Revised Final II

Corrective Measures Study Work Plan
Army Cremator Disposal Site - SWMU 1
Langley Drive Disposal Area - SWMU 2

Naval Station Roosevelt Roads

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LIST OF ACRONYMS AND ABBREVIATIONS

AET	Apparent Effects Threshold
AOC	Area of Concern
AQUIRE	Aquatic Toxicity Information Retrieval
BAF	Bioaccumulation Factor
BAF_m	Soil-Small Mammal Bioaccumulation Factor
BAF_w	Soil-Earthworm Bioaccumulation Factor
Baker	Baker Environmental, Inc.
BCF	Bioconcentration Factor
BCF_f	Surface Water-Fish Bioconcentration Factor
CCC	Criteria Continuous Concentration
CMC	Criteria Maximum Concentration
CMS	Corrective Measure Study
CNO	Chief of Naval Operations
COPC	Chemical of Potential Concern
C_{sed}	Chemical Concentration in Sediment
C_{soil}	Chemical Concentration in Soil
C_{sw}	Chemical Concentration in Surface Water
DI	Dietary Intake
EC_{50}	Median Effective Concentration
EPA	Environmental Protection Agency
ERA	Ecological Risk Assessment
ER-L	Effects Range - Low
ER-M	Effects Range – Medium
FCM	Food Chain Multiplier
g/g-day	Gram per Gram-Day
H	Ratio of Site Area to Home Range Area
HI	Hazard Index
HQ	Hazard Quotient
IR_f	Fish Ingestion Rate
IR_{sed}	Sediment Ingestion Rate
IR_{sw}	Surface Water Ingestion Rate
Kg	Kilogram
Kg/day	Kilogram per day
K_{ow}	Octanol-Water Partition Coefficient
L	Liter
LANTDIV	Naval Facilities Engineering Command, Atlantic Division
LC_{50}	Median Lethal Concentration
L/day	Liter per Day
L/kg	Liter per Kilogram
LOAEL	Lowest Observed Adverse Effect Level
MATC	Maximum Acceptable Test Concentration
MCL	Maximum Contaminant Level
mg/kg	Milogram per Kilogram

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

mg/kg/day	Milogram per Kilogram per day
mg/L	Milogram per Liter
NAWQC	National Ambient Water Quality Criteria
NEESA	Naval Energy and Environmental Support Activity
NOAEL	No Observed Adverse Effect Level
NOEC	No Observed Effect Concentration
NSRR	Naval Station Roosevelt Roads
PCBs	Polychlorinated Biphenyls
pH	Minus the Log of the Hydrogen Ion Concentration
PREQB	Puerto Rico Environmental Quality Board
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
SAP	Sampling and Analysis Plan
SDWA	Safe Drinking Water Act
SRC	Syracuse Research Corporation
SVOC	Semi-Volatile Organic Compound
SWMU	Solid Waste Management Unit
TCDD	2,3,7,8-Tetrachlorodibenzo-p-Dioxin
TCDF	2,3,7,8-Tetrachlorodibenzofuran
TEL	Threshold Effect Level
TSCA	Toxic Substances Control Act
USGS	United States Geological Survey
USFWS	United States Fish and Wildlife Service
VOC	Volatile Organic Compound

1.0 INTRODUCTION

This work plan presents the technical approach for conducting a Corrective Measures Study (CMS) at the Army Cremator Disposal Site (SWMU 1) and the Langley Drive Disposal Area (SWMU 2) located at Naval Station Roosevelt Roads (NSRR), Ceiba, Puerto Rico (see Figure 1-1). This CMS work plan has been prepared under contract to the Atlantic Division, Naval Facilities Engineering Command (LANTDIV), Contract Number N62470-89-4814.

1.1 Basis for the Work Plan

A RCRA Facility Investigation (RFI) was performed at SWMUs 1 and 2. The results of the investigations and subsequent human health risk assessment indicated that there were levels of inorganic and organic constituents present that posed potential risks to future residents and on-site construction workers. Based on the results of the risk assessment, a CMS for the sites is warranted.

The two SWMUs are being addressed together for a number of reasons most notably:

$ The two SWMUs are separated only by a paved access road.

$ The contaminants of concern are similar.

$ The risks posed by the SWMUs is very similar.

$ The corrective measure for the two SWMUs is expected to be the same and will be implemented for both simultaneously.

These conditions allow the units to be included in one CMS, which will result in reduced costs and an accelerated schedule.

1.2 Site Status Summary

The RCRA Corrective Action portion of Roosevelt Road=s permit contained specific requirements for investigations at SWMUs 1 and 2. The RFI was performed in 1997 and 1998. Results of the RFI are provided in the document entitled Revised Draft RCRA Facility Investigation Report for Operable Unit

3/5, Naval Station Roosevelt Roads, Ceiba, Puerto Rico which was submitted in April 1998. This document was revised based on EPA comments and submitted on April 1, 1999.

1.3 Organization of the CMS Work Plan

This CMS Work Plan is organized into six sections. The first section, 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 additional investigations to be performed are discussed in Section 3.0. The tasks to be accomplished as part of the CMS are described in Section 4.0. The project schedule is provided in Section 5.0. References cited in the work plan are provided in Section 6.0.

2.0 CMS OBJECTIVES AND GOALS

2.1 Objectives and Goals

The objective of this CMS Work Plan is to identify those tasks required to obtain additional data to assist in screening applicable remedial technologies for SWMU 1 and SWMU 2 at Naval Station Roosevelt Roads. This Work Plan also 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 which may be applicable to SWMUs 1 and 2 will be developed as part of the CMS ATask I@ reporting effort which will include the results of the ecological evaluation to be performed.

The corrective measure standards 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 Board (PREQB) standards. The Code of Federal Regulations (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 measure standards by incorporating standards that are determined to be protective of ecological receptors by the risk assessment process described in Section 3.2.

3.0 ADDITIONAL INVESTIGATIONS

3.1 Introduction

Human health risks have been calculated for the various possible exposure scenarios at each site; however, potential ecological risks have not been evaluated in detail. This evaluation is required to provide the information needed to completely assess the applicability of various remedial alternatives. An ecological risk evaluation is particularly important to the analysis of an "institutional controls" scenario.

3.2 Screening-Level Ecological Risk Assessment

A screening-level ecological risk assessment (screening-level ERA) will be conducted at SWMUs 1 and 2 to assess potential impacts to ecological receptors from chemicals detected in environmental media. Separate screening-level ERAs will be conducted at each SWMU using the process outlined in the EPA document entitled Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final (EPA 1997) and the Chief of Naval Operations (CNO) document entitled Navy Policy for Conducting Ecological Risk Assessments (CNO 1999).

The EPA and CNO risk assessment guidance contain the same eight-step process for conducting ecological risk assessments; however, the CNO policy clearly defines exit points and sub-steps that are present, but not clearly defined in the EPA guidance. The specific components of the EPA and CNO eight-step process are:

- Screening-level problem formulation and ecological effects evaluation (Step 1).
- Screening-level exposure estimate and risk calculation (Step 2).
- Baseline risk assessment problem formulation (Step 3).
- Study design and data quality objective process (Step 4).
- Field verification of sampling design (Step 5).

- Site investigation and analysis phase (Step 6).
- Risk characterization (Step 7).
- Risk management (Step 8).

Given that a screening-level ERA will be conducted at SWMUs 1 and 2, the screening-level ERA report will cover the first two steps of the EPA and CNO eight-step process (i.e., screening-level problem formulation and ecological effects evaluation and screening-level exposure estimate and risk calculation). The screening-level ERA will determine if a more site-specific investigation is warranted. The screening-level ERA will also be used to identify any data gaps associated with the existing analytical data.

The screening-level ERA will include Sub-Step 3a of the CNO policy. In this sub-step, the conservative exposure assumptions defined in the screening-level exposure estimate (see Section 3.2.3) will be refined and risk estimates will be re-calculated using the same preliminary conceptual model defined as part of the screening-level problem formulation. In the CNO guidance, Sub-Step 3a precedes the baseline risk assessment problem formulation, and is conducted to determine if risks detected in Step 2 are the result of overly conservative exposure assumptions required by the EPA guidance.

Given that ecological evaluations are iterative and dynamic processes, the entire scope of the ERA can not be identified at this time. Any work conducted beyond Sub-Step 3a of the CNO guidance will be identified and described in future risk assessment reports, work plan updates, or task-specific work plans.

3.2.1 Screening-Level Problem Formulation

The screening-level problem formulation involves the development of a preliminary conceptual model that provides the basic framework for the screening-level ERA. As part of this CMS Work Plan, a preliminary conceptual model has been developed for SWMUs 1 and 2. The preliminary conceptual model, presented as Figure 3-1, was developed based on current information and knowledge regarding:

- The environmental setting.

- Chemicals known or suspected to exist at the site.

- Chemical fate and transport mechanisms.

- Complete exposure pathways that might exist at the site.

- The likely ecological receptors that may be affected by chemicals detected at the site.

- Assessment and measurement endpoints used to evaluate potential ecological risks.

The screening-level ERA report for SWMUs 1 and 2 will include a detailed discussion of the issues listed above. An overview of the environmental setting, existing analytical data, and potential exposure pathways are presented in the sections that follow. A preliminary list of ecological receptors selected for evaluation, as well as preliminary assessment and measurement endpoints, are also identified. A discussion of fate and transport mechanisms is not presented in this CMS Work Plan; however, the evaluation of potential exposure pathways includes a discussion of potential migration pathways and exposure routes.

3.2.1.1 Environmental Setting

The screening-level ERA will include a detailed description of the site history, site habitats, and biota. At this time, a habitat characterization has not been conducted at SWMUs 1 and 2; therefore, specific knowledge of site habitat units and the biota that may reside or forage within them are not known at this time. The preliminary conceptual model and the discussion of site habitats and biota presented in this CMS Work Plan were developed using general, literature-based information for Puerto Rico and the entire landmass of NSRR.

In order to obtain site-specific information for SWMUs 1 and 2, a habitat characterization will be conducted as part of the screening-level ERA. The objectives of the habitat characterization will be the identification of:

- Relevant habitat units, including ecologically sensitive habitats, within and adjacent to SWMUs 1 and 2 that may be potentially impacted by previous waste management activities.

- Ecological receptors utilizing habitat units within each SWMU, including usage by special status species (i.e., threatened and endangered species).

- Current land usage within and adjacent to each SWMU.

- Potential fate and transport mechanisms.

- Reference sites that closely resemble the SWMU habitats with regard to their size and ecological traits.

Unrelated to the habitat characterization described above, NSRR has recently completed a base-wide wetland delineation. The screening-level ERA will include figures showing the location of any wetland units within and contiguous to SWMUs 1 and 2. The screening-level ERA will also include figures showing the location and extent of sea grass beds within the marine environment surrounding NSRR. The location of sea grass beds will be determined through a review of existing aerial photographs. Other sources of information regarding the location and extent of sea grass beds in the surrounding marine environment may also be investigated including the U.S. Fish and Wildlife Service (USFWS).

Given that the preliminary conceptual model presented in this CMS Work Plan was developed without specific knowledge of site habitats and wildlife usage, it will likely be refined to address the site-specific information collected during the habitat characterization. The preliminary list of ecological receptors selected for evaluation, as well as the preliminary assessment and measurement endpoints, may also require refinement following completion of the habitat characterization. An overview of the site history and current knowledge of habitats and biota are presented in the sections that follow.

3.2.1.1.1 Site History

Based on previous reports, SWMU 1 (Army Cremator Disposal Site) operated from the early 1940s until the early 1960s and was the main station landfill during this period. Waste was disposed at SWMU 1 by piling, burning, and compacting (A.T. Kearney, Inc. 1988). An estimated 100,000 tons of waste, including scrap metal, inert ordnance, batteries, tires, appliances, cars, cables, dry cleaning solvent cans, paint cans, gas cylinders, construction debris, dead animals, and residential waste was disposed at this site (NEESA 1984). SWMU 2 (Langley Drive Disposal Site) operated as a landfill from approximately 1939 to 1959. Navy documentation indicates that both hazardous and non-hazardous wastes were disposed at this unit.

3.2.1.1.2 Habitat

The upland habitat bounded by NSRR is classified as subtropical dry forest (Ewel and Witmore 1973). Similar to other forested areas of Puerto Rico, this region was previously clear-cut in the early part of the century, primarily for pasture land (Geo-Marine, Inc. 1998). After acquisition by the Navy, a secondary growth of thick scrub, dominated by leadtree (*Leucaena spp*.), box briar (*Randia aculeate*), sweet acacia (*Acacia famesiana*), and Australian corkwood (*Sesbania grandiflora*) grew in the previously grazed sections (Geo-Marine, Inc. 1998). Secondary growth vegetation exists today throughout the station's undeveloped upland, including the upland habitat within and adjacent to SWMUs 1 and 2. The current species composition of the secondary growth vegetation is not known at this time.

In addition to deep water marine habitat, the marine environment surrounding NSRR includes mudflats, mangroves (black mangroves, white mangroves, and red mangroves), and sea grass beds (turtle grass and manatee grass). The total area of mudflats, mangrove forests, and sea grass beds in the surrounding marine environment is approximately 161 acres, 2,200 acres, and 1,900 acres, respectively (Geo-Marine, Inc. 1998). Sea grass beds are important grazing areas for the green sea turtle (*Chelonia mydas*) and the West Indian manatee (*Trichechas manatus*). The green sea turtle is a federally-designated threatened species, while the West Indian manatee is a federally-designated endangered species. Both species have been reported to occur in the marine environment surrounding NSRR (Geo-Marine, Inc. 1998).

The marine environment immediately contiguous to SWMUs 1 and 2 consists of a mangrove forest of unknown species composition (see Figure 1-1). The Ensenada Honda, an open water bay, is located beyond the mangrove forest. The Ensenada Honda has been reported to contain sea grass beds (Geo-Marine, Inc. 1998). As discussed in Section 3.2.1.1, the presence of sea grass beds within the

Ensenada Honda will be verified through aerial photography. The mangrove forest contiguous to SWMUs 1 and 2 likely serves as a nursery for many marine fish species, and represents safe nesting and foraging habitat for a variety of birds. It is not known if mud flats are contiguous to SWMUs 1 and 2. The presence or absence of mud flats downgradient from SWMUs 1 and 2 will be determined during the habitat characterization.

3.2.1.1.3 <u>*Biota*</u>

A total of 22 terrestrial mammal species are known historically from Puerto Rico; however, all mammals except bats (13 species) have been extirpated (USGS 1999). None of the bats found on Puerto Rico are exclusive to the island. Although the occurrence of bats at NSRR has not been documented, their presence is likely. The sea grass beds surrounding NSRR provide important feeding habitat for the West Indian manatee. As discussed in Section 3.2.1.1.2, West Indian manatees are known to occur in the marine environment surrounding NSRR. Several mammals have been introduced in Puerto Rico, including the black rat (*Rattus rattus*), Norway rat (*Rattus norvegicus*), and mongoose (*Herpestes javanicus*). These nonindigenous mammals have been implicated in the decline of several bird and reptile populations (USGS 1999 and USFWS 1996).

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

Numerous native and migratory bird species have been reported at NSRR (Geo-Marine, Inc. 1998). It is noted that the list of known avian occurrences compiled by Geo-Marine, Inc. (1998) is based on literature-based information that pre-dated 1990. Regardless, the list includes the great blue heron (*Ardea herodias*), snowy egret (*Egretta thula*), little blue heron (*Florida caerulea*), black-crowned night heron (*Nycticorax nycticorax*), belted kingfisher (*Ceryle alcyon*), spotted sandpiper (*Actitis macularia*), greater yellowlegs (*Tringa melanoleauca*), black-bellied plover (*Squatarola squatarola*), clapper rail (*Rallus longirostris*), Royal tern (*Thalasseus maximus*), sandwich tern (*Thalasseus sandvicensis*), least tern (*Stema albifrons*), yellow warbler (*Dendroica petechia*), palm warbler (*Dendroica palmarum*), prairie warbler (*Dendroica discolar*), magnolia warbler (*Dendrocia magnolia*), red-legged thrush (*Mimocichla plumbea*), common nighthawk (*Chordeiles minor*), and red-tailed hawk (*Buteo jamaicensis*).

Endemic species reported from NSRR include the Puerto Rican lizard cuckoo (*Saurothera vieilloti*), Puerto Rican flycatcher (*Myiarchus antillarum*), Puerto Rican woodpecker (*Malanerpes portoricensis*), Puerto Rican emerald (*Chlorostilbon maugaeus*), and yellow-shouldered blackbird (*Agelaius xanthomus*).

The yellow-shouldered blackbird is a federally-designated endangered species. One of the principal reasons for the status of this species is attributed to parasitism by the nonindigenous shiny cowbird, which lays its eggs in blackbird nests and sometimes punctures the host's eggs (USFWS 1983). Other factors contributing to the status of this species include nest predation by the introduced black rat, Norway rat, and mongoose, as well as habitat modification and destruction (USFWS 1996). The entire land area of NSRR was declared critical habitat for the yellow-shouldered blackbird in 1976; however, a 1980 agreement with the USFWS exempted certain areas from this categorization (Geo-Marine, Inc. 1998). A study conducted by the Naval Facilities Engineering Command (1996) reported that the mangrove forests surrounding NSRR, including those adjacent to SWMUs 1 and 2, should be considered the most important nesting habitats for the yellow-shouldered blackbird. It is noted that the last reported nesting pair of yellow-shouldered blackbirds at NSRR was in 1986 (USFWS 1996). Other federally-designated bird species that have been reported at NSRR or have the potential to occur are the brown pelican (*Pelecanus occidentalis*), roseate tern (*Sterna dougallii dougallii*), and piping plover (*Charadrius melodus*) (Geo-Marine, Inc. 1998). A complete list of birds reported from NSRR is provided in Table 3-1.

A total of 23 amphibians and 47 reptiles are known from Puerto Rico and the adjacent waters (USGS 1999). Fifteen of the amphibians and 29 of the reptiles are endemic, while four amphibian species and three reptilian species have been introduced (USGS 1999). Puerto Rico's native amphibian species include 16 species of tiny frogs commonly called coquis. Only the Puerto Rican ridge-headed toad and the golden coqui have been listed (as threatened) under the provisions of the Endangered Species Act of 1973. Their occurrence at NSRR is not known. Puerto Rico's native reptilian species include 31 lizards, 8 snakes, 1 freshwater turtle, and 5 sea turtles (USGS 1999). Of the five sea turtles, the green sea turtle (*Chelonia mydas*), hawksbill sea turtle (*Eretmochelys imbricata*), and loggerhead sea turtle (*Dermochelys coriacea*) nest within Puerto Rico. These three sea turtles, as well as the Puerto Rican boa (*Epicrates inornatus*), have been listed under the provisions of the Endangered Species Act of 1973 (USFWS 1999). All four species are known to occur or have the potential to occur at NSRR (Geo-Marine, Inc. 1998). It is noted that a comprehensive list of amphibians and reptiles present at NSRR, particularly frogs and lizards, is not available from the literature.

A diverse fish and invertebrate community can be found in the offshore marine environment surrounding NSRR. This can be attributed to the varied habitats that include deep water marine habitat, mud flats, sea grass beds, and mangrove forests. Although too numerous to list individually by species, the fish community is represented by stingrays, herrings, groupers, needlefishes, mullets, barracudas, jacks, snappers, grunts, snooks, lizardfishes, parrotfishes, gobies, filefishes, wrasses, damselfishes, and butterflyfishes (Geo-Marine, Inc. 1998). As discussed in Section 3.2.1.1.2, the mangrove forest adjacent to SWMUs 1 and 2 likely functions as a nursery for many of the fish species found in the surrounding marine environment.

3.2.1.2 Available Analytical Data

Sampling activities at SWMUs 1 and 2 have previously been conducted under a Confirmation Study (1988), Supplemental Investigation Study (1993), Relative Risk Ranking Study (1995) and two RFI Studies (1996 and 1997). A summary of the general analyses performed for specific media is presented below. Sampling locations are shown on Figures 3-2 (SWMU 1) and 3-3 (SWMU 2).

Surface and Subsurface Soil

Confirmation Study (SWMU 2): VOCs, SVOCs, Pesticides/PCBs, and Inorganics
Supplemental Investigation (SWMUs 1 and 2): VOCs, SVOCs, Pesticides/PCBs, and Inorganics
1996/1997 RFI (SWMUs 1 and 2): Appendix IX List and Explosives

Groundwater

Confirmation Study (SWMUs 1 and 2): VOCs, SVOCs, Pesticides/PCBs, and Inorganics
Supplemental Investigation (SWMU 1): SVOCs, Pesticides/PCBs, and Inorganics
Supplemental Investigation (SWMU 2): VOCs, SVOCs, Pesticides/PCBs, and Inorganics
1996/1997 RFI (SWMUs 1 and 2): Appendix IX List, Explosives, and Sodium

Surface Water

Confirmation Study (SWMUs 1 and 2): VOCs, SVOCs, Pesticides/PCBs, and Inorganics

Sediment

Confirmation Study (SWMUs 1 and 2): VOCs, SVOCs, Pesticides/PCBs, and Inorganics
Relative Risk Ranking Study (SWMUs 1 and 2): Appendix IX List
1996 RFI (SWMUs 1 and 2): Appendix IX List and Explosives

Base-wide background surface soil, subsurface soil, and groundwater samples were also collected during the 1996 RFI investigation. These background samples were analyzed for the Appendix IX list. Analytical results from each investigation, including the background analytical data, have previously been reported in the document entitled Revised Draft RCRA Facility Investigation Report for Operable Unit 3/5 (Baker 1999). As such, they are not included in this report.

For the evaluation of potential risks to ecological receptors, the analytical results from each investigation will be combined into one unified database. The screening-level ERA will contain summary tables for the combined database that show the frequency of detection, range of positive detections and non-detected results, maximum detected concentrations, location of maximum detections (i.e., sample identification), and arithmetic mean concentrations for each environmental media. For those reasons discussed in Section 3.2.1.3.3, chemicals detected in subsurface soil samples will not be retained for evaluation in the screening-level ERA. Furthermore, for a given medium, only those chemicals detected in at least one sample will be included in the evaluation of potential risks.

Chemicals detected in site media will not be eliminated from evaluation based on a comparison to background data; however, the background data will be evaluated in the screening-level ERA. Specifically, estimated risks from potential exposures to chemicals detected in background media (surface soil and groundwater) will be compared to estimated risks from potential exposures to chemicals in site media. This comparison will determine if risks detected at SWMUs 1 and 2 are site-related.

The analytical data from the Confirmation Study, Supplemental Investigation, Relative Risk Ranking Study, and 1996/1997 RFI Studies have not previously been evaluated by a screening-level ERA. However, Baker (1999) did compare the available sediment analytical data for SWMUs 1 and 2 to Effects Range-Low (ER-L) and Effects Range-Median (ER-M) marine and estuarine sediment quality guidelines (Long et al. 1995). Detections exceeding ER-L and ER-M sediment quality guidelines are shown in Figures 3-4 (SWMU 1) and 3-5 (SWMU 2). Given that ER-L and ER-M sediment quality guidelines may not represent conservative threshold screening values (see Section 3.2.2.1), the results of the comparison were not used in the development of this work plan. It is acknowledged that exceedences of the ER-L and ER-M sediment quality guidelines shown in Figures 3-4 and 3-5 indicate that potential risks to ecological receptors (sediment-associated biota) exist within the mangrove forest downgradient from SWMUs 1 and 2.

With the exception of a single sample collected from a drainage ditch at the point the ditch intersects the mangrove forest downgradient from SWMU 1, the sediment samples collected during the 1996 RFI investigation were taken from shallow swales located within upland habitat. Although heavy rainfall occurred during the investigation (Baker 1999), flow was not observed within the swales (or the drainage ditch identified in the preceding sentence). As such, they do not represent temporary aquatic habitat. Some or all of the sediment samples collected from swales during the 1996 RFI may be re-designated as surface soil samples. If so, the screening-level ERA report will include a discussion that provides justification for the re-designation.

It is noted that the confirmation study surface water and sediment samples and the Relative Risk Ranking Study sediment samples were collected from the mangrove forest, near its boundary within upland habitat. Surface water and sediment samples have not been collected from the Ensenada Honda during any of the previous field investigations.

3.2.1.3 Identification of Potential Exposure Pathways

In order for an exposure to occur, a complete exposure pathway must exist with the following conditions:

- A source and mechanism of chemical release into the environment.
- An environmental transport medium.
- A point of potential contact with the medium.
- A feasible exposure route at the contact point.

The screening-level ERA for SWMUs 1 and 2 will consider potential receptor exposures to chemicals in groundwater, surface water, sediment, and soil (surface and subsurface soil). A preliminary conceptual model for SWMUs 1 and 2 is presented as Figure 3-1. A discussion of potential exposure pathways, ecological receptors, and exposure routes is presented in the sections that follow.

3.2.1.3.1 Groundwater Exposure Pathway

The potential release source for the groundwater exposure pathway is contaminated surface soil and subsurface soil, with the release mechanism being leaching/desorption and vertical migration of chemicals from surface to subsurface soil and groundwater (or leaching/desorption directly to subsurface soil and groundwater). Although a potential source and mechanism of release exist, the groundwater exposure pathway does not represent a complete exposure pathway for the following reasons:

- There are no known surface expressions of groundwater within SWMUs 1 and 2 (e.g., seeps, springs, etc.).

- Groundwater is not inhabited by ecological receptors.

Ecological receptors may potentially be exposed to chemicals in groundwater only if the chemicals migrate with the groundwater to surface water. Site hydrology indicates that groundwater flow at SWMUs 1 and 2 is toward the mangrove forest and the Ensenada Honda. As a result, ecological receptors residing or foraging within the mangrove forest and Ensenada Honda may be exposed to chemicals that have migrated with groundwater. An evaluation of potential exposures resulting from the migration of chemicals with groundwater is addressed in the evaluation of the surface water and sediment exposure pathway presented in the section that follows.

3.2.1.3.2 Surface Water and Sediment Exposure Pathway

The potential release sources for the surface water and sediment exposure pathway are surface soil and groundwater. Chemicals may migrate to surface water and sediment as a result of soil erosion from unvegetated areas (horizontal migration with storm water run-off and fugitive dust generation from wind erosion) and groundwater discharge. Contaminated sediment may also serve as a release source for adjacent areas if suspended in the water column.

The topography at SWMU 1 gently slopes to the north, south, and east. The topography sloping to the south and east is toward the mangrove forest. The topography at SWMU 2 is characterized as nearly flat, with a very gradual slope to the east from Langley Drive toward the mangrove forest. Shallow drainage features (swales) have been identified at SWMUs 1 and 2 (Baker 1999); therefore, migration of chemicals to the mangrove forest from soil erosion (storm water runoff) is possible. However, migration with storm-water run-off, as well as migration with surface soil from wind erosion, is likely to be hindered to a great extent by the secondary growth vegetation that is prevalent at SWMUs 1 and 2 (see Figures 3-2 and 3-3). As discussed in Section 3.2.1.3.1, the site hydrology indicates that groundwater flow from SWMUs 1 and 2 is toward the mangrove forest and Ensenada Honda; therefore, groundwater transport is a possible migration pathway for chemicals detected in groundwater.

Marine aquatic life (invertebrates and fish) may be exposed to chemicals that have potentially migrated to the mangrove forest and the Ensenada Honda. Aquatic life may be exposed to chemicals in surface water and sediment through incidental ingestion, dermal absorption, and food chain transfer (ingestion of contaminated food). Herbivorous marine mammals (i.e., West Indian manatees) and marine reptiles (i.e. sea turtles) foraging within the Ensenata Honda may be exposed to chemicals in surface water and sediment through incidental ingestion, dermal absorption, and food chain transfer. Piscivorous birds foraging within the mangrove forest may also be exposed to chemicals in surface water and sediment through incidental ingestion, dermal absorption, and food chain transfer.

Other receptors that may reside or forage within the mangrove forest include reptiles. The potential exposure routes for reptiles are incidental ingestion, dermal absorption, and food chain transfer. Given that surface water within the mangrove forest and the Ensenada Honda is saltwater, the surface water exposure pathway for all potential receptors, including terrestrial receptors, is incomplete for drinking water exposures. However, as discussed above, incidental ingestion is a potential exposure route for wildlife foraging within the mangrove forest and Ersenada Honda. It is noted that for all potential receptors, exposures from food chain transfer will be limited to those chemicals that bioaccumulate in lower trophic level organisms or biomagnify through successive trophic levels. Finally, the vegetation within the mangrove forest and the Ensenada Honda (mangrove trees and sea grass, respectively) may be exposed to chemicals that have potentially migrated to sediment through direct uptake (root uptake) from sediment pore water.

The available analytical data for surface water is limited to samples collected from the fringe of the mangrove forest during the 1988 Confirmation Study (see Section 3.2.1.2). As such, recent data on the nature and extent of contamination is not available. Surface water samples have not been collected from the Ensenada Honda during any of the previous investigations; therefore, it is not known if site-related chemicals have migrated to this water body. It is noted that the mangrove forest will intercept chemicals migrating with surface water run-off and likely intercepts chemicals migrating with groundwater. Regardless, the lack of surface water and sediment data for the Ensenata Honda and the limited surface water and sediment data for the mangrove forest prevents an evaluation of chemical migration at this time.

Given that limited data are available for surface water, the screening-level ERA will also utilize groundwater data from the combined database to evaluate potential risks to saltwater aquatic life. This will be accomplished by comparing maximum detected groundwater concentrations to the surface water threshold screening values identified in Section 3.2.1.2. The evaluation of groundwater data will assume no attenuation or dilution of chemicals detected in the groundwater samples. It is noted that these assumptions are extremely conservative.

3.2.1.3.3 *Subsurface Soil and Surface Soil Exposure Pathway*

The release sources for the subsurface and surface soil exposure pathway are the landfills. The release mechanisms from the landfills include leaching/desorption. Contaminated surface soil may also serve as a release source for downgradient areas. The release mechanisms from contaminated soil are surface water runoff and fugitive dust emissions. As discussed in Section 3.2.1.3.2, the release mechanisms from contaminated surface soil are likely hindered to a great extent by the secondary growth vegetation.

Soil invertebrates, such as earthworms, may be exposed to chemicals in surface soil through dermal absorption and ingestion. Because the toxicological database for soil invertebrates (i.e., earthworms) are based on *in situ* investigations that represent both exposure pathways, the screening-level ERA will consider both pathways together. Plants may be exposed to chemicals in surface soil through root uptake. Terrestrial birds may be exposed to chemicals in surface soil through incidental ingestion and food chain transfer. Dermal absorption is mostly excluded through feather coverings; however, preening will contribute to incidental ingestion. Mammals, reptiles, and amphibians may be exposed to chemicals in surface soil through incidental ingestion and food chain transfer. For mammals and some reptiles (e.g., snakes), dermal absorption is mostly excluded through fur and scale coverings, respectively. Similar to preening by birds, grooming by mammals will contribute to incidental ingestion. It is noted that for all potential terrestrial receptors, exposures from food chain transfer will be limited to those chemicals that bioaccumulate in lower trophic level organisms or biomagnify through successive trophic levels.

Subsurface soil will not be considered a complete exposure pathway for terrestrial receptors for the following reasons (Suter II 1995):

- The mass of most root systems is within the surface soil.
- Most soil heterotrophic activity is within the surface organic layer.
- Soil invertebrates occur on the surface or within the oxidized surface layer.

3.2.1.4 Selection of Ecological Receptors

As discussed in Section 3.2.1, a preliminary list of ecological receptors has been developed for the evaluation of potential risks at SWMUs 1 and 2. The selection of receptors took into consideration the following criteria:

- The ecological receptors are known to occur or are likely to occur at the SWMUs.
- The ecological receptors are representative of species known or likely to occur at the SWMUs.
- Life history information is available from the literature.
- Ecological receptors are represented by a potential complete exposure pathway.
- The ecological receptors are valued by society.

Based on current knowledge and information, sediment-associated biota, saltwater aquatic life, soil organisms (terrestrial plants and earthworms), a marine mammal (West Indian manatee), and four bird species (belted kingfisher, great blue heron, American robin, and red-tailed hawk) have been selected as preliminary receptors for the screening-level ERA at SWMUs 1 and 2. Given the similarities in available habitat and the presence of the same potential complete exposure pathways, identical receptors will be used in the evaluation of ecological risks at each SWMU. It is noted that the list of preliminary receptors may be refined following completion of the habitat characterization.

Sediment-associated biota and saltwater aquatic life were selected as ecological receptors based on their function as lower trophic level organisms within the mangrove forest and the Ensenada Honda food web. Fish that utilize the mangrove forest as a nursery area may also support commercial and sports fisheries in the offshore marine environment. Soil organisms (earthworms and plants) were selected as ecological receptors based on their function as lower trophic level organisms in the on-site terrestrial habitat. Specifically, plants function as primary producers, while earthworms, as well as other soil invertebrates, function as an important food source for a variety of terrestrial vertebrates.

The belted kingfisher and great blue heron were selected to represent the numerous piscivorous birds (i.e., fish-eating birds) know to occur at NSRR (see Table 3-1). The belted kingfisher was selected to represent small piscivores, while the great blue heron was selected to represent large piscivores. Both species have been reported at NSRR (Geo-Marine, inc. 1998) and both are represented by possible complete exposure pathways. As was previously discussed, the list of ecological receptors may be refined based on information collected during the habitat characterization. For example, if the habitat characterization identifies the presence of mud flats downgradient from SWMUs 1 and 2, a representative shore bird that feeds on aquatic invertebrates will likely be added to the list of ecological receptors.

The American robin was selected to represent the numerous insectivorous birds known to occur at NSRR, including the red-legged thrush and yellow-shouldered blackbird (a federally-designated endangered species), as well as the various flycatcher and warbler species (see Table 3-1). It is acknowledged that the American robin is not native to Puerto Rico, nor is it a migratory visitor (Raffaele 1989). An indigenous insectivore was not selected based on the lack of literature-based life history information (i.e., body weights and ingestion rates). Finally, the red-tailed hawk was selected to represent the terrestrial carnivores reported at NSRR. This carnivorous bird has been reported to occur at NSRR (see Table 3-1) and life history information for this species is readily available from the literature (EPA 1993).

It is acknowledged that aquatic invertebrates may serve as a food source for piscivorous birds such as the great blue heron. Therefore, exclusion of this potential exposure route will present uncertainty in the screening level ERA. A plant or seed-eating bird will not be selected as an ecological receptor. Although represented by a few species, primarily pigeons and doves (Geo-Marine, Inc 1998), the vast majority of birds known to occur at NSRR are piscivores and insectivores. Therefore, the screening-level ERA at SWMUs 1 and 2 will focus on those bird species known to be abundant at NSRR.

A terrestrial mammal was not selected as a preliminary ecological receptor for the following reasons:

- With the exception of bats, all native terrestrial mammal species have been extirpated from Puerto Rico.

- The nonindigenous terrestrial mammals present on the island, such as the black rat, Norway rat, and mongoose, are nuisance species that have been implicated in the decline of native reptile and bird populations.

- Life history information for Puerto Rico's native bat species is severely limited or lacking altogether.

Although the nonindigenous terrestrial mammals (rats and mongoose) are considered nuisance species, they may serve as a food source for terrestrial carnivores such as the red-tailed hawk. As discussed in Section 3.2.1.1, the Ensenata Honda may represent foraging habitat for the West Indian manatee. Given that this marine mammal is a federally designated species, it was selected as an ecological receptor. It is noted that the lack of surface water and sediment data for the Ensenada Honda prevents an evaluation of potential ecological risks to the West Indian manatee in the screening-level ERA (Step 1 and Step 2 of the EPA and CNO guidance). This receptor will be retained for evaluation in a subsequent step of the risk assessment process once this analytical data gap has been addressed through additional sampling. Because the West Indian manatee will not be evaluated in the screening-level ERA, this CMS Work Plan does not present methodology for evaluating potential risks to this marine mammal. As discussed in Section 3.2.7, methodology will be presented in a future work plan that will be developed to address analytical data gaps.

Although a potential complete exposure pathway exists for terrestrial amphibians and reptiles and marine reptiles at SWMUs 1 and 2, they will not be selected as receptor species because the toxicological database concerning the effects of chemicals on amphibians and reptiles is severely limited. In addition to being potential receptors, terrestrial amphibians and reptiles may also represent a food source for birds. Soil-small mammal bioaccumulation factors (BAFs) are available from the literature (Sample et al. 1998a); however, BAFs for ground-dwelling amphibians and reptiles have not been established. Based on differences between reptiles, amphibians, and mammals in terms of their physiology and feeding and foraging habits, the mammal BAFs will not be applied to amphibians and reptiles. Their exclusion as ecological receptors, as well as their exclusion as a food source for avian receptors, will present uncertainty in the screening-level ERA.

The vegetation growing within the surface waters downgradient from SWMUs 1 and 2 (i.e., mangrove trees and sea grass) were not selected as ecological receptors due to the lack of threshold screening values for aquatic plants. Surface soil toxicological benchmarks have been established for terrestrial vegetation (Efroymson et al. 1997b); however, these benchmarks will not be applied to the aquatic vegetation.

3.2.1.5 Assessment Endpoints and Measurement Endpoints

Assessment endpoints are intended to focus the risk assessment on particular components of the ecosystem that could be adversely affected by chemicals from the site. Specifically, assessment endpoints are ecological values designated for protection, such as survival, growth, and reproduction. Assessment endpoints usually encompass a group of species or populations with some common characteristic, such as a specific exposure route.

Measurement endpoints are measurable ecological characteristics that are related to the ecological values selected as assessment endpoints. The preliminary assessment endpoints and measurement endpoints selected for sediment-associated biota, saltwater aquatic life, soil organisms, and the avian receptors identified in Section 3.2.1.4 are summarized in Table 3-2. They were selected based on the potential ecological receptors and the potential for receptor exposures to the chemicals in site media. The availability of toxicity information upon which risk calculations could be based was also considered in their selection.

3.2.2 Screening-Level Ecological Effects Evaluation

The purpose of the screening-level ecological effects evaluation is the establishment of chemical exposure levels that represent conservative threshold screening values for adverse ecological effects (EPA 1997). The sections that follow present the specific literature-based threshold screening values that will be used for sediment-associated biota, saltwater aquatic life, soil invertebrates (earthworms and plants), and avian receptors. As discussed in Section 3.2.1.4, potential risks to the West Indian manatee will not be evaluated during the screening-level ERA. As such, threshold screening values for this receptor will be identified in a future work plan (see Section 3.2.7). This receptor has also been excluded form the discussion concerning the screening-level exposure estimate (Section 3.2.3), screening-level risk calculation (Section 3.2.4), and refinement of risk estimates (Section 3.2.6).

3.2.2.1 Threshold Screening Values for Sediment-Associated Biota

The following marine and estuarine sediment quality guidelines will be considered for use as threshold screening values for sediment associated biota:

- Threshold Effects Level (TEL) sediment quality guidelines developed by MacDonald (1994).

- Effects Range-Low (ER-L) marine and estuarine sediment quality guidelines values developed by Long et al. (1995).

- Interim Apparent Effects Threshold (AET) sediment quality guidelines developed by the Washington State Department of Ecology for Puget Sound (Buchman 1999).

For a given chemical, the specific sediment quality guideline selected as a threshold screening value will be the lowest value from the three sources listed above. For example, a TEL, ER-L, and AET value has been developed for copper (18.7 mg/kg, 34 mg/kg, and 390 mg/kg, respectively). For the screening-level ERA at SWMUs 1 and 2, the copper TEL developed by MacDonald (1994) will be used as the threshold screening value.

The screening-level ERA will contain a table summarizing available TEL, ER-L, and AET values for chemicals detected in sediment samples collected from SWMUs 1 and 2. The screening-level ERA will also contain a description of the methods utilized in their derivation.

3.2.2.2 Threshold Screening Values for Saltwater Aquatic Life

Saltwater National Ambient Water Quality Criteria (NAWQC) (EPA 1999a) will be used as threshold screening values for saltwater aquatic life. NAWQC for saltwater aquatic life contains two expressions of allowable magnitude: a criterion maximum concentration (CMC) to protect against acute (short-term) effects and a criterion continuous concentration (CCC) to protect against chronic (long-term) effects. For a given chemical, the specific criterion that will be used as the threshold screening value will be the chronic criterion (i.e., CCC). The use of NAWQC as conservative threshold screening values is documented in the literature (Suter II and Tsao 1996). The screening-level ERA report will contain a table summarizing the available NAWQC for chemicals detected in surface water and groundwater. For metals, total recoverable and dissolved criteria will be presented.

For those chemicals lacking established saltwater NAWQC, literature-based chronic No Observed Effect Concentrations (NOECs) reported by Buchman (1999) will be used as threshold screening values.

For those chemicals detected in surface water and groundwater samples lacking saltwater NAWQC and NOEC values, maximum detected surface water concentrations will be compared to available saltwater toxicity data compiled by the EPA in the Aquatic Toxicity Information Retrieval (AQUIRE) database. AQUIRE is a web-based application available through the EPA ECOTOX search page (EPA 1999b). The types of data that will be selected from the AQUIRE database are listed below.

- Acute values from 96-hour tests conducted with embryos and larvae of barnacles, bivalve mollusks (clams, mussels, oysters, and scallops), sea urchins, lobsters, crabs, shrimp, and abalones based on the percentage of organisms with incompletely developed shells plus the percentage of organisms killed (96-hour EC_{50} values), and acute values from 96-hour tests based on the percentage of organisms with incompletely developed shells, (96-hour EC_{50} values). EC_{50} and LC_{50} values from 48-hour tests were also selected from the database.

- Acute values from 96-hour tests with all other animal species (fish) and older life stages of barnacles, bivalve mollusks, sea urchins, lobsters, crabs, shrimps, and abalones based on the percentage of organisms exhibiting loss of equilibrium, plus the percentage of organisms immobilized, plus the percentage or organisms killed (96-hour EC_{50} values) and acute values from 96-hour tests based on the percentage of organisms killed (96-hour LC_{50} values). EC_{50} and LC_{50} values from 48-hour tests were also selected from the database.

- Acute values from 48-hour and 96-hour tests conducted with algae based on such endpoints as reductions in productivity and rate of population growth (48-hour EC_{50} and 96-hour EC_{50} values).

- Chronic values, such as NOECs and Maximum Acceptable Test Concentrations (MATCs) from life-cycle and partial life-cycle toxicity tests based on survival and growth of adults and young, maturation of males and females, eggs spawned per female, and hatchability and chronic values from early life stage tests based on survival and growth.

With the exception of 48-hour acute values for algae, the types of data listed above are recommended by the EPA (1994a) for deriving NAWQC. The EPA recommends the use of 96-hour acute values for algae (reason unknown). Acute values for algae based on a 48-hour endpoint will be included in the types of data selected from the AQUIRE database to maximize the literature data used in this screening-level ERA. It is noted that the AQUIRE database does not include detailed information regarding test procedures (e.g., exposure system and exposure conditions); therefore, the methodology used to generate a data entry will not be reviewed to determine the acceptability of the reported test endpoint. The screening-level ERA will contain a table summarizing the available effect concentration data for those chemicals lacking NAWQC and chronic NOECs.

It is noted that only chronic effect concentration data will be used as threshold screening values. If the database for a given chemical is limited to acute values, acute effect concentrations will not be used as threshold screening values for the following reasons:

- LC_{50} and EC_{50} values represents the chemical concentration that kills and adversely effects (kills, immobilizes, etc.), respectively, 50 percent of the exposed organisms.

- Acute effect concentrations do not represent chronic effect concentrations for sensitive endpoints (growth and reproduction).

3.2.2.3 Threshold Screening Values for Soil Organisms

Surface soil toxicological benchmarks developed by Efroymson et al. (1997a and 1997b) will be used as threshold screening values for soil organisms (earthworms and plants). The screening-level ERA will contain a table summarizing the available toxicological benchmarks for chemicals detected in site surface soils.

3.2.2.4 Threshold Screening Values for Avian Dietary Intake Exposures

Literature-based No Observed Adverse Effect Level (NOAEL) values, expressed as a dose (mg/kg/day) and compiled by Sample et al. (1996), will be used as dietary intake threshold screening values for the belted kingfisher, great blue heron, American robin, and red-tailed hawk. Only literature-based NOAELs for avian species will be selected as threshold screening values. Mammalian NOAELs will not be used given the uncertainty of using data for one Class of organisms (Mammalia) and applying them to species from a second Class (Aves).

The specific NOAEL values selected as threshold screening values will be based on dietary ingestion exposures. In many cases, Sample et al. (1996) estimated an NOAEL from a reported LOAEL by dividing the LOAEL by a factor of ten. This method of estimation is consistent with EPA (1997) recommendations. For several chemicals, such as arsenic, lead, mercury, and selenium, Sample et al. (1996) has identified more than one avian NOAEL value from the literature. For a given chemical, the lowest NOAEL identified in Sample et al. (1996) will be selected as the dietary intake threshold screening value.

It is noted that the chemical-specific NOAEL values compiled by Sample et al. (1996) are based on toxicological studies with avian species other than those selected as preliminary receptor species for the screening-level ERA. Body-weight scaling factors are typically used for interspecies extrapolation among mammals (Travis and White 1988 and Travis et al. 1990); however, Sample et al. (1996) consider a NOAEL scaling factor of 1.0 most appropriate for interspecies extrapolation between birds. Therefore, the literature-based NOAELs will not be adjusted to reflect the body weight of the avian receptors selected for evaluation.

The screening-level ERA will contain a table that summarizes the chemical-specific NOAEL values selected as threshold screening values. For each NOAEL value, the summary table will also include the laboratory test species and the chemical form of material tested.

3.2.3 Screening-Level Exposure Estimate

The screening-level exposure estimate defines the exposure point concentrations used to evaluate potential risks to the preliminary list of receptors selected for evaluation. Dietary intake models are also developed and exposure assumptions defined.

3.2.3.1 Exposure Point Concentrations

Maximum detected chemical concentrations in sediment, surface water/groundwater, and surface soil will be used as exposure point concentrations for direct comparison to threshold screening values for sediment-associated biota, aquatic life, and soil organisms. Maximum detected chemical concentrations in sediment, surface water, and surface soil will also be used as exposure point concentrations for the following avian exposure routes:

- Ingestion of water.

- Ingestion of sediment.

- Ingestion of surface soil.

Exposure point concentrations will be estimated in the tissue of prey consumed by the avian receptors using maximum measured media concentrations and, when available, conservative literature-based bioconcentration factors (BCFs) and bioaccumulation factors (BAFs). A BCF indicates the degree to which a chemical may accumulate in organisms coincident with the concentration of the chemical in the surrounding media. They are calculated by dividing the concentration of a chemical in the tissue of organisms by the concentration in the surrounding media. In the absence of laboratory derived BCF values, aquatic life BCF values for organic chemicals can be estimated from their Log K_{ow} value. It is noted that BCF values do not account for the uptake of chemicals from dietary exposures. BAF values consider direct exposure to the surrounding media, as well as uptake from dietary exposures. The sections that follow identify sources of BCF/BAF values and the methodology that will be used to estimate the tissue concentration of chemicals in fish, earthworms, and small mammals. The screening-level ERA will contain a table summarizing the various BCF and BAF values that were used to estimate the tissue concentration of chemicals in the prey of avian receptors.

3.2.3.1.1 Estimation of Tissue Concentrations in the Prey of the Belted Kingfisher and Great Blue Heron

For the screening-level ERA, it will be assumed that the diet of the belted kingfisher and the great blue heron is 100 percent fish. The EPA (1995a) has reported that fish consumed by the belted kingfisher and the great blue heron are from trophic level 3. The tissue concentration of chemicals in trophic level 3 fish will be estimated by multiplying maximum detected surface water concentrations by chemical-specific BAF values. The BAF values will be derived by multiplying maximum, literature-based BCF values by an appropriate food chain multiplier (FCM) (EPA 1995b). BCF values will be taken from a variety of sources, including Sample et al. (1996), EPA (1994b), and ambient water quality criteria documents, as well as the EPA AQUIRE database (EPA 1999b) and the Syracuse Research Corporation (SRC) environmental fate database (SRC 2000).

For most inorganic compounds, BCFs and BAFs are assumed to be equal (EPA 1991, EPA 1995b, and Sample et al. 1996). Therefore, BAF values for inorganics will be estimated by multiplying their respective BCF values by an FCM of 1.0. In the case of mercury and selenium, an FCM may be applicable since their organometallic forms biomagnify (Sample et al. 1996).

For those organic chemicals detected in surface water that lack literature-based BCF values, BCF values will be estimated using the following regression equation from Veith and Kosian (1983):

$$\text{Log BCF} = (0.79)(\text{Log } K_{ow}) - 0.40$$

Log K_{ow} values that will be used to estimate BCF values are those reported by the EPA (1995c). BAF values for organic chemicals will be estimated by multiplying literature-based or estimated BCF values by appropriate FCMs. For a given organic chemical, the FCM is dependent on its Log K_{ow} value. For values less than 2.0, the trophic level 3 FCM is assumed to be equal 1.0 (EPA 1995b). Trophic level 3 FCM values for organic chemicals with Log K_{ow} values greater than 2.0 will be those established for the Great Lakes System (EPA 1995b).

It is acknowledged that the method described above for estimation of chemical concentrations in the tissue of fish will not account for the potential bioaccumulation of chemicals from sediment exposures through dermal absorption and incidental ingestion. For pelagic fish, these exposure routes are likely to be insignificant.

3.2.3.1.2 *Estimation of Tissue Concentrations in the Prey of the American Robin*

For the screening-level ERA, it will be assumed that the diet of the American robin is 100 percent earthworms. The tissue concentration of chemicals in earthworms will be estimated by multiplying maximum detected surface soil concentrations by chemical-specific soil-earthworm BAF values obtained from Sample et al. (1998b). Sample et al. (1998b) developed earthworm BAF values for ten metals (arsenic, cadmium, chromium, copper, mercury, manganese, nickel, lead, selenium, and zinc) and two organics (PCBs and TCDD) by compiling data from the literature that reported chemical concentrations in co-located earthworm and soil samples. BAF values were calculated for each observation and chemical and summary statistics were generated (mean BAF, median BAF, and 90th percentile BAF values).

The soil-earthworm BAF values used in the screening-level ERA will be based on the 90th percentile. For chemicals lacking Sample et al (1998b) soil-earthworm BAF values, maximum BAFs reported by Beyer and Stafford (1993) will be used to estimate the concentration of chemicals in the tissue of earthworms. For those chemicals lacking a BAF value from Sample et al. (1998b) and Beyer and Stafford (1993), a soil-earthworm BAF of 1.0 will be assumed. Under this assumption, the concentration of a chemical in the tissue of earthworms is assumed to equal the maximum concentration of that chemical in the tissue of earthworms.

3.2.3.1.3 *Estimation of Tissue Concentrations in Prey of the Red-Tailed Hawk*

In the screening-level ERA, it will be assumed that the prey of the red-tailed hawk is 100 percent small mammals. The tissue concentration of chemicals in small mammals will be estimated by multiplying maximum detected surface soil concentrations by chemical-specific soil-small mammal BAF values obtained from Sample et al. (1998a). Sample et al. (1998a) developed general, insectivore, herbivore, and omnivore trophic group BAF values for thirteen metals (arsenic, barium, cadmium, chromium, cadmium, cobalt, copper, iron, mercury, nickel, lead, selenium, and zinc), fluoride, and two organics (TCDD and TCDF) by compiling data from the literature that reported chemical concentrations in co-located small mammal and soil samples. BAF values were calculated for each observation and chemical and summary statistics were generated (mean BAF, median BAF, and 90th percentile BAF values).

The soil-small mammal BAF values used in the screening-level ERA will be based on the 90th percentile. As a measure of conservatism, the maximum 90th percentile values reported from the general, insectivore, herbivore, and omnivore trophic groups will be used for a given chemical. For those chemicals lacking a literature-derived soil-small mammal BAF, a BAF of 1.0 will be used (i.e., the concentration of the chemical in the tissue of small mammals is assumed to equal the maximum concentration of that chemical in site surface soil).

3.2.3.2 Avian Dietary Exposure Models

Conservative assumptions will be used to estimate the dietary intake of chemicals by the belted kingfisher, great blue heron, American robin, and red-tailed hawk. The specific conservative assumptions that will be applied to the dietary intake models are identified below.

- Maximum detected sediment, surface water, and surface soil concentrations will be used as exposure point concentrations for ingestion of sediment, surface water and surface soil.

- The concentration of chemicals in prey consumed by the upper trophic level avian receptors will be estimated using maximum detected concentrations for surface water and surface soil and conservative literature-derived BCFs and BAFs (see Section 3.2.3.1).

- The ratio of site area to home range area (foraging area) will be assumed to equal 1.0. That is, it will be assumed that receptors obtain 100 percent of there dietary intake from the consumption of prey located within SWMUs 1 and 2.

- All avian receptors will be considered permanent residents of Puerto Rico (i.e., non-migratory).

- Literature-based minimum body weights and maximum food ingestion rates will be used as model input parameters. For those receptors lacking literature-based food ingestion rates, values will be estimated using allometric equations (EPA 1993). When allometric equations are used, ingestion rates will be estimated using maximum body weights.

The dietary intake models that will be used to estimate the dietary intake of chemicals by the belted kingfisher, great blue heron, American robin, and red-tailed hawk are presented in the sections that follow. Species-specific model input parameters are also discussed and presented in Table 3-2.

3.2.3.2.1 *Dietary Intake Model for the Belted Kingfisher and Great Blue Heron*

The exposure routes addressed by the dietary intake model for the belted kingfisher and great blue heron will be ingestion of prey (fish), ingestion of water, and ingestion of sediment. Although there are no permanent freshwater bodies within or contiguous to SWMUs 1 and 2, it will be conservatively assumed that all water intake for both species occurs while they forage for fish within the mangrove forest adjacent to SWMUs 1 and 2. The dietary intake of chemicals from fish ingestion, surface water ingestion, and sediment ingestion will be estimated using the following equation modified from the EPA (1993):

$$DI = \frac{[(C_{sw})(BCF_f)(FCM)(IR_f) + (C_{sw})(IR_{sw}) + (C_{sed})(IR_{sed})][H]}{BW}$$

Where:

DI	=	Dietary intake (dose) of chemical (mg chemical/kg body weight/day)
C_{sw}	=	Chemical concentration in surface water (mg/L)
BCF_f	=	Surface water-fish bioconcentration factor (L/kg)
FCM	=	Food chain multiplier (unitless)
IR_f	=	Fish ingestion rate (kg/day)
IR_{sw}	=	Surface water ingestion rate (L/day)
C_{sed}	=	Chemical concentration in sediment (mg/kg)
IR_{sed}	=	Sediment ingestion rate (kg/day)
H	=	Ratio of site area to home range area (unitless)
BW	=	Body weight (kg)

As discussed in section 7.3.1.2, the screening-level ERA will assume that the belted kingfisher and great blue heron consume trophic level 3 fish. The body weight, fish ingestion rate, surface water ingestion rate, and sediment ingestion rate that will be utilized in the dietary intake model for the belted kingfisher are 0.125 kg, 0.1075 kg/day (dry weight), 0.02107 L/day, and 0.01075 kg/day (dry weight), respectively. The body weight represents a minimum body weight (unpublished data from Powdermill Nature Center as cited in EPA 1993). The fish ingestion rate was estimated from a maximum ingestion rate of 0.5 g/g-day (Alexander 1977 as cited in EPA 1993) and a maximum body weight of 0.215 kg (unpublished data from Powdermill Nature Center as cited in EPA 1993). The water ingestion rate was estimated from an allometric equation for birds (Calder and Braun 1983) and a maximum body weight of 0.215 kg. There are no data available from the literature regarding sediment ingestion rates for the belted kingfisher or similar species. The sediment ingestion rate that will be utilized in the screening-level ERA corresponds to 10 percent of the total fish ingestion rate. This percentage was arbitrarily selected to represent a conservative value.

The body weight, fish ingestion rate, water ingestion rate, and sediment ingestion rate that will be utilized in the dietary intake model for the great blue heron are 2.204 kg, 0.45183 kg/day (dry weight), 0.11122 L/day, and 0.045183 kg/day (dry weight), respectively. The body weight represents a minimum body weight (Hartman 1961 as cited in EPA 1993). The ingestion rate was estimated using an allometric equation for wading birds (Kushlan 1978) and a maximum body weight of 2.576 kg (Hartman 1961 as cited in EPA 1993). The drinking water ingestion rate was estimated using an allometric equation for birds (Calder and Braun 1983) and a maximum body weight of 2.576 kg. There are no data available from the literature regarding sediment ingestion rates for the great blue heron or similar species. The sediment ingestion rate that will be utilized in the screening-level ERA corresponds to 10 percent of the total fish ingestion rate. The percentage was estimated from data for waterfowl (Beyer et al. 1994). Identical to the belted kingfisher, this percentage was arbitrarily selected to represent a conservative value.

3.2.3.2.2 Dietary Intake Model for the American Robin

The exposure routes addressed by the dietary intake model for the American robin will be ingestion of prey (earthworms) and ingestion of soil. Because there are no freshwater bodies within or contiguous to SWMUs 1 and 2, ingestion of water does not represent a complete exposure route for the American robin. As such, this exposure route is not included in the dietary intake model. The dietary intake of chemicals from earthworm ingestion and surface soil ingestion will be estimated using the following equation modified from the EPA (1993):

$$DI = \frac{[(C_{soil})(BAF_w)(IR_w) + (C_{soil})(IR_{soil})][H]}{BW}$$

Where:

DI	=	Dietary intake (dose) of chemical (mg chemical/kg body weight/day)
C_{soil}	=	Chemical concentration in surface soil (mg/kg)
BAF_w	=	Soil-earthworm bioaccumulation factor (unitless)
IR_w	=	Earthworm ingestion rate (kg/day)
IR_{soil}	=	Surface soil ingestion rate (kg/day)
H	=	Ratio of site area to home range area (unitless)
BW	=	Body weight (kg)

The screening-level ERA will assume that the diet of the American robin is 100 percent earthworms. The body weight, earthworm ingestion rate, and surface soil ingestion rate that will be utilized in the dietary intake model are 0.0635 kg, 0.02045 kg/day (dry weight), and 0.00213 kg/day (dry weight), respectively. The body weight represents a minimum body weigh reported by Clench and Leberman (1978). The earthworm ingestion rate was estimated using an allometric equation for passerine birds (Nagy 1987) and a maximum body weight of 0.103 kg (Clench and Leberman 1978). The surface soil ingestion rate was estimated from data for the American woodcock (Beyer et al.1994). This ingestion rate corresponds to 10.4 percent of the total earthworm ingestion rate.

3.2.3.2.3 Dietary Intake Model for the Red-Tailed Hawk

The exposure routes addressed by the dietary intake model for the red-tailed hawk will be ingestion of prey (small mammals) and ingestion of surface soil. Identical to the American robin, surface water ingestion is not considered to be a complete exposure pathway for this receptor due to the absence of freshwater bodies within or contiguous to SWMUs 1 or 2. The dietary intake of chemicals by the red-tailed hawk will be estimated using the following equation modified from the EPA (1993):

$$DI = \frac{[(C_{soil})(BAF_m)(IR_m) + (C_{soil})(IR_{soil})][H]}{BW}$$

Where:

DI	=	Dietary intake (dose) of chemical (mg chemical/kg body weight/day)
C_{soil}	=	Chemical concentration in surface soil (mg/kg)
BAF_m	=	Soil-small mammal bioaccumulation factor (unitless)
IR_m	=	Small mammal ingestion rate (kg/day)
IR_{soil}	=	Surface soil ingestion rate (kg/day)
H	=	Ratio of site area to home range area (unitless)
BW	=	Body weight (kg)

The body weight, small mammal ingestion rate, and soil ingestion rate that will be utilized in the dietary intake model are 0.957 kg, 0.13585 kg/day (dry weight), and 0.013585 kg/day (dry weight). The body weight represents a minimum body weight (Steenhof 1983 as cited in EPA 1993). The small mammal ingestion rate was estimated from a maximum ingestion rate of 0.11 g/g-day (Craighead and Craighead 1956 as cited in EPA 1993) and a maximum body weight of 1.235 kg (Springer and Osborne 1983 as cited in EPA 1993). There are no data available from the literature regarding surface soil ingestion rates for the red-tailed hawk or similar species. The surface soil ingestion rate that will be utilized in the screening-level ERA corresponds to 10 percent of the total small mammal rate. This percentage was arbitrarily selected to represent a conservative value.

3.2.4 Screening-Level Risk Calculation

Maximum detected chemical concentrations in sediment, surface water, and surface soil will be used as exposure point concentrations for sediment-associated biota, saltwater aquatic life, and soil organisms, respectively. For each detected chemical in a given medium, a Hazard Quotient (HQ) value will be calculated using the following equation (EPA 1997):

HQ = Maximum Detected Concentration/Threshold Screening Value

For a given chemical, the threshold screening value for sediment-associated biota will be the lowest sediment quality guideline established by MacDonald (1994), Long et al. (1995) or the Washington State Department of Ecology (Buchman 1999). The surface water threshold screening values will be EPA NAWQC for saltwater aquatic life (EPA 1999). For those chemicals lacking established NAWQC, chronic NOEC values reported by Buchman (1999) will be used as surface water threshold screening values. For those chemicals lacking NAWQC and chronic NOEC values, maximum detected surface water concentrations will be compared to literature-based effect concentrations taken from the AQUIRE database (EPA 1999b). As discussed in Section 3.2.2.2, if the effect concentration database for a given chemical does not include chronic test data, HQ values will not be calculated since acute effect concentrations do not represent conservative threshold screening values. The surface soil threshold screening values will be toxicological benchmarks for earthworms and plants developed by Efroymson et al. (1997a and 1997b, respectively).

Those chemicals detected at concentrations exceeding their respective threshold screening values (i.e., chemicals with HQ values greater than 1.0) will be considered to present an unacceptable risk to associated ecological receptors. A chemical with a HQ value less than one will indicate that the chemical alone presents negligible risk to associated ecological receptors. Chemicals with HQ values greater than 1.0, chemicals lacking conservative threshold screening values, and chemicals not detected but whose laboratory reporting limits exceed applicable threshold screening values, will be retained as ecological COPCs in the screening-level ERA. The significance of HQ values has previous been judged as follows (Menzie et al. 1993):

- HQ values greater than 1.0 but less than 10: Some small potential for environmental effects.

- HQ values greater than 10 but less than 100: Significant potential that greater exposures could result in effects based on experimental evidence.

- HQ values greater than 100: Effects may be expected since this represents an exposure level at which effects have been observed in other species.

HQ values will also be calculated for avian receptor dietary intakes using the following equation (EPA 1997):

HQ = Estimated Dietary Intake/Literature-Based NOAEL or LOAEL

As was previously discussed, NOAEL and LOAEL values will be taken from Sample et al. (1996). It is noted that only NOAEL-based HQ values will be used to identify chemicals that present unacceptable risk. Therefore, the HQ values referred to in this screening-level risk calculation for avian receptors are NOAEL-based values.

HQ values for avian dietary exposures will be interpreted in an identical manner as those calculated for sediment-associated biota, saltwater aquatic life, and soil organisms. Specifically, HQ values greater than 1.0 will indicate that associated chemicals present an unacceptable risk, while HQ values less than 1.0 will indicate negligible risk. Chemicals with HQ values greater than 1.0 and chemicals lacking NOAELs, will be retained as ecological COPCs for avian receptors. The screening-level ERA will contain tables summarizing risk calculations (HQ values) for all receptors. Avian receptor and risk calculation worksheets will also be included in the screening-level ERA report for the avian receptors.

In addition to HQ values, Hazard Index (HI) values will be calculated for each receptor. HI values will be calculated for a given receptor by summing the individual chemical-specific HQ values. For the screening-level ERA, HI values will be calculated separately for inorganics, volatile organics, semi-volatile organics, and pesticides/PCBs. It is noted that the HI values should only be calculated for those chemicals that produce the same toxic mechanisms. The specific toxic mechanism of many chemicals is not known; therefore, the HI values presented in the screening-level ERA may not represent realistic combined risks from simultaneous exposures to chemicals detected in site media. For this reason, they will be presented in summary tables, but excluded from the discussion of potential risks.

3.2.5 Screening-Level Uncertainty Analysis

The screening-level ERA report will include a discussion and analysis of uncertainties, including uncertainties associated with toxicological benchmarks, ecological receptors, avian dietary intake models, and available analytical data.

3.2.6 Refinement of Conservative Exposure Assumptions and Recalculation of Risk Estimates

If the screening-level ERA (Step 1 and Step 2 of the EPA and CNO guidance) indicates the potential for adverse ecological effects, the conservative exposure assumptions applied in the screening-level ERA will be refined and risk estimates (HQ values) will be recalculated using the same conceptual model developed for each site. The refinement of exposure assumptions will represent Step 3a of the CNO guidance.

3.2.6.1 Refinement of Exposure Assumptions

The following modifications will be made to the conservative exposure assumptions utilized in the screening-level ERA:

- In place of maximum detected concentrations, arithmatic mean sediment, surface water/groundwater, and surface soil concentrations will be used as exposure point concentrations for direct comparison to threshold screening values for sediment-associated biota, aquatic life, and soil organisms, respectively. For mobile aquatic life, such as fish, mean chemical concentrations will provide a more reasonable estimate of exposure levels. It is acknowledged that sediment-associated biota and soil organisms are relatively immobile; therefore, an exceedence of threshold screening values at any location would imply a potential risk to some individual receptors. However, use of mean chemical concentrations will be more indicative of the level of impact that might be expected at the population level.

- Avian receptors are expected to forage at several locations within each SWMU. Therefore, in place of maximum detected sediment, surface water, and surface soil concentrations, arithmatic mean concentrations will be used as exposure point concentrations for estimation of avian dietary exposures to chemicals in these media.

- In place of maximum detected surface soil concentrations and 90th percentile BAF values, the tissue concentration of chemicals in the prey of the American robin and red-tailed hawk (earthworms and small mammals, respectively) will be estimated using arithmetic mean surface soil concentrations and log-linear regression models developed by Sample et al. (1998a and 1998b). For those chemicals lacking a regression model or a regression model with significant fit, median literature-based BAF values will be used in place of 90th percentile BAF values (Sample et al. 1998a and 1998b and Beyer and Stafford 1993). For those chemicals lacking a literature-based log-linear regression model or BAF value, a BAF value of 1.0 will be used.

- Average body weights, food ingestion rates, and drinking water ingestion rates (see Table 3-4) will be used in place of maximum body weights, food ingestion rates, and drinking water ingestion rates (see Table 3-3) for the estimation of avian receptor dietary intakes. The use of average exposure parameters will more closely represents the characteristics of a greater number of individuals within the population.

Conservative assumptions will still be applied to the recalculation of risks. For example, the ratio of site area to home range areas for avian receptors will be assumed to equal 1.0. Maximum BCF values will also be used to estimate the tissue concentrations of chemicals in the prey of the belted kingfisher and great blue heron. Furthermore, it will be assumed that all avian receptors are permanent residents (i.e., non-migratory). This assumption is not unreasonable given that the receptor species selected for evaluation are either permanent residents of Puerto Rico (Raffaele 1989) or are representative of permanent residents.

3.2.6.2 Recalculation of Risk Estimates

Based on the refined exposure assumptions presented in Section 3.2.6.1, the screening-level risk estimates will be recalculated using the same preliminary conceptual model (see Figure 3-1). The screening-level ERA report will include tables that summarize the recalculated risk estimates (HQ and HI values) for each receptor. Avian dietary intake and risk calculation worksheets for the refined exposure assumptions will also be included in the screening-level ERA report.

3.2.7 Sampling and Analytical Program to Address Data Gaps

Analytical data gaps identified during the screening-level ERA will be addressed by a focused field sampling and analytical program. A known data gap at this time is the lack of surface water and sediment data for the Ensenada Honda. Additional sampling may also be conducted to address uncertainties associated with the existing data. The analytical data generated to address data gaps and uncertainties will be used to evaluate potential risks to the West Indian manatee, further refine the screening-level ERA for those receptors evaluated in the screening-level ERA, and determine if the risk assessment process will proceed to the baseline ecological risk assessment problem formulation (See Section 3.2.8). It is noted that known data gaps will not be addressed prior to implementation of the screening-level ERA since additional data gaps may be identified at some point during the screening-level ERA process.

The sampling and analytical program addressing data gaps and uncertainties associated with existing data will be presented in a future work plan. This work plan will also include the methodology that will be used to evaluate potential risks to the West Indian manatee.

3.2.8 Baseline Risk Assessment Problem Formulation

The baseline ecological risk assessment problem formulation (Step 3 of the EPA guidance and Sub-Step 3b of the Navy guidance) will be performed if the screening-level ERA and Sub-Step 3a of the CNO guidance indicate that ecological receptors may be adversely affected by chemicals detected in the various environmental media. As part of the baseline risk assessment problem formulation, the preliminary conceptual model developed during the screening-level ERA process, including receptors, exposure pathways, and measurement and assessment endpoints, will be refined based upon the results of the screening-level ERA. 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 a 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 objective process) following approval of the baseline risk assessment problem formulation. 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 and described in a future work plan and Sampling and Analysis Plan (SAP). Any field sampling activities and studies conducted within site habitats will be duplicated within the appropriate reference sites identified during the habitat characterization discussed in Section 3.2.1.1.

4.0 POTENTIAL CORRECTIVE MEASURES

Following completion of the ecological evaluation, work will be started on the formal CMS. 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 following sections.

4.1 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 remediation of the contamination based on the objectives established for the corrective action. This will be based on the results of the RFI investigations at SWMUs 1 and 2 along with the ecological evaluations described within this document.

4.1.1 Description of the Current Situation

The current situation and the known nature and extent of contamination at SWMUs 1 and 2 will be described in this section. A statement of the purpose for the response, based on the results of the previous investigations will be provided as will the actual or potential exposure pathways that will be addressed by the corrective measures.

4.1.2 Establishment of Corrective Action Objectives

Site specific objectives for the corrective action will be established in conjunction with the EPA. These objectives will be based be based on public health and environmental criteria, information obtained from previous investigations, EPA 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.

4.1.3 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. This screening process focuses on eliminating those technologies which 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.

4.1.4 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 which appear most suitable for the site based on sound engineering shall be retained. Technologies can be combined to form the overall corrective action alternative or alternatives. The reasons for excluding any technology shall be documented.

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

Task II will be combined with Task I as it is expected that some variation of Ainstitutional controls@ will be the appropriate corrective measure for these SWMUs. Should this situation change as a result of the ecological evaluation a full Task II will be performed including analysis of the technical/environmental/human health/institutional aspects of each potentially appropriate corrective measure and the preparation of a cost estimate.

4.3 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 EPA 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 following sections will be used to justify the final corrective measure or measures.

4.3.1 Technical

4.3.1.1 Performance

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

4.3.1.2 Reliability

Corrective measure or measures which 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.

4.3.1.3 Implementability

Corrective measure or measures which 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.

4.3.1.4 Safety

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

4.3.2 Human Health

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

4.3.3 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.

4.4 Task IV - Reports

4.4.1 Progress

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

4.4.2 Corrective Measure Study (CMS) Final Report

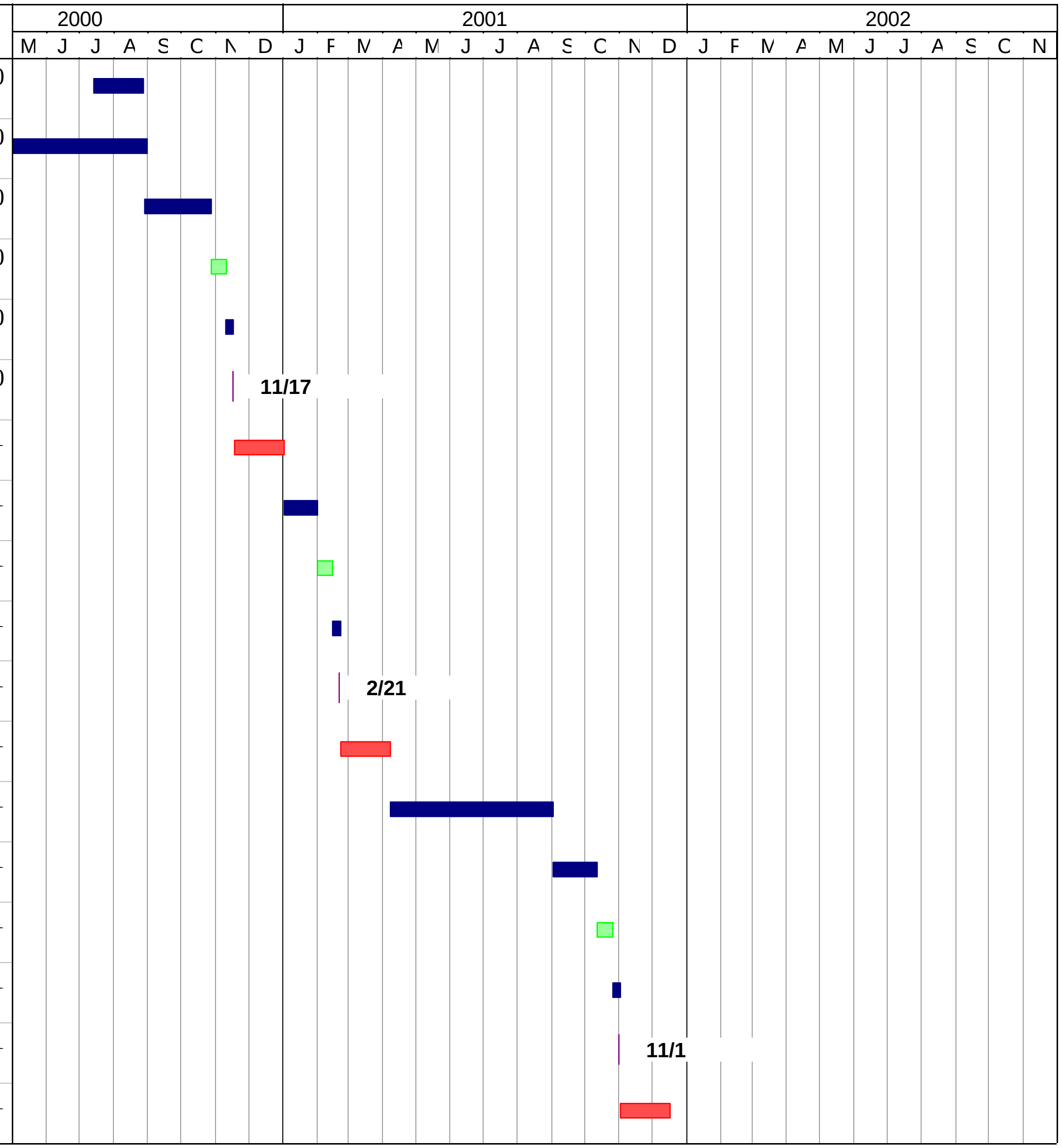
A CMS Final Report will be developed which includes all the information gathered under the approved CMS Work Plan. At a minimum the report will include a description of the facility, a summary of the corrective measure or measures, a summary of the previous investigations impact on the selected corrective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

5.0 SCHEDULE

The schedule for the implementation of this work is dependent upon the EPA approval of this document (Figure 5-1). This schedule will need to be revised if the EPA does not approve this Work Plan by 8/28/00. This schedule reflects the need for a Phase II Screening Level Ecological Risk Assessment. If the Initial Screening-Level Ecological Risk Assessment requires the Phase II Screening Level Ecological Risk Assessment to be performed, then the CMS portion of the schedule may need to be adjusted to reflect any necessary impacts to the schedule. The schedule is also heavily dependent on EPA review times. The potential for modifications to the schedule exists if the EPA review times and approval vary from those listed in the schedule. Other factors that may extend the schedule include the following: 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 EPA's comments are incorporated. The schedule of events included in this Work Plan is presented in Figure 5-1.

Figure 5-1
Corrective Measures Study - Proposed Schedule
SWMU 1 (Army Cremator Disposal Site) and SWMU 2 (Langley Drive Disposal Site)
Naval Station Roosevelt Roads, Puerto Rico

Task Name	Duration	Start	Finish
(estimated)	45 edays	7/14/00	8/28/00
Characterization	122 edays	5/1/00	8/31/00
Assessment	60 edays	8/28/00	10/27/00
Review	14 edays	10/27/00	11/10/00
Revisions	7 edays	11/10/00	11/17/00
EPA	1 day	11/17/00	11/17/00
Review	45 edays	11/17/00	1/1/01
Assessment	30 edays	1/1/01	1/31/01
Review	14 edays	1/31/01	2/14/01
Revisions	7 edays	2/14/01	2/21/01
EPA	1 day	2/21/01	2/21/01
Review/Approval	45 edays	2/21/01	4/7/01
required)	147 edays	4/7/01	9/1/01
Report	40 edays	9/1/01	10/11/01
Review	14 edays	10/11/01	10/25/01
Revisions	7 edays	10/25/01	11/1/01
EPA	1 eday	11/1/01	11/2/01
Review	45 edays	11/2/01	12/17/01



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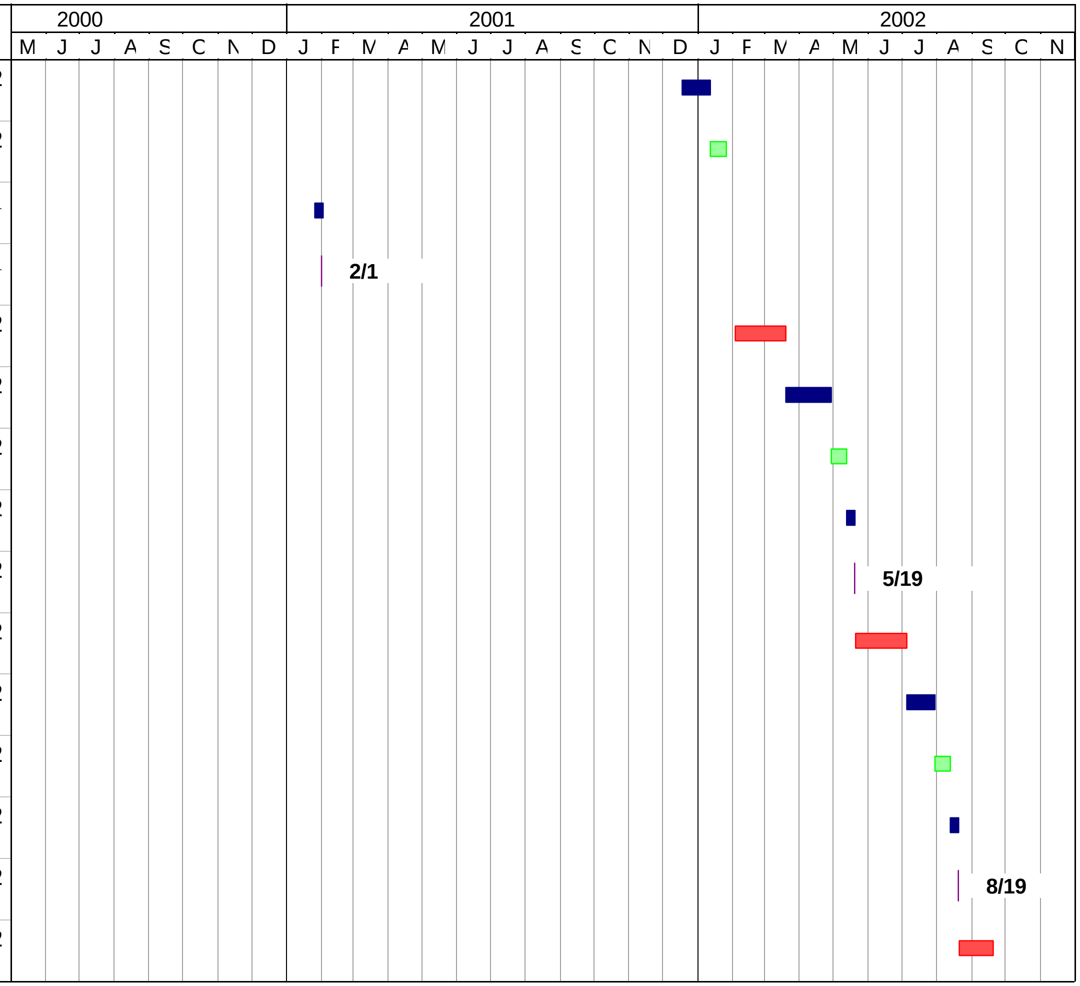
Baker Task
EPA Review
Navy Review
Submittal to EPA

Figure 5-1
Corrective Measures Study - Proposed Schedule
SWMU 1 (Army Cremator Disposal Site) and SWMU 2 (Langley Drive Disposal Site)
Naval Station Roosevelt Roads, Puerto Rico

Task Name	Duration	Start	Finish
Report	25 edays	12/17/01	1/11/02
Review	14 edays	1/11/02	1/25/02
Revisions	7 edays	1/25/01	2/1/01
EPA	1 eday	2/1/01	2/2/01
Review/Approval	45 edays	2/2/02	3/19/02
Report	40 edays	3/19/02	4/28/02
Review	14 edays	4/28/02	5/12/02
Revisions	7 edays	5/12/02	5/19/02
EPA	1 eday	5/19/02	5/20/02
Review/Approval	45 edays	5/20/02	7/4/02
Report	25 edays	7/4/02	7/29/02
Review	14 edays	7/29/02	8/12/02
Revisions	7 edays	8/12/02	8/19/02
EPA	1 eday	8/19/02	8/20/02
Review/Approval	30 edays	8/20/02	9/19/02



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TABLES

TABLE 3-1

**LIST OF BIRDS REPORTED FROM NAVAL STATION ROOSEVELT ROADS
SMWU 1 (ARMY CREMATOR DISPOSAL SITE) AND
SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
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 3-1 (Continued)

LIST OF BIRDS REPORTED FROM NAVAL STATION ROOSEVELT ROADS SMWU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA) 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 3-2

PRELIMINARY ASSESSMENT ENDPOINTS, RISK HYPOTHESES, MEASUREMENT ENDPOINTS, AND RECEPTORS
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Assessment Endpoint	Risk Hypothesis	Measurement Endpoint	Receptor Species
Protection of sediment-associated biota from the toxic effects (on survival and growth) of site-related chemicals present in sediment.	Are levels of site-related chemicals present in sediment sufficient to cause adverse effects on the survival and growth of sediment-associated biota at the site?	Comparison of exposure HQs to a reference HQ of 1.0. Exposure HQs are calculated for individual chemicals by dividing the sediment concentrations by sediment threshold screening values. A reference HQ of 1.0 represents a condition where the sediment concentration is equal to the screening threshold value.	Sediment-Associated Aquatic Life
Protection of saltwater aquatic life from the toxic effects (on survival, growth, and reproduction) of site-related chemicals present in surface water.	Are levels of site-related chemicals present in surface water sufficient to cause adverse effects on the survival, growth, and reproduction of saltwater aquatic life at the site?	Comparison of exposure HQs to a reference HQ of 1.0. Exposure HQs are calculated for individual chemicals by dividing the surface water concentrations by surface water screening threshold values. A reference HQ of 1.0 represents a condition where the surface water concentration is equal to the screening threshold value.	Saltwater Aquatic Life (Invertebrates and Fish)
Protection of soil invertebrate and plant communities from the toxic effects (on survival and growth) of site-related chemicals present in surface soil.	Are levels of site-related chemicals present in surface soils sufficient to cause adverse effects on the survival and growth of soil invertebrates and plants at the site?	Comparison of exposure HQs to a reference HQ of 1.0. Exposure HQs are calculated for individual chemicals by dividing the soil concentrations by invertebrate, microorganism, or plant-based soil screening threshold values. A reference HQ of 1.0 represents a condition where the soil concentration is equal to the screening threshold value.	Earthworms and Plants
Protection of herbivorous marine mammals from the toxic effects (on survival, growth, and reproduction) of site-related chemicals present in surface water and sediment.	Are levels of site-related chemicals present in surface water, sediment, and forage (e.g., sea grass) sufficient to cause adverse effects on the survival and growth of herbivorous marine mammals	Comparison of dietary intake HQs to a reference of 1.0. Dietary HQs are calculated for individual chemicals by dividing an estimated level of exposure by an ecotoxicity value that is associated with a NOAEL. A reference HQ of 1.0 represents a dietary dose that is equal to the NOAEL ecotoxicity value.	West Indian Manatee

TABLE 3-2 (Continued)

PRELIMINARY ASSESSMENT ENDPOINTS, RISK HYPOTHESES, MEASUREMENT ENDPOINTS, AND RECEPTORS
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Assessment Endpoint	Risk Hypothesis	Measurement Endpoint	Receptor Species
Protection of piscivorous birds consuming fish to ensure that ingestion of chemicals in surface water, sediment, and prey does not have a negative impact on survival, growth, and reproduction.	Are levels of site chemicals in surface water, sediment, and prey sufficient to cause adverse effects on the survival, growth, and reproductive success of piscivorous birds utilizing the site?	Comparison of dietary intake HQs to a reference of 1.0. Dietary HQs are calculated for individual chemicals by dividing an estimated level of exposure by an ecotoxicity value that is associated with a NOAEL. A reference HQ of 1.0 represents a dietary dose that is equal to the NOAEL ecotoxicity value.	Great Blue Heron Belted Kingfisher
Protection of insectivorous birds consuming soil invertebrates (earthworms) to ensure that ingestion of chemicals in soil and prey does not have a negative impact on survival, growth, and reproduction.	Are levels of site chemicals in soil and prey (soil invertebrates) sufficient to cause adverse effects on the growth, survival, and reproductive success of insectivorous birds using the site?	Comparison of dietary HQs to a reference of 1.0. Dietary HQs are calculated for individual chemicals by dividing an estimated level of exposure by an ecotoxicity value that is associated with a NOAEL. A reference HQ of 1.0 represents a dietary dose that is equal to the NOAEL ecotoxicity value.	American Robin
Protection of carnivorous birds consuming small mammals to ensure that ingestion of chemicals in soil and prey does not have a negative impact on survival, growth, and reproduction.	Are levels of site contaminants in soils and prey (small mammals) sufficient to cause adverse effects on the growth, survival, and reproductive success of carnivorous birds using the site?	Comparison of dietary HQs to a reference of 1.0. Dietary HQs are calculated for individual chemicals by dividing an estimated level of exposure by an ecotoxicity value that is associated with a NOAEL. A reference HQ of 1.0 represents a dietary dose that is equal to the NOAEL ecotoxicity value.	Red-Tailed Hawk

TABLE 3-3

CONSERVATIVE AVIAN RECEPTOR LIFE HISTORY PARAMETERS
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Life History Parameters	Belted Kingfisher	Great Blue Heron	American Robin	Red-Tailed Hawk
Diet	100% Trophic Level 3 Fish	100% Trophic Level 3 Fish	100% Earthwoms	100% Small Mammals
Body Weight	0.125 kg (1)	2.204 kg (5)	0.0635 kg (9)	0.957 kg (13)
Food Ingestion Rate	0.1075 kg/day (2) (Dry Weight)	0.45183 kg/day (6) (Dry Weight)	0.02045 kg/day (10) (Dry Weight)	0.13585 kg/day (14) (Dry Weight)
Water Ingestion Rate	0.02107 L/day (3)	0.11122 L/day (7)	Not Applicable (11)	Not Applicable (11)
Percent Sediment/Soil in Diet	10% (4) (Dry Weight)	10% (8) (Dry Weight)	10.4% (12) (Dry Weight)	10% (15) (Dry Weight)

Notes:

(1) Minimum body weight reported by Powdermill Nature Center (unpublished data cited in EPA 1993).

(2) Estimated from an ingestion rate of 0.5 g/g-day (Alexander 1977) and a maximum body weight of 0.215 kg reported by Powdermill Nature Center (unpublished data cited in EPA 1993).

(3) Estimated using an allometric equation for birds (Calder and Braun 1983) and a maximum body weight of 0.215 kg reported by Powdermill Nature Center (unpublished data cited in EPA 1993).

(4) Data was not available from the literature. The percentage shown represents a conservative estimate. Given a food ingestion rate of 0.1075 kg/day, this percentage corresponds to a sediment ingestion rate of 0.01075 kg/day.

(5) Minimum average body weight reported by Hartman (1961) for adult females as cited in EPA 1993.

(6) Estimated using an allometric equation for wading birds (Kushlan 1978) and a maximum body weight of 2.576 kg reported by Hartman (1961) as cited in EPA 1993.

(7) Estimated using an allometric equation for birds from (Calder and Braun 1983) and a maximum body weight of 2.576 kg reported by Hartman (1961) as cited in EPA 1993.

(8) Data was not available from the literature. The percentage shown represents a conservative estimate. Given a food ingestion rate of 0.45183 kg/day, this percentage corresponds to a sediment ingestion rate of 0.045183 kg/day.

(9) Minimum body weight reported by Clench and Leberman (1978).

(10) Estimated using an allometric equation for passerine birds (Nagy 1987) and a maximum body weight of 0.103 kg (Clench and Leberman 1978).

(11) Not applicable, the surface water exposure pathway does not represent a complete exposure pathway for this receptor.

(12) Estimated from data reported by Beyer et al. (1994) for the American woodcock. Given a food ingestion rate of 0.02045 kg/day, this percentage corresponds to a soil ingestion rate of 0.00213 kg/day.

TABLE 3-3 (Continued)

CONSERVATIVE AVIAN RECEPTOR LIFE HISTORY PARAMETERS
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Notes (continued):

(13) Minimum body weight reported by Steenhof (1983) as cited in EPA 1993.

(14) Estimated from a maximum ingestion rate of 0.11 g/g-day (Craighead and Craighead 1956) as cited in EPA 1993 and a maximum body weight of 1.235 kg reported by Springer and Osborne (1983) as cited in EPA 1993.

(15) Data was not available from the literature. The percentage shown represents a conservative estimate. Given a food ingestion rate of 0.13585 kg/day, this percentage corresponds to a soil ingestion rate of 0.013585 kg/day.

TABLE 3-4

LESS CONSERVATIVE AVIAN RECEPTOR LIFE HISTORY PARAMETERS
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Life History Parameters	Belted Kingfisher	Great Blue Heron	American Robin	Red-Tailed Hawk
Diet	100% Trophic Level 3 Fish	100 % Trophic Level 3 Fish	100% Earthwoms	100% Small Mammals
Body Weight	0.148 kg (1)	2.229 kg (5)	0.0773 kg (9)	1.126 kg (13)
Food Ingestion Rate	0.074 kg/day (2) (Dry Weight)	0.39289 kg/day (6) (Dry Weight)	0.01603 kg/day (10) (Dry Weight)	0.111474 kg/day (14) (Dry Weight)
Water Ingestion Rate	0.016403 L/day (3)	0.10095 L/day (7)	Not Applicable (11)	Not Applicable (11)
Percent Sediment/Soil in Diet	10% (4) (Dry Weight)	10% (8) (Dry Weight)	10.4% (12) (Dry Weight)	10% (15) (Dry Weight)

Notes:

(1) Average body weight reported by Powdermill Nature Center (unpublished data cited in EPA 1993).

(2) Estimated from an ingestion rate of 0.5 g/g-day (Alexander 1977) and an average body weight of 0.148 kg (Powdermill Nature Center as cited in EPA 1993).

(3) Estimated using an allometric equation for birds (Calder and Braun 1983) and an average body weight of 0.148 kg (unpublished data from Powdermill Nature Center as cited in EPA 1993).

(4) Data was not available from the literature. The percentage shown represents a conservative estimate. Given a food ingestion rate of 0.074 kg/day, this percentage corresponds to a sediment ingestion rate of 0.0074 kg/day.

(5) Average body weight reported by Quinney (1982).

(6) Estimated using an allometric equation for wading birds (Kushlan 1978) and an average body weight of 2.229 kg (Quinney 1982).

(7) Estimated using an allometric equation for birds (Calder and Braun 1983) and an average body weight of 2.229 kg (Quinney 1982).

(8) Data was not available from the literature. The percentage shown represents a conservative estimate. Given a food ingestion rate of 0.39289 kg/day, this percentage corresponds to a sediment ingestion rate of 0.039289 kg/day.

(9) Average body weight reported by Clench and Leberman (1978).

(10) Estimated using an allometric equation for passerine birds (Nagy 1987) and an average body weight of 0.0773 kg (Clench and Leberman 1978).

(11) Not applicable, the surface water exposure pathway does not represent a complete exposure pathway for this receptor.

(12) Estimated from data for the American woodcock (Beyer et al. 1994). Given a food ingestion rate of 0.01603 kg/day, this percentage corresponds to a soil ingestion rate of 0.00167 kg/day.

TABLE 3-4 (Continued)

LESS CONSERVATIVE AVIAN RECEPTOR LIFE HISTORY PARAMETERS
SWMU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

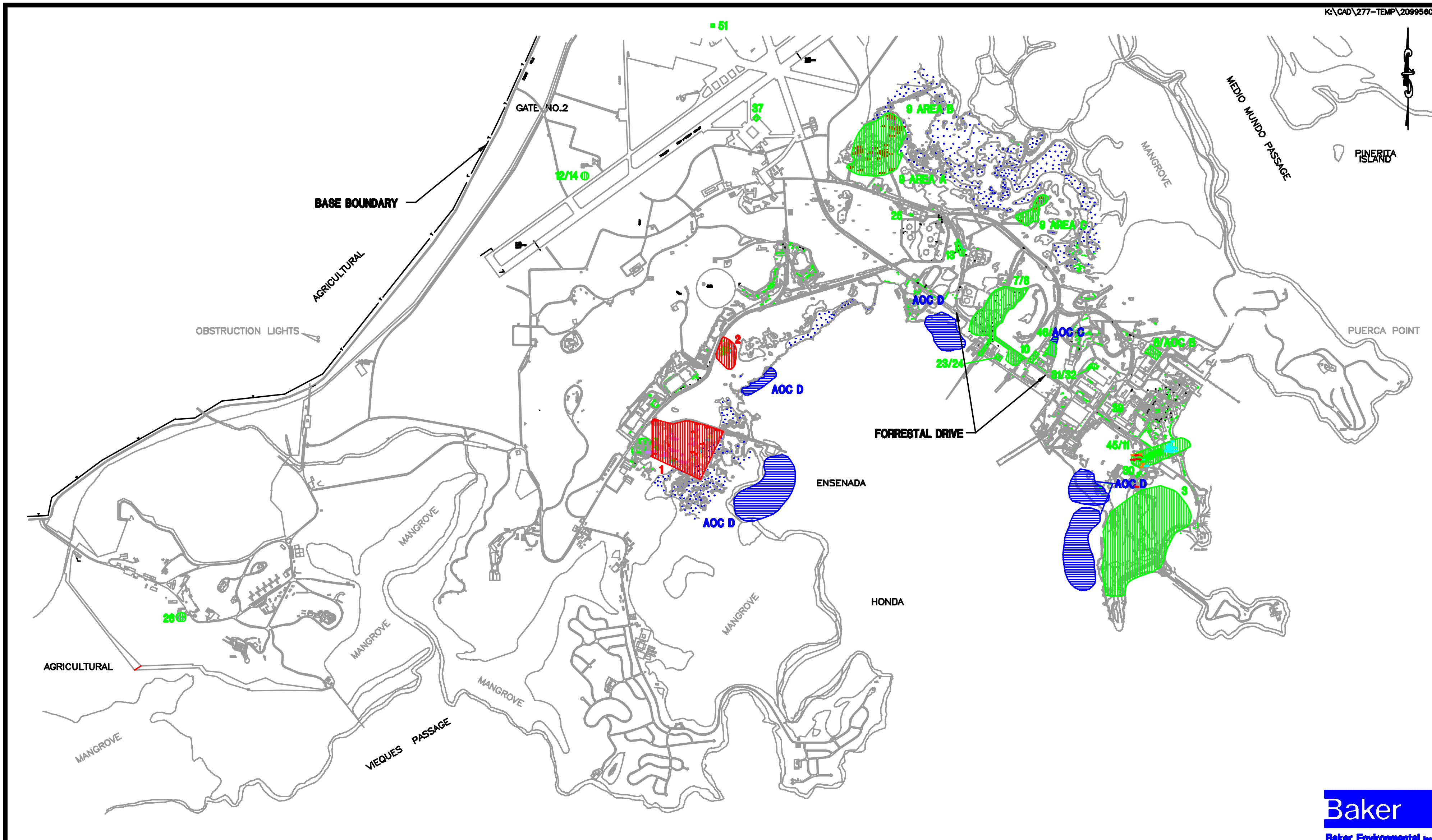
Notes (continued):

(13) Arithmatic average of mean male and female body weights reported by Craighead and Craighead (1956) as cited in EPA 1993.

(14) Estimated using an arithmatic average (0.099 g/g-day) of mean ingestion rates reported by Craighead and Craighead (1956) as cited in EPA 1993).

(15) Data was not available from the literature. The percentage shown represents a conservative estimate. Given a food ingestion rate of 0.111474 kg/day, this percentage corresponds to a surface soil ingestion rate of 0.0111474 kg/day.

FIGURES



LEGEND

13 – SWMUs

1 – AREA WHICH THIS INVESTIGATION PERTAINS TO

AOC D – AOCs

SOURCE: LANTDIV, FEB. 1992/1997

2500 0 1250 2500

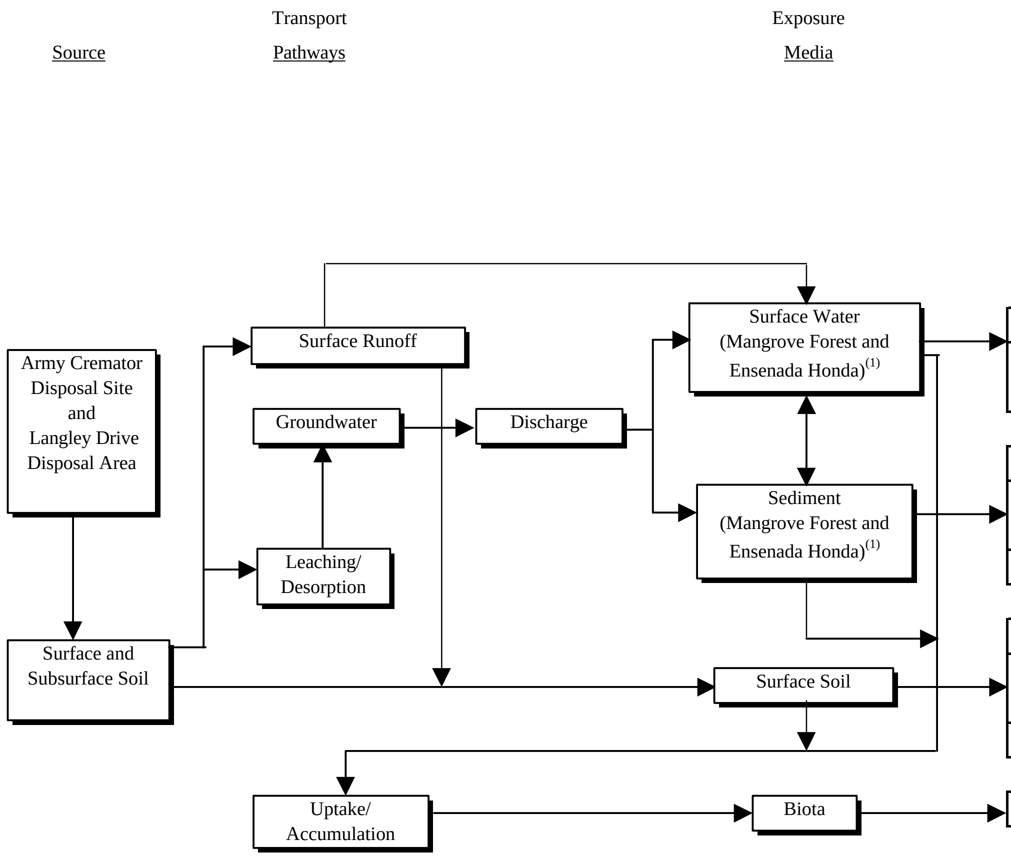
1 inch = 2500 ft.

FIGURE 1–1
SWMU/AOC LOCATION MAP

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

FIGURE 3-1

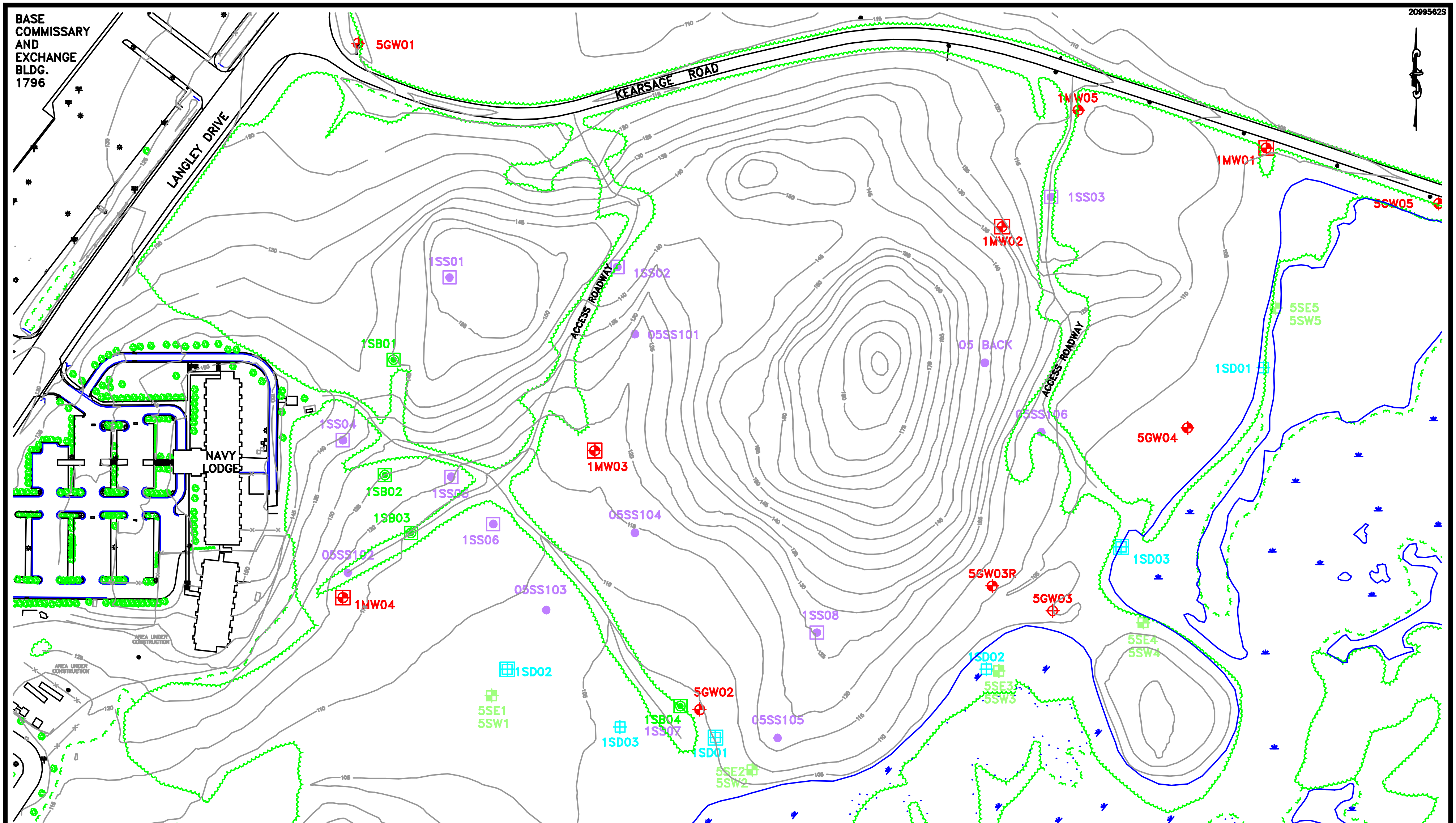
PRELIMINARY CONCEPTUAL MODEL
SMWU 1 (ARMY CREMATOR DISPOSAL SITE) AND SWMU 2 (LANGLEY DRIVE DISPOSAL AREA)
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO



Exposure Route	Aquatic: Plants	Aquatic: Invertebrates	Aquatic: Fish	Aquatic: Amphibians / Reptiles	Aquatic: Mammals	Aquatic: Birds	Terrestrial: Plants	Terrestrial: Invertebrates	Terrestrial: Amphibians / Reptiles	Terrestrial: Mammals	Terrestrial: Birds
Ingestion		●	●	●	●	●					
Dermal Absorption	●	●	●	●	●	●					
Ingestion		●	●	●	●	●					
Dermal Absorption		●	●	●	●	●					
Root Uptake	●										
Ingestion								●	●	●	●
Dermal Absorption								●	●	●	●
Root Uptake							●				
Ingestion		●	●	●	●	●		●	●	●	●

Legend
→ Solid lines indicate possible complete exposure pathways

(1) Surface runoff to mangrove forest only.



LEGEND

- EXISTING MONITORING WELL LOCATION (CONFIRMATION STUDY)
- MONITORING WELL LOCATION (1996 RFI)
- SURFACE SOIL SAMPLE LOCATION (1996 RFI)
- SOILBORING LOCATION (1996 RFI)
- SEDIMENT SAMPLE LOCATION (1996 RFI)
- REPORTED LOCATION OF 5GW03 (NOT LOCATED DURING 1996 RFI FIELD WORK)
- 5SE1 5SW1 – SURFACE WATER/SEDIMENT SAMPLE LOCATION (CONFIRMATION STUDY)
- 05SS101 – SOIL SAMPLE LOCATION (SUPPLEMENTAL INVESTIGATION)
- 1SD02 – SEDIMENT SAMPLE LOCATION (RELATIVE RISK RANKING)

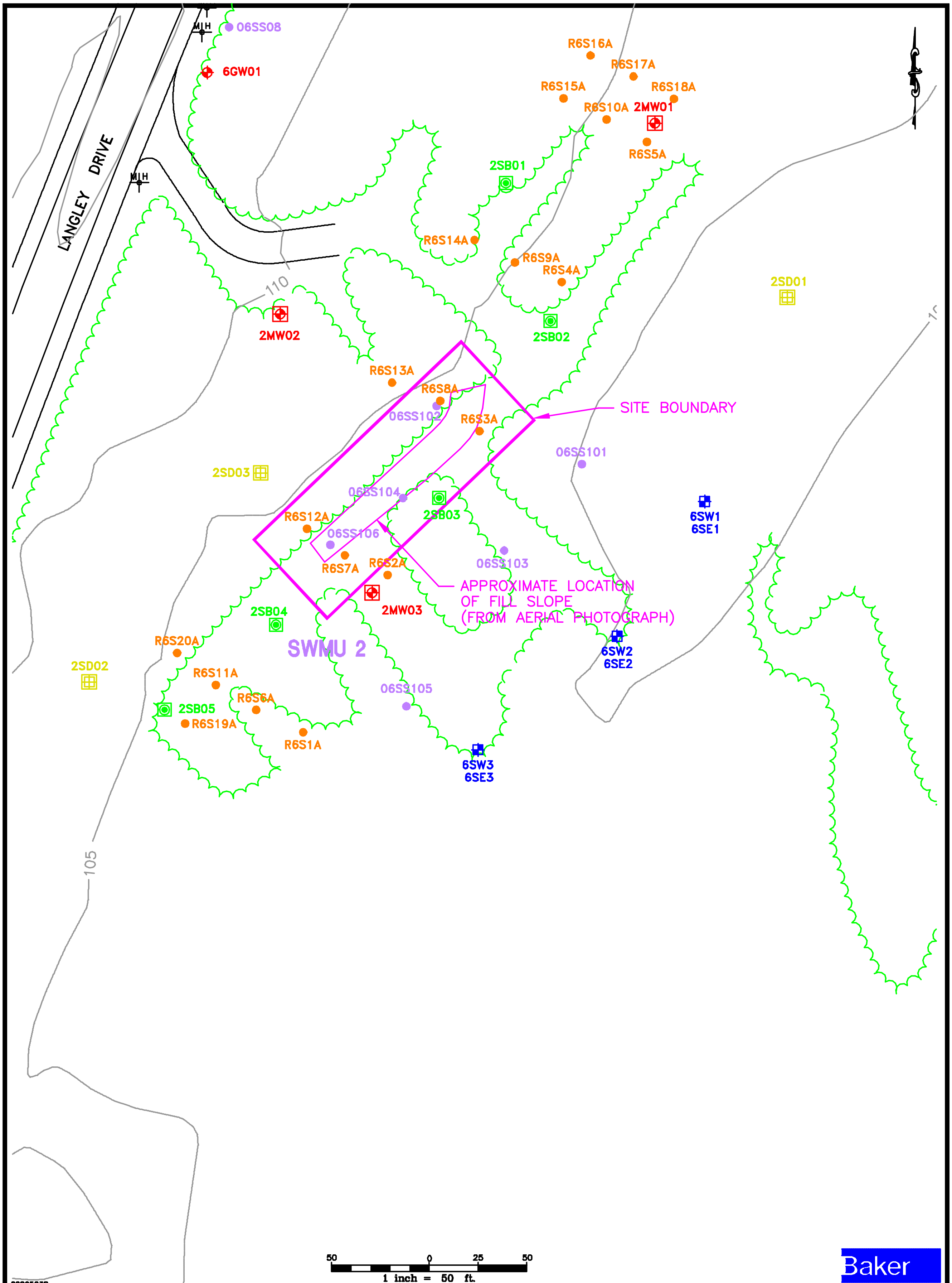
150 0 75 150

1 inch = 150 ft.

Baker

FIGURE 3-2
SWMU 1 SAMPLING LOCATIONS

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

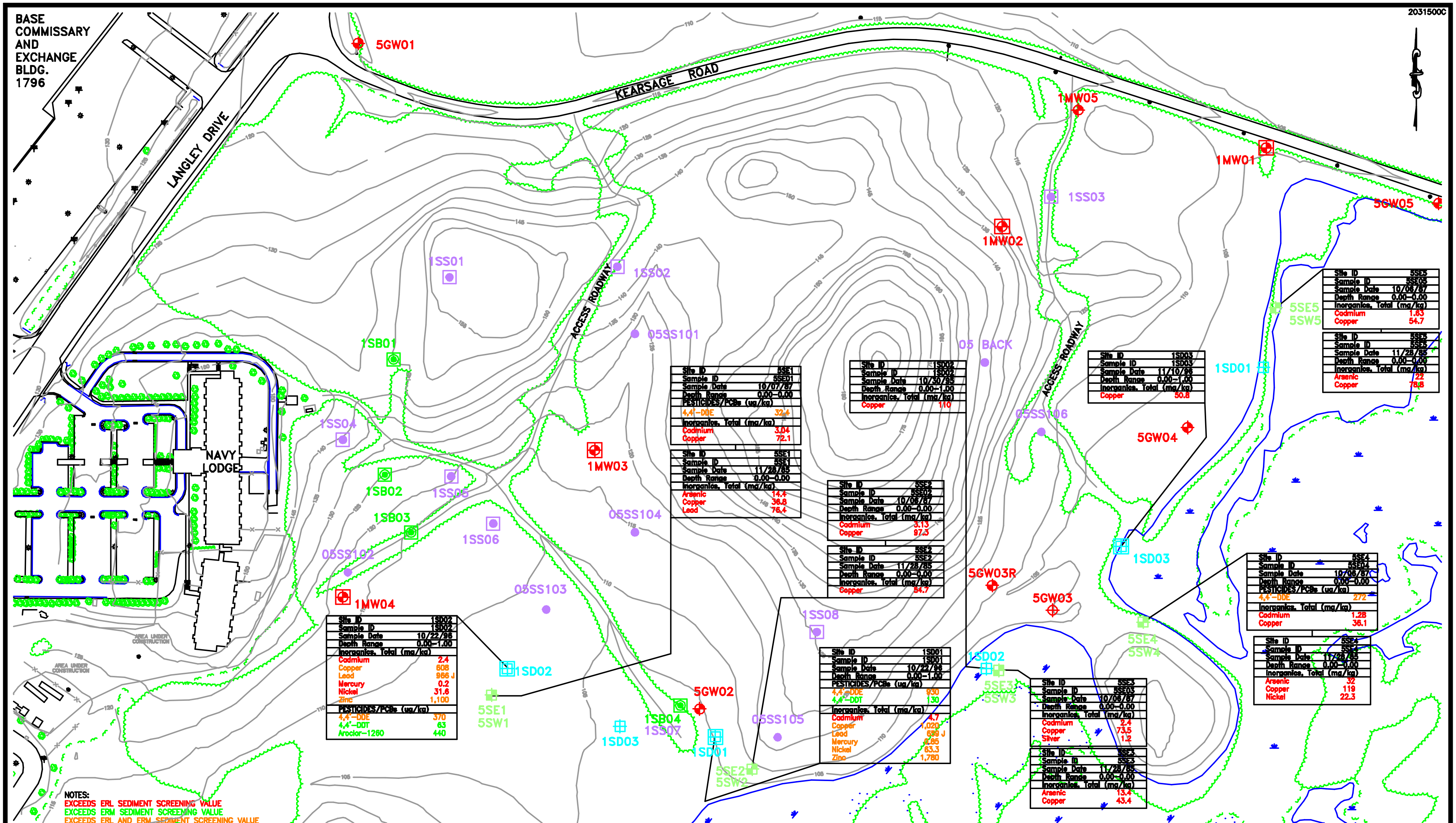


LEGEND

- MONITORING WELL LOCATION (1996 RFI)
- SOIL BORING LOCATION (1996 RFI)
- SEDIMENT SAMPLE LOCATION (1996 RFI)
- 6GW01 – EXISTING MONITORING WELL LOCATION (CONFIRMATION STUDY)
- SURFACE WATER/SEDIMENT SAMPLE LOCATION (CONFIRMATION STUDY)
- SOIL SAMPLE LOCATION (APPROXIMATE) (SUPPLEMENTAL INVESTIGATION)
- SOIL SAMPLE LOCATION (APPROXIMATE) (CONFIRMATION STUDY)
- SEDIMENT SAMPLE LOCATION (RELATIVE RISK RANKING)
- 110 – SURFACE ELEVATION CONTOUR

FIGURE 3–3
SWMU 2 SAMPLING LOCATIONS

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



LEGEND

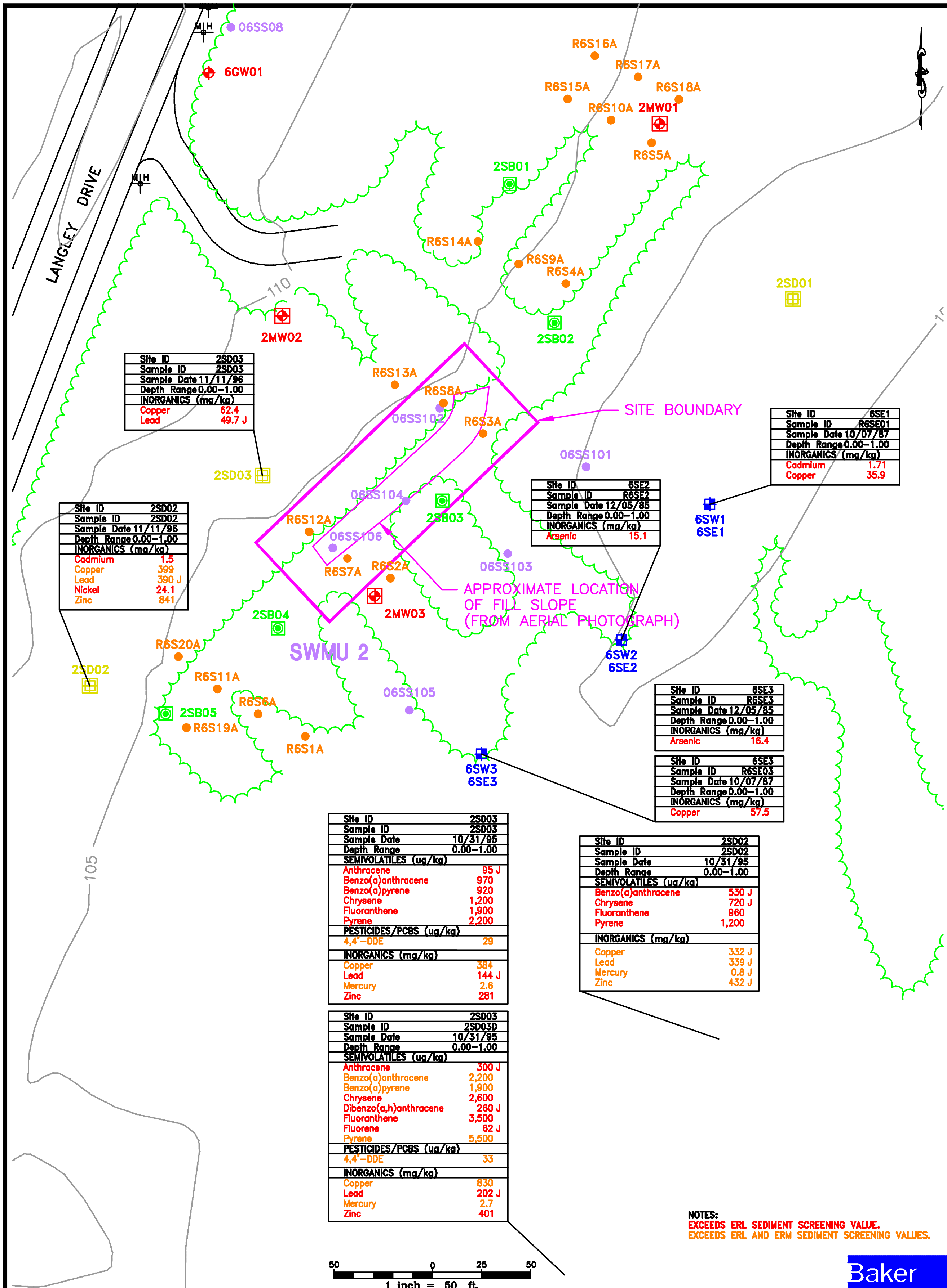
- EXISTING MONITORING WELL LOCATION (CONFIRMATION STUDY)
- MONITORING WELL LOCATION (1996 RFI)
- SURFACE SOIL SAMPLE LOCATION (1996 RFI)
- SOILBORING LOCATION (1996 RFI)
- SEDIMENT SAMPLE LOCATION (1996 RFI)
- REPORTED LOCATION OF 5GW03 (NOT LOCATED DURING 1996 RFI FIELD WORK)
- 5SE1 5SW1 – SURFACE WATER/SEDIMENT SAMPLE LOCATION (CONFIRMATION STUDY)
- 05SS101 – SOIL SAMPLE LOCATION (SUPPLEMENTAL INVESTIGATION)
- 1SD02 – SEDIMENT SAMPLE LOCATION (RELATIVE RISK RANKING)

150 0 75 150

1 inch = 150 ft.

Baker

FIGURE 3-4
SEDIMENT DETECTIONS
ABOVE SCREENING CRITERIA
SWMU 1
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



Site ID	2SD03
Sample ID	2SD03
Sample Date	11/11/96
Depth Range	0.00–1.00
INORGANICS (mg/kg)	
Copper	62.4
Lead	49.7 J

Site ID	2SD02
Sample ID	2SD02
Sample Date	11/11/96
Depth Range	0.00–1.00
INORGANICS (mg/kg)	
Cadmium	1.5
Copper	399
Lead	390 J
Nickel	24.1
Zinc	841

Site ID	6SE1
Sample ID	R6SE01
Sample Date	10/07/87
Depth Range	0.00–1.00
INORGANICS (mg/kg)	
Cadmium	1.71
Copper	35.9

Site ID	6SE2
Sample ID	R6SE2
Sample Date	12/05/85
Depth Range	0.00–1.00
INORGANICS (mg/kg)	
Arsenic	15.1

Site ID	6SE3
Sample ID	R6SE3
Sample Date	12/05/85
Depth Range	0.00–1.00
INORGANICS (mg/kg)	
Arsenic	16.4

Site ID	6SE3
Sample ID	R6SE03
Sample Date	10/07/87
Depth Range	0.00–1.00
INORGANICS (mg/kg)	
Copper	57.5

Site ID	2SD03
Sample ID	2SD03
Sample Date	10/31/95
Depth Range	0.00–1.00
SEMIVOLATILES (ug/kg)	
Anthracene	95 J
Benzo(a)anthracene	970
Benzo(a)pyrene	920
Chrysene	1,200
Fluoranthene	1,900
Pyrene	2,200
PESTICIDES/PCBS (ug/kg)	
4,4'–DDE	29
INORGANICS (mg/kg)	
Copper	384
Lead	144 J
Mercury	2.6
Zinc	281

Site ID	2SD02
Sample ID	2SD02
Sample Date	10/31/95
Depth Range	0.00–1.00
SEMIVOLATILES (ug/kg)	
Benzo(a)anthracene	530 J
Chrysene	720 J
Fluoranthene	960
Pyrene	1,200
INORGANICS (mg/kg)	
Copper	332 J
Lead	339 J
Mercury	0.8 J
Zinc	432 J

Site ID	2SD03
Sample ID	2SD03D
Sample Date	10/31/95
Depth Range	0.00–1.00
SEMIVOLATILES (ug/kg)	
Anthracene	300 J
Benzo(a)anthracene	2,200
Benzo(a)pyrene	1,900
Chrysene	2,600
Dibenzo(a,h)anthracene	260 J
Fluoranthene	3,500
Fluorene	62 J
Pyrene	5,500
PESTICIDES/PCBS (ug/kg)	
4,4'–DDE	33
INORGANICS (mg/kg)	
Copper	830
Lead	202 J
Mercury	2.7
Zinc	401

NOTES:
EXCEEDS ERL SEDIMENT SCREENING VALUE.
EXCEEDS ERL AND ERM SEDIMENT SCREENING VALUES.

LEGEND

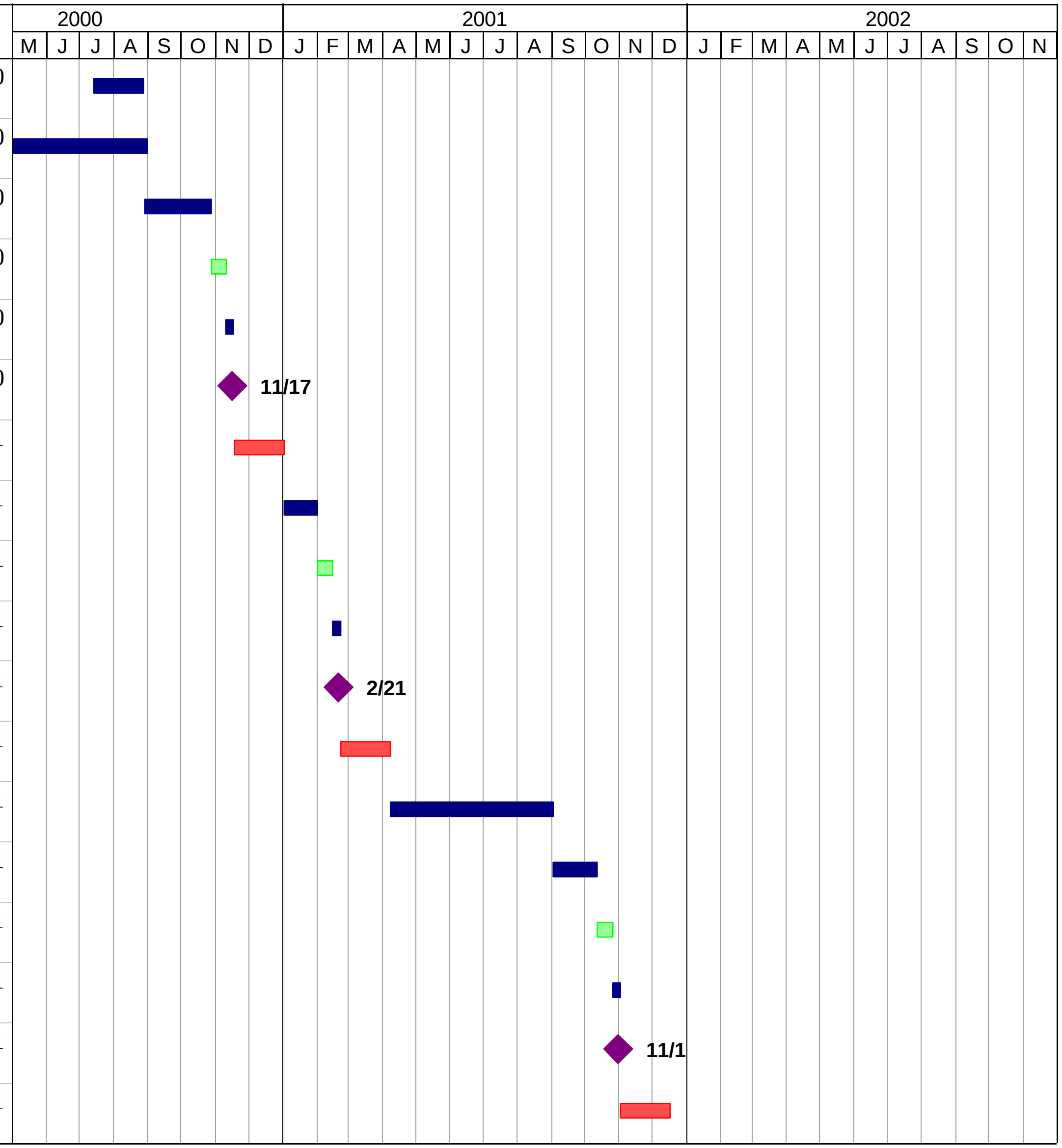
- MONITORING WELL LOCATION (1996 RFI)
- SOIL BORING LOCATION (1996 RFI)
- SEDIMENT SAMPLE LOCATION (1996 RFI)
- 6GW01 – EXISTING MONITORING WELL LOCATION (CONFIRMATION STUDY)
- SURFACE WATER/SEDIMENT SAMPLE LOCATION (CONFIRMATION STUDY)
- SOIL SAMPLE LOCATION (APPROXIMATE) (SUPPLEMENTAL INVESTIGATION)
- SOIL SAMPLE LOCATION (APPROXIMATE) (CONFIRMATION STUDY)
- SEDIMENT SAMPLE LOCATION (RELATIVE RISK RANKING)
- 110 – SURFACE ELEVATION CONTOUR

FIGURE 3–5
SEDIMENT DETECTIONS
ABOVE SCREENING CRITERIA
SWMU 2

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

Figure 5-1
Corrective Measures Study - Proposed Schedule
SWMU 1 (Army Cremator Disposal Site) and SWMU 2 (Langley Drive Disposal Site)
Naval Station Roosevelt Roads, Puerto Rico

Task Name	Duration	Start	Finish
CMS Work Plan Approval (estimated)	45 edays	7/14/00	8/28/00
Habitat Characterization	122 edays	5/1/00	8/31/00
Draft Screening-Level Ecological Risk Assessment	60 edays	8/28/00	10/27/00
Navy Review	14 edays	10/27/00	11/10/00
Draft Screening-Level Ecological Risk Assessment Revisions	7 edays	11/10/00	11/17/00
Draft Screening-Level Ecological Risk Assessment Due to EPA	1 day	11/17/00	11/17/00
EPA Review	45 edays	11/17/00	1/1/01
Final Screening-Level Ecological Risk Assessment	30 edays	1/1/01	1/31/01
Navy Review	14 edays	1/31/01	2/14/01
Final Screening-Level Ecological Risk Assessment Revisions	7 edays	2/14/01	2/21/01
Final Screening-Level Ecological Risk Assessment Due to EPA	1 day	2/21/01	2/21/01
EPA Review/Approval	45 edays	2/21/01	4/7/01
Phase II Screening Level Ecological Risk Assessment (if required)	147 edays	4/7/01	9/1/01
Draft CMS Task I Report	40 edays	9/1/01	10/11/01
Navy Review	14 edays	10/11/01	10/25/01
Draft CMS Task I Report Revisions	7 edays	10/25/01	11/1/01
Draft CMS Task I Report Due to EPA	1 eday	11/1/01	11/2/01
EPA Review	45 edays	11/2/01	12/17/01



Baker Task
Navy Review
EPA Review
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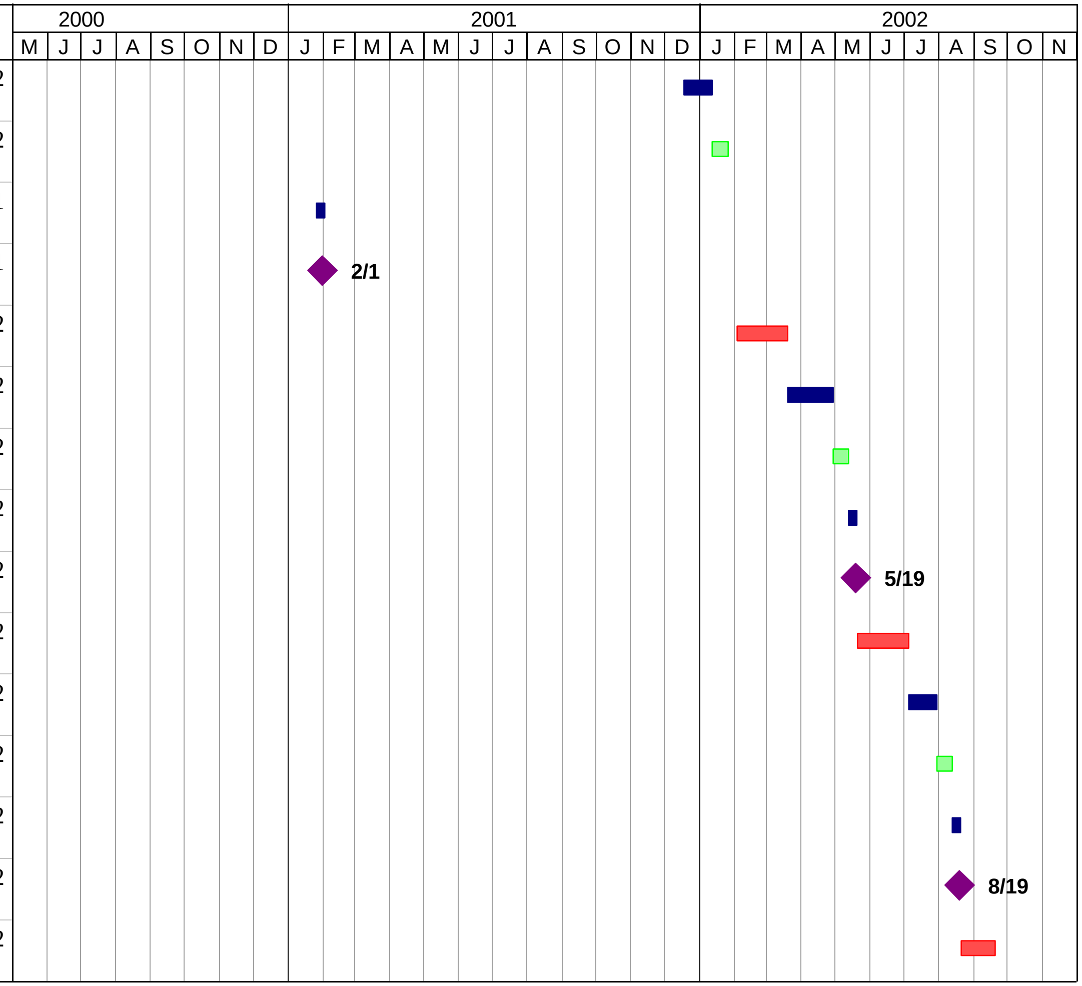
Figure 5-1
Corrective Measures Study - Proposed Schedule
SWMU 1 (Army Cremator Disposal Site) and SWMU 2 (Langley Drive Disposal Site)
Naval Station Roosevelt Roads, Puerto Rico

Task Name	Duration	Start	Finish
Final CMS Task I Report	25 edays	12/17/01	1/11/02
Navy Review	14 edays	1/11/02	1/25/02
Final CMS Task I Report Revisions	7 edays	1/25/01	2/1/01
Final CMS Task I Report Due to EPA	1 eday	2/1/01	2/2/01
EPA Review/Approval	45 edays	2/2/02	3/19/02
Draft CMS Final Report	40 edays	3/19/02	4/28/02
Navy Review	14 edays	4/28/02	5/12/02
Draft CMS Final Report Revisions	7 edays	5/12/02	5/19/02
Draft CMS Final Report Due to EPA	1 eday	5/19/02	5/20/02
EPA Review/Approval	45 edays	5/20/02	7/4/02
Final CMS Final Report	25 edays	7/4/02	7/29/02
Navy Review	14 edays	7/29/02	8/12/02
Final CMS Final Report Revisions	7 edays	8/12/02	8/19/02
Final CMS Final Report Due to EPA	1 eday	8/19/02	8/20/02
EPA Review/Approval	30 edays	8/20/02	9/19/02



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