NO	[2]
2-Chloronaphthalene	NO	[2]
2-Chlorophenol	NO	[2]
4-Chlorophenyl phenyl ether	YES	No information could be found
Chrysene	YES	Component of crude oil and/or by default
m,p-Cresol	YES	Component of crude oil and/or by default
ortho-Cresol	YES	Detected in environmental media
Diallate	NO	[2]
Dibenzofuran	YES	Component of crude oil and/or by default
Di-n-butyl phthalate	YES	Detected in environmental media
Dibenzo(a,h)anthracene	YES	Component of crude oil and/or by default
1,4-Dichlorobenzene	NO	[2]
1,2-Dichlorobenzene	NO	[2]
1,3-Dichlorobenzene	NO	[2]
3,3'-Dichlorobenzidine	NO	[2]
2,4-Dichlorophenol	NO	[2]
2,6-Dichlorophenol	NO	[2]
Diethylphthalate	YES	Detected in environmental media
p-(Dimethylamino)azobenzene	NO	[2]
7,12-Dimethyl benz(a)anthracene	YES	Component of crude oil and/or by default
3,3-Dimethyl benzidine	NO	[2]
2,4-Dimethylphenol	YES	Gasoline additive
alpha, alpha-Dimethylphenethylamine	YES	No information could be found
Dimethyl phthalate	YES	Detected in environmental media
m-Dinitrobenzene	NO	[2]

TABLE 5-3 (Continued)

IDENTIFICATION OF CHEMICALS SELECTED FOR ECOLOGICAL RISK EVALUATION IN THE CORRECTIVE MEASURES STUDY INVESTIGATION
SWMU 9 - TANKS 212-217
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical [1]	Selected for Evaluation (Yes/No)	Reason for Selection or Elimination From Evaluation
Appendix IX Semivolatiles (continued):		
4,6-Dinitro-o-cresol	NO	[2]
2,4-Dinitrophenol	NO	[2]
2,4-Dinitrotoluene	NO	[2]
2,6-Dinitrotoluene	NO	[2]
Di-n-octylphthalate	NO	[2]
1,4-Dioxane	NO	[2]
Dinoseb	NO	[2]
Ethylmethanesulfonate	NO	[2]
Fluoranthene	YES	Component of crude oil and/or by default
Fluorene	YES	Component of crude oil and/or by default
Hexachlorobenzene	NO	[2]
Hexachlorobutadiene	NO	[2]
Hexachlorocyclopentadiene	NO	[2]
Hexachloroethane	NO	[2]
Hexachlorophene	NO	[2]
Hexachloropropene	NO	[2]
Indeno(1,2,3-cd)pyrene	YES	Component of crude oil and/or by default
Isophorone	NO	[2]
Isosafrole	NO	[2]
Methapyrilene	NO	[2]
3-Methylcholanthrene	NO	[2]
Methyl methanesulfonate	NO	[2]
2-Methylnaphthalene	YES	Detected in environmental media
Naphthalene	YES	Component of crude oil and/or by default
1,4-Naphthoquinone	NO	[2]
1-Naphthylamine	NO	[2]
2-Naphthylamine	NO	[2]
o-Nitroaniline	NO	[2]
m-Nitroaniline	YES	No information could be found
p-Nitroaniline	NO	[2]
Nitrobenzene	NO	[2]
o-Nitrophenol	NO	[2]
p-Nitrophenol	NO	[2]
4-Nitroquinoline-1-oxide	YES	No information could be found

TABLE 5-3 (Continued)

IDENTIFICATION OF CHEMICALS SELECTED FOR ECOLOGICAL RISK EVALUATION IN THE CORRECTIVE MEASURES STUDY INVESTIGATION
SWMU 9 - TANKS 212-217
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical [1]	Selected for Evaluation (Yes/No)	Reason for Selection or Elimination From Evaluation
Appendix IX Semivolatiles (continued):		
n-Nitrosodi-n-butylamine	YES	No information could be found
n-Nitrosodiethylamine	YES	Gasoline product additive
n-Nitrosodimethylamine	NO	[2]
n-Nitrosodiphenylamine	YES	Compound of gasoline
n-Nitrosodi-n-propylamine	NO	[2]
n-Nitrosomethylethylamine	NO	[2]
n-Nitrosomorpholine	NO	[2]
n-Nitrosopiperidine	NO	[2]
n-Nitrosopyrrolidine	YES	No information could be found
5-Nitro-o-toluidine	NO	[2]
2,2'-Oxybis(1-chloropropane)	NO	[2]
Pentachlorobenzene	NO	[2]
Pentachloronitrobenzene	NO	[2]
Pentachlorophenol	NO	[2]
Phenacetin	NO	[2]
Phenanthrene	YES	Component of crude oil and/or by default
Phenol	YES	Component of crude oil and/or by default
p-Phenylenediamine	YES	Component of gasoline
2-Picolin	NO	[2]
Pronamide	NO	[2]
Pyrene	YES	Component of crude oil and/or by default
Pyridine	NO	[2]
Safrole	NO	[2]
1,2,4,5-Tetrachlorobenzene	NO	[2]
2,3,4,6-Tetrachlorophenol	NO	[2]
o-Toluidine	NO	[2]
1,2,4-Trichlorobenzene	NO	[2]
2,4,5-Trichlorophenol	NO	[2]
2,4,6-Trichlorophenol	NO	[2]
sym-Trinitrobenzene	NO	[2]

TABLE 5-3 (Continued)

IDENTIFICATION OF CHEMICALS SELECTED FOR ECOLOGICAL RISK EVALUATION IN THE CORRECTIVE MEASURES STUDY INVESTIGATION
SWMU 9 - TANKS 212-217
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical [1]	Selected for Evaluation (Yes/No)	Reason for Selection or Elimination From Evaluation
Appendix IX PCBs:		
Aroclor-1016	NO	[2]
Aroclor-1221	NO	[2]
Aroclor-1232	NO	[2]
Aroclor-1242	NO	[2]
Aroclor-1248	NO	[2]
Aroclor-1254	NO	[2]
Aroclor-1260	NO	[2]
Appendix IX Inorganics:		
Antimony	YES	By default
Arsenic	YES	By default
Barium	YES	By default
Beryllium	YES	By default
Cadmium	YES	By default
Chromium	YES	By default
Cobalt	YES	By default
Copper	YES	By default
Lead	YES	By default
Mercury	YES	By default
Nickel	YES	By default
Selenium	YES	By default
Silver	YES	By default
Thallium	YES	By default
Tin	YES	By default
Vanadium	YES	By default
Cyanide	YES	By default
Sulfide	YES	By default
Zinc	YES	By default

Notes:

[1] The chemicals listed are limited to those analyzed during previous investigations and those that will be analyzed in future investigations.

[2] The chemical is not a component of crude oil, used in the refinement of crude oil, used as a refined product additive, nor was it detected in environmental media collected during previous investigations.

TABLE 5-4

LOG K_{ow} VALUES FOR ORGANIC CHEMICALS RETAINED FOR EVALUATION IN THE CMS INVESTIGATION
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Log K_{ow} Range	Selected log K_{ow}	Reference	Evaluate for Food Web Exposures?	Rationale
Volatiles:					
1,1-DICHLOROETHANE	1.78 to 1.85	1.79	USEPA 1995c	NO	Not significant bioaccumulator - log $K_{ow} < 3.0$
1,2-DIBROMOETHANE	Not reported	2.00	USEPA 1996	NO	Not significant bioaccumulator - log $K_{ow} < 3.0$
1,2-DICHLOROETHANE	1.40 to 1.48	1.47	USEPA 1995c	NO	Not significant bioaccumulator - log $K_{ow} < 3.0$
1,2-DICHLOROPROPANE	1.94 to 1.99	1.97	USEPA 1995c	NO	Not significant bioaccumulator - log $K_{ow} < 3.0$
ACETONE	-0.21 to -0.24	-0.24	USEPA 1995c	NO	Not significant bioaccumulator - log $K_{ow} < 3.0$
BENZENE	1.83 to 2.50	2.13	USEPA 1995c	NO	Not significant bioaccumulator - log $K_{ow} < 3.0$
BROMODICHLOROMETHANE	1.88 to 2.14	2.10	USEPA 1995c	NO	Not significant bioaccumulator - log $K_{ow} < 3.0$
BROMOFORM	2.30 to 2.38	2.35	USEPA 1995c	NO	Not significant bioaccumulator - log $K_{ow} < 3.0$
CARBON DISULFIDE	1.84 to 2.16	2.00	USEPA 1995c	NO	Not significant bioaccumulator - log $K_{ow} < 3.0$
CHLOROFORM	1.81 to 3.04	1.92	USEPA 1995c	YES	maximum log $K_{ow} \geq 3.0$
DIBROMOCHLOROMETHANE	2.13 to 2.24	2.17	USEPA 1995c	NO	maximum log $K_{ow} \geq 3.0$
ETHYLBENZENE	3.07 to 3.57	3.14	USEPA 1995c	YES	maximum log $K_{ow} \geq 3.0$
TOLUENE	2.21 to 3.13	2.75	USEPA 1995c	YES	maximum log $K_{ow} \geq 3.0$
XYLENES (TOTAL)	2.77 to 3.68	3.20	USEPA 1995c	YES	maximum log $K_{ow} \geq 3.0$
Semivolatiles:					
2,4-DIMETHYLPHENOL	1.99 to 2.49	2.36	USEPA 1995c	NO	Not significant bioaccumulator - log $K_{ow} < 3.0$
2-METHYLNAPHTHALENE	Not reported	3.90	USEPA 1996	YES	maximum log $K_{ow} \geq 3.0$
4-CHLOROPHENYL-PHENYLETHER	4.08 to 5.09	4.95	USEPA 1995c	YES	maximum log $K_{ow} \geq 3.0$
4-NITROQUINOLINE-1-OXIDE	Not reported	1.09	SRC, 1998	NO	Not significant bioaccumulator - log $K_{ow} < 3.0$
7, 12-DIMETHYLBENZ(A)ANTHRACENE	Not reported	6.62	USEPA, 1996	YES	maximum log $K_{ow} \geq 3.0$
ACENAPHTHENE	3.77 to 4.49	3.92	USEPA 1995c	YES	maximum log $K_{ow} \geq 3.0$
ACENAPHTHYLENE	Not reported	4.10	USEPA 1996	YES	maximum log $K_{ow} \geq 3.0$
ACETOPHENONE	Not reported	1.64	USEPA, 1996	NO	Not significant bioaccumulator - log $K_{ow} < 3.0$
ANTHRACENE	3.45 to 4.80	4.55	USEPA 1995c	YES	maximum log $K_{ow} \geq 3.0$
BENZO(A)ANTHRACENE	4.00 to 5.79	5.70	USEPA 1995c	YES	maximum log $K_{ow} \geq 3.0$
BENZO(A)PYRENE	5.98 to 6.42	6.11	USEPA 1995c	YES	maximum log $K_{ow} \geq 3.0$
BENZO(B)FLUORANTHENE	5.79 to 6.40	6.20	USEPA 1995c	YES	maximum log $K_{ow} \geq 3.0$
BENZOIC ACID	Not reported	1.86	USEPA, 1996	NO	Not significant bioaccumulator - log $K_{ow} < 3.0$
BENZO(G,H,I)PERYLENE	6.63 to 7.05	6.70	USEPA 1995c	YES	maximum log $K_{ow} \geq 3.0$

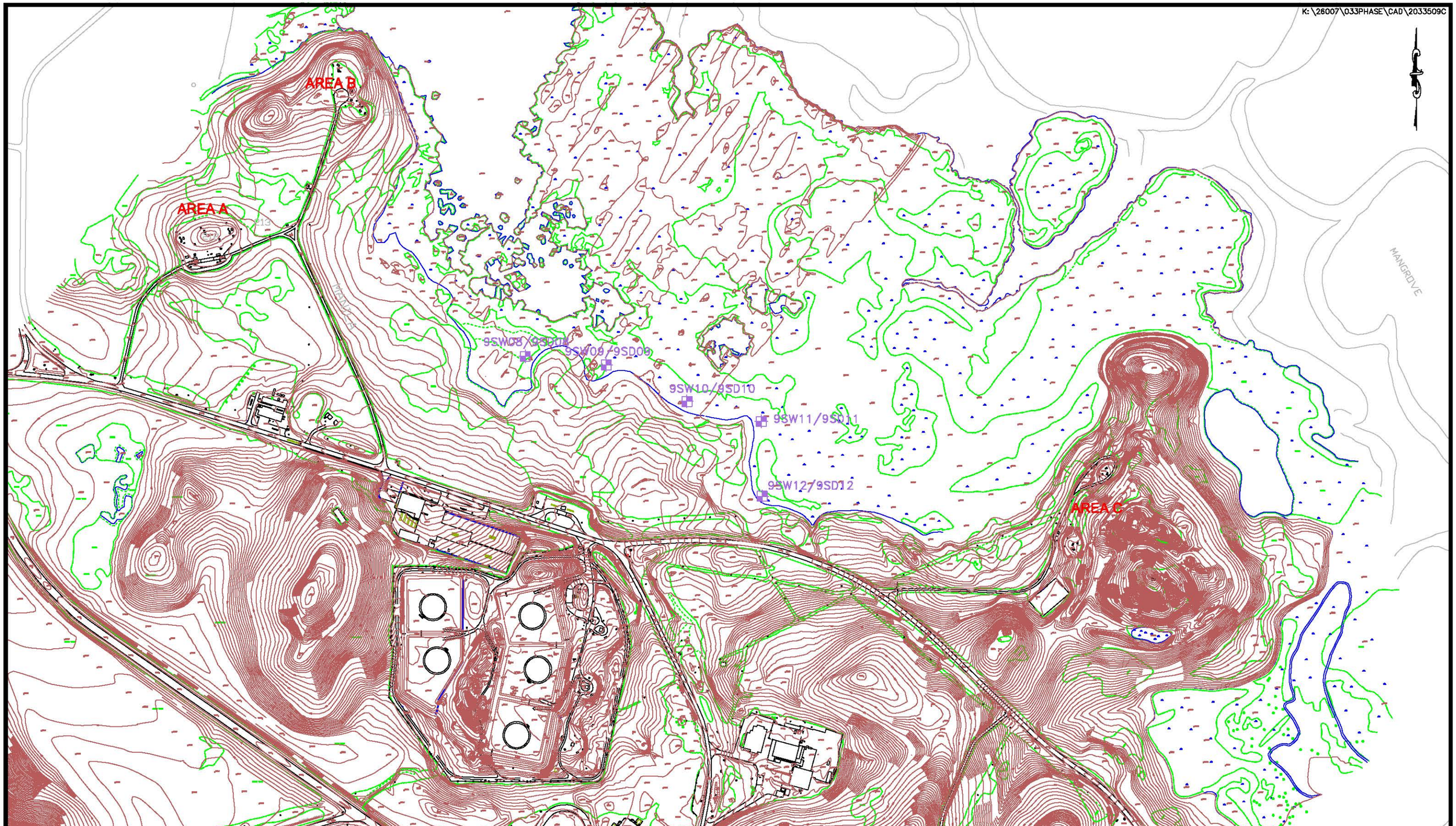
TABLE 5-4 (Continued)
LOG K_{ow} VALUES FOR ORGANIC CHEMICALS RETAINED FOR EVALUATION IN THE CMS INVESTIGATION
NAVAL STATION ROOSEVELT ROADS,
CEIBA, PUERTO RICO

Chemical	Log K_{ow} Range	Selected log K_{ow}	Reference	Evaluate for Food Web Exposures?	Rationale
Semi-volatiles (continued):					
BENZO(K)FLUORANTHENE	6.12 to 6.27	6.20	USEPA 1995c	YES	maximum log $K_{ow} \geq 3.0$
BENZYL ALCOHOL	Not reported	1.11	USEPA, 1996	NO	Not significant bioaccumulator - log $K_{ow} < 3.0$
BIS-(2-ETHYLHEXYL)PHTHALATE	4.20 to 8.61	7.30	USEPA 1995c	YES	maximum log $K_{ow} \geq 3.0$
BUTYLBENZYLPHTHALATE	3.57 to 5.02	4.84	USEPA 1995c	YES	maximum log $K_{ow} \geq 3.0$
CHRYSENE	5.41 to 5.79	5.70	USEPA 1995c	YES	maximum log $K_{ow} \geq 3.0$
M, P-CRESOL	1.95 to 1.97 [(1)]	1.97	USEPA, 1996	NO	Not significant bioaccumulator - log $K_{ow} < 3.0$
O-CRESOL	Not reported	1.99	USEPA, 1996	NO	Not significant bioaccumulator - log $K_{ow} < 3.0$
DIBENZO(A,H)ANTHRACENE	6.50 to 6.88	6.69	USEPA 1995c	YES	maximum log $K_{ow} \geq 3.0$
DIBENZOFURAN	Not reported	4.20	USEPA 1996	YES	maximum log $K_{ow} \geq 3.0$
DIETHYLPHTHALATE	1.40 to 3.00	2.50	USEPA 1995c	YES	maximum log $K_{ow} \geq 3.0$
DIMETHYLPHTHALATE	1.34 to 1.90	1.57	USEPA 1995c	NO	Not significant bioaccumulator - log $K_{ow} < 3.0$
DI-N-BUTYLPHTHALATE	3.74 to 4.79	4.61	USEPA 1995c	YES	maximum log $K_{ow} \geq 3.0$
A, A-DIMETHYLPHENETHYLAMINE	Not reported	1.90	USEPA, 1996	NO	Not significant bioaccumulator - log $K_{ow} < 3.0$
FLUORANTHENE	4.31 to 5.39	5.12	USEPA 1995c	YES	maximum log $K_{ow} \geq 3.0$
FLUORENE	4.04 to 4.40	4.21	USEPA 1995c	YES	maximum log $K_{ow} \geq 3.0$
INDENO(1,2,3-CD)PYRENE	6.58 to 6.72	6.65	USEPA 1995c	YES	maximum log $K_{ow} \geq 3.0$
NAPHTHALENE	3.01 to 4.70	3.36	USEPA 1995c	YES	maximum log $K_{ow} \geq 3.0$
M-NITROANILINE	Not reported	1.37	USEPA, 1996	NO	Not significant bioaccumulator - log $K_{ow} < 3.0$
N-NITRODI-N-BUTYLAMINE	Not reported	2.41	USEPA, 1996	NO	Not significant bioaccumulator - log $K_{ow} < 3.0$
N-NITROSODIETHYLAMINE	Not reported	0.48	USEPA, 1996	NO	Not significant bioaccumulator - log $K_{ow} < 3.0$
N-NITROSODIPHENYLAMINE	3.13 to 3.45	3.16	USEPA 1995c	YES	maximum log $K_{ow} \geq 3.0$
N-NITROSOPYRROLIDINE	Not reported	-0.19	USEPA, 1996	NO	Not significant bioaccumulator - log $K_{ow} < 3.0$
PHENANTHRENE	4.28 to 4.57	4.55	USEPA 1995c	YES	maximum log $K_{ow} \geq 3.0$
PHENOL	0.79 to 1.55	1.48	USEPA 1995c	NO	Not significant bioaccumulator - log $K_{ow} < 3.0$
P-PHENYLENEDIAMINE	Not reported	-0.30	SRC, 1996	NO	Not significant bioaccumulator - log $K_{ow} < 3.0$
PYRENE	4.76 to 5.52	5.11	USEPA 1995c	YES	maximum log $K_{ow} \geq 3.0$

NOTES:

[(1)] The minimum log Kow value for this chemical represents the meta-cresol isomer. The maximum log Kow value for this chemical represents the para-cresol isomer.

FIGURES



LEGEND

- PROPOSED SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS
- 115 – SURFACE ELEVATION CONTOUR
- TELEPHONE POLE
- TREE LINE
- BUILDING
- MANHOLE
- ROAD

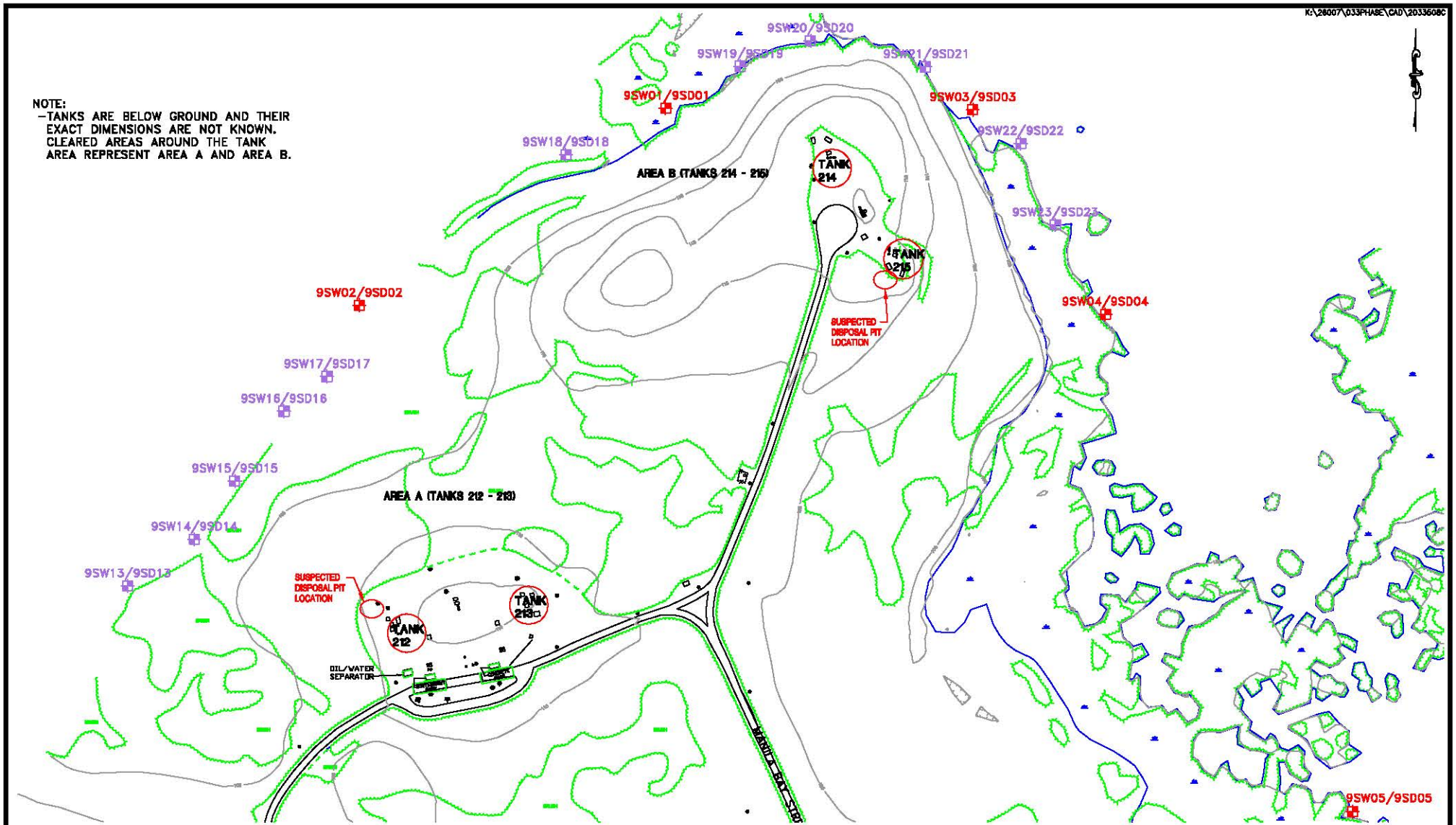
500 0 250 500

1 inch = 500 ft.

Baker

FIGURE 3-1
SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS
SWMU 9 – BACKGROUND

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



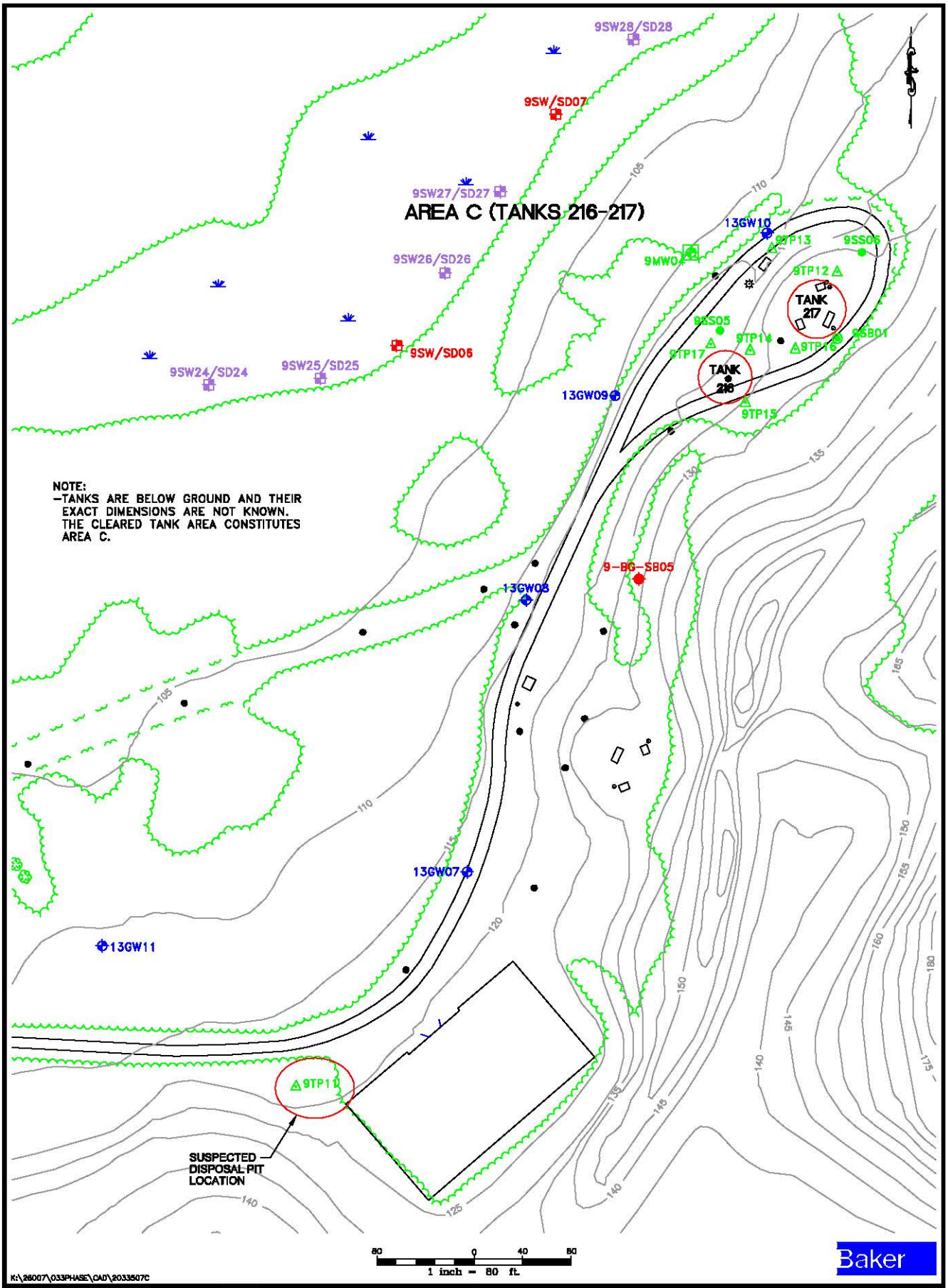
LEGEND

- SURFACE WATER AND SEDIMENT SAMPLING LOCATION (PHASE III)
- PROPOSED SURFACE WATER AND SEDIMENT SAMPLING LOCATION
- SURFACE ELEVATION CONTOUR
- SUSPECTED LOCATION OF DISPOSAL PIT
- TELEPHONE POLE
- TREE LINE
- BUILDING
- MARSH
- ROAD

180 0 90 180
1 inch = 180 ft.

Baker

FIGURE 3-2
SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS
SWMU 9 - AREAS A AND B
TANKS 212 - 215
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

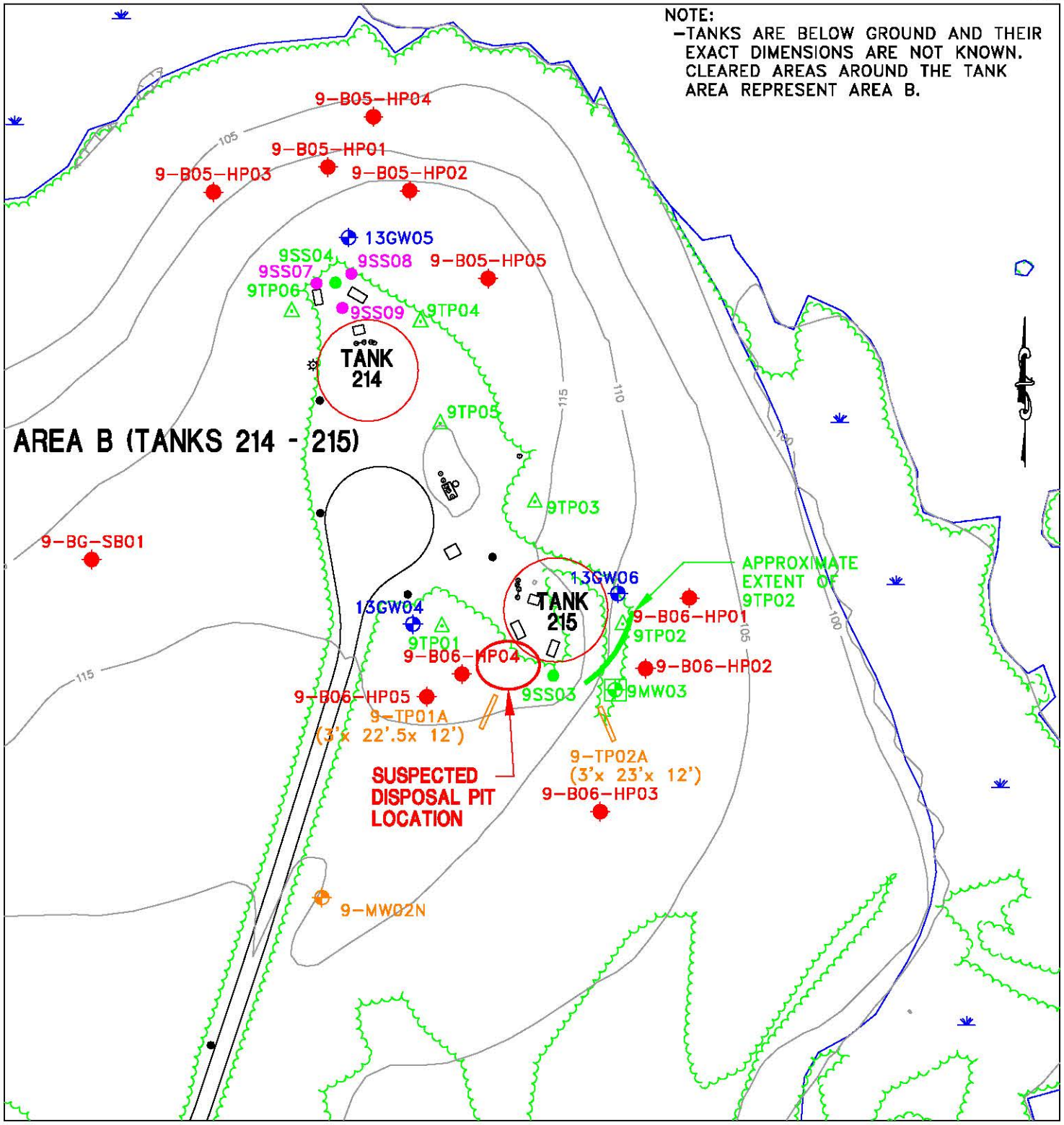


LEGEND

- SURFACE SOIL SAMPLE LOCATION (PHASE I)
- TEST PIT LOCATION (PHASE I)
- SOIL BORING LOCATION (PHASE I)
- EXISTING MONITORING WELL LOCATION
- MONITORING WELL LOCATION (PHASE I)
- SURFACE WATER AND SEDIMENT SAMPLE LOCATION (PHASE III)
- PROPOSED SURFACE WATER AND SEDIMENT SAMPLE LOCATION
- HYDROPUNCH SOIL AND/OR GROUNDWATER SAMPLE LOCATION (PHASE III)
- 110 – SURFACE ELEVATION CONTOUR
- SUSPECTED LOCATION OF DISPOSAL PIT
- TELEPHONE POLE

FIGURE 3-3
SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS
SWMU 9 – AREA C
TANKS 216 – 217

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



LEGEND

- PROPOSED SURFACE SOIL SAMPLE LOCATION
- SURFACE SOIL SAMPLE LOCATION (PHASE I)
- TEST PIT LOCATION (PHASE I)
- TEST PIT LOCATION (PHASE II)
- EXISTING MONITORING WELL LOCATION
- MONITORING WELL LOCATION (PHASE I)
- MONITORING WELL LOCATION (PHASE II)
- HYDROPUNCH SOIL AND/OR GROUNDWATER SAMPLE LOCATION (PHASE III)
- 110 – SURFACE ELEVATION CONTOUR
- SUSPECTED LOCATION OF DISPOSAL PIT
- TELEPHONE POLE

FIGURE 3-4
SURFACE SOIL SAMPLING LOCATIONS
SWMU 9 – AREA B
TANKS 214 – 215

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

FIGURE 5-1

SCREENING-LEVEL ERA PRELIMINARY CONCEPTUAL MODEL FOR SWMU 9 - AREAS A, B, AND C
SWMU 9 - TANKS 212-217
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

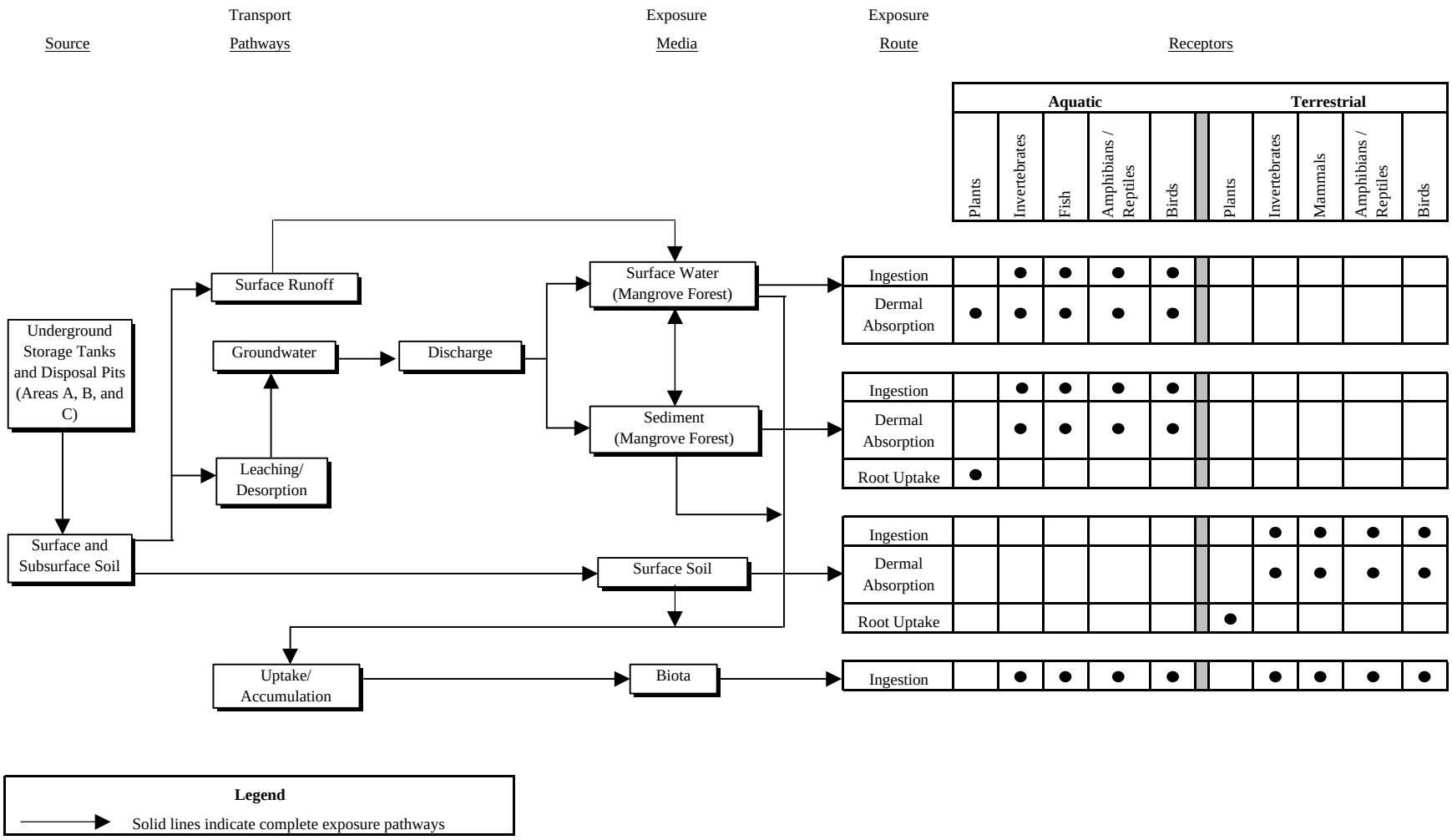
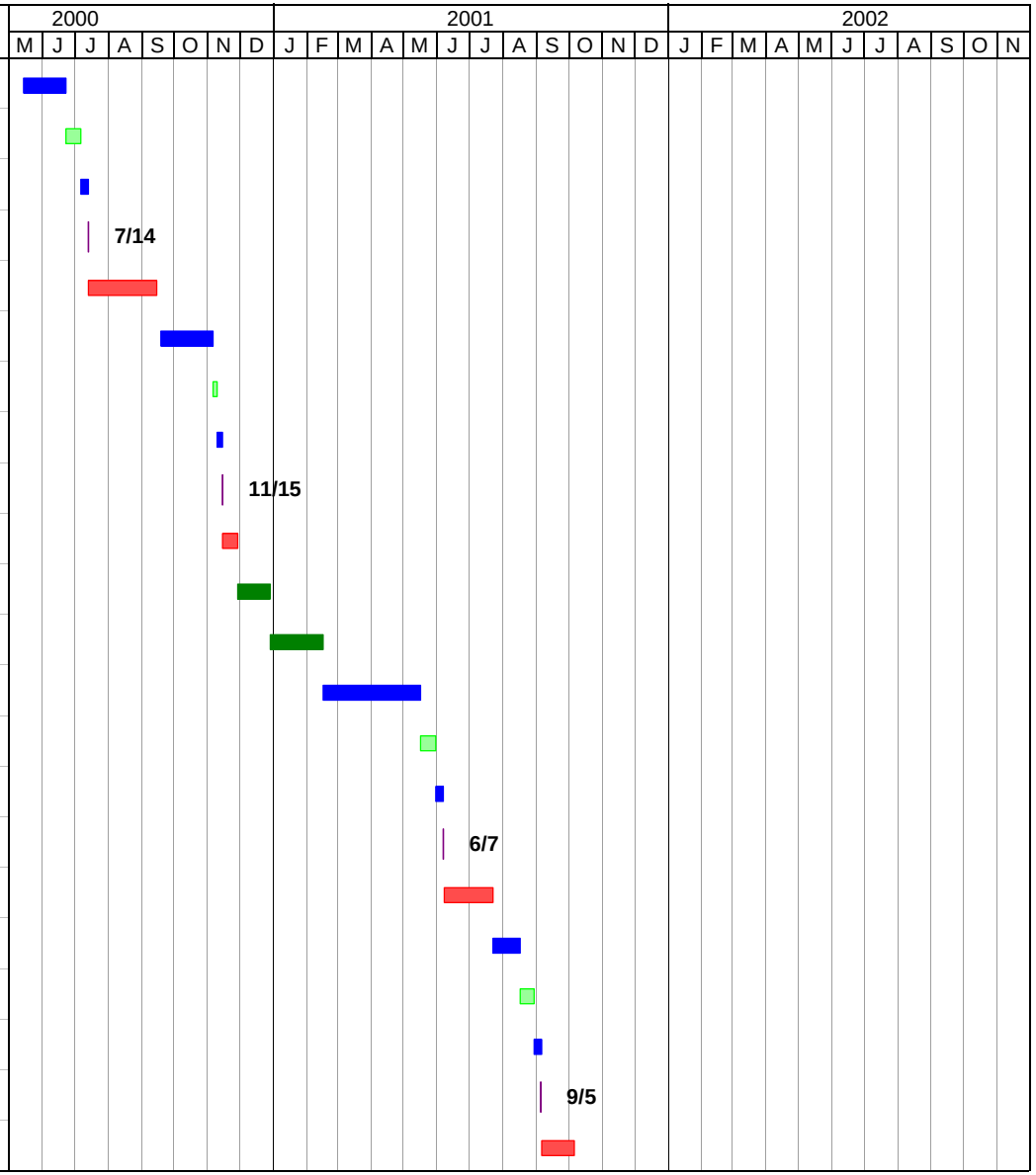


Figure 7-1
Corrective Measures Study - Proposed Schedule
SWMU 9 - Tanks 212-217
Naval Station Roosevelt Roads, Puerto Rico

Task Name	Duration	Start	Finish
Draft CMS Work Plan	39 edays	5/15/00	6/23/00
Navy Review	14 edays	6/23/00	7/7/00
Draft CMS Work Plan Revisions	7 edays	7/7/00	7/14/00
Draft CMS Work Plan Due To EPA	1 day	7/14/00	7/14/00
EPA Review	63 edays	7/14/00	9/15/00
Final CMS Work Plan	48 edays	9/19/00	11/6/00
Navy Review	4 edays	11/6/00	11/10/00
Final CMS Work Plan Revisions	5 edays	11/10/00	11/15/00
Final CMS Work Plan Due to EPA	1 day	11/15/00	11/15/00
EPA Review/Appproval	14 edays	11/15/00	11/29/00
Initiate Field Work	30 edays	11/29/00	12/29/00
Field Work/Lab/Validation	49 edays	12/29/00	2/16/01
Draft CMS Investigation Report	90 edays	2/16/01	5/17/01
Navy Review	14 edays	5/17/01	5/31/01
Draft CMS Investigation Report Revisions	7 edays	5/31/01	6/7/01
Draft CMS Investigation Report Due to EPA	1 day	6/7/01	6/7/01
EPA Review	45 edays	6/7/01	7/22/01
Final CMS Investigation Report	25 edays	7/22/01	8/16/01
Navy Review	13 edays	8/16/01	8/29/01
Final CMS Investigation Report Revisions	7 edays	8/29/01	9/5/01
Final CMS Investigation Report Due to EPA	1 day	9/5/01	9/5/01
EPA Review/Approval	30 edays	9/5/01	10/5/01

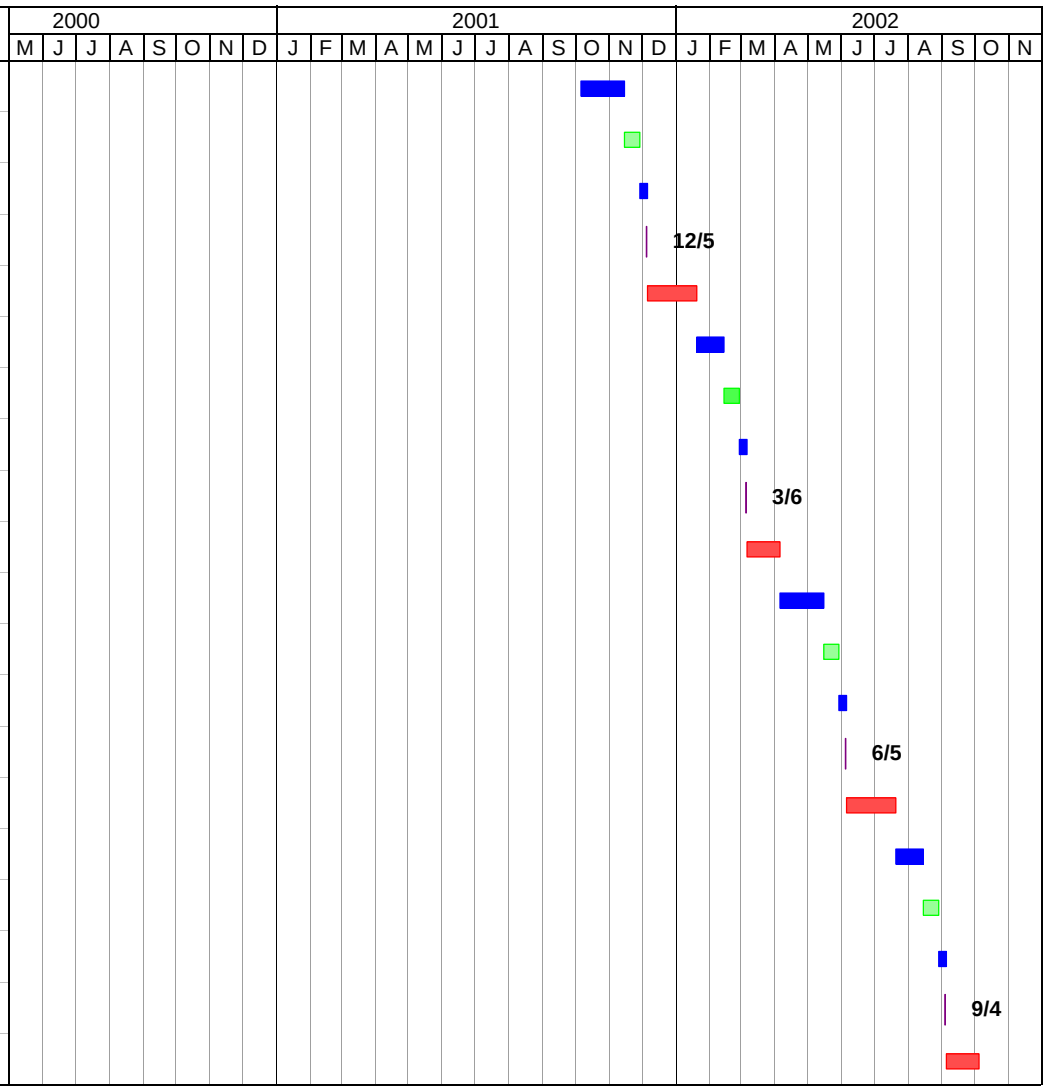


Project: CTO-0033
Date: 11/6/00
Page : 1

Baker Task
Navy Review
EPA Review
Submittal to EPA

Figure 7-1
Corrective Measures Study - Proposed Schedule
SWMU 9 - Tanks 212-217
Naval Station Roosevelt Roads, Puerto Rico

Task Name	Duration	Start	Finish
Draft CMS Task I Report	40 edays	10/5/01	11/14/01
Navy Review	14 edays	11/14/01	11/28/01
Draft CMS Task I Report Revisions	7 edays	11/28/01	12/5/01
Draft CMS Task I Report Due to EPA	1 day	12/5/01	12/5/01
EPA Review	45 edays	12/5/01	1/19/02
Final CMS Task I Report	25 edays	1/19/02	2/13/02
Navy Review	14 edays	2/13/02	2/27/02
Final CMS Task I Revisions	7 edays	2/27/02	3/6/02
Final CMS Task I Report Due to EPA	1 day	3/6/02	3/6/02
EPA Review/Approval	30 edays	3/6/02	4/5/02
Draft CMS Task II Report	40 edays	4/5/02	5/15/02
Navy Review	14 edays	5/15/02	5/29/02
Draft CMS Task II Report Revisions	7 edays	5/29/02	6/5/02
Draft CMS Task II Report Due To EPA	1 day	6/5/02	6/5/02
EPA Review/Approval	45 edays	6/5/02	7/20/02
Final CMS Task II Report	25 edays	7/20/02	8/14/02
Navy Review	14 edays	8/14/02	8/28/02
Final CMS Task II Revisions	7 edays	8/28/02	9/4/02
Final CMS Task II Report Due to EPA	1 day	9/4/02	9/4/02
EPA Review/Approval	30 edays	9/4/02	10/4/02



Project: CTO-0033
Date: 11/6/00
Page : 2

Baker Task
Navy Review
EPA Review
Submittal to EPA