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Final

Corrective Measures Study
Task I Report

Tow Way Fuel Farm

Naval Station Roosevelt Roads
RCRA/HSWA Permit No. PR2170027203
Ceiba, Puerto Rico
Volume I of II - Text

Prepared For

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command
Norfolk, Virginia

Contract No. N62470-95-D-6007
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April 22, 2003

Prepared by

CH2M HILL

Federal Group, Ltd.

Baker
Environmental, Inc.

CDM
Federal Programs Corp.

FINAL

CORRECTIVE MEASURES STUDY
TASK I REPORT
TOW WAY FUEL FARM

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VOLUME I OF II – TEXT

CONTRACT TASK ORDER 0034

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Prepared for:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
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Under the:

LANTDIV CLEAN Program
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TABLE OF CONTENTS

Page

LIST OF ACRONYMS AND ABBREVIATIONS viii

1.0 INTRODUCTION 1-1
1.1 Context of this Report 1-1
1.2 Objectives of the Task I Effort 1-1
1.3 Report Format 1-2

2.0 DESCRIPTION OF CURRENT SITUATION 2-1
2.1 General Site Description 2-1
2.1.1 Station Description 2-1
2.1.2 SWMU 7 – Tow Way Fuel Farm 2-1
2.1.3 SWMU 8 – Tow Way Fuel Farm Sludge Disposal Pits 2-1
2.1.4 Fuel Loss History 2-2
2.2 Previous RCRA Activities at the Tow Way Fuel Farm 2-3
2.2.1 Initial Assessment Study 2-3
2.2.2 Confirmation Study 2-3
2.2.3 Underground Fuel Investigation 2-3
2.2.4 Preliminary Site Assessment Underground Storage Tank Site No. 443 2-4
2.2.5 Draft Corrective Action Plan 2-4
2.2.6 Site Characterization and CAP 2-5
2.2.7 Multi-Stage Product Recovery Test Report 2-6
2.2.8 Closure Report for Tank 56A/B 2-8
2.2.9 Project Close-Out Report Interim Corrective Measure Free Product Recovery System 2-8
2.2.10 Operation of ICM 2-9
2.2.11 Other Letter Reports Submitted 2-9
2.2.12 Corrective Measures Study Investigations 2-10
2.2.13 Additional Data Collection Investigation 2-10
2.3 Summary of Site Conditions 2-11
2.3.1 Soil Contamination 2-11
2.3.2 Groundwater Contamination 2-12
2.3.3 Surface Water Analytical Results 2-12
2.3.4 Sediment Analytical Results 2-13
2.3.5 Groundwater Level and Free Product Level Measurements 2-13
2.3.6 Interim Corrective Measure 2-13
2.3.7 CleanOx Pilot Study 2-14
2.3.8 Pneumatic Fracturing Pilot Study 2-15
2.4 Statement of Purpose 2-16

3.0 SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT AND STEP 3A OF THE BASELINE ECOLOGICAL RISK ASSESSMENT 3-1
3.1 Environmental Setting 3-1
3.1.1 Site History 3-1
3.1.2 Terrestrial and Marine Habitats 3-2
3.1.3 Biota 3-3
3.2 Sources of Available Analytical Data 3-5
3.3 Screening-Level Problem Formulation 3-5
3.3.1 Preliminary Conceptual Model 3-6
3.3.2 Endpoints and Risk Hypotheses 3-8
3.3.3 Fate and Transport Mechanisms 3-11
3.3.4 Mechanisms of Toxicity 3-12

TABLE OF CONTENTS
(Continued)

3.4 Screening-Level Effects Evaluation 3-12
3.4.1 Media-Specific Screening Values 3-12
3.4.2 Ingestion Screening Values 3-14
3.5 Screening-Level Exposure Estimation 3-15
3.5.1 Selection Criteria for Analytical Data 3-15
3.5.2 Exposure Estimation 3-17
3.6 Screening-Level Risk Characterization 3-22
3.6.1 Selection of Preliminary Ecological Chemicals of Potential Concern. 3-22
3.6.2 Uncertainties Associated with the Screening-Level Risk Characterization 3-26
3.6.3 Screening-Level Risk Conclusions 3-29
3.7 Step 3a of the Baseline Risk Assessment (Refinement of Conservative Exposure Assumptions) 3-29
3.7.1 Refined Screening-Level Risk Characterization 3-31a
3.7.2 Uncertainties Associated with the Refined Screening-Level Risk Characterization 3-39
3.7.3 Conclusions and Recommendations 3-42
3.8 References 3-43

4.0 ESTABLISHMENT OF CORRECTIVE ACTION OBJECTIVES 4-1
4.1 Introduction 4-1
4.2 Land Use and Potentially Exposed Receptors 4-1
4.3 Summary of Human Health Risk Assessment and Selection of Contaminants of Potential Concern 4-2
4.3.1 Methodology 4-2
4.3.2 COPC Details 4-2
4.4 Exposure Assessment and Methodology for Development of CAOs 4-3a
4.4.1 Qualitative CAOs 4-3a
4.4.2 Quantitative CAOs 4-4
4.5 Toxicity Evaluation 4-7
4.5.1 Modification to Dermal Exposure Route 4-8
4.5.2 Noncancer Effects Associated with Lead 4-8
4.5.3 Approach to Evaluating Carcinogenic PAHs 4-9
4.6 Background Concentrations as CAOs 4-10
4.7 Quantitative CAOs 4-10
4.8 References 4-11

5.0 IDENTIFICATION OF COCs 5-1
5.1 Groundwater COCs 5-1
5.2 Soil COCs 5-2
6.0 PRELIMINARY CORRECTIVE MEASURE TECHNOLOGIES 6-1
6.1 Soil Remedial Technologies 6-1
6.2 Groundwater Remedial Technologies 6-1
6.3 Phase Separated Hydrocarbon Remedial Technologies 6-2
7.0 SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES 7-1
7.1 Site Characteristics 7-1
7.1.1 Soils 7-1
7.1.2 Groundwater 7-1
7.1.3 Phase Separated Hydrocarbon 7-2
7.2 Waste Characteristics 7-2
7.2.1 Soils 7-2
7.2.2 Groundwater 7-2

TABLE OF CONTENTS
(Continued)

7.3 Technology Limitation 7-3
7.4 Technology Screening 7-3

8.0 IDENTIFICATION OF THE CORRECTIVE MEASURE ALTERNATIVE 8-1

9.0 REFERENCES 9-1

LIST OF TABLES

3-1 List of Birds Reported from Naval Station Roosevelt Roads
3-2 Surface Soil Sample Matrix
3-3 Subsurface Soil Sample Matrix
3-4 Groundwater Sample Matrix
3-5 Surface Water Sample Matrix
3-6 Sediment Sample Matrix
3-7 Preliminary Assessment Endpoints, Risk Hypotheses, and Measurement Endpoints
3-8 LOG K_{ow} and K_{oc} Values for Organic Chemicals
3-9 Surface Soil Screening Values
3-10 Marine Surface Water Screening Values
3-11 Sediment Screening Values
3-12 Ingestion-Based Screening Values for Birds
3-13 Ingestion Based Screening Values for Mammals
3-14 Conservative Soil Bioaccumulation Factors Used for Terrestrial Plants and Invertebrates
3-15 Conservative Soil Bioaccumulation Factors Used for Small Mammal Prey Items
3-16 Conservative Sediment Bioaccumulation Factors Used for Aquatic Invertebrates and Fish
3-17 Conservative Surface Water Bioaccumulation Factors used for Fish
3-18 Conservative Exposure Parameters for Upper Trophic Level Receptors
3-19 Dietary Composition for Upper Trophic Level Receptors
3-20 Frequency and Range of Surface Soil Data (Maximum Concentrations) Compared to Surface Soil Screening Values
3-21 Frequency and Range of Groundwater Data (Maximum Concentrations) Compared to Surface Water Screening Values
3-22 Frequency and Range of Surface Water Data (Maximum Concentrations) Compared to Surface Water Screening Values
3-23 Frequency and Range of Sediment Data (Maximum Concentrations) Compared to Sediment Screening Values
3-24 Summary of Hazard Quotients for Conservative Food Web Exposures – Terrestrial Receptors
3-25 Summary of Hazard Quotients for Conservative Food Web Exposures – Aquatic Receptors
3-26 Summary of Preliminary Ecological Chemicals of Potential Concern
3-27 Less Conservative Soil Bioaccumulation Factors Used for Terrestrial Plants and Invertebrates
3-28 Less Conservative Soil Bioaccumulation Factors Used for Small Mammal Prey Items
3-29 Less Conservative Sediment Bioaccumulation Factors Used for Aquatic Invertebrates and Fish
3-30 Less Conservative Exposure Parameters for Upper Trophic Level Receptors
3-31 Frequency and Range of Surface Soil Data (Mean Concentrations) Compared to Surface Soil Screening Values
3-32 Frequency and Range of Groundwater Data (Mean Concentrations) Compared to Surface Water Screening Values

LIST OF TABLES
(Continued)

3-33 Frequency and Range of Surface Water Data (Mean Concentrations) Compared to Surface Water Screening Values
3-34 Frequency and Range of Sediment Data (Mean Concentrations) Compared to Sediment Screening Values
3-35 Summary of Hazard Quotients for Less Conservative Food Web Exposures – Terrestrial Receptors
3-36 Summary of Hazard Quotients for Less Conservative Food Web Exposures – Aquatic Receptors
3-37 Frequency and Range of Surface Soil Data Compared to Background
3-38 Frequency and Range of Groundwater Data Compared to Background
3-39 Frequency and Range of Sediment Data (Mean Concentrations) Compared to Equilibrium Partitioning-Based Sediment Screening Values Calculated Using the Average TOC Concentration for Ensenada Honda Sediment Samples
3-39a Comparison of Maximum and Mean PAH Sediment Concentrations to EqP-Based Sediment Benchmarks Developed Using a Target Lipid Model
3-40 Frequency and Range of Sediment Data (Mean Concentrations) Compared to Equilibrium Partitioning-Based Sediment Screening Values Calculated Using the Minimum TOC Concentration for Ensenada Honda Sediment Samples
3-41 Frequency and Range of Sediment Metals Data (Mean Concentrations, Excluding 7SD9, 7SD10, and 7SD11) Compared to Sediment Screening Values
3-42 Frequency and Range of 7SD5 and 7SD6 Metals Data (Mean Concentrations) Compared to Sediment Screening Values

4-1 Total Site Incremental Lifetime Cancer Risks (ILCRs) and Hazard Indices (HIs) from RFI for Current and Future Potential Human Receptors
4-2 Incremental Lifetime Cancer Risks (ILCRs) and Hazard Indices (HIs) from RFI for Current On-Site Workers
4-3 Incremental Cancer Risks (ILCRs) and Hazard Indices (HIs) from RFI for Future Adult and Young Child Residents
4-4 Surface Soil Data and COPC Selection Summary
4-5 Subsurface Soil Data and COPC Selection Summary
4-6 Groundwater Data and COPC Selection Summary
4-7 Summary of Quantitative CAO Calculations—Exposure via Ingestion of Chemicals in Soil
4-8 Summary of Quantitative Soil CAO Calculations—Exposure via Inhalation of Chemicals in Particulates
4-9 Summary of Quantitative Soil CAO Calculations—Exposure via Inhalation of Volatiles Emitted from Soil
4-10 Summary of Soil-to-Air Volatilization Factor (VF) Calculation
4-11 Chemical-Specific Volatilization Factor Data
4-12 Summary of Quantitative CAO Calculations—Exposure via Dermal Absorption of Chemicals in Soil
4-13 Summary of Quantitative CAO Calculations—Exposure via Ingestion of Chemicals in Groundwater
4-14 Summary of Quantitative CAO Calculations—Exposure via Inhalation of Volatiles in Groundwater
4-15 Summary of Quantitative CAO Calculations—Dermal Absorption of Chemicals in Groundwater
4-16 Determination of Dermal Absorption Factor (DAF) for Use in Calculating Dermal Absorption of Organic Chemicals from Water
4-17 Dermal Absorption Factor Parameter Values for Groundwater COPCs

LIST OF TABLES
(Continued)

4-18 oxicological Data Summary
4-19 Quantitative Soil CAOs for TWFF
4-20 Quantitative Groundwater CAOs for TWFF

5-1 Groundwater COCs and CAOs
5-2 Soil COCs and CAOs

6-1 Potentially Applicable Corrective Measure Technologies Soil Matrix
6-2 Corrective Measures Treatment Technology Descriptions Soil Matrix
6-3 Potentially Applicable Corrective Measures Treatment Technology Descriptions Groundwater Matrix
6-4 Corrective Measures Treatment Technology Descriptions Groundwater Matrix
6-5 Potentially Applicable Corrective Measure Technologies Phase Separated Hydrocarbon

7-1 Treatment Technologies Screening Matrix
7-2 Applicable Corrective Measure Technologies Soil Matrix
7-3 Applicable Corrective Measure Technologies Groundwater Matrix
7-4 Applicable Corrective Measure Technologies Phase Separated Hydrocarbon

8-1 Alternative Development Process

LIST OF FIGURES

2-1 Regional Location Map
2-2 TWFF Location Map
2-3 Site Plan
2-4 Benzene in Groundwater Isopleth Map
2-5 TCE in Groundwater Isopleth Map
2-6 Fluorene in Groundwater Isopleth Map
2-7 Naphthalene in Groundwater Isopleth Map
2-8 2-Methylnaphthalene in Groundwater Isopleth Map
2-9 Free Product Thickness and Extent Map

3-1 Navy Ecological Risk Assessment Tiered Approach
3-2 Zone Location Map
3-3 Terrestrial and Aquatic Habitat Occurring at Naval Station Roosevelt Roads
3-4 Naval Station Roosevelt Roads Wetlands Delineation
3-5 The Cowardin Wetland Classification System
3-6 Preliminary Conceptual Model
3-7 Stormwater Drainage Map
3-8 Locations of Samples Used in Ecological Risk Assessment
3-9 Base Background Surface Soil and Groundwater Sample Locations

5-1 1,2,4-Trimethylbenzene Dissolved Groundwater Plume
5-2 Benzene Dissolved Groundwater Plume
5-3 Ethylbenzene Dissolved Groundwater Plume
5-4 Trichloroethene Dissolved Groundwater Plume
5-5 Phase Separated Hydrocarbon Plume
5-6 Surface Soil with Arsenic above CAO

LIST OF FIGURES
(Continued)

5-7 Surface Soil with Benzo(a)anthracene above CAO
5-8 Surface Soil with Benzo(a)pyrene above CAO
5-9 Surface Soil with Benzo(b)fluoranthene above CAO
5-10 Surface Soil with Indeno(1,2,3-cd)pyrene above CAO
5-11 Total Surface and Subsurface Soil with Benzo(a)pyrene above CAO

LIST OF APPENDICIES

A Chemical Profiles
B Equilibrium Partitioning Approach
C Identification of Bioaccumulative Chemicals
D Analytical Data Used In the Ecological Risk Assessment
E Additional Data Collection Investigation Report
F Unified Data Set for Tow Way Fuel Farm
G Final Calibrated Groundwater Flow Model
H Corrective Action Objective (CAO) Calculations
I Results of Johnson and Ettinger 1991 Model-Summary and Results to be Used for Groundwater CAOs
J Supporting Calculations for Construction Worker Exposure to Groundwater

LIST OF ACRONYMS AND ABBREVIATIONS

ACR	acute-to-chronic ratio
AET	Apparent Effects Threshold
AOC	Area of Concern
AQUIRE	Aquatic Toxicity Information Retrieval
ATSDR	Agency for Toxic Substances and Disease Registry
AUF	Area Use Factor
AVS	acid volatile sulfides
BAF	Bioaccumulation Factor
BAF_{sed}	Sediment-to-Fish Bioaccumulation Factor
BAF_{sw}	Surface Water-to-Fish Bioaccumulation Factor
Baker	Baker Environmental, Inc.
BaP	benzo (a) pyrene
BB&L	Blasland, Bouck, and Lee, Inc.
BCF	Bioconcentration Factor
BCF_{sw}	Surface Water-to-Fish Bioconcentration Factor
bgs	below ground surface
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
BW	Body Weight
BW_t	Body Weight of Test Species
BW_w	Body Weight of Wildlife Species
B_v	Surface Soil-to-Plant Bioconcentration Factor
CAO	Corrective action Objective
CAP	Corrective Action Plan
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMS	Corrective Measures Study
CMES	Corrective Measures Screening
cm/sec	centimeters per second
CNO	Chief of Naval Operations
COPC	Chemical of Potential Concern
CS	Confirmation Study
C_{sat}	saturated concentration
C_{sed}	Concentration in Sediment
C_{sw}	Concentration in Surface Water
C_{xf}	Concentration of Chemical x in Whole-Body Fish
DDT	Dichlorodiphenyltrichloroethane
DI_x	Dietary Intake for chemical x
DFM	Diesel Fuel Marine
DRMO	Defense Reutilization and Marketing Office
DRO	diesel range organics
EC_{50}	Median Effective Concentration
ECGO®	Electro Chemical Geo Oxidation
EqP	Equilibrium-Partitioning
EPA	Environmental Protection Agency
ERA	Ecological Risk Assessment
ER-L	Effects Range-Low
ESE	Environmental Science and Engineering

FCM	Food Chain Multiplier
FC_{xi}	Maximum Concentration of Chemical x in Food Item i
FCV	Final Chronic Values
FIR	Food Ingestion Rate
g/ml	grams per milliliter
GRO	gasoline range organics
HSWA	Hazardous and Solid Waste Amendments
HQ	Hazard Quotient
IAS	Initial Assessment Study
ID	inside diameter
IEUBK	integrated exposure uptake/biokinetic model
IR	Installation Restoration
IRIS	Integrated Risk Information System
K_d	Adsorption Coefficient
kg	kilograms
kg/day	kilograms per day
K_d	adsorption coefficient
K_{oc}	Organic Carbon Partition Coefficient
K_{ow}	Octanol-Water Partition Coefficient
L/kg	Liter per kilogram
LANTDIV	Atlantic Division, Naval Facilities Engineering Command
LC_{50}	Median Lethal Concentration
LD_{50}	Median Lethal Dose
LOAEL	Lowest Observed Adverse Effect Level
LOEC	Lowest Observed Effect Concentration
LOEL	Lowest Observable Effect Level
log K_{ow}	log octanol-water partition coefficient
MATC	Maximum Acceptable Toxicant Concentration
MCL	maximum contaminant level
mg/kg-BW/day	milligrams per kilogram Body Weight of the Receptor per day
mg/kg/day	milligrams per kilogram per day
mg/kg	milligrams per kilogram
mg/L	milligrams per Liter
MHSPE	Ministry of Housing, Spatial Planning and Environment
NACIP	Navy Assessment and Control of Installation of Pollutants
NAWQC	National Ambient Water Quality Criteria
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effect Level
$NOAEL_t$	NOAEL of Test Species
$NOAEL_w$	NOAEL of Wildlife Species
NOEC	No Observed Effect Concentration
NSRR	Naval Station Roosevelt Roads
PAH	Polynuclear Aromatic Hydrocarbon

PAH_cs	carcinogenic polynuclear aromatic hydrocarbons
PCB	Polychlorinated Biphenyl
PDF_i	Proportion of Diet Composed Food Item i
PDS	Proportion of Diet Composed of Soil/Sediment
PF	pneumatic fracturing
ppt	parts per thousand
PREQB	Puerto Rico Environmental Quality Board
PSH	Phase Separated Hydrocarbons
PVC	polyvinyl chloride
R	rejected
RA	risk assessment
RAGS	Risk Assessment Guidelines
RCRA	Resource Conservation and Recovery Act
RBC	Risk Based Concentration
RfC	reference concentration
RFI	RCRA Facility Investigation
SA	skin surface area
SC_x	Concentration of Chemical x in Soil/Sediment
SCV	Secondary Chronic Value
SQUIRT	Screening Quick Reference Table
STSC	Superfund Technical Support Center
SVOC	Semi-Volatile Organic Compound
SWMU	Solid Waste Management Unit
T	exposure time
TCE	Trichloroethene
TCLP	Toxicity Characteristic Leaching Procedure
TEL	Threshold Effects Level
TOC	Total Organic Carbon
TOX	Total Organic Halogens
TPH	Total Petroleum Hydrocarbons
TWFF	Tow Way Fuel Farm
U	not detected at the reported sample quantitation limit
µg/kg	micrograms per kilogram
UJ	not detected at the reported sample quantitation limit, estimated value
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UST	Underground Storage Tank
VF	volatilization factor
VOC	Volatile Organic Compound

LIST OF ACRONYMS AND ABBREVIATIONS

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IAS	Initial Assessment Study
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IEUBK	integrated exposure uptake/biokinetic model
IR	Installation Restoration
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PREQB	Puerto Rico Environmental Quality Board
PSH	Phase Separated Hydrocarbons
PVC	polyvinyl chloride
R	rejected
RA	risk assessment
RAGS	Risk Assessment Guidelines
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USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UST	Underground Storage Tank
VF	volatilization factor
VOC	Volatile Organic Compound

1.0 INTRODUCTION

This document presents the Corrective Measure Study (CMS) Task I Report for the Tow Way Fuel Farm (TWFF) located at Naval Station Roosevelt Roads (NSRR), Ceiba, Puerto Rico under the Corrective Action provisions of the Station's Resource Conservation and Recovery Act (RCRA) permit (RCRA/HSWA Permit No PR 2170027203). This report has been prepared by Baker Environmental, Inc. (Baker) under contract to the Atlantic Division, Naval Facilities Engineering Command (LANTDIV), Contract Number N62470-95-D-6007.

On October 20, 1994, the United States Environmental Protection Agency (USEPA) Region II issued a Final RCRA Part B Permit to NSRR. This permit contains requirements for RCRA Facility Investigations (RFI) activities at 24 solid waste management units (SWMUs) and three areas of concern (AOC). Prior to 1993, environmental activities at NSRR, exclusive of underground storage tanks (USTs), were conducted in compliance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) regulations under the Department of the Navy's (DoN's) Installation Restoration (IR) Program. The RCRA Part B Permit, issued for the Defense Reutilization and Marketing Office (DRMO) at NSRR, included provisions for corrective action under the Hazardous and Solid Waste Amendments (HSWA) provisions of RCRA.

1.1 Context of this Report

This report was developed to meet the requirement of Task I under Module III, Appendix B (Scope of Work for a Corrective Measure Study) as contained in the Stations RCRA Part B Permit. The Task I CMS report identifies the preliminary corrective measure technologies to address the soil and groundwater contamination present at the site from the site operations. The technologies identified are screened and developed for removal, containment, treatment and/or other remediation of the contamination based on the objectives established for the corrective action.

Numerous environmental investigations have been performed and reported on at this site including an Initial Assessment Study (1982), Confirmation Study (1986), Underground Fuel Investigation (1991), Preliminary Site Assessment Underground Storage Tank Site No. 443 (1992), Draft Corrective Action Plan (1992), Site Characterization and CAP (1994), Multi-Stage Product Recovery Test Report (1996), Closure Report for Tank 56A/B (1996), Project Close-Out Report Interim Corrective Measure Free Product Recovery System (1997), Corrective Measures Study Investigation (1998), and the Additional Data Collection Investigation (2002). A more detailed discussion of these reports is provided in Section 2.2 of this document. A CleanOX Pilot Study was conducted in January 1999 and is discussed in Section 2.3.5. A pilot test to evaluate enhancement of product recovery at the TWFF was completed in August 2000 and is detailed further in Section 2.3.6.

1.2 Objectives of the Task I Effort

The objective of this Task I CMS for the TWFF is to identify, screen, and develop the corrective measure alternative or alternatives for removal, containment, treatment and/or other remediation of the contamination based on the objectives established for the corrective action. The Task I CMS includes the initial screening of the possible corrective actions for the TWFF, a description of current conditions at the site and establishes the clean-up goals. The evaluation of the corrective measure alternative or alternatives is conducted in the Task II CMS. The Task III CMS justifies and recommends a corrective measure alternative using technical, human health, and environmental criteria. The Task II and Task III CMS reports will follow the approval of the Task I CMS.

1.3 Report Format

This report is divided into nine sections. Section 1.0 of this document includes this introduction and the objectives of this Task I CMS Report. The description of the current situation of the site is described in Section 2.0. The Ecological Risk Assessment, Steps 1 through 3a is presented in Section 3.0. Section 4.0 presents the establishment of corrective action objectives. Contaminants of concern are introduced in Section 5.0 of this document. Section 6.0 identifies the preliminary corrective measure technologies. The screening of these corrective measure technologies is conducted in Section 7.0. Section 8.0 identifies the corrective measure alternative or alternatives. The references utilized in development of this report are provided in Section 9.0.

2.0 DESCRIPTION OF CURRENT SITUATION

This section of the report provides an update to the information describing the current situation at the TWFF and the known nature and extent of the contamination as documented by the RFI Report (Baker, 1997), the Corrective Measures Study Investigation Report (Baker, 1999a), the Additional Data Collection Investigation Report (see Appendix E), and the most recent Tow Way Fuel Farm Quarterly Summary Progress Report No. 21 (Baker 2002). An update of the previous RCRA activities at the TWFF including previous response activities and any interim measures that have or are being implemented are also provided. The facility-specific statement of the purpose for the response, based on the results of the RFI is included in this section of the report. The statement of purpose identifies the actual or potential exposure pathways that should be addressed by the corrective measures.

2.1 General Site Description

This section contains a description of the Station, the two SWMUs located at the TWFF, and a summary of the fuel loss history through the years of operations at the TWFF.

2.1.1 Station Description

NSRR occupies part of the northern side of the east coast of Puerto Rico, along Vieques Passage with Vieques Island lying to the east about 10 miles from the harbor entrance. The northern entrance to NSRR is about 35 miles east along the coast road (Route 3) from San Juan. The closest large town is Fajardo (population approximately 37,000), which is about 10 miles north of NSRR on Route 3. Ceiba (population approximately 17,000) adjoins the west boundary of NSRR (see Figure 2-1).

NSRR occupies over 33,500 acres at the northeastern most portion of Puerto Rico. NSRR has administrative and command responsibilities for operations separated from the main base on Vieques Island.

NSRR was commissioned in 1943 as a Naval Operations Base, and finally redesignated a Naval Station in 1957. The primary mission of NSRR today is provision of full support for Atlantic Fleet weapons training and development activities.

2.1.2 SWMU 7 - Tow Way Fuel Farm

The TWFF is located on a hillside along Forrestal Road north of Ensenada Honda (Figure 2-2). Constructed prior to 1957, the fuel farm originally consisted of nine USTs containing diesel fuel marine (DFM), Bunker C fuel, and jet fuel (JP-5). That number has since been reduced to seven (Figure 2-3) by the removal of two tanks. Data obtained from previous reports indicate that the USTs have been used solely for the storage of marine fuel and jet fuel since their construction.

2.1.3 SWMU 8 - Tow Way Fuel Farm Sludge Disposal Pits

Prior to RCRA regulations, it was common industry practice to dispose of accumulated sludge material in excavated pits adjacent to the tanks during tank cleaning operations. This practice was apparently employed by TWFF personnel prior to the current practice of disposal by a licensed contractor. Previous investigations were unable to locate evidence of the pits; however, SWMU 8 was included in the permit as a full RFI site.

2.1.4 Fuel Loss History

There have been numerous spills of small and large quantities of fuels stored in the TWFF. The known fuel loss history according to O=Brien & Gere (1992) is summarized as follows:

- 1957/1958 - Approximately 420,000 gallons of Bunker C fuel leaked from UST No. 82.
- 1960s/1970s/1980s - A cumulative volume of approximately 420,000 gallons of fuel leaked from UST Nos. 56A and 56B during this time period.
- 1971/1972 - Approximately 3,900 to 7,500 cubic yards of Bunker C fuel-sludge was removed from UST Nos. 83 and 1080 and was buried in pits excavated adjacent to the USTs.
- 1978 - Approximately 65,000 gallons of diesel fuel leaked from UST No. 1080. Approximately 10,000 gallons were recovered during cleanup operations.
- 1986 - Approximately 91,000 gallons of JP-5 leaked from UST No. 85. Approximately 32,000 gallons were recovered by various methods.

Seven fuel storage tanks are located north of Forrestal Road on a hill overlooking Ensenada Honda. As referenced from the NEESA report 13-051, September 1984, spills, leaks, and sludge disposal have occurred here since 1957. The following paragraphs provide more detail for the above billeted items.

In 1957 or 1958, a fuel line to Tank 82 leaked, resulting in a spill of Bunker C fuel. It is estimated that approximately 420,000 gallons of Bunker C fuel leaked from the storage tank. The oil spill followed a path downhill toward the harbor in a southwesterly direction towards Ensenada Honda, extending to the shoreline and the Ensenada Honda mangrove swamp across the harbor.

From approximately the 1960s through the 1980s, it is also estimated that approximately 420,000 gallons of fuel spilled from Tanks 56A and 56B onto the surrounding soil over a 15- to 20-year period. The tanks were replaced in February 1984. A dark fuel-stained soil was present around the old tanks. Isolated pools of oil from the spills and leaks were evident on the groundwater that seeped into the holes where the tanks had been removed.

Between 1971 and 1972, Tanks 83 and 1080 were cleaned and the Bunker C fuel-sludge was emptied into two pits dug within a 100-foot radius of the tanks. One pit was dug approximately 100 feet in circumference and 10 to 20 feet in depth near Tank 83; the second pit was 50 feet in circumference and 10 to 20 feet in depth near Tank 1080. It is estimated that 3,900 to 7,500 cubic yards of Bunker C fuel-sludge were cleaned from the tanks and disposed of at the site in these pits.

In 1978 a leak occurred at Tank 1080, resulting in the release of approximately 65,000 gallons of diesel fuel from the tank. It is estimated that about 10,000 gallons were recovered during cleanup operations.

In November 1986, Tank 85 leaked approximately 91,000 gallons of JP-5. Approximately 22,000 gallons were recovered. Another 10,000 gallons were trapped in sand under the tank. As a result, approximately 59,000 gallons were unaccounted for during the spill.

The seven USTs are located in the Upper TWFF, which is on an area of higher elevation than the Lower TWFF. Forrestal Drive separates the Upper and Lower TWFFs. Based on the TWFF topography and

historic groundwater flow directions, fuel leaking from the USTs and associated piping flows radially from monitor well UGW2. However, the free-product plume at the site does not extend to Ensenada Honda, it pools at the base of the hill that separates the Lower and Upper TWFFs.

One spill event of over 100,000 gallons of fuel caused fuel to enter Ensenada Honda directly. It was known prior to the start of RFI investigations that free product was present in the subsurface floating on the groundwater surface (active remediation of this condition is underway). For this reason, the TWFF was included in the Corrective Action portion of the RCRA permit as a SWMU requiring a full RFI.

2.2 Previous RCRA Activities at the Tow Way Fuel Farm

Numerous environmental investigations have been conducted at NSRR; however, this section deals only with those associated with SMWU 7/8 which comprise the TWFF.

2.2.1 Initial Assessment Study

As part of the Navy-wide program to manage past disposal sites through the Navy Assessment and Control of Installation Pollutants (NACIP), NSRR was designated for an Initial Assessment Study (IAS) in 1982. Conducted in 1983 and 1984 by Greenleaf/Telesca Planners, Engineers, Architects (Miami, Florida) and Ecology and Environment (Buffalo, New York), the IAS consisted of a records search at various government agencies, national and regional archives, and United States Geological Society (USGS); an on-site survey; and personnel interviews. The study identified 16 sites that warranted further study under NACIP including SWMU 7/8 (formerly referred to as IR Site 12).

2.2.2 Confirmation Study

In May 1986, a Confirmation Study (CS) was performed by Environmental Science and Engineering (ESE) of Gainesville, Florida. Fifteen of the 16 sites identified in the IAS were investigated as part of this study including SMWU 7/8. This study consisted of two rounds of sample collection from the 15 sites. Completed in April 1988, the CS indicated 14 sites, including SWMU 7/8, required additional investigation.

2.2.3 Underground Fuel Investigation

Initial investigatory work at the TWFF was performed under the provisions of the RCRA Underground Storage Tank (UST) program for which Puerto Rico Environmental Quality Board (PREQB) had primacy over.

This investigation was a groundwater and soil assessment conducted by O=Brien and Gere Engineers, Inc. in 1991. The study included the installation of ten soil borings (B-1 through B-10) to an average depth of 15 feet below ground surface (bgs) and 18 monitoring wells (UGW-1 through UGW-18) at SWMU 7/8 to define the extent of groundwater contamination, free floating product, and soil contamination. The soil samples were analyzed for total organic halogens (TOX), toxicity metals, flash point, and total petroleum hydrocarbon (TPH).

The monitoring wells installed between February 1991 and March 1991 were constructed of 2-inch inside diameter (ID) polyvinyl chloride (PVC) and designated UGW-1 through UGW-18. One round of groundwater samples were collected and analyzed for volatile aromatic and unsaturated organic compounds (USEPA Method 503.1) and lead. In addition, in situ tests were conducted in 11 monitoring wells to determine site hydraulic conductivity, newly existing monitoring wells were surveyed with the

elevations tied into the U. S. Geological Survey datum, and two rounds of groundwater and product thickness measurements were collected (March 29 and April 4, 1991).

Semi-confined aquifer conditions were encountered in nine monitoring wells (UGW-1, UGW-3, UGW-4, UGW-8, UGW-9, UGW-10, UGW-12, UGW-13, and UGW-14). At each of these locations, the monitoring well screen was placed across the top of the aquifer (first encountered saturated conditions); however, with time, the water level and/or product layer was found to occur above the well screen. The field investigation defined the extent of free floating product, but only partially defined the extent of groundwater and soil contamination.

2.2.4 Preliminary Site Assessment Underground Storage Tank Site No. 443

Law Environmental-Caribe completed a limited site assessment in 1992 in the area surrounding a leaking 550-gallon waste oil tank that had failed a tightness test. This tank was located approximately 100 feet west of monitoring well UGW-18 along Forrestal Drive (Figure 2-3). Three soil borings were advanced to a depth of 20 feet bgs surrounding the tank. One soil sample with highest OVA reading from each soil boring was sent to the laboratory and analyzed for benzene, toluene, ethylbenzene, and total xylenes (BTEX) and TPH. The soil samples that were sent had a strong hydrocarbon odor. Laboratory TPH analyses indicated concentrations in the soil ranging from 230 to 1,200 milligrams per kilogram (mg/kg) in excess of the PREQB standard of 100 mg/kg. Horizontal and vertical extent of soil contamination was not determined for the soil underlaying and surrounding the 443 UST site.

2.2.5 Draft Corrective Action Plan

A series of four soil borings were installed in November 1992 at the TWFF to support preparation of a Draft Corrective Action Plan (CAP) which was submitted by Law Environmental-Caribe in October 1993. These four borings were advanced to depths ranging from 8 feet to 19 feet. Two of the soil borings were located just north of Forrestal Drive in the vicinity of existing monitoring wells UGW-3 and UGW-14. The remaining soil borings were located south of Forrestal Drive in the vicinity of existing monitoring wells GW-4 and UGW-18. Each soil boring was sampled for subsurface soil from 5 feet above the water table to the water table and composited into one sample for laboratory analysis. Soil samples were analyzed for Toxicity Characteristic Leaching Procedure (TCLP) metals, TOX, flash point, and TPH. The report noted that soil from only one boring contained TPH concentration in excess of PREQB standards (100 mg/kg). All other soil sample results were below this standard.

Groundwater samples were collected from 11 monitoring wells and analyzed for volatile aromatic and unsaturated organic compounds (USEPA Method 502.2 and 503.1), lead, and TPH. Groundwater and product thickness measurements were conducted with a interface probe for four consecutive months (August 31, September 28, November 17, and December 12, 1992). Screened intervals for nine monitoring wells (UGW-1, UGW-3, UGW-4, UGW-8, UGW-9, UGW-10, UGW-12, UGW-13, and UGW-14) were confirmed to be below the measured groundwater and/or free product elevations. Free product was detected in nine monitoring wells (UGW-1, UGW-2, UGW-4, UGW-5, UGW-12, UGW-13, UGW-14, UGW-17, and GW-04). Free product was detected in UGW-2 in 1992, but was not detected in 1991 measurements.

It was concluded that the horizontal extent of free product had not been adequately determined. A four phased CAP was proposed to include monthly groundwater and product measurements and quarterly groundwater collection of groundwater samples analyzed for BTEX, lead, and TPH.

2.2.6 Site Characterization and CAP

Blasland, Bouck, and Lee, Inc. (BB&L) completed a site characterization study in April 1994. This investigation was designed to define the extent of contamination in soil and groundwater at the TWFF through the installation of seven soil borings, eight monitoring wells, performance of wellhead tests, and preparation of a site-specific risk assessment.

The fieldwork was conducted from November to December 1993. Seven soil borings were installed to delineate the outermost boundary of soil contamination and were completed to the water table. Select soil samples were submitted to the laboratory for BTEX and TPH confirmatory analysis based on field screening results. The results from the field screening and laboratory were below 100-mg/kg PREQB TPH contamination level. Groundwater samples were collected from the open borehole and analyzed for volatile organic compounds (VOCs) and TPH in the field. Confirmatory groundwater samples for three soil borings were sent to the laboratory. If the groundwater in the soil boring was determined to be outside of the free product area, a groundwater monitoring well was installed. Soil boring BBSB-4 was the only soil boring to be drilled within the free product area and a monitoring well was not installed in the soil boring. Soil boring BBSB-5 was installed further from the TWFF than BBSB-4 to insure the extent of groundwater effect was defined. Six monitoring wells were installed to the top of the water table (UGW-19, UGW-20, UGW-21, UGW-23, UGW-24, and UGW-25). One monitoring well was installed as a deep monitoring well (UGW-26) 40 feet below the water table. Monitoring well UGW-22 was installed in the center of the free product plume as a 6-inch monitoring well to accurately estimate the thickness of the free-floating product on top of the water table. The eight newly installed monitoring wells (UGW-19 through UGW-26) and ten existing monitoring wells (UGW-6 through UGW-11, UGW-15, UGW-16, UGW-18, and GW-02) that did not contain free product were sampled and analyzed for VOCs and TPH.

Other field activities included collecting groundwater and product elevations in on-site monitoring wells, conducting an aquifer performance test in monitoring well UGW-22, conducting one in situ test (rising head) in four monitoring wells, performing free product bail-down tests in four monitoring wells, performing preliminary product recovery rate tests, and conducting a double-ring infiltrometer test. The in situ tests and the aquifer performance test indicate permeability of sediment in the TWFF is too low to support a conventional groundwater recovery system. The product bail down tests indicated the majority of free product was located in a relatively small area north of Forrestal Drive in the vicinity of USTs 56A/56B and monitoring wells UGW-1, UGW-5, and UGW-22.

Results of the investigation showed that contamination in the soil and groundwater is confined to the general area of the TWFF and has not migrated into Ensenada Honda. The configuration of the groundwater plume generally conforms to the location of fuel distribution lines from the tanks and is primarily diesel fuel and JP-5 fuel. Also reported in the study was the indication that site soil and bedrock are of low permeability that inhibits migration of contaminants beyond the boundaries of the fuel farm. The volume of contaminated soil at the TWFF was estimated to be 2 million feet^3, contaminated groundwater was estimated to be between 3.5 and 11.1 million gallons, and free product was estimated to be between 100,000 and 243,000 gallons based on the product thickness map and an assumed soil porosity of 0.3. The true thickness of free product ranges from a few inches in perimeter monitoring wells to less than three feet in the center of the plume. The vertical and horizontal extent of free-product and groundwater contamination plume was defined within the TWFF, except on the hill east of the Upper TWFF and north of Forestall Drive due to steep terrain and dense vegetation. The report recommended that remediation should concentrate on the free product layer on the groundwater table due to the low migration rates of the soil and groundwater contamination plumes.

Data collected during this investigation was used in the preparation of a Corrective Action Plan (BB&L, September 1994). Alternatives discussed in this CAP included passive surface skimming, hand bailing,

and active skimming.

2.2.7 Multi-Stage Product Recovery Test Report

An informal report for multi-stage product recovery test was submitted by Terra Vac on March 25, 1996 to the EPA. Terra Vac conducted a single, dual, and three-phase testing of free product recovery systems. Single phase recovery is free product only pumping (i.e., free product only); two-phase recovery is vacuum enhanced free product only pumping (i.e., free product and vapors); three-phase recovery is vacuum enhanced groundwater and free product recovery (i.e., free product, vapors, and groundwater). The purpose of the tests was to determine the best available technology to enhance free product recovery without causing the product to spread further. Concerns were expressed by the USEPA that upward spreading of product might occur by wicking-up the product under vacuum extraction methods or smearing the product to lower depths by lowering the water table during simultaneous product and groundwater pumping. To address USEPA concerns, low level pumping techniques were used to maintain minor groundwater elevation reduction. The scope of work included soil testing, measurement of water and product levels, product recovery rates, installation and testing of recovery systems and evaluation of radius of influence and capture zone.

A product-only (one-phase) recovery system was installed in seven existing monitoring wells on site. Advantages of a skimmer-type system are that the product is the predominant fluid recovered and hence the cost of treatment and/or disposal of recovered water is saved. Other advantages include low power requirements and operations may be based on intrinsically safe electrical or air operated systems. This was a passive system since it does not provide any driving force for product to move toward the well; it operates essentially in hydrostatic conditions. The system was limited by the rate at which product drains into the well from the capillary fringe. Without any additional driving force, other than gravity, product moves very slowly from the formation, especially in low permeability formations that are present at the site. In addition, the radius of influence of such a system is very limited; typically a few inches to a few feet. Product goes into a holding tank where the levels are monitored such that the pumping system will shut down at 90% of the capacity of the tank. The system was Aturned on@ on February 4, 1994. Monitoring well UGW-1 had the greatest thickness of free product measured.

Product thickness in monitoring well UGW-25 had increased 214 percent from January to August 1995. This report recommended that installation of a recovery system in UGW-25 should be considered at this time to control the expanding free product plume.

Pneumatic pumps (two-phase) were installed in seven monitoring wells in July until September 14, 1995. On September 14 the system was shut down in preparation for installation of seven new recovery systems (three-phase). During the installation of the seven new recovery system wells, 69 soil samples were collected. The soil samples were sent to a contract laboratory for TPH analysis. The seven new recovery systems were installed in six new 4-inch wells identified as PW-1 through PW-6 and one new 2-inch monitoring well labeled as MW-1. Three additional 2-inch wells were installed as monitoring wells and were identified as MW-2, MW-3, and MW-4. Well installation took place from September 11 to September 27, 1995. One of the reasons for installing new wells was to identify the impact of free product pumping in nearby monitoring wells over the previous three years. If the free product only pumping systems were effective, the surrounding area would contain no free product in these monitoring wells. Also, measurement of the product/water interface could be assessed under various operating conditions as requested by the USEPA. Phase 1 testing of these wells recovered 30 gallons of product. Based on the results of Phase I and the estimated spill volume of 243,000 gallons, it would take 44 years or more to recover the total volume of spilled product and would take approximately 270 wells spaced 15 feet to recover the free product at the site.

The total amount of product recovered from the project start in 1994 through 1995 was 12,630 gallons. Monitoring well UGW-4 had the largest product layer in September 1995. In this report, Terra Vac determined that the product layer across the site appeared to have reached a steady state even though there was still a substantial product level. It appeared the product recovery system had reached its capture capacity in the present configuration. Terra Vac indicated that the installation of vacuum assisted recovery system had the potential to greatly increase the recovery rate at the site.

Phase 2 testing began on October 10, 1995. The Phase 2 system used product recovery with product only pumps as in Phase 1 with the simultaneous addition of vacuum extraction (soil vapor extraction). The Phase 2 process was designed to extract a negative relative pressure within the well to enhance the flow of fluids into the recovery wells. If the system, as tested, was allowed to operate at these rates for 1 year and assuming product would freely migrate towards the capture zones, potentially 28,700 gallons of product would be recovered. This represents a 420 percent increase in product recovery over the Aproduct only@ system while reducing the recovered water to product ratio by 75 percent. Based on the estimated spill volume of 243,000 gallons, it was estimated that recovery would take 8.5 years or more to recover the total volume. With the radius of influence of the vacuum system, spreading or smearing of the free product would be controlled as the hydrocarbons would either evaporate and be recovered in the vapor phase or migrate along the differential pressure gradient toward the extraction wells where they would be recovered at much higher rates in the liquid phase.

On October 17 and 18, 1995, Phase 3 testing began. The Phase 3 system included lowering vacuum hoses or pipes into the product and/or groundwater and connecting to the vacuum source at the wellhead. No independent product recovery pumps were required. The vacuum source provided the driving force to lift the fluids from the borehole. The vacuum further induces subsurface airflow and provides the velocity required to maintain fluid flow without flooding the intake which is below the static fluid level (i.e., some amount of airflow is required to lift the fluids to the surface). The entrainment process is used to recover groundwater, product, and vapors simultaneously. Free product recovery is optimized by adjusting the depth of the entrainment hoses so they recover as much of the product and vapor and as little of the groundwater as possible. The results of the test indicated that if the system, as tested, was allowed to operated for 1 year and assuming product would freely migrate towards the capture zones, potentially 49,100 gallons of product would be recovered. Based on the estimated spill volume of 243,000 gallons, it would take 5 years or more to recover the total volume. This represented a 70 percent increase in recovery rates over the two-phase recovery test and a 800 percent increase over the product-only, total fluids recovery system. Also, for all of the tests it was determined that the shape of the capture zone is not radially symmetric around the respective test wells, but rather is eccentric, typical of the pattern associated with highly fractured rock. Formal delineation of capture zones are inconclusive due to the heterogeneity's and natural fluctuations in the water table.

The previous system configuration was shut down on October 27, 1995, pending contract authorization. On December 20, 1995 the Vacuum Extraction Unit used during the Multi-Phase testing was demobilized from the site. There were no operations of the free product recovery system in November and December 1995. On January 24, 1996 the free product recovery systems were prepared and tested for operations. January 25, 1996 the seven free product recovery systems began operations in wells PW-1, PW-2, PW-3, PW-4, PW-5, PW-6, and MW-1. Well PW-6 had the largest product thickness measured.

On March 30, 1996 the system was shut down as requested by the Navy representatives. The water discharge hose from the oil/water separator developed a leak in the section that crosses the road. The damage was caused by vehicular traffic. April 18, 1996 repairs were made to the hose by cutting out the damaged section and splicing in a new section.

On August 1, 1996, the entire system was shut down by request of Navy representatives. On August 1, 1996 product samples were collected from the product holding Tank B and Tank C. The samples were sent to the laboratory for RCRA metals analysis. The product was determined to be non-hazardous. On August 23, 1996 the system was restarted with three phase vacuum recovery systems installed in monitoring wells, UGW-1, UGW-4, UGW-12, and UGW-13. On August 26 the system was found not to be running. The most likely reason was a power outage by unknown sources. The total amount of free product removed from January to August 1996 with the system was 20 gallons. Well UGW-4 had the greatest product thickness from February through August 1996. The VARS product recovery system was demonstrated to be significantly more effective by 1400 percent than the skimmer system.

2.2.8 Closure Report for Tank 56A/B

Reliable Mechanical, Inc. issued a Closure Report for Tank 56 in November 1996. The 2-10,000 gallon steel tanks were located underground in front of Building 56. These tanks were used by the U.S. Navy as storage for diesel fuel that was to be loaded into tanker trucks for use at remote locations. A remote 6-inch underground fuel line that had been replaced filled the tanks. New 2-inch fiberglass pipes in 3-inch containment pipes were installed. Two new, 15,000 gallon double walled USTs were installed and outfitted with electronic overfill protection, interstitial leak detection piping, sump leak detection, and electronic gauging. Four soil samples were collected (two at the tank ends, one in the tank middle area, and one from the stockpiled soil from the excavation) from each tank excavation. Additionally three soil samples were collected along the pipeline excavation for a total of 11 soil samples. All samples were analyzed for TPH and BTEX by a certified, on-site mobile laboratory. Contaminated soil (329 tons) was bioremediated and disposed as a non-regulated disposal.

2.2.9 Project Close-Out Report Interim Corrective Measure Free Product Recovery System

ICHOR Services, Inc. (formerly PDGES) issued the Project Close-Out Report on February 24, 1997 for J.A. Jones Environmental Services. The primary objective was to address the identified product plume at the TWFF. Secondary objectives include controlling the product plume to minimize migration of the plume to the south and collect as much free product as practical at the TWFF. The installation plan was developed in accordance with Response to Comment No. 5 contained in the AResponse to USEPA=s Comments dated June 20, 1996 and September 13, 1996, TWFF@ prepared by BB&L dated September 26, 1996. The recovery wells were positioned within the limits of the free-floating product plume to maximize recovery. Product was to be recovered with eight pneumatic operated product recovery wells (RW-1 through RW-8). Seven of the wells were newly installed (6-inch ID installed in a 12-inch OD soil boring) and one pump was to be located in existing monitoring well UGW-22 (RW-3). The recovery pump was ultimately not installed in well UGW-22 because product did not accumulate significantly in this well. However, a well vault and piping was installed to this well so that a pump may be added in the future should product thickness increase. Mobilization of the project was delayed until an installation plan to address USEPA comments was prepared. Free product (296 gallons) was removed from the recovery wells from December 1996 through February 1997.

ICHOR Services, Inc. issued the Pre-Final Operation and Maintenance Manual on April 9, 1997 for J.A. Jones Environmental Services.

2.2.10 Operation of ICM

The commissioning phase of the ICM was completed on April 30, 1997. Free product removal from the ICM began in March 1997 was suspended in October 1999 for the performance of the pneumatic

fracturing pilot study. Product removal was resumed during March 2001 and is presently performed by removing product from any well with product present through a portable pump. The free product recovered from March 1997 through October 1999 yielded a total 1,611 gallons of free product recovered. The free product recovered from March 2001 through April 2002 yielded 111 gallons.

2.2.11 Other Letter Reports Submitted

J. F. Martinez & Co. and Altol Environmental Services, Inc. performed emergency repair to a 12-inch DFM fuel line at TWFF area according to the Project Status Report #1 on April 29, 1997. The project was executed in two phases. The first comprised soil and pipe integrity testing, replace 1,850 linear feet of damaged pipe at tunnel, and contamination and debris removal. The second consisted of repair by replacement of the piping as described below.

1. Remove ruptured pipe from utility tunnel.

2. Provide hydro pressure testing to the remaining underground piping.

3. If piping passes the hydro pressure testing then proceed to replace the 150 linear feet at the tunnel, hydro test the complete pipe section including the new pipe section again, perform soil and ultrasonic testing.

4. If piping does not pass the hydro pressure testing, perform ultrasonic and soil testing, according to applicable project scope items, and wait for instructions.

The program included the following tasks: test pit excavation, soil sampling, replacement of 150 linear foot DFM Pipe (12-inch diameter), and restoration of tunnel and excavated areas. Thirteen test pits were excavated to expose the main DFM pipe and assess pipe and soil conditions. Test pits were excavated to a maximum depth of 12 feet bgs. No groundwater was encountered. Soil screening was conducted for organic vapor concentrations. Thirteen soil samples were collected from the bottom and center of each excavation at a depth of 5-12 feet bgs at the DFM pipe area. Three soil sample results were not provided in the Project Status Report. Soil samples were collected from the backhoe's bucket and analyzed for TPH and BTEX. Two composite soil samples were collected from the excavated soil piles and analyzed for full RCRA TCLP analysis (VOCs, SVOCs, total metals, reactivity, corrosivity, and ignitability). Strong hydrocarbon odor was perceived in soil. TPH concentrations ranged from 122 to 43,400 mg/kg in soil samples (S-1 through S-10, D-1, and D-2) which exceeded USEPA and PREQB regulatory levels. The soil piles did not have hazardous characteristics. The existing fuel line was cut just upgradient and just downgradient of the tunnel. The cut section of pipe was removed from the tunnel. This section was replaced and the line was subsequently pressure tested. The removed section of pipe was noticeably corroded in areas, and a strong petroleum odor was evident in the tunnel. Furthermore, product was reportedly observed on the tunnel floor prior to the cutting of the pipe. Based on conversations with Activity personnel, the presence of product in the vadose zone and shallow groundwater is attributable to past storage/spills - not related to the main fuel line that is being repaired. Product stored in the past includes JP-5 jet fuel, No. 6 fuel oil, and diesel fuel. Two types of fuel are currently stored at the fuel farm including JP-5 jet fuel and DFM. Another potential source of contamination is the overflowing of the valve pit that is located upgradient from the tunnel near 7MW17. Product was not observed seeping from the exposed fuel line, no cracks, holes, or voids were noted in the fuel line. The most severe soil staining was observed above the level of the pipe.

Baker prepared a site visit memorandum for the existing fuel line inspection. Baker was on site to provide environmental and health and safety services. Baker did not observe any evidence substantiating that the

fuel line was leaking at the excavated pit locations. For example, product was not observed seeping from the exposed fuel line, no cracks, holes, or voids were noted in the fuel line, and the most severe soil staining was observed above the level of the pipe. The soil immediately underlying the fuel line at test pits 2 and 3 was discolored; however, this may be attributable to a spill originating from another source or to the color of the backfill material. A very small seepage face of dark brown product was observed just below the pipe at the north end of test pit 9. Heavy staining of soil was observed in test pits 1, 8, and 10. Slight staining of soil was observed in test pits 2, 3, and 9. No staining was observed in test pits 4, 5, 6, and 7. The test pit locations are presented on Figure 2-3 at locations S-1 through S-13. Five samples were collected of product. Samples 97-DFM-01 and 97-JP5-01 were collected from the fuel farm-sampling tap and contain fresh DFM and JP-5 jet fuel, respectively. One sample of unknown product (97-VP-01) was collected from the valve pit north of the tunnel. Two samples were collected from test pit numbers 1 (97-PIT01-W01) and 10 (97-PIT10-W01), which represented the two most contaminated test pits based on visual observations. The unknown samples closely matched the fingerprint of sample 97-DFM-01. The laboratory reports that it appears that some weathering has occurred to the three unknown samples based on the loss of the early portion of the fingerprint. The amount of weathering appeared to be the greatest in sample 97-PIT01-W01 and the least in sample 97-VP-01.

2.2.12 Corrective Measures Study Investigations

A CMS Investigation was performed during the Spring of 1998 to gather additional data with respect to the fuel related contamination to assist in the development of the CMS and selection of the most applicable remedial approach.

The investigation included the performance of 30 direct push soil borings with the collection of 68 subsurface soil samples. The subsurface soil samples were analyzed for BTEX, TPH diesel range organics (DRO) and gasoline range organics (GRO), total organic carbon (TOC), bulk density, and particle size distribution. A total of ten soil gas samples were collected and analyzed for percent oxygen, percent carbon dioxide, and TPH (DRO and GRO). Three in-situ vertical permeability tests were conducted, as was groundwater sampling from 41 monitoring wells across the site. The groundwater samples were analyzed for BTEX, TPH (DRO and GRO), methane, nitrate, sulfate, alkalinity, chloride, and ferrous iron.

2.2.13 Additional Data Collection Investigation

An Additional Data Collection Investigation was performed during the first part of 2002 to address the additional data requirements identified from the previous investigations and to support the ongoing efforts of the CMS.

This investigation included the installation of eleven additional monitor wells and eight soil borings. Surface and subsurface soil samples were collected during the drilling operations. Surface soil samples were analyzed for VOCs, SVOCs, and Appendix IX Inorganics. Subsurface soil samples were analyzed for PAHs and SVOCs. Groundwater samples were collected from the eleven new monitor wells and 22 existing monitor wells throughout the site. The groundwater samples were analyzed for VOCs, SVOCs, and Appendix IX Inorganics. Select samples were additionally analyzed for natural attenuation parameters including nitrate, nitrite, sulfate, methane, ethane, ethene, TOC, and groundwater density. Slug tests were conducted on sixteen of the monitor wells. Eleven sediment and nine surface water samples were collected and analyzed for VOCs, SVOCs, low level PAHs, and Appendix IX Inorganics. The sediment samples were additionally analyzed for TOC. Two samples of the phase-separated hydrocarbons present at the site were collected and analyzed for Brookville kinematic viscosity and product density.

This investigation along with the Corrective Measures Study Investigation was conducted to provide a recent update of the soil and groundwater contamination present at the site. A brief discussion of the results from these investigations is summarized in the following section of this report.

2.3 Summary of Site Conditions

A description of the most recent site conditions is provided in the following subsections of this report. The data included is summarized from the Additional Data Collection Investigation Report (see Appendix E), and the Tow Way Fuel Farm Quarterly Summary Progress Report No. 21 (February 1, 2002 through April 30, 2002) (Baker, 2002). All historical data collected from the TWFF is provided as Appendix F of this document. This appendix contains a unified data set from all the historical data at the TWFF.

2.3.1 Soil Contamination

Twelve surface soil samples were collected during the investigation. A total of seven volatiles: styrene, toluene, xylene, 1,1,1-Trichloroethane, methylene chloride, 2-butanone, and trichloroethene were detected in the 12 surface soil samples. A majority of the maximum detections in surface soil were reported in sample 7SB30-00. This sample was located in the northern TWFF area along Palau Street as presented in Figure 2-3.

A total of eight semivolatiles: bis(2-ethylhexyl)phthalate, benzo(g,h,i)perylene, benzo(b)fluoranthene, fluoranthene, chrysene, benzo(a)anthracene, di-n-butylphthalate, and phenanthrene were detected in the surface soil. The majority of the semivolatile detections in surface soil were reported in sample 7SB29-00. This sample was also located in the northern TWFF area along Palau Street as presented on Figure 2-3.

Along with the semivolatile analysis, 7MW16-00 was also analyzed for low level PAHs. A total of ten PAHs were detected in 7MW16-00, with concentrations as follows: pyrene [4.3J micrograms per kilogram (µg/kg)], benzo(g,h,i)perylene (3.2J µg/kg), indeno(1,2,3-cd)pyrene (2.2J µg/kg), benzo(b)fluoranthene (2.5J µg/kg), fluoranthene (6.2J µg/kg), benzo(k)fluoranthene (3.6J µg/kg), chrysene (3.3J µg/kg), benzo(a)pyrene (2.7J µg/kg), benzo(a)anthracene (3.2J µg/kg), and phenanthrene (3.4J µg/kg).

A total of fifteen different metals were detected in the surface soil samples, including lead, mercury, nickel, thallium, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, vanadium, zinc, and selenium. There did not seem to be a trend in the metals analysis of surface soil.

Twelve subsurface soil samples were collected during the investigation. A total of seven SVOCs: bis(2-

ethylhexyl)phthalate, pyrene, 7,12-dimethyl benz(a)anthracene, p-dimethylaminoazobenzene, 2,6-dinitrotoluene, phenanthrene, and 5-nitro-o-toluidine were detected in the subsurface soil.

Along with the SVOC analysis, all 14 subsurface soil samples were analyzed for low level PAHs. A total of 14 low level PAHs were detected in the subsurface soil. Seven of the 14 listed low level PAH constituents were detected in soil boring 7MW19, located at the top of the hill north of the back gate entrance to the TWFF.

2.3.2 Groundwater Contamination

A total of 21 VOCs were detected in the groundwater samples that were collected during the Additional Data Collection Investigation. Of the 21 VOC constituents detected, only two of those VOCs (benzene and trichloroethene) were detected in four or more of the monitor wells sampled. Figures 2-4 and 2-5 are isopleth maps showing graphically the levels of detections within each monitor well of benzene and trichloroethene, respectively. As presented on Figure 2-4, the detections of benzene appear to be centrally located in the area of monitor wells 470MW1 and 470MW3. As presented on Figure 2-5, the highest detections of TCE appear to be in the area of 7MW07.

There were 21 SVOCs detected in the groundwater samples. Of the 21 SVOC constituents detected, only three of those SVOCs (fluorene, naphthalene, and 2-methylnaphthalene) were detected in four or more of the monitor wells sampled. Figures 2-6 through Figure 2-8 are isopleth maps showing graphically the levels of detections within each monitor well of fluorene, naphthalene, and 2-methylnaphthalene, respectively. As presented on Figure 2-6, the highest detections of fluorene appear to be in three distinct areas. One area appears to be centrally located around monitor well 470MW1, while the second area appears to be centrally located at the intersection of Palua Street and Forrestal Drive. The third area is located around monitor well UGW10. As presented on Figure 2-7, the highest detections of naphthalene appear to be in two distinct areas, one of which centrally located around monitor wells 470MW1 and 470MW3, while the second area is located around monitor well 7MW08. Figure 2-8 presents the highest detections of 2-methylpahpthalene in three distinct areas. The first area encompasses much of the lower TWFF area north of Forrestal Drive, while the second area is centrally located around monitor well 7MW12. The third area containing high detections of 2-methylnaphthalene is centrally located around monitor well 7MW08.

2.3.3 Surface Water Analytical Results

Nine surface water samples were collected at the TWFF during the Additional Data Collection Investigation as presented on Figure 2-3. Carbon disulfide was the only VOC detected in any of the surface water samples collected, with concentrations ranging from 2.9J µg/L (7SW6) to 3.3J µg/L (7SW2). Bis(2-ethylhexyl)phthalate was the only SVOC detected in any of the samples collected with a concentration of 12 µg/L in sample 7SW3. Along with the semivolatile analysis, each sample was also analyzed for low level PAHs. A total of six PAHs were detected including anthracene, pyrene, fluoranthene, acenaphthene, phenanthrene, and naphthalene. A majority of the PAHs detected were found in samples 7SW4 and it's duplicate sample 7SW4D.

A total of 11 different total metals were detected in the surface water samples collected at the TWFF, including lead, mercury, tin, antimony, arsenic, barium, cadmium, copper, vanadium, zinc, and selenium. There did not seem to be a trend in the total metals analysis of surface water in the location of maximum detection column.

A total of ten different dissolved metals were detected in the surface water collected at the TWFF samples. The dissolved metals detected in the samples included lead, thallium, tin, antimony, arsenic, barium, cadmium, copper, vanadium, and zinc. Five of the ten detections were found in either sample 7SW4 or 7SW4D, located north of the Fueling Pier along the Ensenada Honda coastline as shown on Figure 2-3.

2.3.4 Sediment Analytical Results

A total of 13 sediment samples and two duplicate samples were collected at the TWFF during the Additional Data Collection Investigation as presented on Figure 2-3. Seven VOCs were detected, including styrene, toluene, xylene, acetone, methylene chloride, carbon disulfide, and 2-butanone.

There were a total of 13 SVOCs constituents detected in the sediment samples collected at the TWFF. A majority of the SVOC detections were found in sample 7SD12 located along the bulkhead in the Ensenada Honda between Pier 2 and the Berthing Pier.

Along with the semivolatile analysis, each sample was also analyzed for low level PAHs. A total of 16 low level PAHs were detected. A majority of the low level PAH detections were found in sample 7SD12 located along the bulkhead in the Ensenada Honda between Pier 2 and the Berthing Pier.

All 15 sediment samples including the duplicate sample were also analyzed for TOC, with ranges from 2,000,000 µg/kg in sample 7SD4, to 18,000,000 µg/kg in samples 7SD7 and 7SD11.

A total of 16 different total metals were detected in the sediment samples collected at the TWFF. Eight of the 16 detections were located in sample 7SD3, located along the coastline in the northwest portion of the Ensenada Honda as presented on Figure 2-3.

2.3.5 Groundwater Level and Free Product Level Measurements

During this investigation, complete round of water levels and free product levels were collected. Of the 84 monitor wells that were measured for free product on February 2, 2002, only eight of the monitor wells contained measureable amounts of free product. These monitor wells included UGW12, UGW19, UGW21, PW2, GW02, 470MW1, 7MW08, and 7MW15. However, the free product levels referred to in the above-mentioned text, were not presented on Figure 2-9. The rationale for this is that the monitor wells at the TWFF were purged on January 31, 2002 by the base's subcontractor under the JA Jones contract. Therefore, the measurements that Baker collected on February 2, 2002 would not accurately depict PSH extent at the TWFF. The free product levels presented on Figure 2-9 are from the base subcontractor's February 28, 2002 round of water levels as well as free product levels. These values would depict realistic levels of PSH at the TWFF.

2.3.6 Interim Corrective Measure

Construction of the ICM at the Tow Way Fuel Farm (including the commissioning phase) was completed April 30, 1997. Prior to that point, product recovery efforts were undertaken on an Aemergency recovery system@ basis. The paragraphs that follow briefly describe the work done to date.

Product recovery testing started with product-only skimming pumps in several of the existing wells at the TWFF which constituted the Aemergency recovery system@. During this time, there were also small scale pilot tests run on various combination of recovery systems which included extraction of single, dual and triple phases (product skimming only, product skimming with groundwater table depression, and

product skimming with groundwater table depression assisted by vacuum extraction of the vapor phase). Navy records indicate that a total of 12,630 gallons was recovered during the time interval beginning March 1994 through September 1995. The three-phase recovery pilot study recovered a total of 7,544 gallons between September 1994 and February 1995. The combination of the emergency recovery system and the pilot study were effective in removing a total of 13,773 gallons in the period March 1994 through September 1996.

The ICM was commissioned on April 30, 1997. The ICM was initially to be comprised of eight wells equipped with product skimming pumps. One well did not receive a pump since there was no free product in the well at the time of installation. Since the original system was installed wells have been added and deleted from the system based on the presence or absence of free product in the various wells. It is very common to pump a well for a month or two whereupon there is no more free product in the well. When this occurs, the pump is moved to another well. It is equally common to see free product return to a well that was previously pumped.

The operation of the ICM was modified in March 2001. The modifications consisted of turning off the recovery system and begin to pump product from every well with product present. This removal of product is being accomplished through a portable submersible pump on a monthly basis. Following the monthly gauging operations, the wells are pumped to remove any product present in the wells at the TWFF. This modification seems to be effective since it covers more well than just those designated for pumping. The original purpose of the system was to stabilize the plume and to stop its further migration. In this area it has been reasonably effective (with the exception of the area along Forrestal Drive where additional migration has occurred, additional wells were installed and the plume is being monitored). The second purpose was to begin recovering product from the subsurface.

2.3.7 Clean OX Pilot Study

ManTech Environmental Corporation (ManTech) has recently completed a patented CleanOX technology pilot study at the TWFF. The findings and recommendations are presented in the *CleanOX Pilot Test Report Final* dated October 1999. The principal objectives of the pilot test were to verify that the CleanOX Process reagents can be applied safely, in a controlled manner, and can induce desorption, dissolution, and desired oxidation reactions at the TWFF.

ManTech performed a two-well pilot test of the CleanOX Process at the TWFF between January 11 and January 29, 1999. Field activities included application well and monitoring well installation, baseline soil and groundwater sampling, two rounds of CleanOX reagent application, waste disposal, and post treatment soil and groundwater sampling.

The infiltration rate of CleanOX reagents at the TWFF was limited during the pilot test. While the infiltration rate was limited, subsequent groundwater sampling and analysis suggests that the pilot test was successful in oxidizing a significant mass of contaminants and the CleanOX Process is technically feasible for the TWFF.

ManTech estimated mass destruction through calculations in two areas of the TWFF after one week and after 60 days. The calculations resulted in an estimated total of 8,215 kg (or 2,259 gallons) of petroleum constituent destruction after one week and 12,889 kg (or 3,544 gallons) of petroleum constituent destruction after 60 days. This degree of destruction for a two-cycle round of chemical application to two application wells demonstrates the relative effectiveness of the process for source-area mass reduction at the TWFF. However, post pilot study measurements of free product showed infiltration in the application wells.

Cost estimates for full-scale application of the CleanOX Process were relatively high, however final evaluation and comparison of costs will be performed in the CMS Task II report.

2.3.8 Pneumatic Fracturing Pilot Study

A pneumatic fracturing pilot study was completed using pneumatic fracturing (PF) technology by McLaren/Hart, Inc. to enhance the performance of free product recovery. The PF established a network of fractures in the formation to increase permeability and interconnect the pockets of product so that free product removal could be increased.

Between March 2000 and July 2000, a pneumatic fracturing (PF) pilot test was completed at the TWFF. The pilot test was conducted at two areas of the TWFF site where product recovery wells are currently being operated. Fracturing depths ranged from 8 to 25 feet bgs. Both wells in these locations, RW-1 and PW-6, are used for skimming product from a weathered volcanic rock formation that is classified as inorganic clays of low to high plasticity, gravely and sandy clays.

The goals of the pilot test were to evaluate a program to enhance the removal of free product form these two locations. This involved the application of PF technology to increase the permeability of the soil formation in the test areas. Product removal was monitored at the recovery wells, and product levels in surrounding wells were monitored.

The following objectives of the pilot test were performed.

1) Establish baseline conditions for the test areas. This was done by conducting short-term product recovery tests.
2) Evaluation of the change in product recovery rates after fracturing in both test plots. This evaluation involved conversion of selected fracture boreholes to recovery wells and repeating the baseline short-term tests.
3) Evaluation of various product recovery well construction techniques.
   - Enhancement of existing recovery wells with PF
   - Enhancement of an existing monitoring well with PF
   - Installation of dry media (proppant) into two PF open boreholes and conversion to recovery wells.
   - Installation of recovery well in a PF open borehole after fracturing has occurred.
4) Obtain site-specific engineering design data necessary for a full-scale system design.

Prior to implementation of the pilot study, operation of the existing Free Product Recovery System was suspended in the pilot test areas. This allowed products levels in the recovery and monitoring wells to stabilize and present a more representative picture of the true subsurface, groundwater and free product conditions at the site.

After completion of all the objectives, the data was analyzed and is presented in the *Draft Pilot Test to Evaluate Enhancement of Product Recovery Report SWMU 7/8 (Baker, 2000).* Results were mixed.

2.4 Statement of Purpose

The overall purpose of the corrective measure(s) at the Tow Way Fuel Farm is to address contamination exposure pathways that may present an unacceptable risk to human health and the environment. The potential pathways that have been identified are:

- Inhalation, ingestion, dermal contact, and food chain exposure for teresterial ecological evaluation; and ingestion, dermal contact, incedental ingestion, and food chain exposure for aquatic ecological evaluation; and,

- Inhalation, ingestion, and dermal contact from surface soils, subsurface soils, and groundwater for human health risk evaluation.

The corrective measures will ensure that any unacceptable risks from the aforementioned exposure pathways are addressed. Some pathways may not be complete and some may be incidental. Pathways are further evaluated in the human health and ecological sections of this report.

3.0 SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT AND STEP 3A OF THE BASELINE ECOLOGICAL RISK ASSESSMENT

This section presents a screening-level ecological risk assessment (ERA) and Step 3a of the baseline ERA for SWMU 7/8 (Tow Way Fuel Farm [TWFF]), located at Naval Station Roosevelt Roads (NSRR), Ceiba, Puerto Rico. The ERA was conducted in accordance with the Chief of Naval Operations (CNO) document entitled Navy Policy for Conducting Ecological Risk Assessments (CNO 1999).

The Navy ERA process (see Figure 3-1) consists of eight steps organized into three tiers and represents a clarification and interpretation of the eight-step ERA process outlined in the United States Environmental Protection Agency (USEPA) ERA guidance for the Superfund program (USEPA 1997). Tier 1 of the Navy ERA process represents the screening-level ERA:

- Screening-level problem formulation and ecological effects evaluation (Step 1).
- Screening-level exposure estimate and risk calculation (Step 2).

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

3.1 Environmental Setting

The sections that follow provide a brief description of the site. The habitats occurring within and 7contiguous to the TWFF are also described, as well as the biota that may be present. The description of habitats and biota relies primarily on literature-based information for Puerto Rico and NSRR. This information is supplemented by site-specific information when available.

3.1.1 Site History

NSRR occupies over 33,500 acres on the East Coast of Puerto Rico, along Vieques Passage (see Figure 2-1). NSRR was commissioned in 1943 as a Naval Operations Base and re-designated a Naval Station in 1957. The primary mission of NSRR is provision of full support for Atlantic Fleet weapons training and development activities.

The Tow Way Fuel Farm (TWFF) is located on a hillside along Forrestal Drive north of Ensenada Honda (see Figure 2-2). Constructed prior to 1957, the fuel farm originally consisted of nine underground storage tanks (USTs) containing diesel fuel marine (DFM), Bunker C fuel, and jet fuel (JP-5). That number has since been reduced to seven by the removal of two tanks. Of the seven tanks remaining, two are actively used for fuel storage and distribution. A third tank is used for fuel storage, but the tank is not connected to the distribution infrastructure. Once drained this third tank will no longer be used for fuel storage.

There have been numerous fuel spills/leaks of small and large quantities at the TWFF that have impacted surface soil, subsurface soil, and/or groundwater. A listing of the known product release history is provided below (O'Brien & Greer, 1992):

- 1957/1958 - Approximately 420,000 gallon of Bunker C fuel leaked from UST No. 82
- 1960s/1970s/1980s - A cumulative volume of approximately 420,000 gallons of fuel leaked from UST Nos. 56A and 56B
- Between 1971 and 1972 - An estimated 3,900 to 7,500 cubic yards of Bunker C fuel sludge was cleaned from Tanks 83 and 1080 between 1971 and 1972 and emptied into two pits dug within a 100 foot radius of the tanks
- 1978 - Approximately 65,000 gallons of DFM leaked from UST No 1080 (an estimated 10,000 gallons were recovered during cleanup operations)
- 1986 - Approximately 91,000 gallons of JP-5 leaked from UST. 85 (an estimated 32,000 gallons were recovered during cleanup operations)

Impacts from product release have primarily been limited to subsurface soil and groundwater. A discussion of the hydrogeologic conditions present at the TWFF, including groundwater elevations and flow direction, is included in Appendix E.

The TWFF has been divided into six zones based on known or potential impacts to groundwater (see Figure 3-2). Zones 1, 2, and 6 are areas where phase separated hydrocarbons (PSH) have been detected on the water table. Zone 4 represents the location of a dissolved trichloroethene (TCE) plume, while Zone 5 represents a dissolved benzene plume underlying Zones 1 and 2. Although not associated with fuel storage activities, the TCE plume is being evaluated in this Draft Final Corrective Measures Study (CMS) since it is located within the TWFF's area of investigation. Zone 3 represents an area near the fueling pier where PSH was reported to have the potential to occur on the water table (McLaren Hart 2000). However, based on information contained in recent Resource Conservation and Recovery Act (RCRA) Corrective Action Quarterly Progress Reports (Baker 2002a and 2002b) and groundwater data collected during a recent sampling event (see Section 3.0), there is no indication that PSH is present on the water table.

3.1.2 Terrestrial and Marine Habitats

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 pastureland (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 communities (upland coastal forest communities and coastal scrub forest communities) exist today throughout the station's undeveloped upland. The habitat within the boundaries of the TWFF is limited to maintained grasses of unknown species composition. The site is bordered by coastal scrub/coastal forest communities to the north, east, and west and Forrestal Drive to the south (see Figure 3-3). Beyond Forrestal Drive, the land can be characterized as a man-made coastal plain. This land area borders the Ensenada Honda and is highly developed (buildings, parking lots, etc.) with little vegetative cover.

The marine environment surrounding NSRR includes mudflats, mangroves (black mangrove and red mangrove communities), and seagrass beds (turtle grass and manatee grass). The total area of mudflats, mangroves, and sea grass beds in the offshore environment is approximately 161 acres, 2,700 acres, and 1,900 acres, respectively (Geo-Marine, Inc. 1998). Coral reefs are also located in the offshore marine environment. Seagrass beds represent grazing areas for the green sea turtle (*Chelonia mydas*) and the West Indian manatee (*Trichechas manatus*). The green sea turtle is a federally threatened species, while the West Indian manatee is a federally endangered species. Both species have been reported from the marine environment surrounding NSRR.

A map showing the spatial relationship of the TWFF to the Ensenada Honda is provided as Figure 3-4. Included on this map are wetland units delineated by Geo-Marine, Inc. in December 1999 from 1993 color infrared and 1998 true color aerial photography. Twenty percent of the wetlands delineated by aerial photography were field checked to verify the accuracy of the delineations. Field verification was based on the 1987 Corps of Engineers wetland delineation manual (USACE 1987). As evidenced by Figure 3-4, there are no freshwater wetland units within the boundary of the TWFF. A small mangrove community is located adjacent to the Ensenada Honda, southwest of the TWFF. Based on the Cowardin Wetland Classification System [Cowardin et al. 1979 (see Figure 3-5)], this community is classified as E2SS3 (estuarine, intertidal, scrub-shrub, broad-leaved evergreen).

Several docks and piers are located within the Ensenada Honda, down-gradient and southeast of the TWFF (see Figure 3-4). In addition to the existing docks/piers depicted on Figure 3-4, a dock is currently being constructed immediately west of the fueling pier for use by the coast guard. Seawalls have also been constructed along a portion of the Ensenada Honda, between the fueling pier (Pier 1) and the berthing pier. Sea grass beds are not located within the Ensenada Honda immediately down-gradient from the TWFF (see Figure 3-3). This is likely attributable to naval shipping activities within this portion of the bay. However, they are prevalent throughout much of the Ensenada Honda, in shallow water adjacent to the bay's interface with upland and estuarine wetland habitat (i.e., mangroves). This includes the area offshore of the small mangrove community located southwest of the TWFF. Pockets of coral are located within the Ensenada Honda. The coral is primarily restricted to the mouth of the bay, however, a small pocket is located immediately down gradient from the TWFF, west of the fueling pier (see Figure 3-3).

3.1.3 Biota

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. The West Indian manatee is known to occur in the marine environment surrounding NSRR. As depicted on Figure 3-3, sea grass beds are located throughout much of the shallow water habitat within the Ensenada Honda. Their locations represent potential feeding habitat for the West Indian manatee.

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 native bird and reptile populations (USGS 1999 and USFWS 1996a).

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). A list of bird species reported at NSRR or having the potential to occur is summarized in Table 3-1. The list, compiled from literature-based information pre-dating 1990, 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*), mourning dove (*Zenaida macroura*), 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 endangered species. One of the principal reasons for the status of this species is attributed to parasitism by the nonindigenous shiny cowbird, which lays its eggs in blackbird nests and sometimes punctures the host's eggs (USFWS 1983). Other factors contributing to the status of this species include nest predation by the introduced black rat, Norway rat, and mongoose, as well as habitat modification and destruction (USFWS 1996a). The entire land area of NSRR was declared critical habitat for the yellow-shouldered blackbird in 1976; however, a 1980 agreement with the U.S. Fish and Wildlife Service 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 should be considered the most important nesting habitats for the yellow-shouldered blackbird. The TWFF is not located within the critical habitat designation for the yellow-shouldered blackbird. It is noted that the last reported nesting pair of yellow-shouldered blackbirds at NSRR was in 1986 (USFWS 1996a). Other federally listed bird species that have been reported at NSRR or have the potential to occur are the brown pelican (*Pelecanus occidentalis occidentalis*), roseate tern (*Sterna dougallii dougallii*), and the piping plover (*Charadrius melodus*) (Geo-Marine, Inc. 1998).

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 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, only the green sea turtle (*Chelonia mydas*), hawksbill sea turtle (*Eretmochelys imbricata*), and loggerhead sea turtle (*Dermochelys coriacea*) nest within Puerto Rico. The green sea turtle, hawksbill sea turtle, and the loggerhead sea turtle, as well as the leatherback sea turtle (*Caretta caretta*) and the Puerto Rican boa (*Epicrates inornatus*) have been listed under the provisions of the Endangered Species Act of 1973 (USGS 1999).

A diverse fish and invertebrate community can be found in the marine environment surrounding NSRR. This can be attributed to the varied habitats that include marine and estuarine open water habitat, mud flats, sea grass beds, and mangrove forests. 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). The benthic invertebrate community includes sponges, corals, anemones, sea cucumbers, sea stars, urchins, and crabs. A list of known species residing within the Ensenada Honda is not available.

3.2 Sources of Available Analytical Data

Sampling activities at the TWFF have been conducted under a variety of investigations, including a RCRA Facility Investigation (RFI), a CMS, and a TCE investigation. Environmental media collected during these field investigations included surface soil, subsurface soil (i.e., soil collected at depths greater than one foot below ground surface [bgs]), and groundwater. The field investigations and associated analytical data were presented and discussed in the documents listed below.

- Revised Draft RCRA Facility Investigation Report for Operable Unit 2 (SWMU 7/8), Naval Station Roosevelt Roads, Ceiba, Puerto Rico (Baker 1997)

- Final Corrective Measures Study Investigation Report for Tow Way Fuel Farm, Naval Station Roosevelt Roads, Ceiba, Puerto Rico (Baker 1999)

- Final TCE Investigation Report for SWMU 7/8 TWFF (Baker 2000)

In addition to the RFI, CMS, and TCE investigations discussed above, surface soil, subsurface soil, groundwater, surface water, and sediment were collected during a sampling event completed in March 2002. The field investigation, presented and discussed in Appendix E, was conducted in accordance with the Final Work Plan for Additional Data Collection (Baker 2001).

A listing of the surface soil, subsurface soil, groundwater, surface water, and sediment samples collected during the RFI, CMS, TCE, and additional data collection field investigations is presented in Tables 3-2, 3-3, 3-4, 3-5, and 3-6, respectively. Included in the tables are collection dates, sample depths (where applicable), and analytical parameters (by chemical group). Sample locations are depicted on Figure 2-3. The specific analytical data used in the screening-level ERA, as well as the criteria used to select the data are presented and discussed in Section 3.5.1.

3.3 Screening-Level Problem Formulation

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

3.3.1 Preliminary Conceptual Model

Figure 3-6 depicts a preliminary conceptual model for the TWFF. The model outlines potential sources of contaminants, transport pathways, exposure media, potential exposure routes, and receptor groups. Exposure, and thus potential for risk, can only occur if each of the following conditions are present (USEPA 1998):

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

Components of the conceptual model (source areas, transport pathways, and exposure pathways and routes are discussed in the sections that follow.

3.3.1.1 Source Areas

The USTs and associated piping have historically represented source areas where spills and leaks have resulted in the release of fuel directly to abiotic media (surface soil, subsurface soil, and groundwater). Contaminated surface and subsurface soil, as well as the Bunker C fuel sludge buried in pits excavated adjacent to Tank Nos. 83 and 1080 also represent potential source areas for the release of chemicals to groundwater, and/or downgradient surface soil and surface water.

In addition to the sources identified above, analytical data from a groundwater sampling event conducted in April 1998 as part of the CMS Investigation for the TWFF indicate the presence of an unknown source of TCE. TCE was detected in monitoring well 7-MW07 at 2.0 mg/L (see Figure 2-3 for the location of this well). TCE was also detected in the groundwater sample collected from this well during the additional data collection field investigation at 28 mg/L. Based on interviews with base personnel, a building located immediately northeast of 7-MW07 (destroyed during Hurricane Hugo in September 1989) was used for the storage and maintenance of small watercraft. Given that maintenance was performed at this building, cleaning and degreasing operations may have been performed, which could have resulted in the release of TCE.

3.3.1.2 Transport Pathways

A transport pathway describes the mechanisms whereby chemicals may be transported from a source of contamination to ecologically relevant media. As depicted in Figure 3-6, the primary mechanisms for contaminant transport from potential source areas are believed to include the following:

- Overland transport of chemicals with surface soil via surface runoff to downgradient surface soil (transport to downgradient surface soil within the TWFF [see discussion below])

- Overland transport of chemicals with surface soil via surface runoff to downgradient storm sewers and subsequent discharge to Ensenada Honda surface water (transport to Ensenada Honda is restricted to a single outfall [see discussion below]).

- Leaching of chemicals from surface soil and/or subsurface soil by infiltrating precipitation and transport to surface water and sediment with groundwater.

- Uptake by biota from surface soil, surface water, and/or sediment and trophic transfer to upper trophic levels.

Figure 3-7 depicts the location of storm sewers within and contiguous to the TWFF and associated storm water outfalls. Drainage areas for each outfall are also shown. As evidenced by the figure, the only outfall that can discharge surface runoff originating from the TWFF is Outfall 010 (NPDES-permitted outfall). Drainage areas for the other outfalls depicted on Figure 3-7 (i.e., Outfalls 011, 012, NR-012, NR-013, and NR-014) do not include the TWFF. Furthermore, there are no sheet flow conveyances originating from the TWFF that could serve as chemical transport pathways to off-site surface soil and/or impervious areas included within their drainage areas. As such, the Outfall 010 storm sewer system represents the only potential transport pathway for chemicals to migrate with surface soil (via surfaced runoff) to the Ensenada Honda.

3.3.1.3 Exposure Pathways and Routes

An exposure pathway links a source of contamination with one or more receptors via exposure to one or more media. Requirements for a complete exposure pathway were presented in Section 3.3.1. As depicted on Figure 3-6, potential complete exposure pathways exist for surface soil on the site, as well as downgradient surface water and sediment within the Ensenada Honda.

An exposure route describes the specific mechanism(s) by which a receptor is exposed to a chemical present in an environmental medium. The most common exposure routes are dermal contact, direct uptake, ingestion, and inhalation. Terrestrial plants may be exposed to chemicals present in surface soils through their root surfaces during water and nutrient uptake. Unrooted, floating aquatic plants, rooted submerged aquatic plants, and algae may be exposed to chemicals directly from the water or (for rooted plants) from sediments. Terrestrial and aquatic invertebrates may be exposed to chemicals in surface soil, sediment, or surface water through dermal adsorption and ingestion. Much of the toxicological data available for terrestrial and aquatic invertebrates are based upon *in situ* studies that represent both pathways. Therefore, both pathways are considered together in this screening-level ERA. Invertebrates also present a link between soil/sediment chemicals and invertebrate consumers through food web transfer. As such, they are also included as prey items for upper trophic level dietary exposures.

Birds and mammals may be exposed to chemicals through: (1) the inhalation of gaseous chemicals or chemicals adhered to particulate matter; (2) the incidental ingestion of contaminated abiotic media (e.g., soil or sediment) during feeding or cleaning activities; (3) the ingestion of contaminated water; (4) the ingestion of contaminated plant and/or animal tissues for chemicals that have entered food webs; and/or (5) dermal contact with contaminated abiotic media. These exposure routes, where applicable, are depicted on Figure 3-6. Their relative importance depends in part on the chemical being evaluated. For chemicals having the potential to bioaccumulate (e.g., polychlorinated biphenyls [PCBs]), the greatest exposure to wildlife is likely to be from the ingestion of prey. For chemicals having a limited potential to bioaccumulate, the exposure of wildlife to chemicals is likely to be greatest through the direct ingestion of abiotic media, such as soil or sediment.

Direct ingestion of drinking water is only considered if the salinity of a drinking water source is less than 15 parts per thousand (ppt), the approximate toxic threshold for wildlife receptors (Humphreys 1988). The only potential drinking water source contiguous to the TWFF is the Ensenada Honda. Based on field measurements conducted in January 2002, the salinity of Ensenada Honda surface water ranged from 18.7 to 35.2 ppt, which is above the toxic threshold. Thus, ingestion of drinking water is not a possible complete exposure pathway and will not be considered in risk calculations for upper trophic level receptors.

Several potential exposure pathways and/or routes identified on or excluded from Figure 3-6 were not evaluated in the screening-level ERA. Based on the general fate properties (e.g. high adsorption to solids) of the majority of compounds detected in surface soil (e.g., metals and PAHs) and the protection offered by feathers, dermal exposures for avian receptors are not considered significant relative to ingestion exposures and are therefore not evaluated in the screening-level ERA. Incidental ingestion of soil or sediment during feeding and preening activities is, however, considered in the risk estimates.

Reptiles could be exposed to chemicals in surface soil, sediment, and/or surface water. However, adequate data is not available in the scientific literature with which to evaluate the potential for adverse effects. Potential complete and significant exposure pathways for terrestrial mammals (e.g., incidental ingestion of surface soil and the ingestion of contaminated plant and/or animal tissues for chemicals that have entered food webs) were not selected for evaluation. The exclusion of mammals is appropriate because the potentially exposed mammalian receptors are limited to nonindigenous, nuisance species (see Section 3.1.3). However, because they represent a potential link between surface soil chemicals and avian carnivores, they are included in this screening-level ERA as food items.

Inhalation of gaseous chemicals and chemicals adhered to particulate matter (e.g., soil) were also excluded from evaluation in this screening-level ERA. Given the vegetative groundcover over much of the TWFF and the low levels of VOCs detected in surface soil collected from the site, the chemical contribution from the inhalation pathway is considered insignificant relative to ingestion pathways. Furthermore, native and resident bird species reported from NSRR do not nest in underground burrows (Raffaele 1989), precluding inhalation exposures that may otherwise occur during nest building and/or rearing of hatchlings.

3.3.2 Endpoints and Risk Hypotheses

The conclusion of the screening-level problem formulation includes the selection of ecological endpoints. Two types of endpoints, assessment endpoints and measurement endpoints, are defined as part of the ERA process as are risk hypotheses or risk questions (USEPA 1997). An assessment endpoint is an explicit expression of the environmental component or value that is to be protected. A measurement endpoint is a measurable ecological characteristic that is related to the component or value chosen as the assessment endpoint. The considerations for selecting assessment and measurement endpoints are summarized in USEPA (1997) and discussed in detail in Suter II (1989, 1990, and 1993). Risk hypotheses are testable hypotheses about the relationship among the assessment endpoints and their predicted responses when exposed to contaminants.

Endpoints in the ERA define ecological attributes that are to be protected (assessment endpoints) and a measurable characteristic of those attributes (measurement endpoints) that can be used to gauge the degree of impact that has or may occur. Assessment endpoints most often relate to attributes of biological populations or communities, and are intended to focus the risk assessment on particular components of the ecosystem that could be adversely affected by chemicals

attributable to the site (USEPA 1997). Assessment endpoints contain an entity (e.g., spotted sandpiper population) and an attribute of that entity (e.g., survival rate). Individual assessment endpoints usually encompass a group of species or populations (the receptor) with some common characteristic, such as specific exposure route or chemical sensitivity, with the receptor then used to represent the assessment endpoint in the risk evaluation.

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

Assessment endpoints, risk hypotheses, and measurement endpoints selected for the screening-level ERA are presented in Table 3-7. The assessment endpoints selected were based on the survival, growth, and reproduction of terrestrial receptor groups (terrestrial plants and invertebrates), aquatic receptor groups (aquatic plants [algae], benthic invertebrates, and fish), upper trophic level birds (herbivores, omnivores, and carnivores), and upper trophic level mammals (herbivores). The population traits of interest for each of the assessment endpoints represent components of a healthy population. Failure or impairment of survival, growth, or reproduction will adversely affect the ability of the population to be healthy and viable and fill its appropriate role in an ecosystem.

3.3.2.1 Selection of Ecological Receptors

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

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

Lower trophic level receptor species were evaluated based on those taxonomic groupings (e.g., terrestrial plants and invertebrates, fish, benthic invertebrates, and aquatic plants) for which

screening values have been developed. These groupings and screening values are used in most ERAs. As such, specific species of terrestrial and aquatic biota were not chosen as receptor species because of the limited information available for specific species and because terrestrial and aquatic biota are dealt with on a community level via a comparison to surface water and sediment screening values.

The upper trophic level receptor species listed below were chosen for dietary exposure modeling based on the criteria listed above, the general guidelines presented in USEPA (1991a), habitats occurring at the TWFF, and the assessment endpoints (see Table 3-7).

Terrestrial species:

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

Aquatic/semi-aquatic species:

- Spotted Sandpiper (*Actitis macularia*) (avian benthic invertebrate consumer)
- Double-crested cormorant (*Phalacrocorax auritus*) (avian piscivore)
- West Indian manatee (*Trichechus manatus*) (mammalian herbivore)

With the exception of the American robin and double-crested cormorant, the upper trophic level receptors listed above are known to occur at NSRR. The American robin and double-crested cormorant were selected to represent birds reported from NSRR with similar feeding habits and dietary preferences. Although not previously reported from NSRR, the double-crested cormorant is known to occur in Puerto Rico (Raffaele 1989).

As previously discussed, a terrestrial mammal was not selected as an ecological receptor for the following reasons:

- With the exception of bats, all native terrestrial mammals have been extirpated from Puerto Rico. Life history information for Puerto Rico's native bat species is severely limited or lacking altogether.
- The terrestrial mammals represented by potentially complete exposure pathways are limited to nonindigenous, nuisance species (i.e. Norway rat, black rat and mongoose) that have been implicated in the decline of native reptile and bird populations.

Sea grass beds are not located within the Ensenada Honda immediately down gradient from the TWFF. Several piers are located within this area of the Ensenada Honda, which are used by naval warships and harbor support craft. A small pocket of sea grass is located offshore of the small mangrove community southwest of the TWFF, between a marina used by recreational boats and the piers used by naval ships (see Figure 3-4). Given the minimal sea grass habitat within this area of the Ensenada Honda, as well as regular disturbances caused by recreational boats and naval ships, it is unlikely that manatees use this portion of the Ensenada Honda as foraging habitat. The presence of substantial seagrass beds elsewhere in the marine environment offshore from NSRR would also preclude this area of the Ensenada Honda as preferential foraging habitat.

Regardless, the West Indian manatee was selected as an ecological receptor given its status as an endangered species.

As previously indicated, exposure pathways to terrestrial and aquatic reptiles are likely to be complete. However, a reptilian species was not selected as a receptor species in this screening-level ERA since the life history and toxicological database concerning the effects of chemicals on reptiles is severely limited. It is assumed that reptiles potentially present at the TWFF are not exposed to significantly higher concentrations of COPCs and are not more sensitive to chemicals than the other receptor species evaluated in the risk assessment. This assumption is a source of uncertainty in the screening-level ERA.

3.3.3 Fate and Transport Mechanisms

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

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

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

Octanol-water partitioning indicates whether a compound is hydrophilic or hydrophobic. The Octanol-water partition coefficient (K_{ow}) expresses the relative partitioning of a compound between octanol (lipids) and water. A high affinity for lipids equates to a high K_{ow} and vice versa. As discussed above, K_{ow} has been shown to correlate well with Bioconcentration Factors (BCFs) in aquatic organisms, adsorption to soil or sediment particles, and the potential to bioaccumulate in the food chain (Howard 1991). Typically expressed as log K_{ow}, a value of three (3.0) or less generally indicates that the chemical will not bioconcentrate to a significant degree (Maki and Duthie 1978). Log K_{ow} values for organic chemicals analyzed in environmental media collected from the Tow Way Fuel Farm (e.g., Appendix IX VOCs and semivolatile organic compounds [SVOCs]) are presented in Table 3-8. A log K_{ow} of three equates to an aquatic species BCF of about 100, using the following equation from Lyman et al. (1990):

$$\log BCF = (0.76)(\log K_{ow}) - 0.23 \qquad \text{(Equation 3-1)}$$

Degradability is an important factor in determining whether there will be significant loss of mass or change in the form of a chemical over time in the environment. The half-life of a compound is

typically used to describe losses from either degradation (biological or abiotic) or from transfer from one compartment to another (e.g., volatilization from soil to air). The half-life is the time required for one-half of the mass of a compound to undergo the loss or degradation process.

3.3.4 Mechanisms of Toxicity

Mechanisms of toxicity for metals and bioaccumulative organic chemicals are discussed in the chemical profiles provided as Appendix A (see Section 3.4.2 for the definition used in this screening-level ERA for bioaccumulative organic chemicals and the rational supporting this definition).

3.4 Screening-Level Effects Evaluation

The purpose of the screening-level effects evaluation is the establishment of chemical exposure levels (screening values) that represent conservative thresholds for adverse ecological effects. One set of screening values is typically developed for each selected assessment endpoint. For this evaluation, two types of screening values were developed (media-specific screening values and ingestion-based screening values). Media-specific screening values were developed for surface soil, surface water, and sediment, while ingestion-based screening values were developed for upper trophic level food web (dietary) exposures.

3.4.1 Media-Specific Screening Values

The sections that follow describe the various criteria and toxicological benchmarks that were used as media-specific screening values (toxicological thresholds) for chemicals in surface soil, surface water, and sediment. Media-specific screening values, summarized in Tables 3-9 (surface soil), 3-10 (surface water), and 3-11 (sediment), represent conservative exposure thresholds above which adverse ecological effects may occur. The surface water screening values listed in Table 3-10 were also used in the evaluation of groundwater data.

3.4.1.1 Surface Soil Screening Values

The literature-based toxicological benchmarks listed below, expressed as dry weight concentrations, were selected for use as surface soil screening values.

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

For a given chemical, when more than one screening value was available from the sources listed above, the lowest value was conservatively selected as the surface soil screening value for use in the screening-level ERA. For those chemicals lacking a literature-based toxicological threshold from Efroymson et al. 1997a and 1997b, toxicity reference values contained in USEPA 1999a and Dutch Ministry of Housing, Spatial Planning and Environment (MHSPE) soil standards (MHSPE 1994) were used as surface soil screening values. MHSPE standards were derived assuming a minimum default soil organic carbon content of 2.0 percent (MHSPE 1994). When more than one value was available from USEPA 1999a and MHSPE 1994 for a given chemical, the lowest value was conservatively selected as the surface soil screening value.

3.4.1.2 Surface Water Screening Values

Chronic saltwater NAWQC (USEPA 1999b) were selected for use as surface water screening values. The USEPA NAWQC for cadmium, copper, chromium, lead, mercury, selenium, and zinc are expressed as dissolved concentrations. NAWQC for these metals were converted to total recoverable concentrations using the appropriate conversion factors (USEPA 1999b). For those chemicals lacking a saltwater NAWQC, surface water screening values were identified from the following information listed in their order of decreasing preference:

- Final Chronic Values (FCVs) for saltwater contained in Ecotox Thresholds (USEPA 1996b)

- Chronic screening values for saltwater contained in Ecological Risk Assessment Bulletins – Supplement to Risk Assessment Guidelines (RAGS) (USEPA 2001)

- Minimum chronic toxicity test endpoints (No Observed Effect Concentration [NOEC] and Maximum Acceptable Toxicant Concentration [MATC] values) for saltwater species reported in the ECOTOX Database System (Aquatic Toxicity Information Retrieval [AQUIRE] database) (USEPA 2000a)

- Chronic Lowest Observable Effect Levels (LOELs) for saltwater contained in National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference Tables (SQUIRTs) (Buchman 1999)

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

- Acute LOELs for saltwater contained in NOAA SQUIRTs (Buchman 1999)

- Acute toxicity test endpoints (NOEC, Lowest Observed Effect Concentration [LOECs], median lethal concentration [LC_{50}], and median effective concentration [EC_{50}] values) for saltwater species contained in the ECOTOX Database System (AQUIRE database) (USEPA 2000).

- LC_{50} values for saltwater species contained in Superfund Chemical Matrix (USEPA 1996a)

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

- An uncertainty factor of 10 was used to convert an acute NOEC, LOEC, or LOEL to a chronic-based screening value.

- An uncertainty factor of 100 was used to convert an EC_{50} or LC_{50} to a chronic-based screening value.

When acute toxicity data were used to extrapolate a chronic screening value, NOECs were given preference over LOECs/LOELs, LOECs/LOELs were given preference over LC_{50} and EC_{50} values, and EC_{50} values were given preference over LC_{50} values. For a given test endpoint (e.g.,

NOEC), when more than one value was available from the literature, the minimum value was conservatively used to extrapolate a chronic screening value. In some cases, chronic and acute LOELs for chemical classes (e.g., PAHs) were available from Buchman (1999). A LOEL based on a chemical class was used to derive a chronic screening value only if that chemical lacked literature-based benchmarks and/or toxicity test endpoints.

For those chemicals lacking saltwater toxicological thresholds and literature values, surface water screening values were identified or developed from freshwater values using the sources and procedures discussed in the preceding paragraphs with one exception. This exception involved the consideration of freshwater Secondary Chronic Values (SCVs) developed by the USEPA (1996b) and Suter II (1996).

3.4.1.3 Sediment Screening Values

The literature-based toxicological benchmarks listed below, expressed as bulk sediment concentrations (dry weight), were used as sediment screening values.

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

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

- Apparent Effects Threshold (AET) marine sediment quality guidelines (Buchman 1999)

For a given chemical, when more than one sediment quality guideline was available from the sources listed above, the minimum value was conservatively selected as the sediment screening value. As evidenced by Table 3-11, a screening value for total PAHs was identified from the literature. The value selected as the total PAH screening value (1,680 ug/kg) represents a TEL value derived by MacDonald (1994). The total PAH screening value refers to the sum of the concentrations of thirteen individual PAHs for which TEL values have been derived (MacDonald 1994). These thirteen PAHs are acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorine, 2-methylnaphthalene, naphthalene, phenanthrene, and pyrene.

For those organic chemicals lacking a literature-based toxicological benchmark, screening values were derived using the USEPA equilibrium partitioning (EqP) approach (USEPA 1993a). A description of the procedure used to derive EqP-based sediment screening values is included as Appendix B.

3.4.2 Ingestion Screening Values

Ingestion-based screening values for dietary exposures were derived for each receptor species and chemical evaluated for food web exposures. Toxicological information from the literature for wildlife species most closely related to the receptor species was used if available. This information was supplemented by laboratory studies of non-wildlife species (e.g., laboratory mice) when necessary.

Chronic No Observed Adverse Effect Levels (NOAELs) based on growth or reproduction were preferentially used as ingestion-based screening values for upper trophic level receptors.

NOAELs represent the highest dose of a chemical at which an effect being measured in a toxicity test does not occur. If several chronic toxicity studies were available from the literature, the most appropriate study was selected for each receptor species based on study design, study methodology, study duration, study endpoint and test species. When chronic NOAEL values were unavailable, estimates were derived or extrapolated from chronic Lowest Observed Adverse Effect Levels (LOAELs) or acute values (LD_{50}). LOAELs represent the lowest dose of a chemical at which an effect being measured in a toxicity test occurs, while an LD_{50} represents the

dose of a chemical at which half of the organisms being tested die. An uncertainty factor of 10 was used to convert a reported LOAEL to a NOAEL, while an uncertainty factor of 100 was used to convert the acute LD_{50} to a chronic NOAEL (i.e., the LD_{50} was multiplied by 0.01 to obtain the chronic NOAEL).

Ingestion screening values for birds (American robin, mourning dove, spotted sandpiper, and double-crested cormorant) and mammals (West Indian manatee), expressed as milligrams of the chemical per kilogram body weight of the receptor per day (mg/kg-BW/day), are summarized in Tables 3-12 and 3-13, respectively. NOAEL and LOAEL values were not adjusted in the screening-level risk calculation to reflect differences in body weights between test species and receptor species.

Not all chemicals analyzed in surface soil, surface water, and sediment were evaluated for food web exposures. The organic chemicals evaluated for food web exposures were limited to those chemicals listed in Table 3-8 with the potential to bioaccumulate to a significant extent. Bioaccumulative organic chemicals are defined in this screening-level ERA as those with a maximum reported log octanol-water partition coefficient (log K_{ow}) greater than or equal to 3.0. Rational for using a log K_{ow} of 3.0 to define an organic chemical with the potential to bioaccumulate is included as Appendix C. For conservatism, all inorganic chemicals were also evaluated for food web exposures. The exception is cyanide, which is excluded from the evaluation of food web exposures because it is readily metabolized and does not bioaccumulate (Eisler 1991). The list of chemicals selected for the evaluation of food web exposures by the methodology presented in Appendix C contains many chemicals that are not identified as "important bioaccumulative compounds" by the USEPA (2000b). Their inclusion in the evaluation of food web exposures is consistent with the conservatism of this screening-level ERA.

3.5 Screening-Level Exposure Estimation

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

3.5.1 Selection Criteria for Analytical Data

The available surface soil, groundwater, surface water, and sediment analytical data (described in Section 3.3 and summarized in Tables 3-3 through 3-7) were reviewed against a set of selection criteria to identify specific data that would be used to estimate potential ecological receptor exposures. The analytical data selected for use in this screening-level ERA are included as Appendix D. The specific criteria used to select these analytical data are listed below.

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

- For surface soil, analytical data for samples collected from the surface to a maximum depth of one foot bgs were used since this depth range is the most active biological zone (Suter II 1995). All available sediment samples, collected from the surface to a maximum depth of 0.5 feet bgs, were used in the screening-level ERA.

- Total (unfiltered) metal concentrations were used for surface water screening. However, as discussed in Section 3.5.2.2.1, dissolved (filtered) surface water data for metals were used in aquatic food web modeling.

- Maximum detection limits were conservatively used to estimate exposure for non-detected chemicals.

- In some instances, duplicate samples have been collected in the field. The maximum concentration of each chemical (or the maximum non-detected value) in the original or duplicate sample will be used as a conservative estimate of contaminant concentration at a particular sampling point.

Sediment samples were collected from two distinct habitats within the Ensenada Honda. Samples SD-01 through SD-06 were collected from shallow water habitat within a littoral zone, while sediment samples SD-07 through SD-15 were collected from open water habitat adjacent to either a seawall, dock, or pier. Prior to summarization, analytical data for sediment collected from the littoral zone were grouped separately from the open water sediment data and used to estimate exposure point concentrations for a representative shorebird (i.e., spotted sandpiper). Analytical data for all sediment samples were grouped together and used to estimate exposure point concentrations for all remaining aquatic receptors.

Although analytical data are available for surface water and sediment, an evaluation of groundwater was conducted by comparing groundwater data directly to surface water screening values without consideration given to dilution or attenuation. The evaluation was performed due to the proximity of several plumes to the Ensenada Honda and the limited surface water and sediment data available for this surface water body. The groundwater data used in the evaluation were limited to data for samples collected from monitoring wells located south of Forrestal Drive during the most recent monitoring event (i.e., data form the additional data collection filed investigation). These data represent groundwater quality nearest the potential exposure point for aquatic receptors (Ensenada Honda). These data also represent the best estimate of potential current exposures for aquatic receptors. It is noted that the groundwater data were not used to estimate potential exposures to upper trophic level receptors.

Subsurface soil does not represent a potential complete exposure pathway since most soil heterotrophic activity occurs within the surface soil and soil invertebrates occur on the surface or within the oxidized root zone. As such, subsurface soil data were not used in the screening-level ERA.

3.5.1.1 Considerations for Interpretation of Surface Water and Sediment Data

The surface water and sediment samples collected from the Ensenada Honda encompassed approximately 900 feet of shoreline. Sample locations were selected to represent potential areas that may be impacted by the transport of chemicals with surface soil (via runoff) and/or groundwater.

The quality of surface water and sediment collected at many locations may not be associated with the release and transport of chemicals from the TWFF. Sediment samples 7SD7, 7SD8, 7SD9, 7SD11, 7SD12, 7SD13, and 7SD14, as well as surface water samples 7SW4, 7SW5, 7SW6, 7SW8, and 7SW9 were collected at locations downgradient and southeast of the TWFF. Based on groundwater flow directions (see Appendix E) and the proximity of known plumes, sediment and/or surface water quality at these locations could be impacted by site-related chemicals migrating with groundwater. However, storm water from industrial/storage areas unrelated to the

TWFF discharge to this area of the Ensenada Honda via storm sewer outfalls and sheet flow (see Figure 3-7). This area of the Ensenada Honda is also heavily used by naval ships and harbor support craft. At the time samples were collected, several craft and barges were docked along the bulkhead between the Fueling Pier and Pier 2.

Differentiating the source (or sources) of contamination (if any) under these conditions is extremely difficult if not impossible. However, based on information presented in Section 3.3.1.2, transport with groundwater represents the only pathway for site-related chemicals to reach this area of the Ensenada Honda. The interpretation of the data and conclusions drawn from risk calculations took this into consideration in Step 3a of the baseline risk assessment.

3.5.2 Exposure Estimation

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

3.5.2.1 Terrestrial and Aquatic Receptor Groups

Maximum measured chemical concentrations in surface soil, groundwater, surface water, and sediment were compared to the medium-specific screening values presented in Section 3.4.1 to conservatively evaluate the potential for adverse ecological effects to the terrestrial and aquatic receptor groups selected as assessment endpoints. Exposure point concentrations for the terrestrial receptor groups (i.e., terrestrial invertebrates and plants) were maximum measured surface soil concentrations, while maximum measured surface water and/or sediment concentrations were used as exposure point concentrations for the aquatic receptor groups (plants, benthic invertebrates, and fish).

3.5.2.2 Upper Trophic Level Receptors

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

Tissue concentrations were modeled for terrestrial plants (food item for American robin and mourning dove), soil invertebrates (food item for American robin), small mammals (food item for red-tailed hawk), aquatic plants (food item for West Indian manatee), aquatic invertebrates (food item for spotted sandpiper, and fish (food item for double-crested cormorant). Specific small mammals species were not selected as dietary items for the red-tailed hawk. Instead, a specific trophic level (omnivore) was used to represent the small mammals present on Puerto Rico that potentially represent dietary food items for the red-tailed hawk (Norway rat and black rat). Small mammal herbivores and insectivores were excluded as dietary items for the red-tailed hawk because they are not part of the Puerto Rican mammalian fauna (see Section 3.1.3).

3.5.2.2.1 Exposure Point Concentrations

The uptake of chemicals from the abiotic media into terrestrial and aquatic food items is based (where available) on conservative (e.g., maximum or 90th percentile) BCFs or Bioaccumulation Factors (BAFs) from the literature. 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. BAF values consider both direct exposures to the surrounding media, as well as uptake from dietary exposures. As such BAFs were given preference over BCFs when estimating prey item tissue concentrations. Default factors of 1.0 were used only when data are unavailable for chemicals in the literature. The methodology and models used to derive these estimates are described below.

Terrestrial Plants. Tissue concentrations in the aboveground vegetative portion of terrestrial plants was estimated by multiplying the maximum measured surface soil concentration for each chemical by chemical-specific soil-to-plant BCFs obtained from the literature. The BCF values used were based on root uptake from soil and on the ratio between dry-weight soil and dry-weight plant tissue. Literature values based on the ratio between dry-weight soil and wet-weight plant tissue were converted to a dry-weight basis by dividing the wet-weight BCF by the estimated solids content for terrestrial plants (15 percent [0.15]; Sample et al. 1997).

BCFs for terrestrial plants are those reported in Baes et al. (1984) or Bechtel Jacobs (1998a). For organic chemicals without literature based BCFs, soil-to-plant BCFs were estimated using the algorithm provided in Travis and Arms (1988):

$$\log B_v = 1.588 - (0.578)(\log K_{ow}) \qquad \text{(Equation 3-2)}$$

where:

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

The log K_{ow} values used in the calculations were obtained primarily from USEPA 1995a and 1996a and are listed in Table 3-8. The soil-to-plant BCFs used in the screening-level ERA are summarized in Table 3-14.

Earthworms. Tissue concentrations in soil invertebrates (earthworms) were estimated by multiplying the maximum measured surface soil concentration for each chemical by chemical-specific BCFs or BAFs obtained from the literature. BCFs are calculated by dividing the concentration of a chemical in the tissues of an organism by the concentration of that same chemical in the surrounding environmental medium (in this case, soil) without accounting for uptake via the diet. BAFs consider both direct exposure to soil and exposure via the diet. Since earthworms consume soil, BAFs are more appropriate values and were used in the food web models when available. BAFs based on depurated analyses (soil was purged from the gut of the earthworm prior to analysis) were given preference over undepurated analyses when selecting BAF values since direct ingestion of soil is accounted for separately in the food web model.

The BCF/BAF values used in this screening-level ERA, summarized in Table 3-14, are based on the ratio between dry-weight soil and dry-weight earthworm tissue. Literature values based on the ratio between dry-weight soil and wet-weight earthworm tissue were converted to a dry-weight basis by dividing the wet-weight BCF/BAF by the estimated solids content for

earthworms (16 percent [0.16]; USEPA 1993b). For inorganic chemicals without available measured BCFs/BAFs, an earthworm BAF of 1.0 was assumed.

Small Mammals. Whole-body tissue concentrations in small mammals (omnivores) were estimated using one of two methodologies. For chemicals with literature-based soil-to-small mammal BAFs, the small mammal tissue concentration was obtained by multiplying the maximum measured surface soil concentration for each chemical by a chemical-specific soil-to-small mammal BAF. The BAF values used are based on the ratio between dry-weight soil and whole-body dry-weight tissue. Literature values based on the ratio between dry-weight soil and wet-weight tissue were converted to a dry-weight basis by dividing the wet-weight BAF by the estimated solids content for small mammals (32 percent [0.32]; USEPA 1993b). The soil-to-small mammal BAFs used in the screeening-level ERA, summarized in Table 3-15, are those in Sample et al. (1998b) for omnivores (or for general small mammals if omnivore values were unavailable).

For those chemicals without soil-to-small mammal BAF values, an alternate approach was used to estimate whole-body tissue concentrations. Because most chemical exposure for small mammal species is via the diet, it was assumed that the concentration of each chemical in the small mammal's tissues is equal to the chemical concentration in its diet, that is, a diet to whole-body BAF (wet-weight basis) of one was assumed. Resulting tissue concentrations (wet-weight) were converted to dry weight using an estimated solids content of 32 percent (see above).

The use of a diet to whole-body BAF of one is likely to result in a conservative estimate of chemical concentrations for chemicals that are not known to biomagnify in terrestrial food chains (e.g., aluminum). For chemicals that are known to biomagnify (e.g., Biphenyls [PCBs]), a diet to whole-body BAF value of one will likely result in a realistic estimate of tissue concentrations based on reported literature values. For example, a maximum BAF (wet weight) value of 1.0 was reported by Simmons and McKee (1992) for PCBs based on laboratory studies with white-footed mice. Menzie et al. (1992) reported BAF values (wet-weight) for dichlorodiphenyltrichloroethane (DDT) of 0.3 for voles and 0.2 for short-tailed shrews. Reported BAF (wet-weight) values for dioxin are only slightly above one (1.4) for the deer mouse (USEPA 1990).

Aquatic Plants. Tissue concentrations in the vegetative portion of aquatic plants (i.e., sea grass) were estimated using the same methodologies as described above for terrestrial plants except that maximum sediment (not soil) concentrations were used in the calculation.

Aquatic Invertebrates. Tissue concentrations in aquatic invertebrates were estimated by multiplying the maximum measured sediment concentration for each chemical by chemical-specific sediment-to-invertebrate BCFs or BAFs obtained from the literature. The BCF/BAF values are based on the ratio between dry-weight sediment and dry-weight invertebrate tissue. Because BAFs consider both direct exposure to sediment and exposure via the diet, BAFs are more appropriate values and were used in the food web models when available. BAFs based on depurated analyses (sediment was purged from the gut of the organism prior to analysis) were given preference over undepurated analyses when selecting BAF values since direct ingestion of sediment is accounted for separately in the food web model.

Literature values based on the ratio between dry-weight sediment and wet-weight invertebrate tissue were converted to a dry-weight basis by dividing the wet-weight BCF/BAF by the estimated solids content for aquatic invertebrates (21 percent [0.21]; USEPA 1993b). For chemicals without available measured literature BCF/BAF values, a BCF/BAF of 1.0 was

assumed. The sediment-to-invertebrate BCFs/BAFs used in the screening-level ERA are summarized in Table 3-16.

Fish. The estimation of tissue concentrations in whole-body fish took into consideration bioaccumulation from surface water, as well as bioaccumulation from sediment. The contribution that sediment bioaccumulation has on whole-body fish tissue concentrations was estimated by multiplying the maximum measured sediment concentration for each chemical by chemical-specific sediment-to-fish BAFs obtained from the literature. The sediment-fish BAF values used were based on the ratio between dry-weight sediment and dry-weight fish tissue. Literature values based on the ratio between dry-weight sediment and wet-weight fish tissue were converted to a dry-weight basis by dividing the wet-weight BAF by the estimated solids content for fish (25 percent [0.25]; USEPA 1993b). For chemicals without literature based sediment-to-fish BAFs, a BAF of 1.0 was assumed. A summary of the sediment-to-fish BAFs used in the screening-level ERA are summarized in Table 3-16.

The contribution that surface water bioaccumulation has on whole-body fish tissue concentrations was estimated by the following equation (USEPA 1995b):

$$C_{xf} = [(C_{sw})(BCF_{sw})(FCM)] \qquad \text{(Equation 3-3)}$$

where C_{xf} is the concentration of chemical x in whole-body fish (mg/kg), C_{sw} is the maximum surface water concentration (mg/L), BCF_{sw} is the measured surface water-to-fish BCF (L/kg), and *FCM* is the food chain multiplier (unitless). The surface water-to-fish BCF values used in Equation 3-2 were based on dry weight fish tissue. Literature values based on wet-weight fish tissue were converted to a dry-weight basis by dividing the wet-weight BAF by 0.25 (see above).

For a given organic chemical, surface water-to-fish bioaccumulation was only considered if the chemical was detected in surface water and the chemical's log K_{ow} value is greater than or equal to 3.0. If an organic chemical with a log K_{ow} value greater than or equal to 3.0 was not detected in surface water, the contribution that surface water bioaccumulation has on the tissue concentration in whole-body fish was considered to be negligible. In this instance, only sediment bioaccumulation was considered in the estimation of whole-body fish tissue concentrations. Specific organic chemicals detected in surface water samples collected from the Ensenada Honda with log K_{ow} values greater than or equal to 3.0 were bis(2-ethylhexyl)phthalate, acenaphthene, anthracene, fluoranthene, naphthalene, phenanthrene, and pyrene.

The surface water data used for metals in the estimation of surface water-to-fish bioaccumulation was based on the dissolved (filtered) fraction. Dissolved metals data were used since the dissolved fraction more closely approximates the bioavailable fraction of metals in the water column (USEPA 1995b and 1999a). If a metal was not detected in the dissolved (filtered) fraction, the contribution that surface water bioaccumulation has on the whole-body fish tissue concentration of that metal was considered negligible.

Surface water-to-fish BAFs used in the screening-level ERA are summarized in Table 3-17. Surface water-to-fish BCFs and BAFs for metals were assumed to be equal (USEPA 1991b, USEPA 1995b, and Sample et al 1996), thus an FCM of 1.0 was used to convert measured surface water-to-fish BCFs to surface water-to-fish BAFs. Although the USEPA (1995c) has derived FCMs for organic chemicals using a food chain model developed by Gobas (1993), an FCM of 1.0 was also used to convert measured surface water-to-fish BCFs to surface water-to-fish BAFs. Rational for use of an FCM equal to 1.0 for organic chemicals is listed below:

- Although the 1993 Gobas model includes an input parameter to account for metabolism (metabolic rate constant), it was set to zero by the USEPA (1995c). Therefore, the FCMs developed by the USEPA do not take into consideration metabolism. The majority of chemicals detected in surface water were PAHs. Given that invertebrates and fish are capable of metabolizing PAHs (James 1989, Varanasi et al. 1989, Buhler and Williams 1989, and Foureman 1989), use of an FCM would overstate bioaccumulation from dietary food items.

- The 1993 Gobas model incorporates the exposure of organisms to chemicals from the sediment by including a benthic food-chain exposure. Bioaccumulation from sediment is accounted for separately in the food web model.

The contribution of surface water-to-fish and the contribution of sediment-to-fish bioaccumulation on whole-body fish tissue concentrations were summed to derive a final whole-body fish tissue concentration:

$$C_{xf} = [(C_{sw})(BAF_{sw})+(C_{sed})(BAF_{sed})] \qquad \text{(Equation 3-4)}$$

where C_{sed} is the maximum sediment concentration (mg/kg), BAF_{sed} is the sediment-to-fish *BAF* (unitless), and C_{xf}, C_{sw}, BCF_{sw}, and *FCM* are as previously described.

3.5.2.2.2 Dietary Intakes

Dietary intakes for each upper trophic level receptor species were calculated using the following formula (Equation 3-5) modified from USEPA (1993b).

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

where:

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

Conservative receptor-specific exposure parameters (maximum food ingestion rates and minimum body weights) are provided in Table 3-18, while dietary compositions are provided in Table 3-19. As previously discussed, receptor exposures via surface water ingestion were not included in the estimation of dietary intakes. As such, drinking water ingestion rates for upper trophic level receptor species are not included in Table 3-18.

Although not evaluated for food web exposures, Table 3-18 contains exposure parameters and Table 3-19 contains a dietary composition for a small mammal omnivore. As discussed in Section 3.5.2.2, the diet of the red-tailed (excluding surface soil) was assumed to be small mammal omnivores. This assumption is based on likely small mammal prey species present in

Puerto Rico (rats). Identification of exposure parameters and food items was necessary when estimating small mammal omnivore whole body tissue concentrations for those chemicals that lack a literature-based soil-to-small mammal BAF. An assumed diet of 49 percent terrestrial vegetation, 49 percent terrestrial invertebrates, and 2 percent soil was selected as the diet for a small mammal omnivore.

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

3.6 Screening-Level Risk Characterization

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

3.6.1 Selection of Preliminary Ecological Chemicals of Potential Concern

Preliminary ecological COPCs were selected using the hazard quotient (HQ) method. For a given chemical, an HQ was calculated by dividing the maximum chemical concentration in the medium being evaluated by the corresponding media-specifc screening value or, in the case of upper trophic level receptors, by dividing the maximum exposure doses by the corresponding ingestion-based screening value.

The following conservative methodology was used to identify preliminary ecological COPCs for abiotic media:

- The maximum detected concentration in each media (surface soil, groundwater, surface water, and sediment) was used to calculate media-specific HQs. For a given medium, chemicals with HQs greater than or equal to 1.0 based on maximum detected concentrations will be identified as preliminary ecological COPCs for that medium.

- For chemicals not detected in any samples of a particular medium, the maximum reporting limit was used to calculate media-specific HQs. For a given medium, non-detected chemicals with HQs greater than or equal to 1.0 based on maximum reporting limits were identified as preliminary ecological COPCs for that medium.

- Chemicals without screening values for a given medium were identified as preliminary ecological COPCs for that medium.

To select preliminary ecological COPCs by evaluating food web exposures, maximum chemical concentrations in each media (surface soil, surface water, and/or sediment) were used to estimate dietary doses for each receptor. As indicated previously, all inorganics (excluding cyanide) and all organic chemicals with a log K_{ow} greater than or equal to 3.0 were evaluated in the food web models (see Section 3.5.2.2.1 for exceptions related to surface water bioaccumulation in fish). HQs were calculated with NOAELs, LOAELs, and MATCs (the geometric mean of the NOAEL and LOAEL). Calculations with NOAELs provide the most conservative risk estimate, while calculations with LOAELs provide the least conservative risk estimate. Calculations with MATCs provide realistic risk estimates since the MATC represents an estimation of the threshold

concentration (i.e., the concentration above which a toxic effect on the test endpoint is produced). For the screening-level ERA, chemicals (detected and non-detected) with NOAEL-based HQs greater than or equal to 1.0 were identified as preliminary ecological COPCs. Identical to the media-specific screening, chemicals without ingestion-based screening values were also identified as preliminary ecological COPCs for upper trophic level receptors.

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

It is noted that the screening-level ERA considers independent effects of chemicals. However, the potential does exist for multiple chemicals in environmental media to interact. Much uncertainty is involved with the interpretation of chemical interactions due to the complexity of potential effects (e.g., synergistic, antagonistic, or additive), and due to varying toxicities of compounds in different species. For these reasons, cumulative effects are not addressed in this screening-level ERA.

3.6.1.1 Screening-Level Risk Calculation for Surface Soil

Table 3-20 presents the results of the screening-level risk calculation for surface soil. Eight VOCs were detected in surface soils collected from the TWFF (1,1,1-trichloroethane, 2-butanone, acetone, methylene chloride, styrene, toluene, trichloroethene, and xylenes). Methylene chloride, styrene, toluene, trichloroethene, and xylenes were not identified as preliminary ecological COPCs because maximum detected concentrations were less than screening values. 1,1,1-Trichloroethane, 2-butanone, and methylene chloride were identified as preliminary ecological COPCs due to the lack of screening values. Although not detected, vinyl chloride was identified as a preliminary ecological COPC because the maximum reporting limit for this VOC exceeded the screening value. Thirty-eight non-detected VOC were also retained as preliminary ecological COPCs due to a lack of surface soil screening values.

Twelve SVOCs, including 10 PAHs, were detected in surface soil. Maximum detected concentrations for each SVOC were less than surface soil screening values. As such, they were not identified as preliminary ecological COPCs. Sixty-six non-detected SVOCs, including two PAHs (1-methylnapthalene and 2-methylnaphthalene), were retained as preliminary ecological COPCs due to the lack of surface soil screening values. Pryridine was also identified as a preliminary ecological COPC because the maximum reporting limit for this SVOC exceeded the screening value.

Sixteen metals were detected in surface soil. Maximum detected concentrations for antimony, arsenic, barium, beryllium, cadmium, lead, mercury, nickel, selenium, and tin were less than surface soil screening values. Maximum concentrations for chromium, cobalt, copper, thallium, vanadium, and zinc exceeded screening values. These six metals were identified as preliminary ecological COPCs.

3.6.1.2 Screening-Level Risk Calculation for Groundwater

Table 3-21 presents results of the screening-level risk calculation for groundwater. Eight VOCs were detected in groundwater samples collected from monitoring wells south of Forrestal Drive (1,1-dichloroethene, bromodichloromethane, chloroform, isobutanol, methylene chloride, propionitrile, toluene, and TCE). Toluene (HQ = 5.41) and TCE (HQ = 140) were identified as ecological COPCs because maximum detected concentrations exceeded screening values.

Twelve SVOCs, including six PAHs (2-methylnaphthalene, acenaphthene, benzo(g,h,i)perylene, fluorine, Indeno(1,2,3-cd)pyrene, and phenanthrene), were detected in groundwater. With the exception of 2-methylnaphthalene (HQ = 16), the maximum concentration for each detected SVOCs was less the screening value. As such, 2-methylnapthalene was identified as a preliminary ecological COPC. Twenty SVOCs were identified as preliminary ecological COPCs because maximum reporting limits greater than or equal to screening values. Twenty-two additional SVOCs were identified as preliminary ecological COPCs due to the lack of screening values.

Four detected metals (copper, mercury, silver, and zinc) were identified as preliminary ecological COPCs because maximum detected concentrations exceeded screening values. Tin and vanadium were also identified as preliminary ecological COPCs due to the lack of screening values. Of these two metals, vanadium was detected in groundwater samples collected from monitoring wells south of Forrestal Drive. Although detected in groundwater samples, arsenic, barium, cadmium, chromium, cobalt, lead, nickel, selenium, thallium were not identified as preliminary ecological COPCs. Maximum detected concentrations were less than screening values.

3.6.1.3 Screening-Level Risk Calculation for Surface Water

Table 3-22 presents results of the screening-level risk calculation for surface water. One VOC (carbon disulfide) were detected in surface water samples collected from the Ensenada Honda. The maximum detected concentration for this VOC was less than the surface water screening value. Three non-detected VOCs (3-chloro-1-propene, acrylonitrile, and ethylbenzene) were identified as preliminary ecological COPCs because maximum detection limits exceeded screening values. Chloroethane, chloroprene, ethyl methacrylate, iodomethane, methacrylonitrile, and trans-1,4-dichloro-2-butene were also identified as preliminary ecological COPCs due to the lack of screening values.

Seven SVOCs (bis(2-ethylhexy)phthalate, acenaphthene, anthracene, fluoranthene, naphthalene, phenanthrene, and pyrene) were detected in surface water samples collected from the Ensenada Honda. Maximum detected concentrations were less than screening values. Nineteen non-detected SVOCs were identified as preliminary ecological COPCs because detection limits exceeded screening values. Twenty-one non-detected SVOCs were also identified as preliminary ecological COPCs due to the lack of screening values.

Eleven metals were detected in surface water (antimony, arsenic, barium, cadmium, copper, lead, mercury, selenium, tin, vanadium, and zinc). Copper was identified as a preliminary ecological COPC because the maximum detected concentration for this metal exceeded the screening value. Tin and vanadium were identified as a preliminary ecological COPC due to the lack of surface water screening values. Nickel and silver were not detected, but was also identified as a preliminary ecological COPC because the maximum reporting limits for these two metals exceeded screening values.

3.6.1.4 Screening-Level Risk Calculation for Sediment

Table 3-23 presents the results of the screening-level risk calculation for sediment. Seven VOCs (2-butanone, acetone, carbon disulfide, methylene chloride, styrene, toluene, and xylenes) were detected in sediment samples collected from the Ensenada Honda. Acetone and xylenes were identified as preliminary ecological COPCs because maximum detected concentrations exceeded sediment screening values. Thirteen non-detected VOCs were identified as preliminary ecological COPCs because maximum detection limits exceeded screening values. Six non-detected VOCs were also identified as preliminary ecological COPCs due to the lack of sediment screening values.

Sixteen SVOCs, including fifteen individual PAHs, were identified as preliminary ecological COPCs because maximum detected concentrations exceeded screening values. The maximum total PAH concentration (21,840 ug/kg [sum of the concentration of the thirteen individual PAH compounds identified in Section 3.4.1.3) also exceeded the total PAH screening value (1,680 ug/kg). Fifty-eight non-detected SVOCs were identified as preliminary ecological COPCs because maximum detection limits exceeded screening values. Twenty-one SVOCs were also identified as preliminary ecological COPCs due to the lack of sediment screening values.

Twelve metals (antimony, arsenic, barium, cadmium, cobalt, copper, lead, nickel, selenium, tin, vanadium, and zinc) were identified as preliminary ecological COPCs because maximum detected concentrations exceeded screening values. Although not detected, silver was identified as a preliminary ecological COPC because the maximum detection limit for this metal exceeded the screening value. Beryllium and thallium were also identified as a preliminary ecological COPC due to the lack of screening values. Both of these metals were detected in sediment samples collected from the Ensenada Honda.

3.6.1.5 Screening-Level Risk Calculation for Food Web Exposures

Results of the risk calculations for food web exposures are provided in Tables 3-24 and 3-25 for terrestrial and aquatic receptors, respectively. A discussion of these results is presented in the sections that follow.

3.6.1.5.1 Terrestrial Food Web Exposures

Based on the comparison of maximum exposure doses to NOAEL-based screening values, seven detected metals (cadmium, chromium, cobalt, lead, mercury, selenium and zinc) had HQ values greater than or equal to 1.0 for one or more of the terrestrial receptors. These seven metals were identified as preliminary ecological COPCs for terrestrial food web exposures. Ten VOCs, 32 SVOCs, and 2 metals were also retained as preliminary ecological COPCs for terrestrial food web exposures due to the lack of ingestion-based screening values.

3.6.1.5.2 Aquatic Food Web Exposures

Twelve detected metals (antimony, arsenic, barium, chromium, cobalt, copper, lead, mercury, selenium, thallium, vanadium, and zinc) had HQ values greater than or equal to 1.0 for one or more of the upper trophic level aquatic receptors. These twelve metals were identified as preliminary ecological COPCs for aquatic food web exposures. Three SVOCs [bis(2-ethylhexyl)phthalate, di-n-butylphthalate, and hexachlorobenzene] were also identified as preliminary ecological COPCs. Bis(2-ethylhexyl)phthalate had an HQ greater than or equal to 1.0 for the double-crested cormorant (HQ = 2.62), while di-n-butylphthalate and hexachlorobenzene had HQ values greater than or equal to 1.0 for the spotted sandpiper (HQ =

1.81 and 2.49, respectively). Of these three organics, only bis(2-ethylhexyl)phthalate was detected in sediment samples collected from the Ensenada Honda.

3.6.2 Uncertainties Associated With the Screening-Level Risk Characterization

The procedures used in this evaluation to assess risks to ecological receptors, as in all such assessments, are subject to uncertainties because of the limitations of the available data and the need to make certain assumptions and extrapolations based on incomplete information. The major uncertainties associated with the screening-level ERA and their effect on risk conclusions are presented and discussed below.

- Detection Limits. Detection limits for many chemicals exceeded surface soil, surface water, and/or sediment screening values.

- Identification of Ecological COPCs. Chemicals without available screening values were identified as preliminary ecological COPCs even if they were not detected. This likely overstates the number of actual COPCs.

  A second source of uncertainty related to the selection of preliminary ecological COPCs applies to the use of NOAEL-based screening values in risk calculations for upper trophic level receptors. The use of NOAEL-based screening values is extremely conservative since they give no indication as to how much higher a concentration must be before adverse effects are observed.

  A third source of uncertainty related to the selection of preliminary ecological COPCs applies to sediment. Given the location of sediment samples relative to naval shipping operations, industrial activities, and storm water outfalls unrelated to the TWFF, Chemicals identified as preliminary ecological COPCs may not be related to site. This uncertainty is addressed by the refined screening-level risk characterization.

  A fourth of uncertainty related to the identification of preliminary ecological COPCs relates to common laboratory contaminants. Common laboratory contaminants, including 2-butanone, acetone, methylene chloride, and several phthalate esters, were identified as preliminary ecological COPCs for surface soil, groundwater, surface water, and/or sediment even though there presence in samples collected from the TWFF is unlikely to be related to the site.

- Exposure Point Concentrations. As is typical in a SERA, a finite number of samples of environmental media are used to develop the exposure estimates. The maximum measured concentration provides a conservative estimate for immobile biota or those with a limited home range. The most realistic exposure estimates for mobile species with relatively large home ranges and for species populations (even those that are immobile or have limited home ranges) are those based on the mean chemical concentrations in each medium to which these receptors are exposed. This is reflected in the wildlife dietary exposure models contained in the Wildlife Exposure Factors Handbook (USEPA 1993), which specify the use of average media concentrations. Given the mobility of the upper trophic level receptor species used in the SERA, the use of maximum chemical concentrations (rather than mean concentrations) to estimate the exposure via food webs is very conservative. The use of mean concentrations to estimate exposure in the Refinement is more likely to provide a more accurate picture of potential risks at the site.

A second source of uncertainty related to exposure point concentrations applies to surface water. Current USEPA guidance (USEPA 1995c and 1999b) indicates that the dissolved metal fraction more closely estimates the bioavailable fraction of metals in the water column. For conservatism, maximum total recoverable metal concentrations were used as exposure point concentrations in the screening-level risk calculation for surface water and groundwater.

A third source of uncertainty related to exposure point concentrations applies to groundwater. Although ecological receptors are not directly exposed to groundwater, maximum groundwater concentrations were compared directly to surface water screening values without consideration to dilution and attenuation. Since significant dilution is likely to occur upon discharge to the Ensenada Honda, this procedure results in a very conservative assessment.

- Media-specific Screening Values. The toxicological benchmarks used as screening values for sediment do not take into consideration site-specific factors (i.e., total organic carbon [TOC] and acid volatile sulfides [AVS]} that can influence bioavailability of chemicals to ecological receptors. This tends to make the resulting benchmark values very conservative and likely overestimates potential risk.

  A second source of uncertainty related to media-specific screening values applies to surface water. Surface water screening values for many chemicals were derived from literature-based toxicological data for a limited number of species. Unlike NAWQC, which are designed to be protective of the vast majority of the components of an aquatic community, the surface water screening values derived from limited toxicological data may not provide a similar level of protection for the Ensenada Honda aquatic community. Uncertainty was also introduced in the derivation of surface water screening values for many chemicals by applying a safety factor of 100 to acute toxicity test endpoints (i.e., EC_{50} and LC_{50} data). The USEPA (1995b) uses an assumed acute-to-chronic ratio (ACR) of 18 in the absence of experimentally derived values for the derivation of Secondary Chronic Values (SCVs). While the use of a safety factor of 100 is potentially conservative, it serves to counter some of the uncertainty associated with derivation of screening values form limited toxicological data. Finally, freshwater toxicological benchmarks were used as surface water screening values. The application of freshwater screening values to a marine environment may overestimate or underestimate potential risks if the toxicity of chemicals to freshwater and marine organisms differ significantly.

- Ingestion-Based Screening Values. Data on the toxicity of many chemicals to the receptor species were sparse or lacking, requiring the extrapolation of data from other wildlife species or from laboratory studies with non-wildlife species. This is a typical limitation for ecological risk assessments because so few wildlife species have been tested directly for most chemicals. The uncertainties associated with toxicity extrapolation were minimized through the selection of the most appropriate test species for which suitable toxicity data were available. The factors that were considered in selecting a test species to represent a receptor species included taxonomic relatedness, trophic level, foraging method, and similarity of diet.

  A second source of uncertainty related to the derivation of ingestion screening values applies to metals. Most of the toxicological studies on which the ingestion screening values for metals were based used forms of the metal (such as salts) that have high water solubility and high bioavailability to receptors. Since the analytical samples on

which site-specific exposure estimates were based measured total metal concentrations, regardless of form, and these highly bioavailable forms are expected to compose only a fraction of the total metal concentration, this is likely to result in an overestimation of potential risks for these chemicals.

A third source of uncertainty related to the derivation of ingestion screening values concerns the use of uncertainty factors. For example, in some cases NOAELs were extrapolated to LOAELs using an uncertainty factor of ten. This approach is likely to be conservative since Dourson and Stara (1983) determined that 96 percent of the chemicals included in a data review had LOAEL/NOAEL ratios of five or less. The use of an uncertainty factor of 10, although potentially conservative, also serves to counter some of the uncertainty associated with interspecies extrapolations, for which a specific uncertainty factor was not used.

A fourth source of uncertainty related to the derivation of ingestion-based screening values applies to mercury and selenium. The ingestion-based screening values used for these two metals were based on organometallic (methylated) forms. For example, the NOAEL-based mercury screening value used for birds (0.0064 mg/kg-BW/day) is based on a laboratory study that used methyl mercury dicyandiamide as the test material. Screening values for inorganic forms of mercury are substantially higher (0.45 mg/kg-BW/day for mercuric chloride [see Table 3-12]). Given that inorganic forms likely contribute significantly to the total mercury and selenium, use of NOAEL-based screening values based on organometallic forms tends to make the screening values for these metals extremely conservative and likely overestimates potential risk. This conclusion is supported by the approach used by the USEPA to derive a surface water BAF for trophic level three fish. The derivation assumes that only 17 percent of the total mercury present in the Great Lakes System is methyl mercury. This assumption is based on data from Gill and Bruland (1990).

- Ecological Receptors. Although exposure pathways to terrestrial and aquatic reptiles are likely to be complete, reptilian species were not selected as ecological receptors because the life history and toxicological database concerning the effects on reptiles is severely limited. It was assumed that any reptiles present at the TWFF are not exposed to significantly higher concentrations of chemicals and are not more sensitive to chemicals than the other receptor species evaluated in the risk assessment.

- Exposure Routes. Although inhalation and/or dermal adsorption represent potential exposure routes for upper trophic level receptors, they were not evaluated in the ERA because they were considered insignificant relative to ingestion exposures (see Section 3.1.1.3). While this is a reasonable assumption for the terrestrial birds selected as ecological receptors, the exclusion of inhalation and dermal adsorption represents a source of uncertainty.

- Food Web Exposure Modeling. Chemical concentrations in terrestrial and aquatic food items (plants, earthworms, small mammal omnivores, aquatic invertebrates, and fish) were modeled from measured media concentrations and were not directly measured. The use of generic, literature-derived exposure models and bioaccumulation factors introduces some uncertainty into the resulting estimates. The values selected and methodology employed were intended to provide a reasonable estimate of potential food web exposure concentrations.

A second source of uncertainty related to the food web models is the use of default assumptions for exposure parameters such as BCFs and BAFs. Although BCFs or BAFs for many bioaccumulative chemicals were readily available from the literature and were used in the ERA, the use of a default factor of 1.0 to estimate the concentration of some chemicals in receptor prey items is a source of uncertainty. However, for most chemicals, the assumption that the chemical body burden in the prey item is at the same concentration as in soil is conservative, particularly when many of the chemicals are known not to accumulate to any significant degree.

A third source of uncertainty related to the food web models is the use of unrealistically conservative exposure parameters. The use of maximum ingestion rates and minimum body weights result in a conservative estimate of exposure. In addition, AUFs were assumed to equal one. This is a conservative assumption since a significant percentage of each upper trophic level receptor species time could be spent foraging off-site in areas not impacted by site-related chemicals or areas where chemical concentrations are expected to be significantly lower.

- Chemical Mixtures. Information on the ecotoxicological effects of chemical interactions is generally lacking, which required (as is standard for ecological risk assessments) that the chemicals be evaluated on a compound-by-compound basis during the comparison to screening value. This could result in an underestimation of risk (if there are additive or synergistic effects among chemicals) or an overestimation of risks (if there are antagonistic effects among chemicals).

  It is noted that PAHs in sediment were evaluated by comparing the maximum total PAH concentration to a total PAH screening value. However, because the screening value is based on only thirteen individual PAH compounds, the comparison may underestimate total PAH risks since several individual PAHs are not evaluated by the comparison.

3.6.3 Screening-Level Risk Conclusions

The screening-level ERA for the TWFF indicated that, based on a set of conservative exposure assumptions, there are multiple chemicals that may present risks to each receptor/receptor group evaluated in the screening-level ERA (see Table 3-27). As such, none of the assessment endpoints identified in Table 3-7 was met. Therefore, additional evaluation is recommended for the TWFF (i.e., Step 3a of the baseline ERA). This evaluation is presented in the sections that follow.

3.7 Step 3a of the Baseline Risk Assessment (Refinement of Conservative Exposure Assumptions)

The results of the screening-level risk calculation indicated that, based on a set of conservative exposure assumptions, there are one or more chemicals that may present a risk to ecological receptor groups/species, the ERA process at the TWFF will proceed to the baseline risk assessment.

According to Superfund guidance (USEPA 1997), Step 3 initiates the problem formulation phase of the baseline ERA. Under Navy guidance (CNO 1999), the baseline ERA is defined as Tier 2, and the first activity under Tier 2 is Step 3a (see Figure 1-1). In Step 3a, the conservative assumptions employed in Tier 1 are refined and risk estimates are recalculated using the same

conceptual model. Step 3a may also include consideration of background data, the frequency at which chemicals were detected, and chemical bioavailability.

The specific assumptions, parameters, and methods that were modified for the recalculation of media-specific and food web exposure HQ values are identified below, along with justification for each modification. These refinements and methods were used to weigh the evidence of

potential risk for each preliminary ecological COPC identified for each media and receptor to assess whether the COPCs should be carried on to Step 3b of the baseline ERA.

- Maximum chemical concentrations were replaced by average (arithmetic mean) chemical concentrations. For individual receptor species, average chemical concentrations provide a better estimate of the likely level of chemical exposure because each receptor would be expected to forage in several different areas of the site, and, in many cases, off-site. Average concentrations are also appropriate for evaluating impacts *to populations* of lower trophic level receptors (i.e., terrestrial invertebrates, terrestrial plants, aquatic plants, benthic invertebrates, and fish). Because some of these receptors are relatively immobile, *individuals* are likely to be impacted by locations of maximum concentrations. However, evaluation of the average exposure case is more indicative of the level of impact that might be expected at the *population* level.

- Literature-based BCFs and BAFs based on, or modeled from, central tendency estimates (e.g., mean, median, midpoint) were used in place of maximum or high-end (e.g., 90th percentile) estimates for many chemicals. An assumed BCF/BAF of 1.0 was still used for those chemicals lacking a literature-based BAF/BCF. A summary of the surface soil-to-terrestrial plant BCFs and surface soil to terrestrial invertebrate BAFs, surface soil-to-small mammal omnivore BAFs, and sediment-to-invertebrate and sediment-to-fish BAFs used in Step 3a are summarized in Tables 3-27, 3-28, and 3-29, respectively. The surface water-to-fish BAFs used in the screening-level ERA (see Table 3-17) were used in Step 3a since many of the values shown were based on a single study.

- Central tendency estimates (e.g., mean, median, midpoint) for body weight and food ingestion rate (see Table 3-30) were used to develop exposure estimates for upper trophic level receptors rather than the minimum body weights and maximum food ingestion rates used in the screening-level ERA. The use of central tendency estimates is more relevant because they represent the characteristics of a greater proportion of the individuals in the population. As evidenced by Table 3-30, the evaluation of food web exposures still assumed an AUF of 1.0.

- In addition to the NOAELs-based risk estimates used in the screening-level ERA, consideration was also given to food web exposure risk estimates based on LOAELs and MATCs.

- Although body-weight scaling factors are typically used for interspecies extrapolation among mammals (Travis and White 1988 and Travis et al. 1990), ingestion-based screening values (i.e., NOAELs and LOAELs) were not adjusted in the screening-level ERA to account for differences between receptor and test organism body weights. Differences in body weights between the mammalian test species and the West Indian manatee were accounted for by converting the test species NOAEL and LOAEL values to receptor-based values. Using the NOAEL as an example, this was accomplished by the following scaling equation (Sample et al. 1996):

$$NOAEL_w = NOAEL_t \, (BW_t / BW_w)^{1/4} \qquad \text{(Equation 3-9)}$$

where:

$NOAEL_w$ = NOAEL of wildlife species (milligrams per kilogram per day [mg/kg-BW/day])

$NOAEL_t$	=	NOAEL of test species (mg/kg-BW/day)
BW_w	=	Body weight of wildlife species (kilogram [kg])
BW_t	=	Body weight of test species (kg)

Sample et al. (1996) consider a scaling factor of 1.0 most appropriate for interspecies extrapolation between birds. Therefore, the NOAEL and LOAEL values summarized in Table 3-12 were not adjusted to reflect differences in body weight between avian test species and receptor species.

- Chemicals that were not identified as preliminary ecological COPCs because maximum detected concentrations (or maximum reporting limits in the case of non-detected chemicals) were less than screening values are dropped from further consideration since a conclusion of no unacceptable risk can be made with high confidence.

- Chemicals that were not detected but identified as preliminary ecological COPCs in the screening-level ERA due to the lack of screening values were dropped from further consideration in Step 3a since it is as likely that the concentrations of these chemicals are near zero and not present at ecologically important concentrations. Chemicals that were not detected but identified as preliminary ecological COPCs because maximum detection limits exceeded screening values were also dropped from further consideration; however, HQ values for these non-detected chemicals are shown in associated screening tables.

- In the screening-level ERA, the comparison of chemical concentrations in groundwater were made directly to surface water screening values and were not adjusted for dilution effects that would occur when groundwater discharges into the Ensenada Honda. Dilution was considered in the Step 3a risk evaluation for groundwater by assuming a dilution factor of 10 (Buchman 1999), a factor that is likely to be very conservative given the nature of the Ensenada Honda (e.g., large size, wave/tidal action).

- Consideration was given to base background surface soil, groundwater, open water marine surface water, and open water marine sediment data (where applicable). The location of base background surface soil and groundwater sampling locations is presented on Figure 3-9, while the location of base background open water marine surface water and sediment sampling locations is presented on Figure 3.4 of the Additional Data Collection Investigation Report for the Tow Way Fuel Farm included as Appendix E). Note that site background data for abiotic media have not been collected at the TWFF. As such, consideration of background data is limited to base background data.

- Consideration was given to site-specific factors that can affect the bioavailability of chemicals in surface water and sediment to aquatic receptor groups. For surface water, consideration was given to the concentration of metals in the dissolved (unfiltered) fraction. For sediment, consideration was given to the affect total organic carbon (TOC) has on the bioavailability of organic chemicals, respectively.

3.7.1 Refined Screening-Level Risk Characterization

Refined media-specific screenings for surface soil, groundwater, surface water, and sediment are presented in Tables 3-31 through 3-34, respectively. Upper trophic level receptor HQ values for the Step 3a food chain modeling are provided in Tables 3-35 and 3-36 for terrestrial and aquatic receptors, respectively. As stated in Section 3.7, non-detected chemicals lacking screening values, as well non-detected chemicals with maximum detection limits exceeding screening values were dropped from further consideration in Step 3a. Only those chemicals with maximum detected concentrations greater than screening values (i.e., HQ values greater than 1.0 based on maximum detected concentrations), as well as detected chemicals lacking screening values are addressed by the refined screening-level risk characterization.

3.7.1.1 Refined Screening-Level Risk Calculation for Surface Soil

The screening-level risk characterization identified three detected VOCs (1,1,1-trichloroethane, 2-butanone, and acetone) as preliminary ecological COPCs for surface soil. They were identified as preliminary ecological COPCs due to the lack of screening values. Six metals (chromium, cobalt, copper, thallium, vanadium, and zinc) were also identified as preliminary ecological COPCs because maximum detected concentrations exceeded screening values. The refined screening-level risk characterization for 1,1,1-trichloroethane, 2-butanone, acetone, chromium, cobalt, copper, thallium, vanadium, and zinc is presented in the paragraphs that follow.

Table 3-31 presents the results of the refined screening-level risk calculation for surface soil. The mean concentration of thallium was less than the surface soil screening value (HQ = 0.98). As such, this metal was not retained as an ecological COPC for surface soil. Mean concentrations for chromium, cobalt, copper, vanadium, and zinc were greater than screening values. Refined HQ values ranged from 1.15 for cobalt to 65.75 for vanadium. These five metals were retained as ecological COPCs for surface soil. The three detected VOCs lacking surface soil screening values were also retained as ecological COPCs in surface soil.

3.7.1.1.1 Risk Evaluation for Surface Soil

The potential for adverse effects associated with ecological COPCs identified in Section 3.7.1.1 and Table 3-31 for surface soil is discussed and evaluated in this section.

Maximum detected concentrations for 1,1,1-trichloroethane and 2-butanone (3.2 J ug/kg and 5.9 J ug/kg, respectively) were less than the available screening values for other VOCs (see Table 3-20). Their frequency of detection was also low (one of twenty-three samples for 1,1,1-Trichloroethane and two of twenty-tree samples for 2-butanone). The low frequency of occurrence at concentrations less than available screening values for other VOCs does not seem to reasonably pose a risk to terrestrial invertebrates and fauna at the site. Although the maximum and mean concentration for acetone (56 J ug/kg and 21.1 ug/kg, respectively) is greater than the minimum available VOC screening value (11 ug/kg for vinyl chloride), they are less than all other available values. This common laboratory contaminant, which is not considered particularly toxic, is also not likely to reasonably pose a risk to terrestrial invertebrates and plants.

To evaluate the potential significance of risks presented by chromium, cobalt, copper, vanadium, and zinc, the site surface soil data for these metals were compared to available base background surface soil concentrations (see Table 3-37). As evidenced by Table 3-37, the maximum and mean background concentrations for copper and vanadium were greater than maximum and mean site concentrations. These data indicate that copper and vanadium are not presenting a risk to terrestrial invertebrates and plants at the site above background levels.

The maximum chromium concentration in surface soil collected from the TWFF was 65 mg/L. Although this maximum concentration exceeds the maximum background concentration (44.1 mg/kg), the mean site concentration for this metal (25.7 mg/kg) was less than the mean background concentration (29.7 mg/kg). Therefore, at the population level, chromium is not presenting a risk to terrestrial invertebrates and plants at the site above background levels.

Maximum and mean concentrations for cobalt and zinc were greater than background concentrations. However, the site maximum and mean cobalt concentrations (38 mg/kg and 22.9 mg/kg, respectively) were only slightly elevated above background maximum and mean concentrations (30.2 mg/kg and 22.0 mg/kg, respectively). These data indicate that cobalt concentrations detected at the site are consistent with background levels. Maximum and mean

concentrations for zinc (290 mg/kg and 78.2 mg/kg, respectively) were elevated above background maximum and mean concentrations (106 mg/kg and 62.6 mg/kg). As evidenced by the surface soil data presented in Appendix D, the maximum concentration for this metal was detected in surface soil sample MW17-00. This surface soil sample was collected from a surface run-off depositional area (depression) south of Tank No. 83. Exclusion of MW17-00 from the site data would result in maximum and mean zinc concentrations equal to 96 J mg/kg and 66.4 mg/kg, respectively. Both values are comparable to background values. Given the low risk presented by zinc (mean HQ = 1.56 [see Table 3-31]) and the localized extent of zinc detections above the maximum background concentration (one sample out of nineteen analyzed), it is unlikely that zinc would adversely effect terrestrial invertebrate and plant populations at the site above background effects. However, the potential risk from this chemical can not be dismissed since surface soil immediately downgradient from MW17-00 has not been characterized.

3.7.1.2 Refined Screening-Level Risk Calculation for Groundwater

Two VOCs (toluene and trichloroethene) and four metals (copper, mercury, silver, and zinc) were identified as preliminary ecological COPCs in groundwater because maximum detected concentrations exceeded screening values. Vanadium was also identified as preliminary ecological COPCs due to the lack of a surface water screening value. This metal was detected in groundwater samples collected from monitoring wells South of Forrestal Drive. The refined screening-level risk characterization for toluene, TCE, 2-methylnaphthalene, copper, mercury, silver, vanadium, and zinc is presented in the paragraphs that follow.

Table 3-32 presents the results of the refined screening-level risk calculation for groundwater. Mean concentrations for toluene (HQ = 0.34), mercury (HQ = 0.18), and zinc (HQ = 0.18) were less than surface water screening values. As such, they were not retained as ecological COPCs in Step 3a. TCE, 2-methylnaphthalene, copper, and silver were retained as ecological COPCs for groundwater because mean concentrations exceeded surface water screening values. HQ values were 7.01 for TCE, 1.60 for 2-methylnaphthalene, 2.54 for copper, and 8.70 for silver. Vanadium was also retained as ecological COPC due to the lack of surface water screening values.

3.7.1.2.1 Risk Evaluation for Groundwater

The potential for adverse effects associated with COPCs identified in Section 3.7.1.2 and Table 3-32 for groundwater is evaluated in this section.

A comparison of site and background groundwater data (total concentrations) for Appendix IX metals is presented in Table 3-38. As evidenced by the table, background maximum and mean concentrations for copper (353 ug/L and 149.5 ug/L, respectively) and vanadium (549 ug/L and 209.4 ug/L, respectively) exceed maximum and mean site concentrations. The site and background data indicate that copper and vanadium are not likely to present a risk to aquatic receptors above background levels.

Silver was not detected in any of the background groundwater samples (total and dissolved fraction). However, total silver was only detected in one of twenty groundwater samples collected from monitoring wells south of Forrestal Drive (7MW06 at 2.0 J ug/L), while dissolved silver was not detected in any of the groundwater samples. Buchman (1999) recommends the use of a dilution factor of ten to account for dilution expected during migration and upon discharge of groundwater to surface water in the absence of site-specific dilution factors. Assuming a dilution factor of ten, a factor that is likely to be very conservative given the nature of the Ensenada Honda (e.g., large size, tidal action), the HQ for silver would be 0.63 based on the single detection. Thus, the occurrence of total silver at a concentration above the screening criteria in

one groundwater sample does not seem to reasonably pose a potential risk to aquatic receptors in the Ensenada Honda. This conclusion is supported by analytical data for surface water and sediment samples collected from the Ensenada Honda. Silver was not detected in any of the surface water and sediment samples collected from the Ensenada Honda, including surface water and sediment samples collected downgradient of 7MW06 (7SW01, 7SW02, 7SD01, 7SD02, 7SD03, 7SD04).

The PAH 2-methylnaphthalene was detected in two of twenty groundwater samples collected from monitoring wells south of Forrestal Drive (96 ug/L in GW04 and 6.2 J ug/L in 7MW12). Both detections exceed the surface water screening value for this PAH (6 ug/L). Monitoring well GW04 is located just south of Forrestal Drive adjacent to Palau Street, while 7MW12 is located downgradient from GW04 near the fueling pier (see Figure 2-3). 2-Methylnaphthalene was not detected (detection limit of 10 ug/L) in several monitoring wells located between GW04 and 7MW12 (UGW08, UGW09, UGW10, UGW26, GW06, and 7MW14).

The location of monitoring wells GW04 and 7MW12 relative to the Ensenada Honda and the magnitude of the detections in samples collected from these wells indicate that it is unlikely that 2-methylnaphthalene would present a risk to aquatic receptors in the adjacent portions of the Ensenada Honda. The detection at 7MW12 (6.2 J ug/L) was slightly above the screening value. Furthermore, if a dilution factor of ten (Buchman 1999) were applied to the mean concentration of 2-methylnaphthalene for all monitoring wells, the HQ would be below the screening value (HQ = 0.16). Analytical data for surface water and sediment samples collected from the Ensenada Honda also indicated that the occurrence of 2-methylnaphthalene in two samples of twenty collected does not seem to reasonably pose a potential risk to aquatic receptors in the Ensenada Honda. This is supported by the analytical data for surface water and sediment samples collected from the Ensenada Honda. 2-Methylnaphthalene was not detected in any of the Ensenada Honda surface water samples. A single detection was reported in sediment (1.6 J ug/kg in sample 7SD7); however, the detected concentration was substantially lower than the sediment screening value (409.4 ug/kg).

TCE was detected in two groundwater samples (28,000 ug/L in 7MW07 and 0.35 J ug/L in UGW11). As discussed in Section 3.3.1.1, the source of TCE in groundwater samples collected from 7MW07 is not known. An analysis presented in Appendix G, Section 4.1 estimates that the time of travel of the TCE plume to the Ensenada Honda is twelve years. TCE was not detected in a downgradient monitoring well (7MW10) located in the estimated travel path of the TCE plume. TCE was also not detected in Ensenada surface water and sediment samples, including those samples collected downgradient from 7MW07 and UGW11 (7SW6, 7SW7, 7SW8, 7SW9, SD9, SD11, SD12, and 7SD14). As such, there is no evidence that TCE is currently migrating with groundwater to the Ensenada Honda. This Draft Final Task I CMS (see section 8.0) has recommended that an investigation be performed to identify the source of TCE at 7MW07. Concurrent with this investigation, groundwater monitoring will be conducted in downgradient wells, including 7MW10 and UGW11. These data will be used to evaluate the temporal trends in groundwater concentrations to determine if chemical concentrations (and thus potential risks) are increasing over time or not. A Corrective Action Objective (CAO) for TCE in groundwater has been developed to address potential human health risks. The CAO, based on an industrial scenario, is 2.2 ug/L. Given a surface water screening value of 200 ug/L, this CAO would be protective of aquatic receptors within the Ensenada Honda.

3.7.1.3 Refined Screening-Level Risk Calculation for Surface Water

Copper was identified as a preliminary ecological COPC because the maximum detected concentration for this metal exceeded the screening value. Tin and vanadium were also identified as preliminary ecological COPCs due to the lack of surface water screening values. Both metals were detected in surface water screening values collected from the Ensenada Honda. The refined screening-level risk characterization for copper, tin, and vanadium is presented in the paragraphs that follow.

The results of the refined risk characterization for surface water is presented in Table 3-33. Copper is retained as an ecological COPC for surface water because the mean concentration for this metal exceeds the screening value (HQ = 1.14). The detected metals lacking a surface water screening value are also retained as ecological COPCs in Step 3a.

3.7.1.3.1 Risk Evaluation for Surface Water

The potential for adverse effects associated with COPCs identified in Section 3.7.1.3 and Table 3-33 for surface water is evaluated in this section.

The mean concentration and screening value used in the comparison presented in Table 3-33 for copper are based on the total (unfiltered) fraction. Given that the dissolved (filtered) fraction for several metals, including copper, more closely approximates the bioavailable fraction in the water column (USEPA 1995b and 1999b), a comparison of dissolved mean concentrations to screening values expressed as dissolved concentrations would reflect their potential bioavailability and thus potential for exposure and risk. Dissolved copper was detected in each surface water sample collected from the Ensenada Honda. Concentrations ranged from 2.1 J ug/L to 8.4 J ug/L, with the mean concentration equal to 3.7 ug/L. The mean concentration is greater than the dissolved NAWQC for this metal (3.1 ug/L).

To evaluate the potential significance of risks presented by total and dissolved copper, the Ensenada Honda surface water data for this metal was compared to total and dissolved background surface water data. The maximum and mean total copper concentrations for the Ensenada Honda surface water samples were 14 J ug/L and 4.2 ug/L, respectively). These values are elevated above maximum and mean background concentrations (2.5 J ug/L and 2.1 ug/L, respectively). However, maximum and mean dissolved concentrations in site surface water (8.4 J ug/l and 3.7 ug/L, respectively) were less than maximum and mean dissolved concentrations for background (9.9 J ug/L and 3.8 ug/L, respectively). Given that the dissolved fraction of copper more closely approximates the bioavailable fraction in the water column (USEPA 1995b and 1999b), copper does not appear to present a risk to aquatic receptors at levels above background.

The magnitude of the tin and vanadium detections were evaluated by comparing their maximum and mean total concentrations to maximum and mean background concentrations. The comparison was limited to total (unfiltered) concentrations since available screening values for these metals are expressed as total concentrations. The maximum total vanadium concentrations in background and site surface water samples were identical (12 J ug/l). The mean background total vanadium concentration was also slightly higher than the mean total vanadium concentration in site surface water (8.0 ug/l). These data indicate that any risk presented by the occurrence of vanadium in Ensenada Honda surface water is below levels presented by background concentrations.

Total (unfiltered) tin was detected in site and background surface water samples at an identical frequency (2/9 [see Appendix D for background surface water data]). Furthermore, the detected concentrations in site surface water (6.8 J ug/L and 11 J ug/L) and background surface water (6.5

concentrations in site surface water (6.8 J ug/L and 11 J ug/L) and background surface water (6.5 J ug/L and 7.3 ug/L) were similar. Given the identical frequency of detection and the similarity in the concentrations detected, the potential site-related risk presented by tin is consistent with background risks.

3.7.1.4 Refined Screening-Level Risk Calculation for Sediment

Two detected VOCs (acetone and xylenes), sixteen detected SVOCs, including fifteen PAHs, and twelve detected metals (antimony, arsenic, barium, cadmium, cobalt, copper, lead, nickel, selenium, tin, vanadium, and zinc) were identified as preliminary ecological COPCs in sediment because maximum concentrations exceeded screening values.

Table 3-33 presents the results of the refined screening-level risk calculation for sediment. The VOCs acetone and xylenes and the SVOCs bis(2-ethylhexyl)phthalate, acenaphthene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, fluoranthene, phenanthrene, and pyrene were retained as ecological COPCs because mean concentrations exceeded screening values. The mean concentration for total PAHs (2,449 ug/kg) also exceeded the total PAH screening value (1,680 ug/kg). Mean concentrations for antimony, arsenic, cobalt, copper, lead, tin, vanadium, and zinc also exceeded screening values. These eight metals, as well as the detected metals lacking sediment screening values (beryllium and thallium) were also retained as ecological COPCs for sediment in Step 3a.

3.7.1.4.1 Risk Evaluation for Sediment

The potential for adverse effects associated with COPCs identified in Section 3.7.1.4 and Table 3-34 for sediment is evaluated in this section.

The sediment screening values used in the screening-level risk calculation and refined screening level risk calculation for xylenes, bis(2-ethylhexyl)phthalate, acenaphthene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, fluoranthene, phenanthrene, and pyrene were literature-based toxicological thresholds (AETs or TELs). These toxicological thresholds do not take into consideration site-specific factors that can influence bioavailability and toxicity. For organics, the primary factor affecting their bioavailability in sediment is TOC (USEPA 1993a). To evaluate the potential significance of risks presented xylenes, bis(2-ethylhexyl)phthalate, acenaphthene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, fluoranthene, phenanthrene, and pyrene, mean sediment concentrations for these organic chemicals were compared to EqP-based sediment screening values derived using the procedures presented in Appendix B (see Table 3-39). The TOC concentration used in the derivation of EqP-based sediment screening values was the mean concentration for Ensenada Honda sediment samples (10,069 mg/kg [1.0069 percent]). The use of an average TOC concentration is appropriate for evaluating the level of impact that might be expected at the population level. As evidenced by Table 3-39, mean sediment concentrations for the organic chemicals retained as ecological COPCs in Step 3a were less than EqP-based screening values.

The EqP-based benchmarks presented in Table 3-39 were derived in accordance with the approach used by the USEPA to develop sediment quality criteria for nonionic organic chemicals (USEPA 1993a and 1993c). A comparison of maximum and mean PAH sediment concentrations to EqP-based benchmarks developed by Di Toro and McGrath (2000) support the conclusion that PAHs in Ensenada Honda sediments are not impacting the Ensenada Honda benthic macroinvertebrate community. As evidenced by Table 3-39a, maximum and mean PAH sediment concentrations were less than Di Toro and McGrath (2000) EqP-based benchmarks.

An EqP-based sediment screening value has not been developed for total PAHs. However, additional literature-based screening values are available for comparison to the mean total PAH concentrations. In addition to the TEL, MacDonald (1994) has developed a Probable Effects Level for total PAHs (16,800 ug/kg). Long et. al (1995) has also developed ER-L and ER-M values for total PAHs (4,022 ug/kg and 44,792 ug/kg, respectively). Based on a comparison of the mean PAH concentration to these three toxicological benchmarks, total PAHs are not likely to represent a potential risk to benthic macroinvertebrates at the population level. This conclusion is supported by a comparison of the mean and maximum total PAH concentration to consensus-based sediment quality guidelines developed by MacDonald et al. (2000) for freshwater systems. These consensus-based total PAH sediment quality guidelines are expressed as a Threshold Effect Concentration (1,610 ug/kg) and a Probable Effect Concentration (22,800 ug/kg). TECs provide an accurate basis for predicting the absence of sediment toxicity, while PECs provide an accurate basis for predicting sediment toxicity. Although the mean total PAH concentration (2,449 ug/kg) exceeded the TEC, it was below the PEC (i.e, the concentration above which the incidence of toxicity to benthic invertebrates is expected to occur). Of the thirteen sediment samples collected, only three had total PAHs concentrations greater than the TEC (3,263 ug/kg in 7SD11, 21,840 ug/kg in 7SD12, and 2,195 ug/kg in 7SD13). None of the individual sediment samples had total PAH concentrations greater than the PEC.

Several sediment samples collected from the Ensenada Honda (7SD1 through 7SD6) had TOC concentrations less than the average value. As a measure of conservatism, EqP-based sediment screening values were derived using the minimum TOC concentration (2,100 mg/kg [0.21 percent]). The comparison of mean concentrations for xylenes, bis(2-ethylhexyl)phthalate, acenaphthene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, fluoranthene, phenanthrene, and pyrene to EqP-based screening values derived using the minimum TOC concentrations is presented in Table 3-40. As evidenced by the comparison presented in Table 3-40, mean concentrations for these organic chemicals are less than EqP-based sediment screening values derived using the minimum TOC concentration.

Acetone was identified as a preliminary ecological COPC in the screening-level risk characterization because the maximum concentration for this VOC exceeded the EqP-based sediment screening value derived using the minimum TOC concentration for Ensenada Honda sediment samples. Acetone was also retained as an ecological COPC in the refined screening-level risk characterization because the mean concentration exceeded the EqP-based sediment screening value derived using the mean TOC concentration. As discussed in Appendix C, application of the EqP-approach to derivation of screening values for ionic organic chemicals likely overestimates their pore water concentrations since adsorption mechanisms other than hydrophobicity may significantly increase the fraction of the chemical sorbed to sediment particles (Jones et al. 1997). Furthermore, the surface water screening value used in the derivation of the EqP-based screening values was estimated by applying a safety factor of 100 to a minimum acute toxicity value from the literature. The USEPA (1995b) uses an assumed acute-to-chronic ratio (ACR) of 18 in the absence of experimentally derived values for the derivation of Secondary Chronic Values (SCVs). Thus, the application of a safety factor of 100 to the minimum acute value for acetone likely resulted in an overly conservative surface water screening value. For these reasons, the occurrence of this common laboratory contaminant at concentrations greater than EqP-based screening values (maximum concentration equal to 120 J ug/kg) is not likely to represent a potential risk to aquatic receptors within the Ensenada Honda.

Sediment quality data (AVS/SEM) are not available to evaluate the bioavailability of SEM metals retained as ecological COPCs (copper, lead, and zinc). Appropriate sediment background data is also not available for comparison to Ensenada Honda sediment data to evaluate the potential significance of risks presented by metals. Background sediment samples were collected during the additional data collection field investigation (see Appendix E); however, the data for these samples are not considered representative of the Ensenada Honda sediment data for the following reasons:

- Background sediment samples were collected from a littoral zone, while many of the site sediment samples were collected from deep water habitat adjacent to docks/piers and sea walls.

- The background sediment samples were collected from an area that is remote from industrial areas. This contrasts with the location of sediment samples collected from the Ensenada Honda. Sediment quality at these locations can be influenced by activities unrelated to the TWFF (naval shipping activities, marine cargo handling, ship repair and material storage [see Figure 3-7]) and storm sewer discharges from drainage areas that do not include the TWFF.

The lack of AVS/SEM data and an appropriate set of background data prevented an evaluation of the potential significance or risks presented by metals in the Ensenada Honda. However, based on the potential transport pathways that can serve as mechanisms for the migration of chemicals from source areas to the Ensenada Honda, the potential significance of site-related risks can be characterized. As discussed in Section 3.3.1.2, the migration of chemicals from source areas at the TWFF to the Ensenada Honda are limited to transport with groundwater and transport with surface soil via surface water run-off through Outfall 010. Based on potential pathways and the location of sediment samples relative to Outfall 010, storm water discharging through this outfall can not reasonably be expected to influence sediment quality at 7SD09, 7SD11, and 7SD12. These three sediment samples were collected east of the fueling pier where the only potential migration pathway from source areas to the Ensenada Honda is transport with groundwater. Based on groundwater analytical data and the evaluation presented in Section 3.7.1.2, groundwater is not likely to be impacting sediment quality at these locations.

If analytical data for 7SD9, 7SD11, and 7SD12 are eliminated from the database, mean concentrations for only four detected metals (arsenic, cobalt, copper, and vanadium) exceed sediment screening values (see Table 3-41). As evidenced by the HQ values in Table 3-42, the magnitude that mean concentrations for arsenic, cobalt, copper, and vanadium exceed screening values is minor. The most likely sediment sample locations potentially impact by the storm water discharge through Outfall 010 is 7SD05 and 7SD06. Based on a comparison of analytical data to screening values for these two samples, only three metals (cobalt, copper, and vanadium) have mean concentrations greater than screening values (see Table 3-42).

Interpretation of the sediment analytical data is further confounded by the presence of a storm water outfall (Outfall 011) immediately adjacent to Outfall 010. The drainage area for this outfall includes a number of industrial activities, including marine cargo handling and ship repair and roadways, as well as material storage areas (see Figure 3-7). This outfall likely contributes to the concentration of metals detected in 7SD5 and 7SD6.

3.7.1.5 Refined Screening-Level Risk Calculation for Food Web Exposures

Seven detected metals were identified as preliminary ecological COPCs for terrestrial food web exposures because maximum exposure doses for one or more of the terrestrial receptors exceeded ingestion-based screening values. Twelve detected metals and the SVOC bis-(2-ethylhexyl)phthalate were also identified as preliminary ecological COPCs for aquatic food web exposures because maximum exposure doses exceeded ingestion-based screening values for one or more of the aquatic receptors. The refined screening-level risk calculation for terrestrial and aquatic food web exposures is presented in the sections that follow.

3.7.1.5.1 Terrestrial Food Web Exposures

Based on the comparison of mean exposure doses to NOAEL-based screening values, cadmium, chromium, cobalt, lead, mercury, selenium and zinc are not retained as ecological COPCs for terrestrial food web exposures. As evidenced by Table 3-35, HQ values for these seven metals were less than 1.0 for each terrestrial receptor.

3.7.1.5.2 Aquatic Food Web Exposures

Based on the comparison of mean exposure doses to NOAEL-based ingestion screening values, chromium, cobalt, and vanadium were retained as ecological COPCs for aquatic food web exposures. HQ values for these three metals exceeded 1.0 for the spotted sandpiper (1.06 for chromium, 1.65 for cobalt, and 1.97 for vanadium [see Table 3-36]). NOAEL-based HQ values for all other chemical-receptor combinations evaluated in Step 3a were less than 1.0. The potential for adverse effects associated with chromium, cobalt, and vanadium is evaluated in the paragraph below.

The use of NOAEL-based screening values is extremely conservative since they give no indication as to how much higher a concentration must be before adverse effects are observed. Furthermore, the NOAEL-based screening values for cobalt and vanadium were estimated from LOAELs by applying a safety factor of ten to the LOAELs. As discussed in Section 3.6.2, this approach is likely to be conservative since Dourson and Stara (1983) determined that 96 percent of the chemicals included in a data review had LOAEL/NOAEL ratios of five or less. Given that LOAEL and MATC-based HQ values for chromium, cobalt, and vanadium were less than 1.0 for

the spotted sandpiper (see Table 3-36) and the conservatism associated with the use of NOAELs, these metals are not likely to present a risk to the spotted sandpiper.

3.7.2 Uncertainties Associated With the Refined Screening-Level Risk Characterization

Many of the uncertainties identified in Section 3.6.2 also apply to the refined screening-level risk characterization. The uncertainties that apply to the refined screening-level risk characterization are listed below.

- Detection Limits. Detection limits for many chemicals exceeded surface soil, surface water, and/or sediment screening values. These chemicals were not retained as ecological COPCs in the refined screening-level risk characterization unless they were detected.

- Identification of Ecological COPCs. Chemicals without available screening values were not retained as ecological COPCs in the refined screening-level risk characterization unless they were detected. As stated above, chemicals with detection limits greater than screening values were also not retained as ecological COPCs unless they were detected.

  A second source of uncertainty related to the identification of ecological COPCs in the refined screening-level risk characterization applies to the use of NOAEL-based screening values in risk calculations for upper trophic level receptors. The use of NOAEL-based screening values is extremely conservative since they give no indication as to how much higher a concentration must be before adverse effects are observed. For illustrative purposes, the application of LOAEL and MATC-based screening values in risk calculations was presented and discussed in applicable sections.

  A third source of uncertainty related to the identification of ecological COPCs in the refined screening-level risk characterization applies to sediment. Many of the metals retained as ecological COPCs may not be related to sources at the TWFF. Many of the sediment samples were collected in the vicinity of storm sewer outfalls that convey surface run-off from industrial and material storage areas not associated with the TWFF or near docks and piers regularly used by naval ships and harbor support craft.

  A fourth source of uncertainty related to the identification of ecological COPCs in the refined screening-level risk calculation relates to common laboratory contaminants. Acetone was retained as an ecological COPC for surface soil and sediment even though the presence of this VOC in samples collected from the TWFF is unlikely to be related to the site.

- Evaluation of Groundwater. Although ecological receptors are not directly exposed to groundwater, groundwater concentrations were compared directly to surface water screening values without the application of any dilution factors. Since significant dilution is likely to occur prior to discharge to the Ensenada Honda, this procedure results in a very conservative assessment. For illustrative purposes, the implications of applying a dilution factor of 10 (recommended in Buchman [1999]) to the groundwater concentrations were provided in each applicable section.

- Media-specific Screening Values. The toxicological benchmarks used as screening values for sediment do not take into consideration site-specific factors (i.e., total organic carbon [TOC] and acid volatile sulfides [AVS]} that can influence bioavailability of chemicals to ecological receptors. This tends to make the resulting benchmark values very conservative and likely overestimates potential risk. The effect that TOC has on the bioavailability of organic chemicals retained as ecological COPCs in sediment was discussed in appropriate sections. Measurements of specific sediment characteristics that can influence the bioavailability of metals (e.g., AVS/SEM) were not available. As such, the potential significance of metal concentrations exceeding sediment toxicological benchmarks could not be evaluated in the refined screening-level risk characterization.

  A second source of uncertainty related to media-specific screening values applies to surface water. Surface water screening values for many chemicals were derived from literature-based toxicological data for a limited number of species. Unlike NAWQC, which are designed to be protective of the vast majority of the components of an aquatic community, the surface water screening values derived from limited toxicological data may not provide a similar level of protection for the Ensenada Honda aquatic community. the derivation of surface water screening values from safety factor In some cases, freshwater toxicological benchmarks were used as surface water screening values. The application of freshwater screening values to a marine environment may overestimate or underestimate potential risks if the toxicity of chemicals to freshwater and marine organisms differ significantly.

- Ingestion-Based Screening Values. Data on the toxicity of many chemicals to the receptor species were sparse or lacking, requiring the extrapolation of data from other wildlife species or from laboratory studies with non-wildlife species. This is a typical limitation for ecological risk assessments because so few wildlife species have been tested directly for most chemicals. The uncertainties associated with toxicity extrapolation were minimized through the selection of the most appropriate test species for which suitable toxicity data were available. The factors that were considered in selecting a test species to represent a receptor species included taxonomic relatedness, trophic level, foraging method, and similarity of diet.

  A second source of uncertainty related to the derivation of ingestion screening values applies to metals. Most of the toxicological studies on which the ingestion screening values for metals were based used forms of the metal (such as salts) that have high water solubility and high bioavailability to receptors. Since the analytical samples on which site-specific exposure estimates were based measured total metal concentrations, regardless of form, and these highly bioavailable forms are expected to compose only a fraction of the total metal concentration, this is likely to result in an overestimation of potential risks for these chemicals.

  A third source of uncertainty related to the derivation of ingestion screening values concerns the use of uncertainty factors. For example, in some cases NOAELs were extrapolated to LOAELs using an uncertainty factor of ten. This approach is likely to be conservative since Dourson and Stara (1983) determined that 96 percent of the chemicals included in a data review had LOAEL/NOAEL ratios of five or less. The use of an uncertainty factor of 10, although potentially conservative, also serves to counter some of the uncertainty associated with interspecies extrapolations, for which a specific uncertainty factor was not used.

A fourth source of uncertainty related to the derivation of ingestion-based screening values applies to mercury and selenium. The ingestion-based screening values used for these two metals were based on organometallic (methylated) forms. For example, the NOAEL-based mercury screening value used for birds (0.0064 mg/kg-BW/day) is based on a laboratory study that used methyl mercury dicyandiamide as the test material. Screening values for inorganic forms of mercury are substantially higher (0.45 mg/kg-BW/day for mercuric chloride [see Table 3-12]). Given that inorganic forms likely contribute significantly to the total mercury and selenium, use of NOAEL-based screening values based on organometallic forms tends to make the screening values for these metals extremely conservative and likely overestimates potential risk. This conclusion is supported by the approach used by the USEPA to derive a surface water BAF for trophic level three fish. The derivation assumes that only 17 percent of the total mercury present in the Great Lakes System is methyl mercury. This assumption is based on data from Gill and Bruland (1990).

- Ecological Receptors. Although exposure pathways to terrestrial and aquatic reptiles are likely to be complete, reptilian species were not selected as ecological receptors because the life history and toxicological database concerning the effects on reptiles is severely limited. It was assumed that any reptiles present at the TWFF are not exposed to significantly higher concentrations of chemicals and are not more sensitive to chemicals than the other receptor species evaluated in the risk assessment.

- Exposure Routes. Although inhalation and/or dermal adsorption represent potential exposure routes for upper trophic level receptors, they were not evaluated in the ERA because they were considered insignificant relative to ingestion exposures (see Section 3.1.1.3). While this is a reasonable assumption for the terrestrial birds selected as ecological receptors, the exclusion of inhalation and dermal adsorption represents a source of uncertainty.

- Food Web Exposure Modeling. Chemical concentrations in terrestrial and aquatic food items (plants, earthworms, small mammal omnivores, aquatic invertebrates, and fish) were modeled from measured media concentrations and were not directly measured. The use of generic, literature-derived exposure models and bioaccumulation factors introduces some uncertainty into the resulting estimates. The values selected and methodology employed were intended to provide a reasonable estimate of potential food web exposure concentrations.

  A second source of uncertainty related to the food web models is the use of default assumptions for exposure parameters such as BCFs and BAFs. Although BCFs or BAFs for many bioaccumulative chemicals were readily available from the literature and were used in the ERA, the use of a default factor of 1.0 to estimate the concentration of some chemicals in receptor prey items is a source of uncertainty. However, for most chemicals, the assumption that the chemical body burden in the prey item is at the same concentration as in soil is conservative, particularly when many of the chemicals are known not to accumulate to any significant degree.

  A third source of uncertainty related to the food web model applies to the West Indian manatee. A total of four metals were identified as potential ecological COPCs in Step 2 of the ERA: antimony (HQ = 1.29), arsenic (HQ = 11.0), lead (HQ = 2.10) and zinc (HQ = 1.43). As discussed in Section 3.7, exposure assumptions were modified in Step 3a of the ERA process for media-specific and food web exposures.

Specific refinements for the West Indian manatee food web model (as well as all receptor food web models) included the use of average chemical concentrations, BCFs/BAFs based on, or modeled from, central tendency estimates, and central tendency estimates for body weight and ingestion rates. Use of the modified exposure assumptions in Step 3a of the ERA resulted in the reduction of NOAEL-based risk estimates (HQs) for antimony, arsenic, lead, and zinc to values less than 1.0 (0.59, 0.48, 0.07, and 0.13, respectively). As such, antimony, arsenic, lead, and zinc were not retained as ecological COPCs in Step 3a of the ERA.

Evaluation of the average exposure case is indicative of the level of impact that might be expected at the population level. However, for endangered species such as the West Indian manatee, effects on individuals may be more important. Although the average exposure case reduces the conservatism of the West Indian manatee food web model at the level of the individual, several assumptions applied to the model still provide a substantial level of conservatism. Identical to the Step 2 risk calculation, it was assumed in Step 3b that the West Indian manatee obtains all of its food from the site (AUF of 1.0). In Florida, manatees range over fairly large areas during the summer (covering up to 200 linear km of river or coastline). Unlike the Florida population, which aggregate within the confines of natural or artificial warm water refuges during winter periods (USFWS 1996b), there is no evidence of periodicity in manatee behavior in Puerto Rico (USGS 1986). As such, it can not be expected that West Indian manatees would exclusively forage within the Ensenada Honda downgradient from the TWFF.

As discussed in Section 3.1.2 much of the analytical data used in the West Indian manatee food web exposure model came from sediment samples located in areas of the Ensenada Honda devoid of sea grass. Although these locations do not represent exposure points, data for these samples were conservatively used in the food web model. It is noted that maximum detections for two metals identified as preliminary ecological COPCs in Step 2 of the ERA occurred in sediment samples collected from areas devoid of sea grass.

- Chemical Mixtures. Information on the ecotoxicological effects of chemical interactions is generally lacking, which required (as is standard for ecological risk assessments) that the chemicals be evaluated on a compound-by-compound basis during the comparison to screening value. This could result in an underestimation of risk (if there are additive or synergistic effects among chemicals) or an overestimation of risks (if there are antagonistic effects among chemicals).

3.7.3 Conclusions and Recommendations

Based upon the evaluation of chemicals detected in surface soil, zinc has the potential to impact terrestrial invertebrate populations in surface soil at the site. The maximum and mean zinc concentrations in site surface soil (290 mg/kg and 78.2 mg/kg, respectively) were elevated above background maximum and mean concentrations (106 mg/kg and 62.6 mg/kg). Although detected in each surface soil sample, only one sample (7MW17-00), collected from a surface run-off depositional area, had a concentration greater than the maximum background concentration. Given the localized spatial extent of zinc concentrations above maximum background levels and the low risk presented by this metal (mean HQ = 1.56), it is unlikely that zinc would adversely effect terrestrial invertebrate and plant populations at the site. However, there is substantial uncertainty in this conclusion since surface soil immediately downgradient from the 7MW17-00 sample location has not been characterized for zinc. To reduce this uncertainty, it is recommended that additional surface soil samples be collected downgradient from sample

7MW17-00 to further characterize zinc concentrations in this area of the TWFF. This recommendation will be incorporated into future corrective measures work at the TWFF (see Section 8.0).

Based upon the evaluation of chemicals detected in groundwater, TCE has the potential to impact aquatic receptor populations in adjacent portions of the Ensenada Honda. There is no evidence that TCE is currently migrating to the Ensenada Honda; however, the concentration detected in

monitoring well 7MW07 has increased from 2 mg/L in 1998 to a current concentration of 28 mg/L. This Draft Final Task I CMS has recommended that an investigation be performed to identify the source of TCE at 7MW07 (see Section 8.0). Concurrent with this investigation, groundwater monitoring will be conducted in downgradient wells. Based on the results of the source investigation, an alternative action will be developed to address the TCE source. A Corrective Action Objective (CAO) for TCE in groundwater has been developed to address potential human health risks. The CAO, based on an industrial scenario, is 2.2 ug/L. Given a surface water screening value of 200 ug/L, this CAO would be protective of aquatic receptors within the Ensenada Honda.

No further evaluation of ecological risk is recommended for surface water. Based on the relatively few exceedences of a reference HQ of 1.0 for detected chemicals and data on the background concentration of inorganics, the conclusion of the assessment is that the levels of chemicals in surface water pose little potential risk to ecological receptor populations.

Based upon the evaluation of chemicals detected in sediment, ten detected metals (antimony, arsenic, beryllium, cobalt, copper, lead, tin, thallium, vanadium, and zinc have the potential to impact aquatic invertebrate populations in adjacent portions of the Ensenada Honda. However, there is much uncertainty as to whether the risk presented by these metals are site related.

As discussed in Section 3.3.1.2, the migration of chemicals from potential source areas at the TWFF to the Ensenada Honda are limited to transport with groundwater and transport with surface soil via surface water run-off through Outfall 010. Based on the evaluation of analytical data for groundwater, chemicals are not likely to be migrating with groundwater to surface water and sediment at concentration that can reasonably pose a potential risk to aquatic receptors. As such, migration with surface soil via surface run-off and discharge through Outfall 010 represents the most reasonable transport pathway from source areas to the Ensenada Honda.

Two sediment samples (7SD5 and 7SD6) were collected in the immediate vicinity of Outfall 010. Based on a comparison of mean concentrations for these two sediment samples to sediment screening values (see table 3-40), only three metals had HQ values greater than the reference HQ of 1.0 (cobalt [HQ = 1.5], copper [HQ = 5.51], and vanadium [HQ = 1.99]. Mean concentrations for antimony, arsenic, lead, tin, and zinc were less than screening values. Although these metals are present at mean concentrations greater than screening values, they may not be site-related. A storm water outfall (Outfall 011) located immediately adjacent to Outfall 010 may be contributing to the concentration of metals detected in sediment samples collected at 7SD5 and 7SD6. A number of industrial activities, including marine cargo handling and ship repair, roadways, parking lots, and material storage areas are located within the Outfall 011 drainage area (see Figure 3-7). Furthermore, the comparison of site surface soil data to background data has shown that the concentration of cobalt, copper, and vanadium are consistent with background concentrations. Therefore, even if cobalt, copper, and vanadium are migrating with surface soil to Ensenada Honda sediments via Outfall 010, sediment concentrations would not be elevated above background conditions. Based on the groundwater evaluation, the low risk presented by detected metals at the population level, and the location of industrial activities unrelated to source areas within the TWFF, additional evaluation of Ensenada Honda sediment is not recommended.

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4.0 ESTABLISHMENT OF CORRECTIVE ACTION OBJECTIVES

4.1 Introduction

The results of the human health risk assessment (RA) portion of the Revised Draft RCRA Facility Investigation (RFI) report (Baker, 1997) indicate that corrective measures must be evaluated for the TWFF. This section of the document established the site-specific objectives and clean up goals used to identify corrective measures.

This Section is an update of the Section 3.0 of the Task 1 Corrective Measures Study (CMS) submission (Baker, 2001b), based on additional data collected at the TWFF and some minor changes in risk assessment methodology. The previous document was requested as a way of improving the CMS process and schedule in a letter from the Navy on November 8, 2000. A meeting was held at EPA Region II headquarters in New York City on December 19, 2000 to discuss the CMS process at the TWFF, including the framework for the previous revision. At the meeting, and subsequent discussions about the meeting, the revised Section 3.0 was approved and the general changes made to the Task 1 CMS Report (Baker, 2000) were agreed to by EPA Region II.

The first step in evaluating corrective measures is to develop corrective action objectives (CAOs), which consist of medium- and chemical-specific goals for protecting human health and the environment. The CAOs are used to focus the development of corrective measure alternatives on technologies that may achieve appropriate target levels, thereby limiting the number of alternatives analyzed.

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

The CAOs for the TWFF, developed in Section 4.6, are based on land use and potential receptor assumptions (Section 4.2), summary of the human health RA and selection of contaminants of potential concern (Section 4.3), exposure assessment and methodology (Section 4.4), and toxicity evaluation (Section 4.5). They were developed in accordance with the U.S. Environmental Protection Agency (EPA) guidance (USEPA, 1989, 1991a, and others), and the human health RA performed as part of the RFI (Baker, 1997).

4.2 Land Use and Potentially Exposed Receptors

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

The TWFF is an industrial area of NSRR where fuel is stored in underground storage tanks (USTs) to support Station activities. Future property use of the TWFF is expected to remain industrial for the duration of Naval operations of NSRR. As a result, potential human exposure is limited to industrial or commercial property use, now and in the foreseeable future.

The baseline human health RA (Baker, 1997) assumed that industrial workers are potentially exposed receptors for the current land use; and that on-base residents, industrial workers, and construction workers are potentially exposed receptors for the future land use. Although future onsite residential land use was quantitatively evaluated as an additional hypothetical exposure scenario in the human health RA, it is not considered reasonably anticipated.

Therefore, based on the RFI and EPA and Department of Defense guidance that CAOs should reflect actual anticipated land use, the assumed land use is continued military use, with industrial workers (i.e., civilians and or military personnel stationed at NSRR) the most likely receptors. Construction workers (e.g., fuel line pipe-fitters) may be exposed to soil from the surface to a depth of ten feet below ground surface. It is extremely unlikely that the TWFF would ever be developed into a residential area given the topography of the area and the fact that the TWFF is critical to the mission of the station. If land use changes in the future, the SWMUs will be reevaluated.

4.3 Summary of Human Health Risk Assessment and Selection of Contaminants of Potential Concern

4.3.1 Methodology

The baseline RA for the TWFF identified the potential for human health risk to onsite workers and future residents exposed to soil affected by site related activities (Table 4-1). This table from the RFI (Baker, 1997), demonstrates that the worker risk exceeds the risk range of $1x10^{-4}$ to $1x10^{-6}$ that USEPA generally considers acceptable, thus causing a CMS to be recommended for the TWFF. Tables 4-2 and 4-3 from the RFI present a breakdown of unacceptable risk values by exposure pathway and identify chemicals responsible for the majority of risk by receptors. Analytical data presented in the RFI (Baker, 1997) were incorporated in the baseline RA by a chemicals of potential concern (COPC) selection process.

More data have been collected at TWFF since the RFI was completed. Therefore, the COPC selection process has been performed again for this report using all of the data and the same methodology as used in the RFI. COPCs are those contaminants retained for further evaluation at this stage of the CMS process. They are contaminants that are detected in at least one sample in a given media at concentrations that are greater than screening criteria. The screening criteria are USEPA Region III Risk-Based Concentrations (RBCs). RBCs are derived by USEPA Region III using default exposure parameter values and the most recent toxicological criteria available. The RBCs used for this report are those issued in April 2002 (USEPA, 2002a) and are based on conservative residential exposure for soil and residential tap water exposure for groundwater. (The target risk used to calculate the RBCs is $1x10^{-6}$, while the target hazard quotient (HQ) is 0.1 to account for cumulative effects.) RBCs are not available for lead due to its unique toxicological characteristics (see Section 4.5.2). EPA's residential action level of 400 mg/kg (USEPA, 1994) for soil and the promulgated maximum contaminant level (MCL) concentration of 15 mg/L (40 CFR 161) for groundwater were used for COPC screening criteria for lead.

4.3.2 COPC Details

Tables 4-4 through 4-6 summarize the data for the three media identified at TWFF (surface soil, zero to two foot depth; subsurface soil, zero to ten foot depth; and groundwater) and the COPC selection process. As in the RFI, frequency of detection was a criterion used to exclude analytes from the COPC list. Table 4-6 shows that eight detected analytes were excluded as groundwater COPCs based on the rationale of detection in less than five percent of the samples and that were

not detected previously (1,2-dibromo-3-dichloropropane, 2-butanone, acetonitrile, acrylonitrile, carbon tetrachloride, acetophenone, indeno(1,2,3-cd)pyrene, and total antimony) In addition, all of these analytes but one (acetephenone) were detected just once and all of the concentrations were less than their detection limit (i.e., J-flagged values). Acrolein was eliminated as a COPC in groundwater based on the rationale that it is a common anthropogenic background compound (primarily as a component in exhaust from combustion of fuels), the Navy policy on anthropogenic background compounds (CNO, 2000), and the fact that it was detected only once in groundwater at a concentration less than the detection limit.

Tables 4-4 through 4-6 indicate several additional COPCs have been identified based on the newly collected data. These are: thallium in surface and total soil; and isobutanol, methyl tert-butyl ether, 3&4-methylphenol, bis(2-ethylhexyl) phthalate, total cadmium, dissolved mercury, dissolved thallium, and dissolved vanadium in groundwater.

COPC selection is based on the detected concentrations of analytes <u>not</u> their detection limits. This criterion introduces some uncertainty as a number of analytes in soil and groundwater have maximum detection limits in excess of the RBCs. These analytes are:

- Surface soil data: benzo(k)fluoranthene, bis(2-ethylhexyl) phthalate (Table 4-4);
- Subsurface soil data: 5-nitro-o-toluidine, benzo(k)fluoranthene, bis(2-ethylhexyl) phthalate, and dibenzofuran (Table 4-5);
- Groundwater data: 1,2-dibromo-3-chloropropane, 2-butanone, acetone, acetonitrile, acrolein, acrylonitrile, carbon tetrachloride, cis-1,2-dichloroethene, methyl methacrylate, styrene, tert-butylbenzene, trichlorofluoromethane, 2,4-dimethylphenol, 2-methylphenol, acenaphthene, acetophenone, bis(2-ethylhexyl) phthalate, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, isophorone, and antimony (Table 4-6).

The principal reason for these elevated detection limits is due to matrix interferences. Samples with gross contamination of fuel constituents (i.e., total petroleum hydrocarbons) require dilution in order to quantify high concentration target compounds. The dilution has the effect of elevating the detection limits of all the analytes in the sample. Dilution is the cause of all the soil and most of the groundwater samples that have detection limits in excess of their RBCs. For the remaining eight groundwater analytes from the list above (1.2-dibromo-3-chloropropane, acetonitrile, acrolein, acrylonitrile, carbon tetrachloride, acetophenone, bis(2-ethylhexyl) phthalate, indeno(1,2,3-cd)pyrene, and antimony) the detection limits of all of the samples exceed the RBCs. In other words, conventional analytical techniques cannot produce detection levels less than the RBCs for these analytes.

Although it cannot be ascertained if these analytes were in fact present or not in some of the samples, the actual effect on the CMS of this uncertainty is minimized by several factors. First, most of these analytes (especially those from the groundwater) are not associated with the primary contamination source at the TWFF, which is spilled fuel. Second, those analytes that are associated with fuel such as the PAHs in soil would likely be present in the same samples with other similar COPCs that will be addressed in the CMS.

4.4 Exposure Assessment and Methodology for Development of CAOs

4.4.1 Qualitative CAOs

4.4.1.1 Groundwater

There is no direct current exposure to contaminated groundwater at the TWFF nor is future exposure likely based on the future land use scenarios discussed in Section 4.2. (Indirect exposure via inhalation of volatiles emitted from the contaminated groundwater through the overlying soils is possible, as discussed in detail below.) Groundwater is not currently used for potable purposes because drinking water is available from El Yunque, which supplies all of NSRR's present and projected needs.

Under nonresidential land use – particularly the continued military future land use scenario, in which the U.S. Navy determines the specific use of the property – it is reasonable to assume that no groundwater well will be installed within the limited volume of contaminated groundwater and be used for domestic purposes. Furthermore, pump test data generated during other investigations performed at NSRR, indicate that the yield of the uppermost aquifer is generally insufficient to be used as a potable source. Besides potential exposure from inhalation of volatiles emitted from groundwater, limited direct contact to contaminated groundwater is possible for construction workers. Section 4.4.2 describes the methodology and exposure pathways for developing quantitative CAOs. The qualitative CAOs for contaminated groundwater are:

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

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

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

- A goal to limit phase-separated hydrocarbons (free product) to a thickness of 0.01 foot based on the limits of technology to recover free product.

4.4.1.2 Soil

Under the continued military land use scenario, contact with contaminants will occur from both surface and subsurface soil at the TWFF. Section 4.4.2 describes the methodology and exposure pathways for developing quantitative CAOs based on these potential exposures. The qualitative CAOs for soil are:

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

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

4.4.2 Quantitative CAOs

Quantitative CAOs are acceptable residual contaminant concentrations. The following components of the human health RA are used to determine CAOs for soil and groundwater:

- Intake by assumed exposure pathways.

- Chemical-specific toxicity data in the form of health effects criteria (see Section 4.5).

- Assumed target cancer risk level and noncancer hazard quotient (HQ).

The target risk level and HQ are general health effects levels deemed acceptable for exposure to individual carcinogenic and noncarcinogenic contaminants, respectively. The general equation for chemical intake used in the human health RA is:

$$Intake(mg/kg\text{-}day) = \frac{C \times IR \times EF \times ED \times CF}{BW \times AT} \qquad \text{(Eq 4-1)}$$

where:

C	=	chemical concentration
IR	=	intake rate
EF	=	exposure frequency
ED	=	exposure duration
CF	=	conversion factor (to attain proper units)
BW	=	body weight
AT	=	averaging time for cancer or noncancer effects.

This equation is algebraically combined with the general expressions for cancer risk and noncancer health effects, respectively:

$$Risk = Intake\ H\ SF \qquad \text{(Eq 4-2)}$$

$$HQ = Intake/RfD \qquad \text{(Eq 4-3)}$$

where:

Risk	=	target risk level ($1H10^{-6}$, or one in 1 million excess cancer cases due to exposure to a chemical, given the assumed exposure pathway).
SF	=	slope factor, or health effects criterion for cancer effects.
HQ	=	target HQ (1.0, implying that intake should not exceed the RfD).
RfD	=	reference dose, or health effects criterion for noncancer effects.

Assumed values for risk and HQ and chemical-specific SFs or RfDs are used to solve for the concentration term, or the pathway-specific CAO.

For the continued military land use scenario at the TWFF, the industrial worker and construction worker are used to characterize potential future exposure to contaminated soil and groundwater. Industrial worker exposure is limited to surface soil (defined as zero to two feet), while construction workers may also be exposed to subsurface soil (zero to ten feet).

The exposure pathways evaluated for developing quantitative CAOs for soil are inadvertent ingestion, inhalation of contaminants in particulates; inhalation of volatiles emitted from soil, and dermal absorption of contaminants following direct contact.

Groundwater exposure for industrial workers is only via inhalation of volatiles emitted through the soil into buildings. The Johnson and Ettinger (1991) model is used to quantify this exposure. EPA placed this model into a spreadsheet format and produced a User's Guide for use at contaminated sites (USEPA, 2000). The version used is an update of the Johnson and Ettinger model used in the previous submission of this Section (Baker, 2001). This new version of the Johnson and Ettinger model is summarized and the results of the modeling efforts for the TWFF are presented in Appendix I. Exposure by indoor inhalation of contaminants is much greater than outdoor exposure due to greater dilution in outside air and enhanced volatilization indoors due to chimney and pressure effects. For these reasons, and because the model assumes full time exposure indoors (i.e., leaving no time for additional outdoor exposure), outdoor inhalation exposure to groundwater is not quantitatively evaluated.

Construction workers may be directly exposed to groundwater following excavation because groundwater at the TWFF is relatively shallow at some locations (i.e., less than 10 feet deep). The exposure pathways used to develop quantitative groundwater CAOs for the construction worker are accidental ingestion, inhalation of volatiles, and dermal absorption.

Tables 4-7 to 4-17 quantitatively summarize each of these pathways and media. The exposure pathway equations and variable values are generally directly from EPA guidance documents and the rationale for their selection is explained in the tables. Those exposure variable value assumptions based on professional judgement or that are not based on standard EPA defaults are discussed further below.

- Target risk levels. It should be noted that, in the absence of regulatory criteria, EPA recommends use of the 1×10^{-6} cancer risk level as a starting point for analysis of remedial alternatives. This reflects EPA's preference for managing risks at the more protective end of the risk range (USEPA, 1991a; NCP preamble, 55 *Federal*

Register 8718-9). This same EPA guidance presents some flexibility in target risk levels ("Preliminary and final remediation goals, i.e., target risk levels, however, may vary from the point of departure depending upon site-specific circumstances.") A $1x10^{-6}$ target risk level is assumed for all COPCs, with the exception of the carcinogenic polynuclear aromatic hydrocarbon (PAH_c) benzo(a)pyrene. A $1x10^{-6}$ target risk level for benzo(a)pyrene would produce a CAO concentration that is less than its detection limit by standard analytical methods and possibly less than background concentrations, since PAHs are a common anthropogenic contaminant produced by sources such as fossil fuel combustion and asphalt (Menzie et al, 1992; Bradley et al, 1994). Furthermore, a $1x10^{-5}$ target risk level was assumed for benzo(a)pyrene to be consistent with the Task 1 CMS Report (Baker, 2000).

- Construction Worker Exposure. The construction worker is assumed to work for six months (i.e., an exposure frequency of 180 days/year and an exposure duration of one year) performing activities such as excavation to repair underground pipes where they may come into contact with subsurface soil to a depth of ten feet. During these activities the possibility exists that they may come in contact with shallow groundwater. To quantify the groundwater exposure it is conservatively assumed that 10% of their time (i.e., exposure frequency of 18 days/year) will be spent in an open hole filled with groundwater at which time they can accidentally ingest small quantities of water, inhale volatiles emitted from the water, and be immersed from the waist down for an assumed duration of one hour (Baker 2001). Supporting calculations are provided in Appendix J.

  The ingestion rate for the construction worker is assumed to be greater than the industrial worker due to their assumed higher contact rate. The assumed value of 100 mg/day is based on the recommendation of EPA (Maddaloni and Rogovin, 2000).

  The construction worker exposure via inhalation of volatiles emitted from groundwater is based on a procedure from EPA's "Preliminary Remediation Goals Guidance" (USEPA, 1991a) that estimated total volatilization from household water. This estimate is considered a conservative measure of what would be volatized from a water-filled hole that a construction worker would be in or near. The groundwater COPCs were screened for volatility using the criteria presented in EPA (1991a) (i.e., Henry's Law constant greater than $1x10^{-5}$ atm-m^3/mole and molecular weight less than 200 g/mole). All the groundwater COPCs at the TWFF are considered volatile by these criteria and are quantitatively evaluated.

  The construction worker exposure via inhalation of particulates is based on dust concentrations in ambient conditions produced by wind erosion at a typical site. The particulate emission factor (PEF) used is from EPA calculations (USEPA, 1996a) and is the same factor used for the industrial exposure scenario. The construction scenario assumes contact with soil during excavation related to pipeline repair activities and it is not expected that heavy earth moving activities or related construction and traffic on unpaved roads would occur on the contaminated portions of the site that could produce higher dust concentrations.

- Volatilization Factor Parameters. The inhalation of volatiles emitted from soil exposure pathway applied to industrial and construction workers uses a soil-to-air volatilization factor (VF) from EPA's "Soil Screening Guidance" (USEPA, 1996a).

Table 4-10 presents the calculation for VF. Default values were used for the VF parameters with the following exceptions. The Q/C term, based on meteorological modeling performed by EPA for a variety of cities throughout the U.S., has been changed from the default value to the value for modeled Zone IX represented by Miami in accordance with EPA guidance (USEPA, 2001b). The variable for total exposure time (T) has been changed from 30 years to 25 years to reflect the difference between industrial and residential exposure. The porosity terms for water- and air-filled porosity have been changed from the default of 0.15 and 0.28, respectively, to 0.20 and 0.23, respectively to conform to the default values used in the Johnson and Ettinger (1991) model used to model volatiles emitted from groundwater (see Appendix I).

Table 4-10 includes the equation for the soil saturated concentration or C_{sat}. The VF equation is not applicable if the soil concentration is greater than C_{sat} because the model does not include free-phase contamination. C_{sat} was calculated for all organic COPCs in soil at the TWFF and it was greater than the VF based CAOs for all COPCs. Therefore, the VF model is applicable for all organic COPCs with inhalation-based toxicity at the TWFF.

- Dermal Exposure to Contaminants in Soil. Recommended default values for workers' skin surface area (SA) and soil adherence factors (AF) have recently changed to 3,300 cm^2 and 0.2, respectively, based on new EPA guidance (USEPA, 2001a). These two default values applied to industrial and construction workers are based on a reinterpretation of data presented in the "Exposure Factors Handbook" (USEPA, 1997a).

4.5 Toxicity Evaluation

For the development of quantitative CAOs based on exposure to chemicals, the following health effects criteria are of principal importance:

- RfDs for oral exposure – estimates of acceptable daily intake for chronic and subchronic exposure that will not produce deleterious noncancer effects. EPA defines subchronic exposure as periods of less than 7 years (USEPA, 1989a). Therefore, subchronic RfDs apply to construction workers, while chronic RfDs apply to industrial workers.

- Reference concentrations (RfCs) for inhalation exposure – estimates of acceptable concentrations for chronic and subchronic exposure that will not produce deleterious noncancer effects. These values are converted to inhalation RfDs by multiplying the RfC by the reference IR value of 20 m^3/day and dividing by the reference BW of 70 kilograms. RfCs are used in the Johnson and Ettinger (1991) model (Appendix I), while other inhalation pathways use the inhalation RfD. Subchronic inhalation RfDs and RfCs apply to the construction worker only, as discussed for RfDs for oral exposure.

- SFs for oral exposure – plausible upper-bound estimates of the probability of an individual developing cancer as a result of lifetime exposure to a potential carcinogen (USEPA, 1989a).

- SFs for the inhalation route – plausible upper-bound estimates of the probability of an individual developing cancer as a result of lifetime exposure to a potential carcinogen (USEPA, 1989a). Inhalation SFs are calculated from inhalation unit risk values in a similar manner as described above for inhalation RfDs. Unit risk values are used in the Johnson and Ettinger (1991) model (Appendix I), while all other inhalation pathways use the inhalation SF.

The primary source of chemical-specific health effects criteria is EPA's Integrated Risk Information System (IRIS) database (USEPA, 2002b). IRIS is a computer-housed catalog of EPA health effects criteria and information. Data in IRIS are reviewed and updated monthly. If health effects criteria are not available in IRIS, EPA recommends use of the Office of Research and Development's Health Effects Assessment Summary Tables (HEAST; USEPA, 1997b) as a secondary data source. The Superfund Technical Support Center (STSC) is used for additional health effects criteria not provided in IRIS or HEAST. STSC develops provisional RfDs and SFs on a site-specific basis for those contaminants with adequate toxicological data, but for which no approved values exist in IRIS or HEAST.

Table 4-18 presents the toxicological criteria used to calculate CAOs for the TWFF COPCs.

4.5.1 Modification to Dermal Exposure Route

Health effects criteria are available only for the oral and inhalation routes, and most of these criteria are based on the administered rather than the absorbed dose (i.e., the amount of chemical at a human exchange boundary, such as skin, that is available for absorption – but not the amount actually absorbed into the blood). As presented in Tables 4-12 and 4-15, the equation for dermal contact exposures defines absorbed dose rather than intake. Thus, the administered dose health effects criteria must be converted to absorbed dose criteria in accordance with EPA methodology (USEPA, 1989a; 1992).

This adjustment is made using oral absorption efficiency data (i.e., data on gastrointestinal absorption) from the species on which the oral health effects criteria are based. The administered dose oral health effects criterion is multiplied (for RfDs) or divided (for SFs) by the gastrointestinal absorption factor to derive the absorbed dose criterion. New EPA guidance on the dermal exposure pathway (USEPA, 2001a) recommends adjusting health effects criteria only if gastrointestinal absorption is less than 50 percent. This source summarizes the available gastrointestinal absorption data in Exhibit 4-1 and these values are used here. A gastrointestinal absorption of 100 percent is assumed as recommended for COPCs not included in Exhibit 4-1 from this source (USEPA, 2001a) or compounds with greater than 50 percent absorption. Tables H-4, H-9, and H-13 in Appendix H, present dermal absorption pathways and the gastrointestinal absorption data used to develop CAOs.

4.5.2 Noncancer Effects Associated with Lead

The evaluation of the potential for noncancer effects associated with exposure to lead is different from that of other chemicals for two reasons:

- Although many studies have evaluated the effects of low-level exposure to lead, EPA study groups have not reached a consensus on a threshold level for lead exposure. It appears that some of lead's effects, particularly those associated with certain blood enzymes and neurobehavioral development, may occur at blood lead levels so low as

to be essentially without a threshold. As a result, no RfD is established for lead, even though adverse effects are well known.

- Lead in the environment originates from a variety of sources, including air pollution, diet, water pipes, soil, and paints. Because exposure is rarely limited to one pathway, the hazards associated with lead cannot be fully evaluated without considering other environmental contributors.

To adjust for these factors, EPA developed the integrated exposure uptake/biokinetic model (IEUBK), which combines the various exposure pathways to calculate blood lead levels in a given

population of children. The results of this model, preformed by EPA using default variable values, produces an acceptable soil concentration of 400 mg/kg (USEPA, 1994) that conservatively screens out all lead in soil data from the TWFF (i.e., lead is not a COPC). The lead MCL (used as a screening criterion for COPC selection since there is no RBC for lead) is not based on toxicity, but is based on the best available treatment technology. Groundwater lead concentrations at the TWFF exceed the MCL so that lead in groundwater is a COPC. However, the IEUBK model is unsuitable for calculating a CAO at the TWFF since residential exposure will not occur. Therefore, until a method can be determined to calculate a health-based groundwater CAO for lead, or a background-based CAO can be developed (see Section 4.5.4), the MCL will be used as an interim CAO so that lead will be evaluated further in the CMS process.

4.5.3 Approach to Evaluating Carcinogenic PAHs

The human health RA performed for the TWFF RFI (Baker, 1997) and the previous draft of this document (Baker, 2000) used two approaches for evaluating carcinogenic polycyclic aromatic hydrocarbons (PAH_cs). Both appear to be acceptable based on current guidance (USEPA, 1993).

- The first approach calls for adjusting the SF of each individual PAH_c using the estimated order of potential potency compared to benzo(a)pyrene (BaP), calculating the risks separately for each PAH_c, and summing the risks.

- The second approach calls for adjusting the soil chemical data using the same estimated order of potential potency values for each PAH_c, summing the adjusted data to produce a BaP equivalency concentration, and calculating the risk using the BaP SF.

Each of these approaches produces the exact same risk given the same data. The RAs for the RFI used the individual PAH_c approach, while the previous draft of this document used the BaP equivalency approach.

However, when comparing data to CAOs, these two approaches do not necessarily produce identical results. The BaP equivalency approach is, theoretically, slightly more conservative. Rather than using an individual target risk, as is done for all other contaminants, it assumes a more restrictive risk for a *combination* of seven PAH_cs. Additivity of risk is usually accounted for within the framework of risk-based cleanup values or CAOs by using a conservative target risk estimate with the understanding that even if several carcinogenic contaminants are present, the overall standards are still protective. It is unnecessary to assume a greater level of protectiveness for PAH_cs compared to other contaminants. The equivalency approach is, theoretically, slightly more conservative – but only in unusual cases at extremely low concentrations, very near the CAOs.

The individual PAH_c approach is used herein rather than the BaP equivalency approach. The effort required to manipulate the TWFF soil data is not warranted based on the minimal differences in results and the sufficient protectiveness of the individual PAH_c approach.

Several advantages of the individual PAH_c approach are noted below:

- It allows determination of which specific PAH_cs may require cleanup at a particular site.

- It allows immediate comparison of future sampling to CAOs without performing an intermediate BaP equivalency calculation for each data point.

- It reduces the complication of evaluating exceedingly high detection levels needed for future statistical calculations of PAH_cs.

4.6 Background Concentrations as CAOs

Background concentrations may be used as quantitative CAOs when they exceed risk-based CAOs. The National Contingency Plan (NCP) preamble (55 *Federal Register*, 8717) states that preliminary remediation goals (PRGs; i.e., the CERCLA equivalent to quantitative CAOs) may be revised based on consideration of "technical factors," which may include background levels of contaminants.

Ideally, it is desirable to prevent any unacceptable risks posed by exposure to environmental conditions. Unfortunately, however, if lifetime exposure is assumed, some chemicals present estimated carcinogenic risks greater than 1×10^{-6}, or HIs greater than 1.0, even at natural concentrations. Studies of risk perception (Slovic *et al*., 1990; Plough and Krimsky, 1990) conclude that people are more willing to accept risks that they feel are beyond anyone's control (e.g., those caused by earthquakes or general air pollution) or are within their control (e.g., driving a car). Highly toxic compounds, such as arsenic and beryllium in natural concentrations in soil, fall into the former category; but site-related contamination does not.

This risk perception generality, the NCP guidance, and the practical impossibility of reducing exposure or remediating background concentrations to reduce risks to acceptable levels lead to the use of certain background concentrations as quantitative CAOs. Therefore, if a calculated CAO is less than background, the background concentration is used as the CAO. For the TWFF, arsenic in soil and groundwater and lead in groundwater are the only analytes for which background-based quantitative CAOs may be used.

4.7 Quantitative CAOs

Quantitative CAOs are calculated based on the exposure methodology, contaminants, and health effects criteria presented in Sections 4.4 and 4.5. Table 4-19 presents the quantitative soil CAOs for the military land use for comparison with site data. These values represent the concentrations at which a target risk level of 1×10^{-6} (or $1\text{x}10^{-5}$ in the case of benzo(a)pyrene) or a target HQ of 1.0 for individual COPCs is achieved by exposure via the exposure pathways presented in Section 4.4. Table 4-20 presents a similar quantitative CAO summary for groundwater.

With the exception of lead in groundwater the quantitative CAOs in Tables 3-19 and 3-20 follow this risk-based approach. The interim lead CAO for groundwater is based on the MCL as discussed in Section 3.5.2.

Tables H-1 through H-14 in Appendix H present pathway- and medium-specific CAOs based on a target risk level of 1×10^{-6} and a target HQ of 1.0. These tables also list the CAOs for target cancer risk levels of 1×10^{-5} and 1×10^{-4} for comparison.

Tables H-5, H-10, and H-14 in Appendix H summarize CAOs for individual pathways, assuming a chemical-specific target risk of 1×10^{-6} (or $1x10^{-5}$ for benzo(a)pyrene) and a target HQ of 1.0 for each pathway, and resulting CAOs assuming exposure via all pathways (i.e., the column headed

"Combination" in the summary tables). Note that the combination CAO is less than the individual pathway CAO because it is based on a total target risk or target HQ posed to a receptor via all of the pathways. Pathway-specific CAOs are algebraically combined using a relationship of the reciprocal of the sum of the reciprocal of the pathway-specific CAOs.

4.8 References

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5.0 IDENTIFICATION OF COCs

Human Health and Ecological COPCs were used to identify COCs. Human Health and Ecological COPCs and their associated CAOs were compared to each other. Only zinc in surface soil and TCE in groundwater were identified as potential ecological risk drivers in Section 3.0. CAOs were not developed for those ecological COPCs that were not identified as potential risk drivers in Section 3.0. Prior to development of a CAO for zinc in surface soil, additional samples will be collected downgradient from MW17-00. These data will be evaluated in conjunction with existing data to determine the need for development of a surface soil CAO. As discussed above, TCE was identified as potential ecological risk driver in groundwater. A CAO equal to the surface water screening value (200 µg/L) has been established for this VOC. Although groundwater does not represent an exposure point for ecological receptors, a CAO equal to the surface water screening value (200 µg/L) was established for this VOC. The CAO is designed to be protective of ecological receptors located within the Ensenada Honda should TCE migrate with groundwater to this surface water body. The Human Health CAO for TCE in groundwater is 22 µg/L. Based on an ecological CAO of 200 µg/L, the human health CAO is protective of ecological receptors. As such, TCE was not carried forward for consideration as an ecological COC. Based on the discussion presented above, only human health COPCS for which CAOs have been developed were identified for consideration as COCs.

The COPC and CAO list for groundwater, surface and subsurface soils was used to determine the COCs within their respective media. Additionally, only those constituents from the RCRA Appendix IX list were considered as COCs.

The first step in selecting a COC was to determine the appropriate CAO for the individual COPC within each media of concern. For groundwater, the lower of the two CAOs, industrial or construction was selected. For surface soils, industrial CAOs were selected because of previous determination during the risk evaluations. Similarly, construction CAOs for subsurface soils were selected. All of these CAOs were used for further evaluations.

All inorganic CAOs were first screened against their respective background levels previously established in the *Revised Draft RCRA Facility Investigation Report for OU 3/5*, (Baker, 1999b) from the basewide background sampling (BGMW01 through BGMW04). The inorganic background levels were all below their respective CAO. Therefore, the lowest risk-based CAOs were used to screen the COPCs to determine COCs.

5.1 Groundwater COCs

The most recent data collected for groundwater (January 2002) was used to make a comparison to determine if there were any positive detections above the individual chemical's CAO. If there were any positive detections above the CAO, then the chemical was retained as a COC. Table 5-1 shows the individual chemicals and CAO that were retained as groundwater COCs. CAOs in Table 5-1 were selected as the lower of the two CAOs presented in Table 4-20.

The next step is to delineate the extent of groundwater impacted by COCs. Using the January 2002 data, all COC positive detections above their individual CAO were plotted on a map. Figures 5-1, 5-2, 5-3, and 5-4 show the aerial extent of the groundwater impacted by the COC.

Total and dissolved lead was sampled and analyzed from 47 wells. Only one sample had detections of lead that were above the CAO. Total lead was detected in 470MW01 at 52 µg/l. The CAO for lead in groundwater is 15 µg/l and it is an action level for children. No action

levels for adults are established because no relevant health effects criteria is available to develop a reasonable risk calculation. The dissolved lead level for this same well is 22 µg/l, which is not significantly high enough to warrant lead as a COC. In addition, using the results from the January 2002 field effort, the 95% UCL is 3.9 µg/l and 3.0 µg/l for total and dissolved lead respectively, which is well below the child protective action level of 15 µg/l. Therefore, lead was not retained as a COC.

A previous field investigation and subsequent analysis of results had indicated 1,2,4-Trimethylbenzene (TMB) was present in groundwater at 470MW01 and 470MW03 at 3.9 mg/L and 4.6 mg/L, respectively (Baker, 1999a). The CAO for TMB is 3.3 ml/L. Groundwater analysis performed on samples collected in January, 2002 field effort included the RCRA Appendix IX list that did not include TMB. However, TMB was considered a COPC and when compared to the previous analytical results collected in 1998 showed the results to be above the CAO. Therefore, TMB will be carried through as a COC.

Phase separated hydrocarbon may not, in the strictest since, be a COC. However, the corrective measures approach for PSH will be handled similar to that required for COCs. For clarity purposes, PSH will be addressed in the corrective measures report and be assigned a regulatory directed corrective action objective. PSH will be treated as a source for remedial purposes. The corrective action objective is to have 0.01 feet or less of measurable PSH in wells at the TWFF. Figure 5-5 shows the extent of PSH at the TWFF from February 28, 2002.

5.2 Soil COCs

The CAO for each individual COPC were used to screen against data from all previously sampled soil borings. Any COPC that had a positive detection above the CAO was retained as a COC. Table 5-2 shows the individual chemicals and CAO that were retained as surface and subsurface soil COCs. Additionally, Figures 5-6 through 5-11 show the aerial extent of the soil impacted by the COC.

6.0 PRELIMINARY CORRECTIVE MEASURE TECHNOLOGIES

This section of the CMS Report provides a preliminary listing of the corrective measure technologies potentially applicable for use at the TWFF. This step of the RFI process was not conducted during the Pre-Investigation Corrective Measures Screening (CMES) Report dated April 29, 1994, since the TWFF was under the Stations UST program at the time the CMES was prepared.

6.1 Soil Remedial Technologies

Several corrective measure technologies are potentially applicable to minimize health and environmental impacts due to contamination in the soil medium. The following general technologies were examined for potential suitability to remediate soils at the TWFF.

- No Action
- Institutional Controls
- Containment
- Excavation and Disposal
- In-situ Biological Treatment
- In-situ Physical/Chemical Treatment
- Ex-situ Biological Treatment
- Ex-situ Physical/Chemical Treatment
- Thermal
- Natural Attenuation
- Asphalt Incorporation
- Electro Chemical Geo Oxidation (ECGO[7])

Table 6-1 provides a listing of more detailed technologies that are generally addressed under the broad categories bulleted above. A brief description of the treatment technologies is presented in Table 6-2. A detailed description of these technologies can be found in the Pre-Investigation Corrective Measures Screening Report (Baker, 1994).

6.2 Groundwater Remedial Technologies

Several corrective measure technologies are potentially applicable to minimize health and environmental impacts due to contamination in the groundwater medium. Literature sources have been reviewed to identify and characterize potential corrective measure technologies. The following general technologies were examined for potential suitability to remediate groundwater at the TWFF.

- No Action
- Institutional Controls
- Containment/Collection
- In-situ Biological Treatment
- In-situ Physical/Chemical Treatment
- Ex-situ Biological Treatment
- Ex-situ Physical/Chemical Treatment

- Discharge
- Monitored Natural Attenuation
- Electro Chemical Geo Oxidation (ECGO[7])

Table 6-3 provides a listing of more detailed technologies that are generally addressed under the broad categories bulleted above. A brief description of the treatment technologies is presented in Table 6-4. A detailed description of these technologies can be found in the Pre-Investigation Corrective Measures Screening Report (Baker, 1994).

A pneumatic fracturing pilot test was conducted at two locations (RW1 and PW6 areas) within the TWFF in the spring and summer of 2000. A description of the process and compilation of the data is presented in the Draft Pilot Test to Evaluate Enhancement of Product Recovery Report (Baker, 2000). The pilot test was applicable to groundwater recovery enhancement as well as PSH recovery enhancement.

6.3 Phase Separated Hydrocarbon Remedial Technologies

Several corrective measure technologies are potentially applicable to minimize health and environmental impacts due to the PSH present in the subsurface. Literature sources have been reviewed to identify and characterize potential corrective measure technologies. The following general technologies were examined for potential suitability for PSH recovery at the TWFF.

- No Action
- Institutional Controls
- Containment/Collection (PSH Pumps, Skimmers, etc...)
- CleanOx[7]
- Pneumatic Fracturing

Table 6-5 provides a listing of more detailed technologies that are generally addressed under the broad categories bulleted above. A detailed description of these technologies can be found in the Pre-Investigation Corrective Measures Screening Report (Baker, 1994).

TABLES

TABLE 6-1

POTENTIALLY APPLICABLE CORRECTIVE MEASURE TECHNOLOGIES
SOIL MATRIX
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Technology	Tow Way Fuel Farm
No Action	X
Institutional Controls	X
Containment:	
Capping	X
Excavation and Disposal:	
Excavation	X
On-Site Disposal	X
Off-Site Disposal	X
Treatment Technologies:	
In-situ Biological Treatment	
Biodegradation	X
Bioventing	X
Oxygen Enhancement with Hydrogen Peroxide (CleanOx®)	X
In-situ Physical/Chemical Treatment	
Soil Vapor Extraction	X
Ex-situ Biological Treatment (assuming excavation)	
Composting	X
Controlled Solid Phase Biological Treatment	X
Land Farming	X
Slurry Phase Biological Treatment	X
Ex-situ Physical/Chemical Treatment (assuming excavation)	
Soil Washing	X
Ex-situ Thermal Treatment (assuming excavation)	
Incineration	X
Low Temperature Thermal Desorption	X
High Temperature Thermal Desorption	X
Vitrification	X
Natural Attenuation	X
Asphalt Incorporation	X
Electro Chemical Geo Oxidation (ECGO[7])	X

X – Retained for further evaluation

TABLE 6-2

CORRECTIVE MEASURES TREATMENT TECHNOLOGY DESCRIPTIONS
SOIL MATRIX
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Technology	Description
SOIL	
In Situ Biological Treatment	
Biodegradation	The activity of naturally occurring microbes is stimulated by circulating water-based solutions through contaminated soils to enhance in situ biological degradation of organic contaminants. Nutrients, oxygen, or other amendments may be used to enhance biodegradation and contaminant desorption from subsurface materials.
Bioventing	Oxygen is delivered to contaminated unsaturated soils by forced air movement (either extraction or injection of air) to increase oxygen concentrations and stimulate biodegradation.
Oxygen Enhancement with Hydrogen Peroxide (CleanOx®)	The CleanOX® technology is an in-situ process utilizing the injection of hydrogen peroxide liquid chemical formulations through monitoring wells into the contaminated portion of the aquifer to increase the available oxygen supply for degredation.
In Situ Physical/Chemical Treatment	
Soil Vapor Extraction	Vacuum is applied through extraction wells to create a pressure/concentration gradient that induces gas-phase volatiles to diffuse through soil to extraction wells. The process includes a system for handling off-gases. This technology also is known as in situ soil venting, in situ volatilization, enhanced volatilization, or soil vacuum extraction.
Ex Situ Biological Treatment (assuming excavation)	
Composting	Contaminated soil is excavated and mixed with bulking agents and organic amendments such as wood chips, animal and vegetative wastes, which are added to enhance the porosity and organic content of the mixture to be decomposed.
Controlled Solid Phase Biological Treatment	Excavated soils are mixed with soil amendments and placed in aboveground enclosures. Processes include prepared treatment beds, biotreatment cells, soil piles, and composting.
Land farming	Contaminated soils are applied onto the soil surface and periodically turned over or tilled into the soil to aerate the waste.
Slurry Phase Biological Treatment	An aqueous slurry is created by combining soil or sludge with water and other additives. The slurry is mixed to keep solids suspended and microorganisms in contact with the soil contaminants. Upon completion of the process, the slurry is dewatered and the treated soil is disposed of.

TABLE 6-2

CORRECTIVE MEASURES TREATMENT TECHNOLOGY DESCRIPTIONS
SOIL MATRIX
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Ex Situ Physical/Chemical Treatment (assuming excavation)	
Soil Washing	Contaminants sorbed onto fine soil particles are separated from bulk soil in an aqueous-based system on the basis of particle size. The wash water may be augmented with a basic leaching agent, surfactant, pH adjustment, or chelating agent to help remove organics and heavy metals.
Ex Situ Thermal Treatment (assuming excavation)	
Incineration	High temperatures, 817 - 1,204 EC (1,600 2,200 EF), are used to combust (in the presence of oxygen) organic constituents in hazardous wastes.
Low-Temperature Thermal Desorption	Wastes are heated to 93 - 315 EC (200 - 600 EF) to volatize water and organic contaminants. A carrier gas or vacuum system transports volatized water and organics to the gas treatment system.
High-Temperature Thermal Desorption	Wastes are heated to 320 to 560 °C (600 to 1,000 °F) to volatize water and organic contaminants. A carrier gas or vacuum system transports volatized water and organics to the gas treatment system.
Vitrification	Contaminated soils and sludges are melted at high temperatures to form a glass and crystalline structure with very low leaching characteristics.
Other Treatment	
Natural Attenuation	Natural subsurface processes - such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials - are allowed to reduce contaminant concentrations to acceptable levels.
Asphalt Incorporation	Contaminated soils and sludges are mixed into hot asphalt. The process stabilizes the contaminants within the asphalt mixture.
ECGO[7]	In Situ process that uses induced electric current to create oxidation-reduction (Redox) reactions leading to complete mineralization of organic constituents (or mobilization of inorganic constituents) present in a volume of soil and groundwater between the electrode locations.

TABLE 6-3

POTENTIALLY APPLICABLE CORRECTIVE MEASURE TECHNOLOGIES
GROUNDWATER MATRIX
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Technology	Tow Way Fuel Farm
No Action	X
Institutional Controls:	
Alternate Water	Already Available
Relocation	X
Containment/Collection:	
Capping	X
Barriers	X
Trenches	X
Extraction Wells	X
Subsurface Drains	X
In-situ Biological Treatment	
Nitrate Enhancement	X
Oxygen Enhancement with Air Sparging	X
Oxygen Enhancement with Hydrogen Peroxide (CleanOx[7])	X
In-situ Physical/Chemical Treatment	
Air Sparging	X
Dual Phase Extraction	X
Steam Stripping/Flushing	X
Vacuum Vapor Extraction	X
Pneumatic Fracturing	X
Ex-situ Biological Treatment (Assuming Pumping)	
Bioreactors	X
Ex-situ Physical/Chemical Treatment (Assuming Pumping)	
Air Stripping	X
Ultraviolet Oxidation	X
Discharge	
NPDES	X
Infiltration	X
Re-injection	X
Waste Water Treatment Plant (WWTP)	X
Monitored Natural Attenuation	X
Electro Chemical GeoOxidation (ECGO®)	X

X – Retained for further evaluation

TABLE 6-4

CORRECTIVE MEASURES TREATMENT TECHNOLOGY DESCRIPTIONS
GROUNDWATER MATRIX
CORRECTIVE MEASURES STUDY – TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Technology	Description
GROUNDWATER	
In Situ Biological Treatment	
aNitrate Enhancement	Nitrate is circulated throughout groundwater contamination zones as an alternative electron acceptor for biological oxidation of organic contaminants by microbes.
Oxygen Enhancement with Air Sparging	Air is injected under pressure below the water table to increase groundwater oxygen concentrations and enhance the rate of biological degradation of organic contaminants by naturally occurring microbes.
Oxygen Enhancement with Hydrogen Peroxide (CleanOx[7])	CleanOX is a patented technology to remediate hydrocarbon and other organic contamination in groundwater and saturated soil. The CleanOX technology is an in-situ process utilizing the injection of proprietary liquid chemical formulations through monitoring wells into the contaminated portion of an aquifer. The technology involves the application of a Fenton-like chemistry to create and migrate hydroxyl radicals, which in turn degrade organic contamination to carbon dioxide and water.
In Situ Physical/Chemical Treatment	
Air Sparging	Air is injected into saturated matrices to remove contaminants through volatilization.
Dual Phase Extraction	A high vacuum system is applied to simultaneously remove liquid and gas from low permeability or heterogeneous formations.
Hot Water or Steam Flushing/Stripping	Steam is forced into an aquifer through injection wells to vaporize volatile and semivolatile contaminants. Vaporized components rise to the unsaturated zone where they are removed by vacuum extraction and then treated.
Vacuum Vapor Extraction	Air is injected into a well, lifting contaminated groundwater in the well and allowing additional groundwater flow into the well. Once inside the well, some of the VOCs in the contaminated groundwater are transferred from the water to air bubbles, which rise and are collected at the top of the well by vapor extraction.
Pneumatic Fracturing	Pneumatic Fracturing can best be described as a process whereby a gas is injected into the subsurface at pressures exceeding the natural in-situ pressures present in the soil / rock interface (i.e. overburden pressure, cohesive stresses, etc.) and at flow volumes exceeding the natural permeability of the subsurface. The fractures create preferable pathways for groundwater to travel.

TABLE 6-4

CORRECTIVE MEASURES TREATMENT TECHNOLOGY DESCRIPTIONS
GROUNDWATER MATRIX
CORRECTIVE MEASURES STUDY – TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Ex Situ Biological Treatment (assuming pumping)	
Bioreactors	Contaminants in extracted groundwater are put into contact with microorganisms in attached or suspended growth biological reactors. In suspended systems, such as activated sludge, contaminated groundwater is circulated in an aeration basin. In attached systems, such as rotating biological contractors and trickling filters, microorganisms are established on an inert support matrix.
Ex Situ Physical/Chemical Treatment (assuming pumping)	
Air Stripping	The air stripping treatment process relies on the transfer of volatile organic compounds from water into air. Contaminated water enters the top of the air stripping tower and flows down through the packing material in a thin film. An air stream is forced upward through the tower. Within the tower, the contaminants are transferred from the thin film of contaminated water into the flowing air stream. Treated water exits from the bottom of the tower, while air containing the volatilized contaminants is exhausted through the top of the tower.
UV Oxidation	Ultraviolet (UV) radiation, ozone, and/or hydrogen peroxide are used to destroy organic contaminants as water flows into a treatment tank. An ozone destruction unit is used to treat off-gases from the treatment tank.
Other Treatment	
Monitored Natural Attenuation	Natural subsurface processes - such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials - are allowed to reduce contaminant concentrations to acceptable levels.
ECGO[7]	In Situ process that uses induced electric current to create oxidation-reduction (Redox) reactions leading to complete mineralization of organic constituents (or mobilization of inorganic constituents) present in a volume of soil and groundwater between the electrode locations.

TABLE 6-5

POTENTIALLY APPLICABLE CORRECTIVE MEASURE TECHNOLOGIES
PHASE SEPARATED HYDROCARBON
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Technology	Tow Way Fuel Farm
No Action	X
Institutional Controls	X
Containment/Collection:	
Barriers	X
Interceptor Trenches	X
Extraction Wells *	X
Dual Phase Extraction	X
Three Phase Extraction	X
Floating Skimmer/Filter Pumps	X
Surface Oil/Water Separators	X
CleanOx[7]	X
Pneumatic Fracturing	X

Note:

*Includes the various combinations of skimming, groundwater table depression and reinjection of water upgradient to enhance head differentials

X – Retained for further evaluation

7.0 SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES

This section of the report reviews the results of the RFI, CMS Investigation, Quarterly Monitoring Reports, and the Additional Data Collection Investigation field effort and assesses the technologies that are applicable to the facility. The identified corrective measure technologies are screened to eliminate those that may prove infeasible to implement, that rely on technologies unlikely to perform satisfactorily or reliably, or that do not achieve the corrective measure objective within a reasonable time period. This screening process focuses on eliminating those technologies that have severe limitations for a given set of waste and site-specific conditions. The screening step may also eliminate technologies based on inherent technology limitations. The site and waste characteristics and technology limitations for the TWFF are discussed in the following subsections.

7.1 Site Characteristics

This section provides a review of the site data during the CMS and Additional Data Collection investigations to identify conditions that may limit or promote the use of certain technologies. Technologies whose use is clearly precluded by the site characteristics described in this section of the report will be eliminated from further consideration.

7.1.1 Soils

The in-situ vertical permeability of the soils was calculated during the CMS Investigation from three different locations on the TWFF hillside. The results from this test yielded a range of 4.4 x 10^{-4} centimeters per second (cm/sec) to 8.5 x 10^{-4} cm/sec. This information is pertinent to the screening of the technologies that utilize groundwater re-injection through surface application.

The bulk density of the soils collected from the TWFF ranged from 1.0 to 1.4 grams per milliliter (g/ml). The bulk density of the soil is utilized when estimating quantities for technologies such as excavation, transportation, and disposal.

7.1.2 Groundwater

Slug tests were conducted during the January 2002 field investigation that yielded an average hydraulic conductivity of 3.52 ft/day from the monitor wells screened in the weathered bedrock. The average hydraulic conductivity of the unconsolidated aquifer (very loose fine to coarse sand) was estimated at 1.85 ft/day.

In May 1999, pumping tests were performed in RW4 and PW03 and reported in the Hydraulic Characteristics Evaluation (McLaren/Hart, 1999). Using the Cooper-Jacob method, the results of the pump tests yielded transmissivity values of 4.65 gpd/ft to 5.8 gpd/ft and storativity values of 0.016 to 0.005. Limited pump tests were also conducted from two monitor wells screened in the fractured bedrock during the RFI for the TWFF (Baker, 1997). The results of the two pump tests yielded hydraulic conductivity results ranging from 1.65 x 10^{-5} cm/sec to 4.13 x 10^{-6} cm/sec, transmissivity values of 288 ft^2/day, and storativity values of approximately 310. This information is valuable when screening those technologies that require groundwater pumping.

7.1.3 Phase Separated Hydrocarbon

Two baildown tests were performed on two of the monitor wells during the CMS Investigation. The results of the baildown test indicated that the recharge of PSH into the monitor wells is very slow over time. For example, the original PSH thickness in groundwater monitor well UGW-19 was estimated to be 1.24 feet thick. Following baildown and a 16 hour recharge period, the PSH only recovered 0.08 feet. Monitor well UGW-21 had a little better response to product recovery then UGW-19. The initial PSH thickness was measured at 1.63 feet, 14.5 hours later the PSH recovered 0.16 feet.

The ICM, when in operation at the TWFF, yielded an average PSH recovery rate of only 1.7 gallons per day (January 1997 through December 1999). This information is pertinent to the screening of those technologies that include PSH recovery.

Additionally, 7.9 gallons per day of PSH was recovered when the ICM system was turned off and PSH was manually bailed or pumped out once a month (March 2001 to April 2002). This information is important in determining the feasibility of operating an effective PSH skimming system.

7.2 Waste Characteristics

Identification of the waste characteristics that limit the effectiveness or feasibility of technologies is an important part of the screening process. These waste characteristics are detailed in this subsection. Technologies that are clearly limited by the waste characteristics will be eliminated from consideration.

7.2.1 Soils

A summary of the contaminants detected in the soil matrix during the previous investigations indicate benzo(a)pyrene contamination in the surface and subsurface soils above the respective CAO. The following table identifies the minimum and maximum concentrations of the referenced constituent and the associated CAO.

SURFACE/SUBSURFACE SOIL WASTE CHARACTERISTICS

Constituent	Minimum Detected Concentration (Φg/kg)	Maximum Detected Concentration (Φg/kg)	CAO (Φg/kg)
Benzo(a)pyrene	2.7 J	23,000 J	3,400

7.2.2 Groundwater

A summary of the contaminants detected in the groundwater matrix during the Additional Data Collection field investigation indicate 1,2,4-trimethylbenzene, benzene, and trichloroethene contamination in the groundwater above the individual CAO. The following table identifies the minimum and maximum concentrations of the referenced constituents and the associated CAO.

GROUNDWATER WASTE CHARACTERISTICS

Constituent	Minimum Detected Concentration (Φg/l)	Maximum Detected Concentration (Φg/l)	CAO (Φg/l)
1,2,4-Trimethylbenzene	5 J	4,600	3,200
Benzene	0.52 J	26,000	550
Trichloroethene	0.35 J	28,000	1,500

7.3 Technology Limitations

The level of technology development, performance record, and inherent construction, operation, and maintenance problems are identified for each technology being considered in this subsection. Technologies that are unreliable, perform poorly, or are not fully demonstrated may be eliminated in the screening process. Table 7-1 provides a screening matrix on the treatment technologies being discussed for the TWFF. This table rates the various topics better, average, and worse. This information is being considered for the initial screening of the corrective measure technology for the TWFF.

7.4 Technology Screening

The technologies listed in Section 6.0 are screened in this subsection. This screening looks at all the limitations discussed in the previous subsections along with inherent technology limitations. Tables 7-2 through 7-4 list the technologies being evaluated, whether or not they are applicable to the site, and the reason for exclusion. It should be kept in mind that some of the technologies passing the screening may be combined when developing a corrective measure alternative for the TWFF.

The TWFF is still an active fuel farm. Therefore, any technology that uses excavation as an option will be implemented in the areas of the fuel farm that do not endanger the continued operation. Excavation should be limited to areas that do not have underground pipelines or areas adjacent to the field constructed tanks. These issues will be addressed during the alternative evaluation of the CMS.

8.0 IDENTIFICATION OF THE CORRECTIVE MEASURE ALTERNATIVE

This section of the CMS Report is designed to develop the corrective measure alternative or alternatives based on the corrective measure objectives and analysis of the preliminary corrective measure technologies. The development should include sound engineering to determine which of the previously identified technologies appear most suitable for the TWFF. Technologies can be combined to form the overall corrective action alternative or alternatives. The selected alternative or alternatives represents a workable number of options that each appears to adequately address all site problems and corrective action objectives.

Those process options that made it through screening are available for alternative development. Table 8-1 illustrates the alternative development process. At least one process option from each technology was incorporated into a viable alternative for further evaluation during the CMS process. For simplification, groundwater and PSH technologies are combined in this table. Monitored natural attenuation was not shown in this table, but was included in each alternative.

During the upcoming evaluation process (Tasks II, III, and IV), each alternative will be evaluated against the criteria identified in the Part B permit. After the evaluation process, if it becomes apparent that an alternative would be more acceptable if a process option was removed and/or replaced, the alternative could be adjusted as necessary.

The following alternatives will be screened further in Task II and Task III for suitability to address groundwater, soil, and phase-separated hydrocarbons at the TWFF.

<u>Alternative 1</u>

- Institutional Controls, Monitored Natural Attenuation, and Containment/Collection (PSH Skimming)

<u>Alternative 2</u>

- Institutional Controls, Monitored Natural Attenuation, In-situ Biological Treatment (Bioventing), Containment/Collection (Dual Phase Extraction and Steam Flushing), Ex-situ Physical/Chemical Treatment (Air Stripping), and Discharge (NPDES)

<u>Alternative 3</u>

- Institutional Controls, Monitored Natural Attenuation, Excavation/Disposal (Off Site), In-situ Physical/Chemical Treatment (ECGO[7]), In-situ Physical/Chemical Treatment (Vacuum Vapor Extraction), Containment/Collection (Extraction Wells and Surface Oil/Water Separators), Ex-situ Biological Treatment (Bioreactors), and Discharge (Re-injection)

<u>Alternative 4</u>

- Institutional Controls, Monitored Natural Attenuation, Excavation/Ex-situ Thermal Treatment (HTTD), In-situ Physical/Chemical Treatment (Soil Vapor Extraction), In-situ Physical/Chemical Treatment (Air Sparging), Containment/Collection (Skimmer Pumps for PSH)

Alternative 5

- Institutional Controls, Monitored Natural Attenuation, Excavation/Ex-situ Biological Treatment (Land Farming), In-situ Biological Treatment (Biodegradation), In-situ Biological Treatment (CleanOx[7]), In-situ Physical/Chemical Treatment (ECGO[7])

Each alternative developed addresses soil, groundwater, and PSH constituents at the site. Institutional controls and monitored natural attenuation are consistent throughout each alternative.

Alternative 1 addresses all the concerns at the site with the minimum amount of disruption to normal operations at the TWFF. The soil and groundwater will be allowed to naturally attenuate while the PSH will be collected using skimmers.

Alternative 2 was developed to address in-situ soils by minimizing the disruption (excavation) of soils within the TWFF. The soils will be treated through bioventing. The groundwater will be collected from dual phase extraction well with enhancement of recovery from steam flushing. The recovered groundwater will be sent through an air stripper for treatment and discharged through a NPDES permitted outfall.

Alternative 3 uses excavation and disposal off-site in accessible areas of the TWFF to address soil contamination. ECGO[7] will be used to treat soil in areas that may be less accessible to excavation technology. Groundwater will be collected using extraction wells and the recovered groundwater will be sent to a bioreactor for treatment. Prior to treatment, the groundwater will be routed through an oil/water separator to capture PSH. Treated groundwater will be discharged through a permitted re-injection well. Vacuum vapor extraction will be used to treat groundwater in areas that are less productive.

Alternative 4 uses excavation and HTTD to treat impacted soil in areas that are accessible. In areas not accessible, soil vapor extraction will be used to treat soil. Skimmer pumps will be used to collect PSH throughout the TWFF. The groundwater will be treated in-situ using air sparging.

Alternative 5 uses excavation and land farming to address soil contamination in accessible areas of the TWFF. In areas that may not allow for excavation, in-situ biodegradation will be used to address impacted soil. CleanOx[7] will be used to treat or destroy PSH in-situ. Groundwater will also be treated in-situ using ECGO[7].

Groundwater will continue to be monitored within the plumes and down gradient of the plumes for all COCs. Additional surface soil sampling, specifically zinc, in the upper TWFF will be collected and analyzed prior to finalizing the CMS.

It is premature at this time to select the most appropriate corrective measure alternative to address the TCE plume at the TWFF site due to the results of analysis from data collected from the Additional Data Collection Investigation. The results showed TCE had increased by an order of magnitude that leaves some doubt about the possible TCE source. Any remedial approach to address the TCE plume may be unsuccessful without further understanding of the possible source of TCE. Before continuing to develop a corrective action approach for the TCE plume, the Navy is recommending a source identification/soil delineation field effort be conducted.

The purpose of the additional data gathering is to delineate unsaturated soils near the 7MW07 monitor well. A Work Plan and Field Report would be developed and approved by the EPA before a final corrective measures alternative is finalized for the TCE plume.

In order to keep this CMS on schedule; the TCE plume will not be discussed in this CMS. The TCE plume will be addressed under a separate cover after the source identification/soil delineation field effort is complete.

9.0 REFERENCES

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Baker, 1999a. Final CMS Investigation Report for Tow Way Fuel Farm, Naval Station Roosevelt Roads, Ceiba, Puerto Rico. April 21, 1999. Coraopolis, Pennsylvania.

Baker, 1999b. Revised Draft RCRA Facility Investigation Report for Operable Unit 3/5, Naval Station Roosevelt Roads, Ceiba, Puerto Rico. April 1, 1999. Coraopolis, Pennsylvania.

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Blasland, Bouck, and Lee, Inc. (BB&L), September 1994. Corrective Action Plan, Tow Way Fuel Farm, Naval Station Roosevelt Roads, Ceiba, Puerto Rico. September 1994.

McLaren/Hart, 1999. Hydraulic Characteristics Evaluation TO #9, Free Product Recovery System, Tow Way Fuel Facility, Naval Station Roosevelt Roads, Ceiba, Puerto Rico. August 31, 1999.

TABLES

TABLE 3-1
LIST OF BIRDS REPORTED FROM NAVAL STATION ROOSEVELT ROADS
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
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
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
TOW WAY FUEL FARM
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]
Least grebe	West Indian whistling duck	Puerto Rican screech owl
Puerto Rican tody		

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
SURFACE SOIL SAMPLE MATRIX
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

			Laboratory Analysis									
Sample ID	**Date Collected**	**Sample Depth (ft bgs)**	**Volatiles**	**BTEX**	**Semivolatiles**	**TPH**	**Low Level PAHs**	**Total Metals**	**% Water/ % Solids: Density**	**Grain Size**	**TOC**	**Comments**
7DP03-01	04/15/98	1.0-2.0		X		X			X			
7DP04-01	04/15/98	1.0-3.0		X		X			X			
7DP06-01	04/15/98	0.0-4.0		X		X						
7DP07-01	04/15/98	0.0-4.0		X		X				X		
7DP07-01D	04/15/98	0.0-4.0		X		X						Duplicate
7DP08-01	04/15/98	0.0-4.0		X		X			X		X	
7DP10-01	04/16/98	1.0-2.0		X		X						
7DP12-01	04/16/98	1.0-3.0		X		X			X			
7DP14-01	04/16/98	1.0-3.0		X		X			X		X	
7DP21-01	04/18/98	1.0-3.0		X		X					X	
7DP22-01	04/18/98	0.0-4.0		X		X						
7DP25-01	04/19/98	0.0-4.0		X		X						
7DP25-01D	04/19/98	0.0-4.0		X		X						Duplicate
7DP27-01	04/19/98	0.0-4.0		X		X						
7DP28-01	04/19/98	1.0-3.0		X		X				X	X	
7DP29-01	04/19/98	1.0-3.0		X		X				X		
7DP30-01	04/19/98	1.0-3.0		X		X						
7MW01-00	03/27/96	0.0-1.0	X		X	X		X	X			
7MW02-00	03/21/96	0.0-1.0	X		X	X		X	X			
7MW03-00	03/21/96	0.0-1.0	X		X	X		X	X			
7MW04-00	03/21/96	0.0-1.0	X		X	X		X	X			
7MW16-00	01/16/02	0.0-1.0	X		X		X	X				
7MW17-00	01/16/02	0.0-1.0	X		X			X				
7MW17-00D	01/16/02	0.0-1.0	X		X			X				Duplicate
7MW18-00	01/29/02	0.0-1.0	X		X			X				
7MW19-00	01/30/02	0.0-1.0	X		X			X				
7SB01-00	03/21/96	0.0-1.0	X		X	X		X	X			
7SB02-00	03/21/96	0.0-1.0	X		X	X		X	X			
7SB03-00	03/21/96	0.0-1.0	X		X	X		X	X			
7SB23-00	01/23/02	0.0-1.0	X		X			X				
7SB24-00	01/23/02	0.0-1.0	X		X			X				
7SB25-00	01/24/02	0.0-1.0	X		X			X				
7SB26-00	01/24/02	0.0-1.0	X		X			X				
7SB27-00	01/12/02	0.0-1.0	X		X			X				
7SB28-00	01/23/02	0.0-1.0	X		X			X				
7SB29-00	01/12/02	0.0-1.0	X		X			X				
7SB30-00	01/12/02	0.0-1.0	X		X			X				
8SS01	04/04/96	0.0-1.0	X		X	X		X	X			
8SS02	04/04/96	0.0-1.0	X		X	X		X	X			

TABLE 3-2 (continued)
SURFACE SOIL SAMPLE MATRIX
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

			Laboratory Analysis									
Sample ID	**Date Collected**	**Sample Depth (ft bgs)**	**Volatiles**	**BTEX**	**Semivolatiles**	**TPH**	**Low Level PAHs**	**Total Metals**	**% Water/ % Solids: Density**	**Grain Size**	**TOC**	**Comments**
8SS03	04/04/96	0.0-1.0	X		X	X		X	X			
8SS03D	04/04/96	0.0-1.0	X		X	X		X	X			Duplicate
8SS04	04/04/96	0.0-1.0	X		X	X		X	X			
8TP02-01	04/02/96	1.0-2.0	X		X	X		X	X			
8TP02-01D	04/02/96	1.0-2.0	X		X	X		X	X			
8TP03-00	04/03/96	1.0-2.0	X		X	X		X	X			
8TP03-01	04/03/96	1.0-2.0	X		X	X		X	X			
8TP07-00	04/04/96	1.0-2.0	X		X	X		X	X			

: Feet below ground surface

TABLE 3-3
SUBSURFACE SOIL SAMPLE MATRIX
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

			Laboratory Analysis																	
Sample ID	**Sample Depth (ft bgs)**	**Date Collected**	**Volatiles**	**Semivolatiles**	**BTEX**	**Low Level PAHs**	**TPH**	**Total Metals**	**TCLP Metals**	**Cyanide**	**TOX**	**TOC**	**Sulfide**	**Sulfate**	**Flash Point**	**Ph**	**Ignitability**	**% Water/ % Solids: Density**	**Grain Size**	**Comments**
1982	12.0-12.0	12/31/1996					X													
1982BO01C	8.5-10.0	11/27/1992			X		X													
1982BO02C	8.5-10.0	11/27/1992			X		X													
1982BO03C	8.5-10.0	11/27/1992			X		X													
1982BO03F	8.5-10.0	11/27/1992			X		X													
443BO01C	8.5-10.0	11/30/1992			X		X													
443BO02C	8.5-10.0	11/30/1992			X		X													
443BO03B	3.5-5.0	11/30/1992			X		X													
56AM	12.0-12.0	08/12/96			X		X													
56AN	12.0-12.0	08/12/96			X		X													
56AS	12.0-12.0	08/12/96			X		X													
56ASTOCK	12.0-12.0	08/12/96			X		X													
56B	12.0-12.0	12/31/96					X													
56BM	12.0-12.0	08/12/96			X		X													
56BM DUP	12.0-12.0	08/12/96			X		X													Duplicate
56BN	12.0-12.0	08/12/96			X		X													
56BS	12.0-12.0	08/12/96			X		X													
56BSTOCK	12.0-12.0	08/12/96			X		X													
56G	12.0-12.0	12/31/96					X													
56H	12.0-12.0	12/31/96					X													
56PIPEM	12.0-12.0	08/28/96			X		X													
56PIPEN	12.0-12.0	08/28/96			X		X													

TABLE 3-3 (continued)
SUBSURFACE SOIL SAMPLE MATRIX
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

			Laboratory Analysis																	
Sample ID	**Sample Depth (ft bgs)**	**Date Collected**	**Volatiles**	**Semivolatiles**	**BTEX**	**Low Level PAHs**	**TPH**	**Total Metals**	**TCLP Metals**	**Cyanide**	**TOX**	**TOC**	**Sulfide**	**Sulfate**	**Flash Point**	**Ph**	**Ignitability**	**% Water/ % Solids: Density**	**Grain Size**	**Comments**
56PIPES	12.0-12.0	08/28/96			X		X													
729-734	12.0-12.0	12/31/96					X													
7DP01-05	8.0-10.0	04/14/98			X		X											X		
7DP01-08	14.0-16.0	04/14/98			X		X											X		
7DP01-11	20.0-22.0	04/14/98			X		X											X		
7DP01-13	24.0-26.0	04/14/98			X		X											X		
7DP01-14	27.0-28.5	04/14/98			X		X											X		
7DP02-05	9.0-10.0	04/15/98			X		X											X		
7DP03-02	3.0-4.0	04/15/98			X		X					X						X	X	
7DP04-03	5.0-7.0	04/15/98			X		X											X		
7DP05-01	2.0-3.0	04/15/98			X		X											X		
7DP05-02	3.0-5.0	04/15/98																X		
7DP05-05	9.0-11.0	04/15/98			X		X													
7DP06-05	8.0-12.0	04/15/98			X		X													
7DP07-04	4.0-8.0	04/15/98			X		X													
7DP07-04D	4.0-8.0	04/15/98			X		X													Duplicate
7DP07-06	12.0-14.0	04/15/98			X		X													
7DP08-04	4.0-8.0	04/15/98			X		X													
7DP09	0.0-9.0	04/16/98																	X	
7DP09-03	5.0-7.0	04/16/98			X		X													
7DP10-03	5.0-7.0	04/16/98			X		X													
7DP10-05	10.0-12.0	04/16/98			X		X											X		

TABLE 3-3 (continued)
SUBSURFACE SOIL SAMPLE MATRIX
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

			Laboratory Analysis																	
Sample ID	**Sample Depth (ft bgs)**	**Date Collected**	**Volatiles**	**Semivolatiles**	**BTEX**	**Low Level PAHs**	**TPH**	**Total Metals**	**TCLP Metals**	**Cyanide**	**TOX**	**TOC**	**Sulfide**	**Sulfate**	**Flash Point**	**Ph**	**Ignitability**	**% Water/ % Solids: Density**	**Grain Size**	**Comments**
7DP11-02	4.0-6.0	04/16/98			X		X													
7DP11-05	10.0-12.0	04/16/98			X		X													
7DP13-02	4.0-5.5	04/16/98			X		X											X		
7DP15-02	3.0-5.0	04/17/98			X		X											X		
7DP15-04	6.0-8.0	04/17/98			X		X											X		
7DP15-07	12.0-14.0	04/17/98			X		X											X		
7DP16-03	2.0-6.0	04/17/98			X		X											X		
7DP16-05	10.0-12.0	04/17/98			X		X											X		
7DP17-02	3.0-6.0	04/17/98			X		X											X		
7DP17-04	7.0-9.0	04/17/98			X		X					X						X		
7DP18-02	4.0-6.0	04/17/98			X		X											X		
7DP19-03	5.0-7.0	04/17/98			X		X													
7DP19-06	12.0-14.0	04/17/98			X		X													
7DP19-08	16.0-18.0	04/17/98			X		X													
7DP20	0.0-9.0	04/17/98																	X	
7DP20-02	3.0-5.0	04/17/98			X		X													
7DP20-05	10.0-12.0	04/17/98			X		X													
7DP23-02	3.0-4.0	04/18/98			X		X					X								
7DP24-01	3.0-5.0	04/18/98			X		X													
7DP24-02	3.0-5.0	04/18/98																	X	
7DP24-03	5.0-7.0	04/18/98			X		X													
7DP24-05	10.0-11.0	04/18/98			X		X													

TABLE 3-3 (continued)
SUBSURFACE SOIL SAMPLE MATRIX
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

			Laboratory Analysis																	
Sample ID	**Sample Depth (ft bgs)**	**Date Collected**	**Volatiles**	**Semivolatiles**	**BTEX**	**Low Level PAHs**	**TPH**	**Total Metals**	**TCLP Metals**	**Cyanide**	**TOX**	**TOC**	**Sulfide**	**Sulfate**	**Flash Point**	**Ph**	**Ignitability**	**% Water/ % Solids: Density**	**Grain Size**	**Comments**
7DP25-03	4.0-7.0	04/19/98			X		X													
7DP25-06	10.0-13.0	04/19/98			X		X													
7DP26-02	2.0-4.0	04/19/98			X		X													
7DP26-04	6.0-10.0	04/19/98			X		X													
7DP26-04D	6.0-10.0	04/19/98			X		X													Duplicate
7DP26-06	12.0-14.0	04/19/98			X		X													
7DP27-04	7.0-8.0	04/19/98			X		X					X								
7DP29-04	7.0-8.0	04/19/98			X		X													
7DP29-04D	7.0-8.0	04/19/98			X		X													Duplicate
7DP30-03	5.0-6.0	04/19/98			X		X													
7MW01-07	14.0-16.0	03/27/96	X	X			X	X										X		
7MW01-12	24.0-26.0	03/27/96	X	X			X	X										X		
7MW01-12D	24.0-26.0	03/27/96	X	X			X	X										X		Duplicate
7MW02-11	22.0-24.0	04/09/96	X	X			X	X										X		
7MW02-11D	22.0-24.0	04/09/96	X	X			X	X										X		Duplicate
7MW02-17	34.0-36.0	04/09/96	X	X			X	X										X		
7MW03-04	8.0-10.0	04/08/96	X	X			X	X										X		
7MW03-04D	8.0-10.0	04/08/96	X	X			X	X										X		Duplicate
7MW03-06	12.0-14.0	04/08/96	X	X			X	X										X		
7MW04-07	14.0-16.0	04/04/96	X	X			X	X										X		
7MW04-07D	14.0-16.0	04/04/96	X	X			X	X										X		Duplicate
7MW04-11	22.0-24.0	04/04/96	X	X			X	X										X		

TABLE 3-3 (continued)
SUBSURFACE SOIL SAMPLE MATRIX
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

			Laboratory Analysis																	
Sample ID	**Sample Depth (ft bgs)**	**Date Collected**	**Volatiles**	**Semivolatiles**	**BTEX**	**Low Level PAHs**	**TPH**	**Total Metals**	**TCLP Metals**	**Cyanide**	**TOX**	**TOC**	**Sulfide**	**Sulfate**	**Flash Point**	**Ph**	**Ignitability**	**% Water/ % Solids: Density**	**Grain Size**	**Comments**
7MW16-06	6.0-7.0	01/16/02		X		X														
7MW17-03	3.0-7.0	01/23/02				X														
7MW17-03D	3.0-7.0	01/23/02				X														Duplicate
7MW18-03	3.0-3.6	01/29/02		X		X														
7MW19-03	3.0-4.6	01/30/02		X		X														
7SB01-04	8.0-10.0	03/27/96	X	X			X	X										X		
7SB01-05	10.0-12.0	03/27/96	X	X			X	X										X		
7SB01-08	16.0-18.0	03/27/96	X	X			X	X										X		
7SB01-11	22.0-24.0	03/27/96	X	X			X	X										X		
7SB02-03	6.0-8.0	04/02/96	X	X			X	X										X		
7SB02-06	12.0-14.0	04/02/96	X	X			X	X										X		
7SB02-07	14.0-16.0	04/02/96	X	X			X	X										X		
7SB03-06	12.0-14.0	04/25/96	X	X			X	X										X		
7SB03-08	16.0-18.0	04/25/96	X	X			X	X										X		
7SB23-07	6.0-7.0	01/22/02				X														
7SB24-07	7.0-11.0	01/23/02		X		X														
7SB24-07D	7.0-11.0	01/23/02		X		X														Duplicate
7SB25-04	4.0-5.2	01/29/02		X		X														
7SB26-07	8.0-9.0	01/24/02		X		X														
7SB27-11	11.0-12.4	01/12/02		X		X														
7SB28-03	3.0-7.0	01/22/02				X														
7SB29-10	10.0-10.75	01/12/02		X		X														

TABLE 3-3 (continued)
SUBSURFACE SOIL SAMPLE MATRIX
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

			Laboratory Analysis																	
Sample ID	**Sample Depth (ft bgs)**	**Date Collected**	**Volatiles**	**Semivolatiles**	**BTEX**	**Low Level PAHs**	**TPH**	**Total Metals**	**TCLP Metals**	**Cyanide**	**TOX**	**TOC**	**Sulfide**	**Sulfate**	**Flash Point**	**Ph**	**Ignitability**	**% Water/ % Solids: Density**	**Grain Size**	**Comments**
7SB30-08	8.0-8.9	01/12/02		X		X														
8TP01-04	7.0-7.5	04/02/96	X	X			X	X										X		
8TP02-02	3.0-3.0	04/02/96	X	X			X	X										X		
8TP02-06	11.0-11.0	04/02/96	X	X			X	X										X		
8TP03-02	4.0-5.0	04/03/96	X	X			X	X										X		
8TP04-03	7.0-7.0	04/03/96	X	X			X	X										X		
8TP06-01	3.0-3.0	04/03/96	X	X			X	X										X		
8TP06-04	8.0-8.0	04/03/96	X	X			X	X										X		
8TP06-04D	8.0-8.0	04/03/96	X	X			X	X										X		Duplicate
8TP07-01	2.0-2.0	04/04/96	X	X			X	X										X		
8TP07-04	7.0-7.0	04/04/96	X	X			X	X										X		
8TP07-05	12.0-12.0	04/04/96	X	X			X	X										X		
AW1(30-32)	30.0-32.0	12/16/98			X		X	X						X						
AW1(30-32)	30.0-32.0	02/08/99			X		X	X						X						
AW1(30-32)	30.0-32.0	04/27/99			X		X	X						X						
AW1(30-32)	30.0-32.0	06/29/99			X		X	X						X						
AW2(24-26)	24.0-26.0	12/16/98			X		X	X						X						
AW2(24-26)	24.0-26.0	02/08/99			X		X	X						X						
AW2(24-26)	24.0-26.0	04/15/99			X		X	X						X						
AW2(24-26)	24.0-26.0	06/29/99			X		X	X						X						
B1	4.0-6.0	02/25/91					X		X		X				X					
B1	6.0-8.0	02/25/91					X		X		X				X					

TABLE 3-3 (continued)
SUBSURFACE SOIL SAMPLE MATRIX
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

			Laboratory Analysis																	
Sample ID	**Sample Depth (ft bgs)**	**Date Collected**	**Volatiles**	**Semivolatiles**	**BTEX**	**Low Level PAHs**	**TPH**	**Total Metals**	**TCLP Metals**	**Cyanide**	**TOX**	**TOC**	**Sulfide**	**Sulfate**	**Flash Point**	**Ph**	**Ignitability**	**% Water/ % Solids: Density**	**Grain Size**	**Comments**
B1	8.0-15.0	02/25/91					X		X		X				X					
B2	2.0-4.0	02/26/91					X		X		X				X					
B2	4.0-6.0	02/26/91					X		X		X				X					
B2	6.0-10.0	02/26/91					X		X		X				X					
B2D	6.0-10.0	02/26/91					X		X		X				X					Duplicate
B3	10.0-12.0	02/26/91					X		X		X				X					
B3	12.0-16.0	02/26/91					X		X		X				X					
B3	4.0-6.0	02/26/91					X		X		X				X					
B4	10.0-14.0	02/27/91					X		X		X				X					
B4	6.0-8.0	02/27/91					X		X		X				X					
B4	8.0-10.0	02/27/91					X		X		X				X					
B5	2.0-4.0	02/27/91					X		X		X				X					
B5	4.0-6.0	02/27/91					X		X		X				X					
B5	6.0-10.0	02/27/91					X		X		X				X					
B6	12.0-16.0	02/28/91					X		X		X				X					
B6	4.0-6.0	02/28/91					X		X		X				X					
B6	6.0-8.0	02/28/91					X		X		X				X					
B7	2.0-4.0	02/28/91					X		X		X				X					
B7	4.0-6.0	02/28/91					X		X		X				X					
B7	6.0-10.0	02/28/91					X		X		X				X					
B8	12.0-16.0	02/28/91					X		X		X				X					
B8	6.0-8.0	02/28/91					X		X		X				X					

TABLE 3-3 (continued)
SUBSURFACE SOIL SAMPLE MATRIX
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

			Laboratory Analysis																	
Sample ID	**Sample Depth (ft bgs)**	**Date Collected**	**Volatiles**	**Semivolatiles**	**BTEX**	**Low Level PAHs**	**TPH**	**Total Metals**	**TCLP Metals**	**Cyanide**	**TOX**	**TOC**	**Sulfide**	**Sulfate**	**Flash Point**	**Ph**	**Ignitability**	**% Water/ % Solids: Density**	**Grain Size**	**Comments**
B8	8.0-10.0	02/28/91					X		X		X				X					
B9	10.0-12.0	03/01/91					X		X		X				X					
B9	12.0-16.0	03/01/91					X		X		X				X					
B9	4.0-6.0	03/01/91					X		X		X				X					
B10	10.0-14.0	03/01/91					X		X		X				X					
B10	4.0-6.0	03/01/91					X		X		X				X					
B10	6.0-8.0	03/01/91					X		X		X				X					
BBSB2 (10-12)	10.0-12.0	11/10/93					X													
BBSB3	6.0-8.0	11/11/93					X													
BBSB4(8'-10')	8.0-10.0	11/10/93					X													
BBSB5	10.0-12.0	11/16/93					X													
BBSB6	65.0-75.0	12/11/93					X													
BBSB7	10.0-14.0	11/16/93					X													
D1	1.0-6.0	03/26/97					X													
D2	1.0-10.0	04/04/97			X		X													
DP32	9.5-11.0	10/06/99					X													
DP33	9.0-11.0	10/06/99					X													
DP34	10.0-11.0	10/06/99					X													
DP35	12.6-13.0	10/06/99					X													
DP36	19.0-19.0	10/05/99					X													
DP36	13.0-14.0	10/06/99					X													
DP37	2.0-2.2	10/05/99					X													

TABLE 3-3 (continued)
SUBSURFACE SOIL SAMPLE MATRIX
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

			Laboratory Analysis																	
Sample ID	**Sample Depth (ft bgs)**	**Date Collected**	**Volatiles**	**Semivolatiles**	**BTEX**	**Low Level PAHs**	**TPH**	**Total Metals**	**TCLP Metals**	**Cyanide**	**TOX**	**TOC**	**Sulfide**	**Sulfate**	**Flash Point**	**Ph**	**Ignitability**	**% Water/ % Solids: Density**	**Grain Size**	**Comments**
DP39	9.8-10.0	10/05/99					X													
DP42	15.9-16.0	10/05/99					X													
DP44	10.0-10.0	10/05/99					X													
DP44	8.0-9.0	10/05/99					X													
DP48	8.0-8.0	10/06/99					X													
DP55	7.0-8.0	10/06/99					X													
DP56	11.6-11.6	10/05/99					X													
DP59	10.0-11.0	10/04/99					X													
DP60	11.0-11.0	10/06/99					X													
DP61	7.6-8.0	10/04/99					X													
MTMW4(18-20)	18.0-20.0	12/16/98			X		X	X						X						
MTMW4(18-20)	18.0-20.0	02/08/99			X		X	X						X						
MTMW4(18-20)	18.0-20.0	04/15/99			X		X	X						X						
MTMW4(18-20)	18.0-20.0	06/29/99			X		X	X						X						
MW1	10.0-10.0	09/19/95					X													
MW1	11.0-11.0	09/19/95					X													
MW1	12.0-12.0	09/19/95					X													
MW1	13.0-13.0	09/19/95					X													
MW1	14.0-14.0	09/19/95					X													
MW1	15.0-15.0	09/19/95					X													
MW1	16.0-16.0	09/19/95					X													
MW1	6.0-6.0	09/19/95					X													

TABLE 3-3 (continued)
SUBSURFACE SOIL SAMPLE MATRIX
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

			Laboratory Analysis																	
Sample ID	**Sample Depth (ft bgs)**	**Date Collected**	**Volatiles**	**Semivolatiles**	**BTEX**	**Low Level PAHs**	**TPH**	**Total Metals**	**TCLP Metals**	**Cyanide**	**TOX**	**TOC**	**Sulfide**	**Sulfate**	**Flash Point**	**Ph**	**Ignitability**	**% Water/ % Solids: Density**	**Grain Size**	**Comments**
MW1	7.0-7.0	09/19/95					X													
MW1	8.0-8.0	09/19/95					X													
MW1	9.0-9.0	09/19/95					X													
PW1	10.0-10.0	09/26/95					X													
PW1	12.0-12.0	09/26/95					X													
PW1	13.0-13.0	09/26/95					X													
PW1	14.0-14.0	09/26/95					X													
PW1	15.0-15.0	09/26/95					X													
PW1	16.0-16.0	09/26/95					X													
PW1	17.0-17.0	09/26/95					X													
PW1	7.0-7.0	09/26/95					X													
PW1	8.0-8.0	09/26/95					X													
PW1	9.0-9.0	09/26/95					X													
PW2	10.0-10.0	09/20/95					X													
PW2	11.0-11.0	09/20/95					X													
PW2	12.0-12.0	09/20/95					X													
PW2	13.0-13.0	09/20/95					X													
PW2	14.0-14.0	09/20/95					X													
PW2	16.0-16.0	09/20/95					X													
PW2	17.0-17.0	09/20/95					X													
PW2	18.0-18.0	09/20/95					X													
PW2	6.0-6.0	09/20/95					X													

TABLE 3-3 (continued)
SUBSURFACE SOIL SAMPLE MATRIX
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

			Laboratory Analysis																	
Sample ID	**Sample Depth (ft bgs)**	**Date Collected**	**Volatiles**	**Semivolatiles**	**BTEX**	**Low Level PAHs**	**TPH**	**Total Metals**	**TCLP Metals**	**Cyanide**	**TOX**	**TOC**	**Sulfide**	**Sulfate**	**Flash Point**	**Ph**	**Ignitability**	**% Water/ % Solids: Density**	**Grain Size**	**Comments**
PW2	7.0-7.0	09/20/95					X													
PW2	8.0-8.0	09/20/95					X													
PW2	9.0-9.0	09/20/95					X													
PW3	10.0-10.0	09/22/95					X													
PW3	14.0-14.0	09/22/95					X													
PW3	15.0-15.0	09/22/95					X													
PW3	6.0-6.0	09/22/95					X													
PW3	7.0-7.0	09/22/95					X													
PW3	8.0-8.0	09/22/95					X													
PW3	10.0-10.0	09/22/95					X													
PW4	10.0-10.0	09/25/95					X													
PW4	12.0-12.0	09/25/95					X													
PW4	14.0-14.0	09/25/95					X													
PW4	16.0-16.0	09/25/95					X													
PW4	18.0-18.0	09/25/95					X													
PW4	20.0-20.0	09/25/95					X													
PW4	21.0-21.0	09/25/95					X													
PW4	22.0-22.0	09/25/95					X													
PW4	6.0-6.0	09/25/95					X													
PW4	8.0-8.0	09/25/95					X													
PW5	10.0-10.0	09/23/95					X													
PW5	11.0-11.0	09/23/95					X													

TABLE 3-3 (continued)
SUBSURFACE SOIL SAMPLE MATRIX
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

			Laboratory Analysis																	
Sample ID	**Sample Depth (ft bgs)**	**Date Collected**	**Volatiles**	**Semivolatiles**	**BTEX**	**Low Level PAHs**	**TPH**	**Total Metals**	**TCLP Metals**	**Cyanide**	**TOX**	**TOC**	**Sulfide**	**Sulfate**	**Flash Point**	**Ph**	**Ignitability**	**% Water/ % Solids: Density**	**Grain Size**	**Comments**
PW5	12.0-12.0	09/23/95					X													
PW5	14.0-14.0	09/23/95					X													
PW5	4.0-4.0	09/23/95					X													
PW5	5.0-5.0	09/23/95					X													
PW5	7.0-7.0	09/23/95					X													
PW5	8.0-8.0	09/23/95					X													
PW5	9.0-9.0	09/23/95					X													
PW6	11.0-11.0	09/26/95					X													
PW6	13.0-13.0	09/26/95					X													
PW6	15.0-15.0	09/26/95					X													
PW6	17.0-17.0	09/26/95					X													
PW6	19.0-19.0	09/26/95					X													
PW6	20.0-20.0	09/26/95					X													
PW6	7.0-7.0	09/26/95					X													
PW6	9.0-9.0	09/26/95					X													
S1	1.0-5.5	03/26/97			X		X													
S2	1.0-7.5	03/26/97			X		X													
S3	1.0-6.0	03/26/97			X		X													
S3DUP	1.0-6.0	03/26/97			X															Duplicate
S4	1.0-6.5	03/26/97			X		X													
S5	1.0-6.0	03/27/97			X		X													
S6	1.0-5.5	03/26/97			X		X													
S7	1.0-5.5	03/27/97			X		X													

TABLE 3-3 (continued)
SUBSURFACE SOIL SAMPLE MATRIX
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

			Laboratory Analysis																	
Sample ID	**Sample Depth (ft bgs)**	**Date Collected**	**Volatiles**	**Semivolatiles**	**BTEX**	**Low Level PAHs**	**TPH**	**Total Metals**	**TCLP Metals**	**Cyanide**	**TOX**	**TOC**	**Sulfide**	**Sulfate**	**Flash Point**	**Ph**	**Ignitability**	**% Water/ % Solids: Density**	**Grain Size**	**Comments**
S8	1.0-10.0	04/04/97			X		X													
S9	1.0-7.0	04/04/97			X		X													
S10	1.0-6.7	04/04/97			X		X													
TWSB01	5.0-8.0	11/23/92					X		X		X				X					
TWSB02	7.0-12.5	11/23/92					X		X		X				X					
TWSB03	15.5-17.0	11/24/92					X		X		X				X					
TWSB04	5.0-13.5	11/24/92					X		X		X				X					
TWSB04DUP	5.0-13.5	11/24/92					X		X		X				X					Duplicate
UGW22	10.0-12.0	12/07/93					X		X	X		X	X			X	X			
UGW26	4.0-8.0	12/15/93					X													

ft bgs = Feet below ground surface

TABLE 3-4
GROUNDWATER SAMPLE MATRIX
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

		Organics				Metals		Indicator Parameters										Monitored Natural Attenuation			TCE Parameters		Misc. Parameter	
Sample ID	**Date Collected**	**Volatiles**	**TEG - Volatiles**	**Semivolatiles**	**BTEX**	**Total Metals**	**Dissolved Metals**	**Soil Gases**	**Dissolved Oxygen**	**TPH**	**TDS**	**Ph**	**Sulfur**	**Hardness**	**Chloride**	**Ferrous Iron**	**Alkalinity**	**Nitrate**	**Sulfate**	**Methane**	**Ethane/Ethene**	**TOC**	**Groundwater Density**	**Comments**
470MW01	01/15/02	X		X		X	X		X			X				X	X	X	X	X				
470MW1	04/18/98	X						X		X					X	X	X	X	X					
470MW3	04/17/98	X						X		X					X	X	X	X	X					
470MW03	01/15/02	X		X		X	X		X			X				X	X	X	X	X				
7GW04	04/19/96	X		X			X																	
7MW01A	05/05/96	X		X			X																	
7MW01A	04/20/98	X						X		X					X	X	X	X	X					
7MW02A	04/23/96	X		X			X																	
7MW02AD	04/23/96	X		X			X																	Duplicate
7MW02	04/19/98	X						X		X					X	X	X	X	X					
7MW03	04/23/96	X		X			X																	
7MW03	04/15/98	X						X		X					X	X	X	X	X					
7MW03	01/25/02	X		X		X	X		X			X				X	X	X	X	X				
7MW04	04/15/98	X						X		X					X	X	X	X	X					
7MW05	04/19/98	X						X		X					X	X	X	X	X					
7MW05	01/09/02	X		X		X	X		X			X				X	X	X	X	X				
7MW06	04/19/98	X						X		X					X	X	X	X	X					
7MW06	01/09/02	X		X		X	X		X			X				X	X	X	X	X			X	
7MW07	04/19/98	X						X		X					X	X	X	X	X					
7MW07D	04/19/98	X						X		X					X		X	X	X					Duplicate
7MW07	06/27/99		X																					
7MW07D	06/27/99		X																					Duplicate
7MW07	01/13/02	X		X		X	X		X			X				X	X	X	X	X	X	X		
7MW07D	01/13/02	X		X		X	X		X			X				X	X	X	X	X	X	X		Duplicate
7MW08	04/18/98	X						X		X					X	X	X	X	X					

TABLE 3-4 (continued)
GROUNDWATER SAMPLE MATRIX
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

		Organics				Metals		Indicator Parameters										Monitored Natural Attenuation			TCE Parameters		Misc. Parameter	
Sample ID	**Date Collected**	**Volatiles**	**TEG - Volatiles**	**Semivolatiles**	**BTEX**	**Total Metals**	**Dissolved Metals**	**Soil Gases**	**Dissolved Oxygen**	**TPH**	**TDS**	**Ph**	**Sulfur**	**Hardness**	**Chloride**	**Ferrous Iron**	**Alkalinity**	**Nitrate**	**Sulfate**	**Methane**	**Ethane/Ethene**	**TOC**	**Groundwater Density**	**Comments**
7MW08D	04/18/98	X						X		X					X	X	X	X	X					Duplicate
7MW08	06/27/99		X																					
7MW08	01/13/02	X		X		X	X		X			X				X	X	X	X	X	X	X		
7MW09	04/18/98	X						X		X					X	X	X	X	X					
7MW09	01/25/02	X		X		X	X		X			X				X	X	X	X	X				
7MW10	01/26/02	X		X		X	X		X			X				X	X	X	X	X	X	X		
7MW11	01/27/02	X		X		X	X		X			X				X	X	X	X	X				
7MW12	02/01/02	X		X		X	X		X			X				X	X	X	X	X				
7MW13	01/27/02	X		X		X	X		X			X				X	X	X	X	X				
7MW14	01/29/02	X		X		X	X		X			X				X	X	X	X	X				
7MW15	01/29/02	X		X		X	X		X			X				X	X	X	X	X				
7MW16	02/01/02	X		X		X	X		X			X				X	X	X	X	X			X	
7MW17	03/01/02	X		X		X	X		X			X				X	X	X	X	X			X	
7MW18	01/31/02	X		X		X	X		X			X				X	X	X	X	X				
7MW18D	01/31/02	X		X		X	X		X			X				X	X	X	X	X				Duplicate
7MW19	01/31/02	X		X		X	X		X			X				X	X	X	X	X			X	
7MW20	01/28/02	X		X		X	X		X			X				X	X	X	X	X	X	X	X	
7TCE101	07/01/99		X																					
7TCE102	07/01/99	X																						
7TCE102x	07/02/99		X																					
7TCE103	07/01/99		X																					
7TCE104	07/01/99	X																						
7TCE104	07/02/99		X																					
7TCE105	07/01/99	X																						
7TCE105	07/02/99		X																					

TABLE 3-4 (continued)
GROUNDWATER SAMPLE MATRIX
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

		Organics				Metals		Indicator Parameters										Monitored Natural Attenuation			TCE Parameters		Misc. Parameter	
Sample ID	**Date Collected**	**Volatiles**	**TEG - Volatiles**	**Semivolatiles**	**BTEX**	**Total Metals**	**Dissolved Metals**	**Soil Gases**	**Dissolved Oxygen**	**TPH**	**TDS**	**Ph**	**Sulfur**	**Hardness**	**Chloride**	**Ferrous Iron**	**Alkalinity**	**Nitrate**	**Sulfate**	**Methane**	**Ethane/Ethene**	**TOC**	**Groundwater Density**	**Comments**
7TCE-1d	06/29/99		X																					
7TCE-1d	06/29/99	X																						
7TCE-1s	06/26/99	X																						
7TCE-1s	06/27/99		X																					
7TCE2d	06/29/99	X	X																					
7TCE2S	06/28/99		X																					
7TCE3d	06/29/99	X	X																					
7TCE3s	06/28/99		X																					
7TCE4d	06/29/99	X	X																					
7TCE4s	06/28/99	X	X																					
7TCEAd	06/30/99	X	X																					
7TCEAs	06/25/99	X	X																					
7TCEBd	06/30/99	X	X																					
7TCEBs	06/24/99		X																					
7TCEBs	06/25/99	X																						
7TCECd	06/30/99	X	X																					
7TCECs	06/26/99		X																					
7TCECs	06/27/99	X																						
7TCEEd	07/01/99		X																					
7TCEEs	06/30/99	X	X																					
7TCEEsD	06/30/99	X																						Duplicate
7TCEMW07	07/02/99		X																					
7TCEMW7	07/01/99	X																						
AW1	01/07/99				X	X				X	X			X			X	X	X					
AW1	02/08/99				X	X				X	X			X			X	X	X					

TABLE 3-4 (continued)
GROUNDWATER SAMPLE MATRIX
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

		Organics				Metals		Indicator Parameters										Monitored Natural Attenuation			TCE Parameters		Misc. Parameter	
Sample ID	**Date Collected**	**Volatiles**	**TEG - Volatiles**	**Semivolatiles**	**BTEX**	**Total Metals**	**Dissolved Metals**	**Soil Gases**	**Dissolved Oxygen**	**TPH**	**TDS**	**Ph**	**Sulfur**	**Hardness**	**Chloride**	**Ferrous Iron**	**Alkalinity**	**Nitrate**	**Sulfate**	**Methane**	**Ethane/Ethene**	**TOC**	**Groundwater Density**	**Comments**
AW1	02/22/99				X	X				X	X			X			X	X	X					
AW1	04/15/99				X	X				X	X			X			X	X	X					
AW1	06/29/99				X	X				X	X			X			X	X	X					
AW2	01/07/99				X	X				X	X			X			X	X	X					
AW2	02/08/99				X	X				X	X			X			X	X	X					
AW2	02/22/99				X	X				X	X			X			X	X	X					
AW2	04/15/99				X	X				X	X			X			X	X	X					
AW2	06/29/99				X	X				X	X			X			X	X	X					
BBSB6	12/12/93				X																			
BBSB6	12/12/93									X														
GW02DUP	11/17/92	X				X				X														Duplicate
GW02L	11/17/92	X				X				X														
GW02	11/12/93	X								X														
GW02D	11/12/93	X								X														Duplicate
GW02	04/21/98	X						X		X					X	X	X	X	X					
GW03L	11/17/92	X				X				X														
GW03	03/23/96	X		X			X																	
GW03	04/21/98	X						X		X					X	X	X	X	X					
GW04	04/16/98	X						X		X					X	X	X	X	X					
GW04	01/10/02	X		X		X	X		X			X				X	X	X	X					
GW06L	11/17/92	X				X				X														
GW06	04/16/98	X						X		X					X	X	X	X	X					
GW06	01/11/02	X		X		X	X		X			X				X	X	X	X	X				
GW18	11/17/92	X			X	X				X														
MTMW1	01/07/99				X	X				X	X			X			X	X	X					

TABLE 3-4 (continued)
GROUNDWATER SAMPLE MATRIX
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

		Organics				Metals		Indicator Parameters										Monitored Natural Attenuation			TCE Parameters		Misc. Parameter	
Sample ID	**Date Collected**	**Volatiles**	**TEG - Volatiles**	**Semivolatiles**	**BTEX**	**Total Metals**	**Dissolved Metals**	**Soil Gases**	**Dissolved Oxygen**	**TPH**	**TDS**	**Ph**	**Sulfur**	**Hardness**	**Chloride**	**Ferrous Iron**	**Alkalinity**	**Nitrate**	**Sulfate**	**Methane**	**Ethane/Ethene**	**TOC**	**Groundwater Density**	**Comments**
MTMW1	02/08/99				X	X				X	X			X			X	X	X					
MTMW1	02/22/99				X	X				X	X			X			X	X	X					
MTMW1	04/15/99				X	X				X	X			X			X	X	X					
MTMW1	06/29/99				X	X				X	X			X			X	X	X					
MTMW2	01/07/99				X	X				X	X			X			X	X	X					
MTMW2	02/08/99				X	X				X	X			X			X	X	X					
MTMW2	02/22/99				X	X				X	X			X			X	X	X					
MTMW2	04/15/99				X	X				X	X			X			X	X	X					
MTMW2	06/29/99				X	X				X	X			X			X	X	X					
MTMW3	01/07/99				X	X				X	X			X			X	X	X					
MTMW3	02/08/99				X	X				X	X			X			X	X	X					
MTMW3	02/22/99				X	X				X	X			X			X	X	X					
MTMW3	04/15/99				X	X				X	X			X			X	X	X					
MTMW3	06/29/99				X	X				X	X			X			X	X	X					
MTMW4	01/07/99				X	X				X	X			X			X	X	X					
MTMW4	02/08/99				X	X				X	X			X			X	X	X					
MTMW4	02/22/99				X	X				X	X			X			X	X	X					
MTMW4	04/15/99				X	X				X	X			X			X	X	X					
MTMW4	06/29/99				X	X				X	X			X			X	X	X					
MW2	04/17/98	X						X		X					X	X	X	X	X					
MW2D	04/17/98	X						X		X					X		X	X	X					Duplicate
MW4	04/19/98	X						X		X					X	X	X	X	X					
RW1	01/07/99				X	X				X	X			X			X	X	X					
RW1	02/08/99				X	X				X	X			X			X	X	X					
RW1	02/22/99				X	X				X	X			X			X	X	X					

TABLE 3-4 (continued)
GROUNDWATER SAMPLE MATRIX
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

		Organics				Metals		Indicator Parameters										Monitored Natural Attenuation			TCE Parameters		Misc. Parameter	
Sample ID	**Date Collected**	**Volatiles**	**TEG - Volatiles**	**Semivolatiles**	**BTEX**	**Total Metals**	**Dissolved Metals**	**Soil Gases**	**Dissolved Oxygen**	**TPH**	**TDS**	**Ph**	**Sulfur**	**Hardness**	**Chloride**	**Ferrous Iron**	**Alkalinity**	**Nitrate**	**Sulfate**	**Methane**	**Ethane/Ethene**	**TOC**	**Groundwater Density**	**Comments**
RW1	04/15/99				X	X				X	X			X			X	X	X					
RW1	06/29/99				X	X				X	X			X			X	X	X					
UGMW24	06/27/99		X																					
UGW1	03/28/91				X	X																		
UGW2	03/26/91				X	X																		
UGW2	03/23/96	X		X			X																	
UGW2	04/15/98	X						X		X					X	X	X	X	X					
UGW03	03/27/91				X	X																		
UGW03D	03/27/91				X	X																		Duplicate
UGW03	11/17/92	X				X				X														
UGW03	03/23/96	X		X			X																	
UGW03	04/20/98	X						X		X				X	X	X	X	X	X					
UGW03	01/07/99				X	X				X	X			X			X	X	X					
UGW03	02/08/99				X	X				X	X			X			X	X	X					
UGW03	02/22/99				X	X				X	X			X			X	X	X					
UGW03	04/15/99				X	X				X	X			X			X	X	X					
UGW03	06/29/99				X	X				X	X			X			X	X	X					
UGW04	03/28/91				X	X																		
UGW04	04/20/98	X						X		X					X	X	X	X	X					
UGW05	03/28/91				X	X																		
UGW05	10/05/93					X																		
UGW05	04/17/98	X						X		X					X	X	X	X	X					
UGW05D	04/17/98	X						X		X					X		X	X	X					Duplicate
UGW06	03/26/91				X	X																		
UGW06	11/17/92	X				X				X														

TABLE 3-4 (continued)
GROUNDWATER SAMPLE MATRIX
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

		Organics				Metals		Indicator Parameters										Monitored Natural Attenuation			TCE Parameters		Misc. Parameter	
Sample ID	**Date Collected**	**Volatiles**	**TEG - Volatiles**	**Semivolatiles**	**BTEX**	**Total Metals**	**Dissolved Metals**	**Soil Gases**	**Dissolved Oxygen**	**TPH**	**TDS**	**Ph**	**Sulfur**	**Hardness**	**Chloride**	**Ferrous Iron**	**Alkalinity**	**Nitrate**	**Sulfate**	**Methane**	**Ethane/Ethene**	**TOC**	**Groundwater Density**	**Comments**
UGW06	11/12/93	X								X														
UGW06	04/15/98	X						X		X					X	X	X	X	X					
UGW06	01/10/02	X		X		X	X		X			X				X	X	X	X					
UGW06D	01/10/02	X		X		X	X		X			X				X	X	X	X					Duplicate
UGW07	03/26/91				X	X																		
UGW07	11/17/92	X				X				X														
UGW07	11/11/93	X								X														
UGW07	03/23/96	X		X			X																	
UGW07	04/15/98	X						X		X					X	X	X	X	X					
UGW07	01/10/02	X		X		X	X		X			X				X	X	X	X					
UGW08	03/26/91				X	X																		
UGW08	11/17/92	X				X				X														
UGW08	11/11/93	X								X														
UGW08	04/16/98	X						X		X					X	X	X	X	X					
UGW08	01/11/02	X		X		X	X		X			X				X	X	X	X	X				
UGW08D	01/11/02	X		X		X	X		X			X				X	X	X	X	X				Duplicate
UGW09	03/26/91				X	X																		
UGW09	11/11/93	X								X														
UGW09	04/16/98	X						X		X					X	X	X	X	X					
UGW09	01/12/02	X		X		X	X		X			X				X	X	X	X	X				
UGW10	03/27/91				X	X																		
UGW10	11/17/92	X				X				X														
UGW10	11/16/93	X								X														
UGW10	03/23/96	X		X			X																	
UGW10	04/16/98	X						X		X					X	X	X	X	X					

TABLE 3-4 (continued)
GROUNDWATER SAMPLE MATRIX
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

		Organics				Metals		Indicator Parameters										Monitored Natural Attenuation			TCE Parameters		Misc. Parameter	
Sample ID	**Date Collected**	**Volatiles**	**TEG - Volatiles**	**Semivolatiles**	**BTEX**	**Total Metals**	**Dissolved Metals**	**Soil Gases**	**Dissolved Oxygen**	**TPH**	**TDS**	**Ph**	**Sulfur**	**Hardness**	**Chloride**	**Ferrous Iron**	**Alkalinity**	**Nitrate**	**Sulfate**	**Methane**	**Ethane/Ethene**	**TOC**	**Groundwater Density**	**Comments**
UGW10	01/12/02	X		X		X	X		X			X				X	X	X	X	X				
UGW11	03/27/91				X	X																		
UGW11	11/17/92	X				X				X														
UGW11	11/15/93	X								X														
UGW11	04/17/98	X						X		X					X	X	X	X	X					
UGW11	01/12/02	X		X		X	X		X			X				X	X	X	X	X			X	
UGW12	03/28/91				X	X																		
UGW12	10/05/93					X																		
UGW12	04/20/98	X						X		X					X	X	X	X	X					
UGW13	03/28/91				X	X																		
UGW13	04/21/98	X						X		X					X	X	X	X	X					
UGW14	03/28/91				X	X																		
UGW14	04/19/98	X						X		X	X				X	X	X	X	X					
UGW14	01/07/99				X	X				X	X			X			X	X	X					
UGW14	02/08/99				X	X				X	X			X			X	X	X					
UGW14	02/22/99				X	X				X				X			X	X	X					
UGW14	04/15/99				X	X				X				X			X	X	X					
UGW14	06/29/99				X	X				X	X			X			X	X	X					
UGW15	03/28/91				X	X																		
UGW15	11/17/92	X				X				X														
UGW15	11/12/93	X								X														
UGW15	04/15/98	X						X		X					X	X	X	X	X					
UGW15	01/09/02	X		X		X	X		X			X				X	X	X	X	X				
UGW16	03/28/91				X	X																		
UGW16	11/12/93	X								X														

TABLE 3-4 (continued)
GROUNDWATER SAMPLE MATRIX
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

		Organics				Metals		Indicator Parameters										Monitored Natural Attenuation			TCE Parameters		Misc. Parameter	
Sample ID	**Date Collected**	**Volatiles**	**TEG - Volatiles**	**Semivolatiles**	**BTEX**	**Total Metals**	**Dissolved Metals**	**Soil Gases**	**Dissolved Oxygen**	**TPH**	**TDS**	**Ph**	**Sulfur**	**Hardness**	**Chloride**	**Ferrous Iron**	**Alkalinity**	**Nitrate**	**Sulfate**	**Methane**	**Ethane/Ethene**	**TOC**	**Groundwater Density**	**Comments**
UGW16	03/23/96	X		X			X																	
UGW16	04/16/98	X						X		X					X	X	X	X	X					
UGW16	01/12/02	X		X		X	X		X			X				X	X	X	X	X	X	X		
UGW17	04/04/91				X	X																		
UGW17	04/21/98	X						X		X					X	X	X	X	X					
UGW18	04/04/91				X	X																		
UGW18	11/17/92	X				X				X														
UGW18	11/12/93	X								X														
UGW18	04/16/98	X						X		X					X	X	X	X	X					
UGW18	01/12/02	X		X		X	X		X			X				X	X	X	X	X				
UGW19	11/18/93	X								X														
UGW19	04/17/98	X						X		X					X	X	X	X	X					
UGW20	11/18/93	X								X														
UGW20	03/23/96	X		X			X																	
UGW20	04/14/98	X						X		X					X	X	X	X	X					
UGW20R	01/11/02	X		X		X	X		X			X				X	X	X	X	X				
UGW21	12/17/93	X								X														
UGW21	04/17/98	X						X		X					X	X	X	X	X					
UGW22	12/15/93	X		X		X				X	X	X	X	X			X					X		
UGW23	12/17/93	X								X														
UGW23	04/18/98	X						X		X					X	X	X	X	X					
UGW23	01/25/02	X		X		X	X		X			X				X	X	X	X	X				
UGW24	12/17/93	X		X						X														
UGW24	04/19/98	X						X		X					X	X	X	X	X					
UGW25	12/17/93	X		X						X														

TABLE 3-4 (continued)
GROUNDWATER SAMPLE MATRIX
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

		Organics				Metals		Indicator Parameters										Monitored Natural Attenuation			TCE Parameters		Misc. Parameter	
Sample ID	**Date Collected**	**Volatiles**	**TEG - Volatiles**	**Semivolatiles**	**BTEX**	**Total Metals**	**Dissolved Metals**	**Soil Gases**	**Dissolved Oxygen**	**TPH**	**TDS**	**Ph**	**Sulfur**	**Hardness**	**Chloride**	**Ferrous Iron**	**Alkalinity**	**Nitrate**	**Sulfate**	**Methane**	**Ethane/Ethene**	**TOC**	**Groundwater Density**	**Comments**
UGW25	04/19/98	X						X		X					X	X	X	X	X					
UGW25	01/07/99				X	X				X	X			X			X	X	X					
UGW25	02/08/99				X	X				X	X			X			X	X	X					
UGW25	02/22/99				X	X				X	X			X			X	X	X					
UGW25	04/15/99				X	X				X	X			X			X	X	X					
UGW25	06/29/99				X	X				X	X			X			X	X	X					
UGW26	12/15/93									X														
UGW26	12/17/93	X		X						X														
UGW26	04/20/98	X						X		X					X	X	X	X	X					
UGW26D	04/20/98	X						X		X					X		X	X	X					Duplicate
UGW26	01/11/02	X		X		X	X		X			X				X	X	X	X	X				
UGW31	01/16/02	X		X		X	X		X			X				X	X	X	X	X			X	
UGW32	01/16/02	X		X		X	X		X			X				X	X	X	X	X				
UGW34	01/16/02	X		X		X	X		X			X				X	X	X	X	X				

TABLE 3-5
SURFACE WATER SAMPLE MATRIX
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

			Laboratory Analysis					Field Measurements				
Sample ID	**Date Collected**	**Sample Depth[1] (ft)**	**App. IX Volatiles**	**App. IX Semivolatiles**	**App. IX Total Metals**	**App. IX Dissolved Metals**	**Low Level PAH**	**Salinity**	**Dissolved oxygen**	**pH**	**Temperature**	**Comments**
7SW1	01/15/02	0.5	X	X	X	X	X	X	X	X	X	
7SW2	01/15/02	0.5	X	X	X	X	X	X	X	X	X	
7SW3	01/15/02	0.5	X	X	X	X	X	X	X	X	X	
7SW4	01/15/02	0.5	X	X	X	X	X	X	X	X	X	
7SW4D	01/15/02	0.5	X	X	X	X	X	X	X	X	X	Duplicate
7SW5	01/16/02	1.0	X	X	X	X	X	X	X	X	X	
7SW6	01/17/02	16	X	X	X	X	X	X	X	X	X	
7SW7	01/16/02	11.5	X	X	X	X	X	X	X	X	X	
7SW8	01/16/02	8	X	X	X	X	X	X	X	X	X	
7SW9	01/16/02	9.5	X	X	X	X	X	X	X	X	X	

Notes:

[1] Depth below water surface.

TABLE 3-6
SEDIMENT SAMPLE MATRIX
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

			Laboratory Analysis													
Sample ID	**Date Collected**	**Sample Depth (ft bgs)**	**Volatiles**	**Semivolatiles**	**Low Level PAH**	**Orthophosphate Pest.**	**Pesticides**	**Aroclors - PCBs**	**Herbicides**	**Dioxins**	**TOC**	**Explosives**	**Total Metals**	**Sulfide**	**Cyanide**	**Comments**
7SD01	10/27/1995	0.0-1.0	X	X		X	X	X	X	X	X	X	X	X	X	
7SD02	10/27/1995	0.0-1.0	X	X		X	X	X	X	X	X	X	X	X	X	
7SD03	10/27/1995	0.0-1.0	X	X		X	X	X	X	X	X	X	X	X	X	
7SD04	10/27/1995	0.0-1.0	X	X		X	X	X	X	X	X	X	X	X	X	
7SD1	01/15/02	0.0-0.5	X	X	X						X		X			
7SD2	01/15/02	0.0-0.5	X	X	X						X		X			
7SD3	01/15/02	0.0-0.5	X	X	X						X		X			
7SD4	01/15/02	0.0-0.5	X	X	X						X		X			
7SD4D	01/15/02	0.0-0.5	X	X	X						X		X			Duplicate
7SD5	01/15/02	0.0-0.5	X	X	X						X		X			
7SD6	01/15/02	0.0-0.5	X	X	X						X		X			
7SD7	01/16/02	0.0-0.3	X	X	X						X		X			
7SD8	01/16/02	0.0-0.3	X	X	X						X		X			
7SD9	01/16/02	0.0-0.3	X	X	X						X		X			
7SD11	01/15/02	0.0-0.3	X	X	X						X		X			
7SD11D	01/15/02	0.0-0.3	X	X	X						X		X			Duplicate
7SD12	01/15/02	0.0-0.3	X	X	X						X		X			
7SD13	01/16/02	0.0-0.3	X	X	X						X		X			
7SD14	01/16/02	0.0-0.3	X	X	X						X		X			

Notes:

ft BGS = Feet below ground surface.

TABLE 3-7
PRELIMINARY ASSESSMENT ENDPOINTS, RISK HYPOTHESES, AND MEASUREMENT ENDPOINTS
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Assessment Endpoint	Risk Hypothesis	Measurement Endpoint
Terrestrial Habitat: Survival, growth, and reproduction of terrestrial soil invertebrate communities.	Are site-retated chemical concentrations in surface soil sufficient to adversely effect terrestrial soil invertebrate communities based on conservative screening values?	Comparison of maximum chemical concentrations in surface soil with surface soil screening values.
Survival, growth, and reproduction of terrestrial plant communities.	Are site-related surface soil concentrations sufficient to adversely effect terrestrial plant communities based on conservative screening values?	Comparison of maximum chemical concentrations in surface soil with surface soil screening values.
Survival, growth, and reproduction of terrestrial avian herbivores.	Are site-related chemical concentrations in surface soil sufficient to cause adverse effects (on growth, survival, or reproduction) to avian species that may consume terrestrial plants from the site?	Comparison of literature-derived chronic No Observed Adverse Effect Level (NOAEL) values for survival, growth, and/or reproductive effects with modeled dietary exposure doses based on maximum chemical concentrations in surface soil.
Survival, growth, and reproduction of terrestrial avian omnivores.	Are site-related chemical concentrations in surface soil sufficient to cause adverse effects (on growth, survival, or reproduction) to avian species that may consume terrestrial plants and soil invertebrates from the site?	Comparison of literature-derived chronic No Observed Adverse Effect Level (NOAEL) values for survival, growth, and/or reproductive effects with modeled dietary exposure doses based on maximum chemical concentrations in surface soil.
Survival, growth, and reproduction of terrestrial avian carnivores.	Are site-related chemical concentrations in surface soil sufficient to cause adverse effects (on growth, survival, or reproduction) to avian species that may consume small mammals from the site?	Comparison of literature-derived chronic No Observed Adverse Effect Level (NOAEL) values for survival, growth, and/or reproductive effects with modeled dietary exposure doses based on maximum chemical concentrations in surface soil.
Aquatic Habitat: Survival, growth, and reproduction of aquatic plant communities (i.e., algae)	Are site-related chemical concentrations in surface water/groundwater sufficient to adversely effect aquatic plant communities?	Comparison of maximum chemical concentrations in groundwater and surface water with surface water screening values.
Survival, growth, and reproduction of benthic invertebrate communities.	Are site-related chemical concentrations in surface water/groundwater/sediment sufficient to adversely effect benthic invertebrate communities?	Comparison of maximum chemical concentrations in surface water, groundwater, and sediment with surface water and/or sediment screening values.

TABLE 3-7 (continued)
PRELIMINARY ASSESSMENT ENDPOINTS, RISK HYPOTHESES, AND MEASUREMENT ENDPOINTS
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Assessment Endpoint	Risk Hypothesis	Measurement Endpoint
Aquatic habitat (continued):		
Survival, growth, and reproduction of fish communities.	Are site-related chemical concentrations in surface water/groundwater sufficient to adversely effect fish communities?	Comparison of maximum chemical concentrations in groundwater and surface water with surface water screening values.
Survival, growth, and reproduction of avian piscivores (fish consumers).	Are site-related chemical concentrations in surface water and sediment sufficient to cause adverse effects (on growth, survival, or reproduction) to avian species that may consume fish from the site?	Comparison of literature-derived chronic No Observed Adverse Effect Level (NOAEL) values for survival, growth, and/or reproductive effects with modeled dietary exposure doses based on maximum chemical concentrations in surface water and/or sediment.
Survival,growth, and reproduction of avian carnivorous omnivores (invertebrate and fish consumers).	Are site-related chemical concentrations in surface water and/or sediment sufficient to cause adverse effects (on survival, growth, or reproduction) to avian species that may consume aquatic invertebrates and fish from the site?	Comparison of literature-derived chronic No Observed Adverse Effect Level (NOAEL) values for survival, growth, and/or reproductive effects with modeled dietary exposure doses based on maximum chemical concentrations in surface water and/or sediment.
Survival, growth, and reproduction of mammiliam herbivores (Order Sirenia).	Are site-related chemical concentrations in sediment sufficient to cause adverse effects (on growth, survival, or reproduction) to mammilian herbivores that may consume aquatic plants from the site?	Comparison of literature-derived chronic No Observed Adverse Effect Level (NOAEL) values for survival, growth, and/or reproductive effects with modeled dietary exposure doses based on maximum chemical concentrations in sediment.

TABLE 3-8
LOG K_{ow} AND K_{oc} VALUES FOR ORGANIC CHEMICALS
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Log K_{ow} Range	Recommended Log K_{ow}	Reference	K_{oc} (1) (L/Kg)	Bioaccumulative Chemical (2)
Volatile Organics:					
1,1,1,2-Tetrachloroethane	2.63 to 3.03	2.63	USEPA 1995a	385	Yes
1,1,1-Trichloroethane	2.47 to 2.51	2.48	USEPA 1995a	274	No
1,1,2,2-Tetrachloroethane	2.31 to 2.64	2.39	USEPA 1995a	224	No
1,1,2-Trichloroethane	2.03 to 2.07	2.05	USEPA 1995a	104	No
1,1-Dichloroethane	1.78 to 1.85	1.79	USEPA 1995a	57.5	No
1,1-Dichloroethene	2.13 to 2.37	2.13	USEPA 1995a	124	No
1,2,3-Trichloropropane	1.98 to 2.63	2.25	USEPA 1995a	163	No
1,2-Dibromo-3-chloropropane	2.26 to 2.41	2.34	USEPA 1995a	200	No
1,2-Dibromoethane	Not Reported	1.96	USEPA 1996a	84.5	No
1,2-Dichloroethane	1.40 to 1.48	1.47	USEPA 1995a	27.9	No
1,2-Dichloropropane	1.94 to 1.99	1.97	USEPA 1995a	86.5	No
2-Butanone	0.26 to 0.69	0.28	USEPA 1995a	1.89	No
2-Hexanone	Not Reported	1.39	USEPA 1996a	23.3	No
3-Chloro-1-propene (3-Chloropropene)	Not Reported	1.93	SRC 1998	79.0	No
4-Methyl-2-pentanone (Methyl isobutyl ketone)	1.17 to 1.25	1.19	USEPA 1995a	14.8	No
Acetone	-0.21 to -0.24	-0.24	USEPA 1995a	0.58	No
Acetonitrile	-0.34 to -0.39	-0.34	USEPA 1995a	0.46	No
Acrolein	-0.01 to 0.90	-0.01	USEPA 1995a	0.98	No
Acrylonitrile	-0.92 to 1.20	0.25	USEPA 1995a	1.76	No
Benzene	1.83 to 2.50	2.13	USEPA 1995a	124	No
Bromodichloromethane	1.88 to 2.14	2.10	USEPA 1995a	116	No
Bromoform	2.30 to 2.38	2.35	USEPA 1995a	204	No
Bromomethane	1.08 to 1.19	1.19	USEPA 1995a	14.8	No
Carbon disulfide	1.84 to 2.16	2.00	USEPA 1995a	92.5	No
Carbon tetrachloride	2.03 to 3.10	2.73	USEPA 1995a	483	Yes
Chlorobenzene	2.46 to 3.79	2.86	USEPA 1995a	648	Yes
Chloroethane	Not Reported	1.43	USEPA 1996a	25.5	No
Chloroform	1.81 to 3.04	1.92	USEPA 1995a	77.2	Yes
Chloromethane	0.90 to 0.94	0.91	USEPA 1995a	7.85	No
Chloroprene (2-Chloro-1,3-butadiene)	2.03 to 2.13	2.08	USEPA 1995a	111	No
cis-1,3-Dichloropropene	Not Reported	2.00	USEPA 1996a	92.5	No
Dibromochloromethane	2.13 to 2.24	2.17	USEPA 1995a	136	No
Dibromomethane	1.53 to 2.50	1.62	USEPA 1995a	39.2	No
Dichlorodifluoromethane	2.00 to 2.37	2.16	USEPA 1995a	133	No
Ethylbenzene	3.07 to 3.57	3.14	USEPA 1995a	1,222	Yes
Ethyl methacrylate	1.59 to 1.65	1.59	USEPA 1996a	36.6	No
Iodomethane	Not Reported	1.51	SRC 1998	30.5	No
Isobutanol (Isobutyl alcohol)	0.65 to 0.83	0.75	USEPA 1995a	5.5	No
Methacrylonitrile	0.54 to 0.70	0.54	USEPA 1996a	0.29	No
Methylene chloride	1.22 to 1.40	1.25	USEPA 1995a	16.9	No
Methyl methacrylate	1.11 to 1.38	1.38	USEPA 1995a	22.7	No
Pentachloroethane	Not Reported	3.06	USEPA 1996a	1,019	Yes
Propionitrile (Ethyl cyanide)	Not Reported	0.16	SRC 1998	1.4	No
Styrene	2.76 to 3.16	2.94	USEPA 1995a	777	Yes
Tetrachloroethene	2.53 to 3.70	2.67	USEPA 1995a	422	Yes
Toluene	2.21 to 3.13	2.75	USEPA 1995a	505	Yes
trans-1,2-Dichloroethene	1.77 to 2.10	2.07	USEPA 1995a	108	No
trans-1,3-Dichloropropene	Not Reported	2.00	USEPA 1996a	92.5	No
trans-1,4-Dichloro-2-butene	Not Reported	2.60	SRC 1998	360	No
Trichloroethene	2.42 to 3.14	2.71	USEPA 1995a	462	Yes
Trichlorofluoromethane	2.44 to 2.58	2.53	USEPA 1995a	307	No

TABLE 3-8 (continued)
LOG K_{ow} AND K_{oc} VALUES FOR ORGANIC CHEMICALS
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Log K_{ow} Range	Recommended Log K_{ow}	Reference	K_{oc} [1] (L/Kg)	Bioaccumulative Chemical [2]
Volatile Organics (continued):					
Vinyl Acetate	0.21 to 0.83	0.73	USEPA 1995a	5.22	No
Vinyl Chloride	1.23 to 1.52	1.50	USEPA 1995a	29.8	No
Xylenes (total) [3]	2.77 to 3.54	3.13	USEPA 1995a	1,194	Yes
Semi-Volatile Organics:					
1,2,4,5-Tetrachlorobenzene	4.51 to 4.83	4.64	USEPA 1995a	36,425	Yes
1,2,4-Trichlorobenzene	3.89 to 4.23	4.01	USEPA 1995a	8,752	Yes
1,2-Dichlorobenzene	3.20 to 3.61	3.43	USEPA 1995a	2,355	Yes
1,3,5-Trinitrobenzene	1.18 to 1.37	1.18	USEPA 1995a	14.5	No
1,3-Dichlorobenzene	Not Reported	3.51	USEPA 1996a	2,822	Yes
1,4,-Dichlorobenzene	3.26 to 3.78	3.42	USEPA 1995a	2,302	Yes
1,4-Dioxane	Not Reported	-0.39	USEPA 1996a	0.41	No
1,4-Naphthoquinone	Not Reported	1.71	SRC 1998	48.0	No
1,4-Phenylenediamine (p-Phenylenediamine)	Not Reported	-0.30	SRC 1998	0.51	No
1-Naphthylamine	2.09 to 2.40	2.24	USEPA 1995a	159	No
2,3,4,6-Tetrachlorophenol	Not Reported	4.44	USEPA 1996a	23,163	Yes
2,4,5-Trichlorophenol	2.39 to 4.19	3.90	USEPA 1995a	6,823	Yes
2,4,6-Trichlorophenol	3.29 to 4.05	3.70	USEPA 1995a	4,339	Yes
2,4-Dichlorophenol	2.80 to 3.30	3.08	USEPA 1995a	1,066	Yes
2,4-Dimethylphenol	1.99 to 2.49	2.36	USEPA 1995a	209	No
2,4-Dinitrophenol	1.40 to 1.79	1.55	USEPA 1995a	33.4	No
2,4-Dinitrotoluene	1.98 to 2.05	2.01	USEPA 1995a	94.6	No
2,6-Dichlorophenol	Not Reported	2.75	SRC 1998	505	No
2,6-Dinitrotoluene	1.72 to 2.03	1.87	USEPA 1995a	68.9	No
2-Acetylaminofluorene	Not Reported	3.12	SRC 1998	1,167	Yes
2-Chloronaphthalene	Not Reported	4.14	USEPA 1996a	11,746	Yes
2-Chlorophenol	0.83 to 2.32	2.15	USEPA 1995a	130	No
2-Methylphenol (o-cresol)	1.90 to 2.04	1.99	USEPA 1995a	90.5	No
2-Naphthylamine	2.09 to 2.42	2.28	USEPA 1995a	174	No
2-Nitroaniline	Not Reported	1.86	USEPA 1996a	67.4	No
2-Nitrophenol	Not Reported	1.77	USEPA 1996a	55.0	No
2-Picoline	Not Reported	1.11	SRC 1998	12.3	No
3,3'-Dichlorobenzidine	3.51 to 3.95	3.51	USEPA 1995a	2,822	Yes
3,3'-Dimethylbenzidine	2.34 to 3.01	2.68	USEPA 1995a	431	Yes
3-Methylcholanthrene	6.42 to 6.76	6.42	USEPA 1995a	2,047,104	Yes
3&4-Methylphenol (m,p-cresol) [4]	1.38 to 2.04	1.95	USEPA 1995a	82.6	No
3-Nitroaniline	Not Reported	1.37	USEPA 1996a	22.2	No
4,6-Dinitro-2-methylphenol	Not Reported	2.14	USEPA 1996a	127	No
4-Aminobiphenyl	Not Reported	2.86	SRC 1998	648	No
4-Bromophenyl phenyl ether	4.89 to 5.24	5.00	USEPA 1995a	82,277	Yes
4-Chloro-3-methylphenol	Not Reported	3.10	SRC 1998	1,116	Yes
4-Chloroaniline	1.57 to 2.02	1.85	USEPA 1995a	65.9	No
4-Chlorophenyl-phenylether	4.08 to 5.09	4.95	USEPA 1995a	73,473	Yes
4-Nitroaniline	Not Reported	1.39	USEPA 1996a	23.3	No
4-Nitrophenol	Not Reported	1.94	USEPA 1996a	80.8	No
4-Nitroquinoline-1-oxide	Not Reported	1.09	SRC 1998	11.8	No
5-Nitro-o-toluidine	Not Reported	1.87	SRC 1998	68.9	No
7,12-Dimethylbenz(a)anthracene	5.98 to 6.66	6.62	USEPA 1995a	3,219,141	Yes
Acetophenone	1.55 to 1.72	1.64	USEPA 1995a	41.0	No
A,A-Dimethylphenethylamine	Not Reported	1.90	SRC 1998	73.8	No
Aniline	0.78 to 1.34	0.98	USEPA 1995a	9.20	No
Aramite (total)	Not Reported	4.82	SRC 1998	54,744	Yes

TABLE 3-8 (continued)
LOG K_{ow} AND K_{oc} VALUES FOR ORGANIC CHEMICALS
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Log K_{ow} Range	Recommended Log K_{ow}	Reference	K_{oc} (1) (L/Kg)	Bioaccumulative Chemical (2)
Semi-Volatile Organics (continued):					
Benzoic acid	1.33 to 2.18	1.86	USEPA 1995a	67.4	No
Benzyl alcohol	0.87 to 1.22	1.11	USEPA 1995a	12.3	No
Bis(2-chloroethoxy)methane	Not Reported	1.30	SRC 1998	19.0	No
Bis(2-chloroethyl)ether	1.00 to 1.29	1.21	USEPA 1995a	15.5	No
Bis(2-chloroisopropyl)ether	2.40 to 2.58	2.58	USEPA 1995a	343.9	No
Bis(2-ethylhexyl)phthalate	4.20 to 8.61	7.30	USEPA 1995a	15,003,065	Yes
Butylbenzylphthalate	3.57 to 5.02	4.84	USEPA 1995a	57,280	Yes
Diallate (total)	3.79 to 5.23	4.49	USEPA 1995a	25,939	Yes
Dibenzofuran	Not Reported	4.20	USEPA 1996a	13,455	Yes
Diethylphthalate	1.40 to 3.00	2.50	USEPA 1995a	287	Yes
Dimethylphthalate	1.34 to 1.90	1.57	USEPA 1995a	35.0	No
Di-n-butylphthalate	3.74 to 4.79	4.61	USEPA 1995a	34,034	Yes
Di-n-octylphthalate	8.03 to 9.49	8.06	USEPA 1995a	83,803,084	Yes
Dinoseb (2-Sec-butyl-4,6-dinitrophenol)	Not Reported	3.14	USEPA 1996a	1,222	Yes
Ethyl methanesulfonate	0.01 to 0.05	0.05	USEPA 1995a	1.12	No
Hexachlorobenzene	5.00 to 7.42	5.89	USEPA 1995a	616,808	Yes
Hexachlorobutadiene	Not Reported	4.81	USEPA 1996a	53,519	Yes
Hexachlorocyclopentadiene	5.04 to 5.51	5.39	USEPA 1995a	198,907	Yes
Hexachloroethane	3.82 to 4.14	4.00	USEPA 1995a	8,556	Yes
Hexachlorophene	7.08 to 7.60	7.54	USEPA 1995a	25,828,548	Yes
Hexachloropropene	Not Reported	4.38	SRC 1998	20,222	Yes
Isophorone	1.67 to 1.90	1.70	USEPA 1995a	46.9	No
Isosafrole	Not Reported	3.37	SRC 1998	2,056	Yes
m-Dinitrobenzene (1,3-Dinitrobenzene)	1.49 to 1.63	1.50	USEPA 1995a	29.8	No
Methapyrilene	Not Reported	2.87	SRC 1998	663	No
Methyl methanesulfonate	Not Reported	-0.66	SRC 1998	0.22	No
Nitrobenzene	1.70 to 2.93	1.84	USEPA 1995a	64.4	No
n-Nitrosodiethylamine	0.29 to 0.56	0.48	USEPA 1995a	2.97	No
n-Nitrosodimethylamine	-0.77 to -0.48	-0.57	USEPA 1995a	0.28	No
n-Nitroso-di-n-butylamine	2.41 to 2.45	2.41	USEPA 1995a	234	No
n-Nitroso-di-n-propylamine	1.31 to 1.49	1.40	USEPA 1995a	23.8	No
n-Nitrosodiphenylamine	3.13 to 3.45	3.16	USEPA 1995a	1,278	Yes
n-Nitrosomethylethylamine	-0.24 to 1.35	-0.12	USEPA 1995a	0.76	No
n-Nitrosomorpholine	Not Reported	-0.44	SRC 1998	0.37	No
n-Nitrosopiperidine	0.25 to 0.63	0.63	USEPA 1995a	4.16	No
n-Nitrosopyrrolidine	-0.29 to -0.19	-0.19	USEPA 1995a	0.65	No
o,o,o-Triethylphosphorothioate	Not Reported	2.64	SRC 1998	393.9	No
o-Toluidine	1.29 to 1.63	1.34	USEPA 1995a	20.8	No
p-Dimethylaminoazobenzene	Not Reported	4.58	SRC 1998	31,799	Yes
Pentachlorobenzene	4.88 to 6.12	5.26	USEPA 1995a	148,204	Yes
Pentachloronitrobenzene	4.18 to 4.64	4.64	USEPA 1995a	36,425	Yes
Pentachlorophenol	3.29 to 5.24	5.09	USEPA 1995a	100,867	Yes
Phenacetin	Not Reported	1.58	SRC 1998	35.8	No
Phenol	0.79 to 1.55	1.48	USEPA 1995a	28.5	No
Pronamide	3.26 to 3.86	3.51	USEPA 1995a	2,822	Yes
Pryridine	0.62 to 1.28	0.67	USEPA 1995a	4.56	No
Safrole	2.66 to 2.88	2.66	USEPA 1995a	412	No
PAHs:					
1-Methylnaphthalene	Not Reported	3.87	SRC 1998	6,375	Yes
2-Methylnaphthalene	Not Reported	3.90	USEPA 1996a	6,823	Yes
Acenaphthene	3.77 to 4.49	3.92	USEPA 1995a	7,139	Yes

TABLE 3-8 (continued)
LOG K_{ow} AND K_{oc} VALUES FOR ORGANIC CHEMICALS
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Log K_{ow} Range	Recommended Log K_{ow}	Reference	K_{oc} [1] (L/Kg)	Bioaccumulative Chemical [2]
PAHs (continued):					
Acenaphthylene	Not Reported	3.55	USEPA 1996a	3,090	Yes
Anthracene	3.45 to 4.80	4.55	USEPA 1995a	29,712	Yes
Benzo(a)anthracene	4.00 to 5.79	5.70	USEPA 1995a	401,218	Yes
Benzo(a)pyrene	5.98 to 6.42	6.11	USEPA 1995a	1,014,869	Yes
Benzo(b)fluoranthene	5.79 to 6.40	6.20	USEPA 1995a	1,244,171	Yes
Benzo(g,h,i)perylene	6.58 to 7.05	6.70	USEPA 1995a	3,858,158	Yes
Benzo(k)fluoranthene	6.12 to 6.27	6.20	USEPA 1995a	1,244,171	Yes
Chrysene	5.41 to 5.79	5.70	USEPA 1995a	401,218	Yes
Dibenzo(a,h)anthracene	6.50 to 6.88	6.69	USEPA 1995a	3,771,812	Yes
Fluoranthene	4.31 to 5.39	5.12	USEPA 1995a	107,954	Yes
Fluorene	4.04 to 4.40	4.21	USEPA 1995a	13,763	Yes
Indeno(1,2,3-cd)pyrene	6.58 to 6.72	6.65	USEPA 1995a	3,445,323	Yes
Naphthalene	3.01 to 4.70	3.36	USEPA 1995a	2,010	Yes
Phenanthrene	4.28 to 4.57	4.55	USEPA 1995a	29,712	Yes
Pyrene	4.76 to 5.52	5.11	USEPA 1995a	105,538	Yes

Notes:

K_{ow} = Octanol-Water Partition Coefficient.
K_{oc} = Organic Carbon Partition Coefficient.

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

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

(3) The log`K_{ow} range and recommended log K_{ow} value shown are for o-xylene.

(4) The log K_{ow} range and recommended log K_{ow} value shown are for 4-methylphenol.

TABLE 3-9
SURFACE SOIL SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Soil Screening Value	Reference	Comment
Volatile Organics (ug/kg):			
1,1,1,2-Tetrachloroethane	---	---	---
1,1,1-Trichloroethane	---	---	---
1,1,2,2-Tetrachloroethane	---	---	---
1,1,2-Trichloroethane	---	---	---
1,1-Dichloroethane	---	---	---
1,1-Dichloroethene	---	---	---
1,2,3-Trichloropropane	---	---	---
1,2-Dibromo-3-chloropropane	---	---	---
1,2-Dibromoethane	---	---	---
1,2-Dichloroethane	401 (1)	MHSPE 1994	---
1,2-Dichloropropane	700,000	Efroymson et. al. 1997a	Toxicological threshold for earthworms
2-Butanone	---	---	---
2-Hexanone	---	---	---
3-Chloro-1-propene	---	---	---
4-Methyl-2-pentanone	---	---	---
Acetone	---	---	---
Acetonitrile	---	---	---
Acrolein	---	---	---
Acrylonitrile	1,000,000	Efroymson et. al. 1997a	Toxicological threshold for earthworms
Benzene	105 (1)	MHSPE 1994	---
Bromodichloromethane	---	---	---
Bromoform	---	---	---
Bromomethane	---	---	---
Carbon disulfide	---	---	---
Carbon tetrachloride	1,000,000	Efroymson et al. 1997a	Toxicological threshold for microbial processes
Chlorobenzene	40,000	Efroymson et al. 1997a	Toxicological threshold for earthworms
Chloroethane	---	---	---
Chloroform	1,000 (1)	MHSPE 1994	---
Chloromethane	---	---	---
Chloroprene	---	---	---
cis-1,3-Dichloropropene	---	---	---

TABLE 3-9 (continued)
SURFACE SOIL SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Soil Screening Value	Reference	Comment
Volatile Organics (continued) (ug/kg):			
Dibromochloromethane	---	---	---
Dibromomethane	---	---	---
Dichlorodifluoromethane	---	---	---
Ethylbenzene	5,005 (1)	MHSPE 1994	---
Ethyl methacrylate	---	---	---
Iodomethane	---	---	---
Isobutanol	---	---	---
Methacrylonitrile	---	---	---
Methylene chloride	1,001 (1)	MHSPE 1994	---
Methyl methacrylate	---	---	---
Pentachloroethane	---	---	---
Propionitrile	---	---	---
Styrene	10,010 (1)	MHSPE 1994	---
Tetrachloroethene	401 (1)	MHSPE 1994	---
Toluene	13,005 (1)	MHSPE 1994	---
trans-1,2-Dichloroethene	---	---	---
trans-1,3-Dichloropropene	---	---	---
trans-1,4-Dichloro-2-butene	1,000,000	Efroymson et. al. 1997a	Toxicological threshold for earthworms
Trichloroethene	6,000 (1)	MHSPE 1994	--
Trichlorofluoromethane	---	---	---
Vinyl acetate	---	---	---
Vinyl chloride	11	MHSPE 1994	---
Xylene	2,505	MHSPE 1994	---
Semi-Volatile Organics (ug/kg):			
1,2,4,5-Tetrachlorobenzene	---	---	---
1,2,4-Trichlorobenzene	20,000	Efroymson et. al. 1997a	Toxicological threshold for earthworms
1,3,5-Trinitrobenzene	---	---	---
1,2-Dichlorobenzene	3,001 (1)	MHSPE 1994	---
1,3-Dichlorobenzene	3,001 (1)	MHSPE 1994	---
1,4,-Dichlorobenzene	20,000	Efroymson et. al. 1997a	Toxicological threshold for earthworms

TABLE 3-9 (continued)
SURFACE SOIL SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Soil Screening Value	Reference	Comment
Semi-Volatile Organics (continued) (ug/kg):			
1,4-Dioxane	---	---	---
1,4-Naphthoquinone	---	---	---
1,4-Phenylenediamine	---	---	---
1-Methylnaphthalene	---	---	---
1-Naphthylamine	---	---	---
2,3,4,6-Tetrachlorophenol	1,000 (1)	MHSPE 1994	---
2,4,5-Trichlorophenol	4,000	Efroymson et. al. 1997b	Toxicological threshold for plants
2,4,6-Trichlorophenol	10,000	Efroymson et. al. 1997a	Toxicological threshold for earthworms
2,4-Dichlorophenol	---	---	---
2,4-Dimethylphenol	---	---	---
2,4-Dinitrophenol	20,000	Efroymson et. al. 1997b	Toxicological threshold for plants
2,4-Dinitrotoluene	---	---	---
2,6-Dichlorophenol	1,001 (1)	MHSPE 1994	Total chlorophenol value
2,6-Dinitrotoluene	---	---	---
2-Acetylaminofluorene	---	---	---
2-Chloronaphthalene	1,033 (1)	MHSPE 1994	---
2-Chlorophenol	---	---	---
2-Methylnaphthalene	---	---	---
2-Methylphenol	---	---	---
2-Naphthalamine	---	---	---
2-Nitroaniline	---	---	---
2-Nitrophenol	---	---	---
2-Picoline	---	---	---
3,3'-Dichlorobenzidine	---	---	---
3,3'-Dimethylbenzidine	---	---	---
3-Methylcholanthrene	---	---	---
3&4-Methylphenol	---	---	---
3-Nitroaniline	---	---	---
4,6-Dinitro-2-methylphenol	---	---	---
4-Aminobiphenyl	---	---	---
4-Bromophenyl phenyl ether	---	---	---

TABLE 3-9 (continued)
SURFACE SOIL SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Soil Screening Value	Reference	Comment
Semi-Volatile Organics (continued) (ug/kg):			
4-Chloro-3-methylphenol	---	---	---
4-Chloroaniline	---	---	---
4-Chlorophenyl-Phenylether	---	---	---
4-Nitroaniline	---	---	---
4-Nitrophenol	7,000	Efroymson et. al. 1997a	Toxicological threshold for earthworms
4-Nitroquinoline-1-oxide	---	---	---
5-Nitro-o-toluidine	---	---	---
7,12-Dimethyl benz(a)anthracene	---	---	---
Acenaphthene	20,000	Efroymson et. al. 1997b	Toxicological threshold for plants
Acenaphthylene	1,200	USEPA 1999a	Value for benzo(a)pyrene used as a surrogate
Acetophenone	---	---	---
A, A-Dimethylphenethylamine	---	---	---
Aniline	---	---	---
Anthracene	1,200	USEPA 1999a	Value for benzo(a)pyrene used as a surrogate
Aramite	---	---	---
Benzo(a)anthracene	1,200	USEPA 1999a	Value for benzo(a)pyrene used as a surrogate
Benzo(a)pyrene	1,200	USEPA 1999a	Toxicological threshold for plants
Benzo(b)fluoranthene	1,200	USEPA 1999a	Toxicological threshold for plants
Benzo(g,h,i)perylene	1,200	USEPA 1999a	Value for benzo(a)pyrene used as a surrogate
Benzo(k)fluoranthene	1,200	USEPA 1999a	Value for benzo(a)pyrene used as a surrogate
Benzoic acid	---	---	---
Benzyl alcohol	---	---	---
Bis(2-chloroethoxy)methane	---	---	---
Bis(2-chloroethyl)ether	---	---	---
Bis(2-chloroisopropyl)ether	---	---	---
Bis(2-ethylhexyl)phthalate	6,010 (1)(2)	MHSPE 1994	Total phthalate value
Butylbenzylphthalate	6,010 (1)(2)	MHSPE 1994	Total phthalate value
Chrysene	1,200	USEPA 1999a	Value for benzo(a)pyrene used as a surrogate
Diallate	---	---	---
Dibenzo(a,h)anthracene	1,200	USEPA 1999a	Value for benzo(a)pyrene used as a surrogate
Dibenzofuran	---	---	---

TABLE 3-9 (continued)
SURFACE SOIL SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Soil Screening Value	Reference	Comment
Semi-Volatile Organics (continued) (ug/kg):			
Diethylphthalate	100,000	Efroymson et. al. 1997b	Toxicological threshold for plants
Dimethylphthalate	200,000	Efroymson et. al. 1997a	Toxicological threshold for earthworms
Di-n-butylphthalate	200,000	Efroymson et. al. 1997b	Toxicological threshold for plants
Di-n-octylphthalate	6,010 (1)(2)	MHSPE 1994	Total phthalate value
Dinoseb	---	---	---
Ethyl methanesulfonate	---	---	---
Fluoranthene	1,200	USEPA 1999a	Value for benzo(a)pyrene used as a surrogate
Fluorene	30,000	Efroymson et. al. 1997a	Toxicological threshold for earthworms
Hexachlorobenzene	---	---	---
Hexachlorobutadiene	---	---	---
Hexachlorocyclopentadiene	10,000	Efroymson et. al. 1997b	Toxicological threshold for plants
Hexachloroethane	---	---	---
Hexachlorophene	---	---	---
Hexachloropropene	---	---	---
Indeno(1,2,3-cd)pyrene	1,200	USEPA 1999a	Value for benzo(a)pyrene used as a surrogate
Isophorone	---	---	---
Isosafrole	---	---	---
m-Dinitrobenzene	---	---	---
Methapyrilene	---	---	---
Methyl methanesulfonate	---	---	---
Naphthalene	1,200	USEPA 1999a	Value for benzo(a)pyrene used as a surrogate
Nitrobenzene	40,000	Efroymson et. al. 1997a	Toxicological threshold for earthworms
n-Nitrosodiethylamine	20,000	---	Value for n-Nitrosdiphenylamine used as a surrogate
n-Nitrosodimethylamine	20,000	---	Value for n-Nitrosdiphenylamine used as a surrogate
n-Nitroso-di-n-butylamine	20,000	---	Value for n-Nitrosdiphenylamine used as a surrogate
n-Nitroso-di-n-propylamine	20,000	---	Value for n-Nitrosdiphenylamine used as a surrogate
n-Nitrosodiphenylamine	20,000	Efroymson et. al. 1997a	Toxicological threshold for earthworms
n-Nitrosomethylethylamine	20,000	---	Value for n-Nitrosdiphenylamine used as a surrogate
n-Nitrosomorpholine	---	---	---
n-Nitrosopiperidine	---	---	---
n-Nitrosopyrrolidine	---	---	---

TABLE 3-9 (continued)
SURFACE SOIL SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Soil Screening Value	Reference	Comment
Semi-Volatile Organics (continued) (ug/kg):			
o,o,o-Triethylphosphorothioate	---	---	---
o-Toluidine	---	---	---
p-Dimethylaminoazobenzene	---	---	---
Pentachlorobenzene	20,000	Efroymson et. al. 1997a	Toxicological threshold for earthworms
Pentachloronitrobenzene	---	---	---
Pentachlorophenol	3,000	Efroymson et. al. 1997b	Toxicological threshold for plants
Phenacetin	---	---	---
Phenanthrene	1,200	USEPA 1999a	Value for benzo(a)pyrene used as a surrogate
Phenol	30,000	Efroymson et. al. 1997a	Toxicological threshold for earthworms
Pronamide	---	---	---
Pryridine	60 (1)	MHSPE 1994	---
Pyrene	1,200	USEPA 1999a	Value for benzo(a)pyrene used as a surrogate
Safrole	---	---	---
Inorganics (mg/kg):			
Antimony	5	Efroymson et. al. 1997b	Toxicological threshold for plants
Arsenic	10	Efroymson et. al. 1997b	Toxicological threshold for plants
Barium	500	Efroymson et. al. 1997b	Toxicological threshold for plants
Beryllium	10	Efroymson et. al. 1997b	Toxicological threshold for plants
Cadmium	4	Efroymson et. al. 1997b	Toxicological threshold for plants
Chromium	0.4	Efroymson et. al. 1997a	Toxicological threshold for plants
Cobalt	20	Efroymson et. al. 1997b	Toxicological threshold for plants
Copper	50	Efroymson et. al. 1997a	Toxicological threshold for earthworms
Lead	50	Efroymson et. al. 1997b	Toxicological threshold for plants
Mercury	0.1	Efroymson et. al. 1997a	Toxicological threshold for earthworms
Nickel	30	Efroymson et. al. 1997b	Toxicological threshold for plants
Selenium	1	Efroymson et. al. 1997b	Toxicological threshold for plants
Silver	2	Efroymson et. al. 1997b	Toxicological threshold for plants
Thallium	1	Efroymson et. al. 1997b	Toxicological threshold for plants
Tin	50	Efroymson et. al. 1997b	Toxicological threshold for plants
Vanadium	2	Efroymson et. al. 1997b	Toxicological threshold for plants
Zinc	50	Efroymson et. al. 1997b	Toxicological threshold for plants

TABLE 3-9 (continued)
SURFACE SOIL SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Notes:

NA = Not Available.
MHSPE = Ministry of Housing, Spatial Planning and Environment.

(1) The screening value shown is an average of the MHSPE target and intervention soil standards. The value is based on a default organic carbon content (f_{oc}) of 0.02 (2.0 percent), which represents a minimum value (adjustment range is 2 to 30 percent).

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

TABLE 3-10
MARINE SURFACE WATER SCREENING VALUES
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Water Screening Value [1]	Reference	Comment
Volatile Organics (ug/L):			
1,1,1,2-Tetrachloroethane	902	Buchman 1999	Acute LOEL with a safety factor of 10
1,1,1-Trichloroethane	312	USEPA 2001	EPA Region 4 chronic screening value
1,1,2,2-Tetrachloroethane	90.2	USEPA 2001	EPA Region 4 chronic screening value
1,1,2-Trichloroethane	340	USEPA 1996a	Acute value (LC_{50}) with a safety factor of 100
1,1-Dichloroethane	47 [2]	USEPA 1996b	Tier II Value
1,1-Dichloroethene	2,240	USEPA 2001	EPA Region 4 chronic screening value
1,2,3-Trichloropropane	274 [2]	USEPA 1996a	Acute value (LC_{50}) with a safety factor of 100
1,2-Dibromo-3-chloropropane	100	USEPA 2000b	Minimum acute value (EC_{50}) with a safety factor of 100
1,2-Dibromoethane	48	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
1,2-Dichloroethane	1,130	USEPA 2001	EPA Region 4 chronic screening value
1,2-Dichloropropane	2,400	USEPA 2001	EPA Region 4 chronic screening value
2-Butanone	40,000	USEPA 2000b	Minimum acute value (NOEC) with a safety factor of 10
2-Hexanone	98.8 [2]	Suter II 1996	Tier II Secondary Chronic Value
3-Chloro-1-propene (3-Chloropropene)	3.4 [2]	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
4-Methyl-2-pentanone (Methyl isobutyl ketone)	164 [2]	Sutter II 1996	Tier II Secondary Chronic Value
Acetone	1,000	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
Acetonitrile	160,000 [2]	USEPA 2000b	Minimum chronic value (NOEC for reproduction)
Acrolein	0.55	USEPA 2001	EPA Region 4 chronic screening value
Acrylonitrile	58.1	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
Benzene	109	USEPA 2001	EPA Region 4 chronic screening value
Bromodichloromethane	6,400	Buchman 1999	Chronic LOEL for chemical class
Bromoform	640	USEPA 2001	EPA Region 4 chronic screening value
Bromomethane	120	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
Carbon disulfide	650	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
Carbon tetrachloride	1,500	USEPA 2001	EPA Region 4 chronic screening value
Chlorobenzene	105	USEPA 2001	EPA Region 4 chronic screening value
Chloroethane	NA	---	---
Chloroform	815	USEPA 2001	EPA Region 4 chronic screening value
Chloromethane	2,700	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
Chloroprene (2-Chloro-1,3-butadiene)	NA	---	---

TABLE 3-10 (continued)
MARINE SURFACE WATER SCREENING VALUES
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Water Screening Value	Reference	Comment
Volatile Organics (ug/L) (continued):			
cis-1,3-Dichloropropene	7.9	USEPA 2001	EPA Region 4 chronic screening value
Dibromochloromethane	6,400	Buchman 1999	Chronic LOEL for chemical class
Dibromomethane	6,400	Buchman 1999	Chronic LOEL for chemical class
Dichlorodifluoromethane	6,400	Buchman 1999	Chronic LOEL for chemical class
Ethylbenzene	4.3	USEPA 2001	EPA Region 4 chronic screening value
Ethyl methacrylate	NA	---	---
Iodomethane	NA	---	---
Isobutanol (isobutyl alcohol)	10,000	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
Methacrylonitrile	NA	---	---
Methylene Chloride	2,560	USEPA 2001	EPA Region 4 chronic screening value
Methyl methacrylate	1,300 (2)	USEPA 1996a	Acute value (LC_{50}) with a safety factor of 100
Pentachloroethane	281	Buchman 1999	Chronic LOEL
Propionitrile (ethyl cyanide)	15,200 (2)	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
Styrene	510	USEPA 2000b	Minimum acute value (NOEC) with a safety factor of 10
Tetrachloroethene	45	USEPA 2001	EPA Region 4 chronic screening value
Toluene	37	USEPA 2001	EPA Region 4 chronic screening value
trans-1,2-Dichloroethene	22,400	Buchman 1999	Acute LOEL (cis and trans isomers) with a safety factor of 10
trans-1,3-Dichloropropene	7.9	USEPA 2001	EPA Region 4 chronic screening value (cis and trans isomers)
trans-1,4-Dichloro-2-butene	NA	---	---
Trichloroethene	200	Buchman 1999	Acute LOEL with a safety factor of 10
Trichlorofluoromethane	6,400	Buchman 1999	Chronic LOEL for chemical class
Vinyl Acetate	10,000	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
Vinyl Chloride	87.8 (2)	Suter II 1996	Tier II Secondary Chronic Value
Xylene (total)	41 (3)	USEPA 2000b	Minimum acute value (EC_{50}) with a safety factor of 100
Semi-Volatile Organics (ug/L):			
1,2,4,5-Tetrachlorobenzene	30	USEPA 2000b	Minimum acute value (NOEC) with a safety factor of 10
1,2,4-Trichlorobenzene	4.5	USEPA 2001	EPA Region 4 chronic screening value
1,2-Dichlorobenzene	19.7	USEPA 2001	EPA Region 4 chronic screening value
1,3,5-Trinitrobenzene	NA	---	---
1,3-Dichlorobenzene	28.5	USEPA 2001	EPA Region 4 chronic screening value
1,4,-Dichlorobenzene	19.9	USEPA 2001	EPA Region 4 chronic screening value
1,4-Dioxane	67,000	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100

TABLE 3-10 (continued)
MARINE SURFACE WATER SCREENING VALUES
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Water Screening Value	Reference	Comment
Semi-Volatile Organics (ug/L) (continued):			
1,4-Naphthoquinone	NA	---	---
1,4-Phenylenediamine (p-phenylenediamine)	200 (2)	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
1-Naphthylamine	NA	---	---
2,3,4,6-Tetrachlorophenol	44	Buchman 1999	Acute LOEL with a safety factor of 10
2,4,5-Trichlorophenol	11	Buchman 1999	Proposed CCC
2,4,6-Trichlorophenol	12.1	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
2,4-Dichlorophenol	5	USEPA 2000b	Minimum acute value (NOEC) with a safety factor of 10
2,4-Dimethylphenol	131	USEPA 2000b	Minimum chronic value (NOEC for survival)
2,4-Dinitrophenol	48.5	USEPA 2001	EPA Region 4 chronic screening value
2,4-Dinitrotoluene	370	Bunchman 1999	Chronic LOEL
2,6-Dichlorophenol	54	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
2,6-Dinitrotoluene	370	---	Screening value for 2,4-dinitrotoluene used as a surrogate
2-Acetylaminofluorene	100 (2)	USEPA 2000b	Minimum acute value (LOEC) with a safety factor of 10
2-Chloronaphthalene	NA	---	---
2-Chlorophenol	53	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
2-Methylphenol (o-cresol)	102	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
2-Naphthylamine	NA	---	---
2-Nitroaniline	48.9 (2)	USEPA 2000b	Minimum acute value (EC_{50}) with a safety factor of 100
2-Nitrophenol	10,000	USEPA 2000b	Minimum chronic value (MATC for survival)
2-Picoline	8,979 (2)	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
3,3'-Dichlorobenzidine	10.5 (2)	USEPA 2000b	Minimum acute value (EC_{50}) with a safety factor of 100
3,3'-Dimethylbenzidine	160 (2)	USEPA 2000b	Minimum chronic value (NOEC for behavior)
3-Methylcholanthrene	NA	---	---
3&4-Methylphenol (m,p-cresol)	50 (4)	USEPA 2000b	Minimum acute value (EC_{50}) with a safety factor of 100
3-Nitroaniline	9.8 (2)	USEPA 2000b	Minimum acute value (EC_{50}) with a safety factor of 100
4,6-Dinitro-2-methylphenol	183 (2)	USEPA 2000b	Minimum chronic value (NOEC for growth)
4-Aminobiphenyl	NA	---	---
4-Bromophenyl phenyl ether	3.6 (2)	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
4-Chloro-3-methylphenol	1,300 (2)	USEPA 2000b	Minimum chronic value (NOEC for reproduction)
4-Chloroaniline	129	Buchman 1999	Chronic LOEL for chemical class

TABLE 3-10 (continued)
MARINE SURFACE WATER SCREENING VALUES
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Water Screening Value	Reference	Comment
Semi-Volatile Organics (ug/L) (continued):			
4-Chlorophenyl-phenylether	7.3 (2)	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
4-Nitroaniline	170 (2)	USEPA 2000b	Minimum acute value (EC_{50}) with a safety factor of 100
4-Nitrophenol	71.7	USEPA 2001	EPA Region 4 chronic screening value
4-Nitroquinoline-1-oxide	NA	---	---
5-Nitro-o-toluidine	225 (2)	USEPA 2000b	Minimum acute value (EC_{50}) with a safety factor of 100
7,12-Dimethyl benz(a)anthracene	30	Buchman 1999	Acute LOEL for chemical class with a safety factor of 10
Acetophenone	1,550 (2)	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
A,A-Dimethylphenethylamine	NA	---	---
Aniline	294	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
Aramite (total)	0.6 (2)	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
Benzoic Acid	1,800 (2)	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
Benzyl Alcohol	150	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
Bis(2-chloroethoxy)methane	6,400	Buchman 1999	Chronic LOEL for the chemical class
Bis(2-chloroethyl)ether	910 (2)	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
Bis (2-chloroisopropyl)ether	NA	---	---
Bis(2-ethylhexyl)phthalate	360	Buchman 1999	Proposed CCC
Butylbenzylphthalate	29.4	USEPA 2001	EPA Region 4 chronic screening value
Diallate (total)	82 (2)	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
Dibenzofuran	100	USEPA 2000b	Minimum acute value (NOEC) with a safety factor of 100
Diethylphthalate	75.9	USEPA 2001	EPA Region 4 chronic screening value
Dimethylphthalate	580	USEPA 2001	EPA Region 4 chronic screening value
Di-n-butylphthalate	3.4	USEPA 2001	EPA Region 4 chronic screening value
Di-n-octylphthalate	3,450	USEPA 2000b	Minimum acute value (NOEC) with a safety factor of 10
Dinoseb (2-sec-butyl-4,6-dinitrophenol)	1.7	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
Ethyl methanesulfonate	NA	---	---
Hexachlorobenzene	10	USEPA 2000b	Minimum acute value (EC_{50}) with a safety factor of 100
Hexachlorobutadiene	0.32	USEPA 2001	EPA Region 4 chronic screening value
Hexachlorocyclopentadiene	0.07	USEPA 2001	EPA Region 4 chronic screening value
Hexachloroethane	9.4	USEPA 2001	EPA Region 4 chronic screening value
Hexachlorophene	8.8 (2)	USEPA 2000b	Minimum chronic value (NOEC for survival and growth)

TABLE 3-10 (continued)
MARINE SURFACE WATER SCREENING VALUES
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Water Screening Value	Reference	Comment
Semi-Volatile Organics (ug/L) (continued):			
Hexachloropropene	NA	---	---
Isophorone	129	USEPA 2001	EPA Region 4 chronic screening value
Isosafrole	NA	---	---
m-Dintrobenzene (1,3-dinitrobenzene)	66.8	---	Screening value for nitrobenzene used as a surrogate
Methapyrilene	NA	---	---
Methyl methanesulfonate	NA	---	---
Nitrobenzene	66.8	USEPA 2001	EPA Region 4 chronic screening value
n-Nitrosodiethylamine	330,000	Buchman 1999	Acute LOEL for chemical class with a safety factor of 10
n-Nitrosodimethylamine	27,000	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
n-Nitroso-di-n-butylamine	330,000	Buchman 1999	Acute LOEL for chemical class with a safety factor of 10
n-Nitroso-di-n-propylamine	330,000	Assumed	Acute LOEL for chemical class with a safety factor of 10
n-Nitrosodiphenylamine	33,000	USEPA 2001	EPA Region 4 chronic screening value
n-Nitrosomethylethylamine	330,000	Assumed	Acute LOEL for chemical class with a safety factor of 10
n-Nitrosomorpholine	NA	---	---
n-Nitrosopiperidine	NA	---	---
n-Nitrosopyrrolidine	NA	---	---
o,o,o-Triethylphosphorothioate	NA	---	---
o-Toluidine	400	USEPA 2000b	Minimum Acute value (LC_{50}) with a safety factor of 100
p-Dimethylaminoazobenzene	NA	---	---
Pentachlorobenzene	129	USEPA 2001	EPA Region 4 chronic screening value
Pentachloronitrobenzene	0.23	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
Pentachlorophenol	7.9	USEPA 1999b	CCC
Phenacetin	NA	---	---
Phenol	58	USEPA 2001	EPA Region 4 chronic screening value
Pronamide	35	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
Pryridine	500	USEPA 2000b	Minimum Acute value (LC_{50}) with a safety factor of 100
Safrole	NA	---	---
PAHs (ug/L):			
1-Methylnaphthalene	19	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
2-Methylnaphthalene	6	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
Acenaphthene	9.7	USEPA 2001	EPA Region 4 chronic screening value
Acenaphthylene	30	Buchman 1999	Acute LOEL for chemical class with a safety factor of 10
Anthracene	50	USEPA 1996a	Acute value (LC_{50}) with a safety factor of 100

TABLE 3-10 (continued)
MARINE SURFACE WATER SCREENING VALUES
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Surface Water Screening Value	Reference	Comment
PAHs (ug/L) (continued):			
Benzo(a)anthracene	30	Buchman 1999	Acute LOEL for chemical class with a safety factor of 10
Benzo(a)pyrene	10	USEPA 1996b	Acute value (LC_{50}) with a safety factor of 100
Benzo(b)fluoranthene	30	Buchman 1999	Acute LOEL for chemical class with a safety factor of 10
Benzo(g,h,i)perylene	30	Buchman 1999	Acute LOEL for chemical class with a safety factor of 10
Benzo(k)fluoranthene	30	Buchman 1999	Acute LOEL for chemical class with a safety factor of 10
Chrysene	10	USEPA 1996b	Acute value (LC_{50}) with a safety factor of 100
Dibenzo(a,h)anthracene	30	Buchman 1999	Acute LOEL for chemical class with a safety factor of 10
Fluoranthene	11	USEPA 1996b	Final Chronic Value
Fluorene	10	USEPA 2000b	Minimum acute value (LC_{50}) with a safety factor of 100
Indeno(1,2,3-cd)pyrene	30	Buchman 1999	Acute LOEL for chemical class with a safety factor of 10
Naphthalene	23.5	USEPA 2001	EPA Region 4 chronic screening value
Phenanthrene	8.3	USEPA 1996b	Final Chronic Value
Pyrene	30	Buchman 1999	Acute LOEL for chemical class with a safety factor of 10
Inorganics (ug/L):			
Antimony	500	Buchman 1999	Proposed CCC
Arsenic	36	USEPA 1999b	Total recoverable CCC for trivalent arsenic
Barium	50,000	USEPA 2000b	Minimum acute value (NOEC) with a safety factor of 10
Beryllium	310	USEPA 2000b	Minimum acute value (LC_{50}) and a safety factor of 100
Cadmium	9.4	USEPA 1999b	Total recoverable CCC
Chromium (total)	50.4	USEPA 1999b	Total recoverable CCC for hexavalent chromium
Cobalt	45	USEPA 2000b	Minimum acute value (LC_{50}) and a safety factor of 100
Copper	3.7	USEPA 1999b	Total recoverable CCC
Lead	8.5	USEPA 1999b	Total recoverable CCC
Mercury	1.1	USEPA 1999b	Total recoverable CCC
Nickel	8.3	USEPA 1999b	Total recoverable CCC
Selenium	71.1	USEPA 1999b	Total recoverable CCC
Silver	0.23	USEPA 2001	EPA Region 4 chronic screening value
Thallium	21.3	USEPA 2001	EPA Region 4 chronic screening value
Tin	NA	---	---
Vanadium	NA	---	---
Zinc	85.6	USEPA 1999b	Total recoverable CCC

TABLE 3-10 (continued)
MARINE SURFACE WATER SCREENING VALUES
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Notes:

NA = Not Available.
CCC = Criteria Continuous Concentration.
LOEL = Lowest Observed Effect Level.
MATC = Maximum Acceptable Toxicant Concentration.
NOEC = No Observed Effect Concentration.
EC_{50} = Median Effective Concentration.
LC_{50} = Median Lethal Concentration.
SCV = Secondary Chronic Value

(1) The values shown are marine/estuarine screening values unless otherwise noted.
(2) The chemical lacks a marine/estuarine surface water screening value. The value shown is a freshwater screening value.
(3) The surface water screening value shown is for o-xylene.
(4) The surface water screening value shown is for 4-methylphenol (p-cresol)

TABLE 3-11
MARINE SEDIMENT SCREENING VALUES
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value	Reference	Comment [1]
Volatile Organics (ug/kg):			
1,1,1,2-Tetrachloroethane	729	USEPA 1993a	EqP-based screening value
1,1,1-Trichloroethane	180	USEPA 1993a	EqP-based screening value
1,1,2,2-Tetrachloroethane	42.4	USEPA 1993a	EqP-based screening value
1,1,2-Trichloroethane	74.0	USEPA 1993a	EqP-based screening value
1,1-Dichloroethane	5.68	USEPA 1993a	EqP-based screening value
1,1-Dichloroethene	584	USEPA 1993a	EqP-based screening value
1,2,3-Trichloropropane	93.8	USEPA 1993a	EqP-based screening value
1,2-Dibromo-3-chloropropane	41.9	USEPA 1993a	EqP-based screening value
1,2-Dibromoethane	8.52	USEPA 1993a	EqP-based screening value
1,2-Dichloroethane	66.2	USEPA 1993a	EqP-based screening value
1,2-Dichloropropane	436	USEPA 1993a	EqP-based screening value
2-Butanone	158	USEPA 1993a	EqP-based screening value
2-Hexanone	4.83	USEPA 1993a	EqP-based screening value
3-Chloro-1-propene (3-Chloropropene)	0.56	USEPA 1993a	EqP-based screening value
4-Methyl-2-pentanone (Methyl isobutyl ketone)	5.09	USEPA 1993a	EqP-based screening value
Acetone	1.22	USEPA 1993a	EqP-based screening value
Acetonitrile	156	USEPA 1993a	EqP-based screening value
Acrolein	0.0011	USEPA 1993a	EqP-based screening value
Acrylonitrile	0.21	USEPA 1993a	EqP-based screening value
Benzene	28.4	USEPA 1993a	EqP-based screening value
Bromodichloromethane	1,559	USEPA 1993a	EqP-based screening value
Bromoform	275	USEPA 1993a	EqP-based screening value
Bromomethane	3.73	USEPA 1993a	EqP-based screening value
Carbon disulfide	126	USEPA 1993a	EqP-based screening value
Carbon tetrachloride	1,521	USEPA 1993a	EqP-based screening value
Chlorobenzene	143	USEPA 1993a	EqP-based screening value
Chloroethane	---	---	---
Chloroform	132	USEPA 1993a	EqP-based screening value
Chloromethane	44.5	USEPA 1993a	EqP-based screening value
Chloroprene (2-Chloro-1,3-butadiene)	---	---	---
cis-1,3-Dichloropropene	1.54	USEPA 1993a	EqP-based screening value
Dibromochloromethane	1,827	USEPA 1993a	EqP-based screening value
Dibromomethane	526	USEPA 1993a	EqP-based screening value
Dichlorodifluoromethane	1,786	USEPA 1993a	EqP-based screening value
Ethylbenzene	4	Buchman 1999	AET
Ethyl methacrylate	NA	---	---
Iodomethane	NA	---	---
Isobutanol (isobutyl alcohol)	115	USEPA 1993a	EqP-based screening value
Methacrylonitrile	---	---	---
Methylene chloride	91.1	USEPA 1993a	EqP-based screening value
Methyl methacrylate	62.1	USEPA 1993a	EqP-based screening value
Pentachloroethane	601	USEPA 1993a	EqP-based screening value
Propionitrile (Ethyl cyanide)	45.9	USEPA 1993a	EqP-based screening value
Styrene	832	USEPA 1993a	EqP-based screening value
Tetrachloroethene	57	Buchman 1999	AET
Toluene	39.3	USEPA 1993a	EqP-based screening value
trans-1,2-Dichloroethene	5,100	USEPA 1993a	EqP-based screening value

TABLE 3-11 (continued)
MARINE SEDIMENT SCREENING VALUES
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value	Reference	Comment [1]
Volatile Organics (ug/kg) (continued):			
trans-1,3-Dichloropropene	1.54	USEPA 1993a	EqP-based screening value
trans-1,4-Dichloro-2-butene	NA	---	---
Trichloroethene	41	Buchman 1999	AET
Trichlorofluoromethane	4,127	USEPA 1993a	EqP-based screening value
Vinyl Acetate	110	USEPA 1993a	EqP-based screening value
Vinyl Chloride	5.50	USEPA 1993a	EqP-based screening value
Xylene (total)	4	Buchman 1999	AET for total xylenes
Semi-Volatile Organics (ug/kg):			
1,2,4,5-Tetrachlorobenzene	2,295	USEPA 1993a	EqP-based screening value
1,2,4-Trichlorobenzene	4.8	Buchman 1999	AET
1,2-Dichlorobenzene	13	Buchman 1999	AET
1,3,5-Trinitrobenzene	NA	---	---
1,3-Dichlorobenzene	169	USEPA 1993a	EqP-based screening value
1,4,-Dichlorobenzene	110	Buchman 1999	AET
1,4-Dioxane	58.2	USEPA 1993a	EqP-based screening value
1,4-Naphthoquinone	---	---	---
1,4-Phenylenediamine (p-Phenylenediamine)	0.21	USEPA 1993a	EqP-based screening value
1-Naphthylamine	---	---	---
2,3,4,6-Tetrachlorophenol	2,140	USEPA 1993a	EqP-based screening value
2,4,5-Trichlorophenol	751	Buchman 1999	AET
2,4,6-Trichlorophenol	6	Buchman 1999	AET
2,4-Dichlorophenol	5	Buchman 1999	AET
2,4-Dimethylphenol	18	Buchman 1999	AET
2,4-Dinitrophenol	3.40	USEPA 1993a	EqP-based screening value
2,4-Dinitrotoluene	73.5	USEPA 1993a	EqP-based screening value
2,6-Dichlorophenol	57.3	USEPA 1993a	EqP-based screening value
2,6-Dinitrotoluene	53.6	USEPA 1993a	EqP-based screening value
2-Acetylaminofluorene	245	USEPA 1993a	EqP-based screening value
2-Chloronaphthalene	NA	USEPA 1993a	EqP-based screening value
2-Chlorophenol	8	Buchman 1999	AET
2-Methylphenol (o-cresol)	8	Buchman 1999	AET
2-Naphthylamine	NA	---	---
2-Nitroaniline	6.92	USEPA 1993a	EqP-based screening value
2-Nitrophenol	1,155	USEPA 1993a	EqP-based screening value
2-Picoline	233	USEPA 1993a	EqP-based screening value
3,3'-Dichlorobenzidine	62.2	USEPA 1993a	EqP-based screening value
3,3'-Dimethylbenzidine	145	USEPA 1993a	EqP-based screening value
3-Methylcholanthrene	---	---	---
3&4-Methylphenol (m,p-cresol)	8.68	USEPA 1993a	EqP-based screening value
3-Nitroaniline	0.46	USEPA 1993a	EqP-based screening value
4,6-Dinitro-2-methylphenol	48.8	USEPA 1993a	EqP-based screening value
4-Aminobiphenyl	NA	---	---
4-Bromophenyl phenyl ether	622	USEPA 1993a	EqP-based screening value
4-Chloro-3-methylphenol	3,046	USEPA 1993a	EqP-based screening value
4-Chloroaniline	17.9	USEPA 1993a	EqP-based screening value
4-Chlorophenyl-phenylether	1,126	USEPA 1993a	EqP-based screening value
4-Nitroaniline	8.30	USEPA 1993a	EqP-based screening value

TABLE 3-11 (continued)
MARINE SEDIMENT SCREENING VALUES
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value	Reference	Comment (1)
Semi-Volatile Organics (ug/kg) (continued):			
4-Nitrophenol	57.9	USEPA 1993a	EqP-based screening value
4-Nitroquinoline-1-oxide	NA	---	---
5-Nitro-o-toluidine	32.6	USEPA 1993a	EqP-based screening value
7,12-Dimethylbenz(a)anthracene	202,806	USEPA 1993a	EqP-based screening value
Acetophenone	133	USEPA 1993a	EqP-based screening value
A,A-Dimethylphenethylamine	---	---	---
Aniline	5.68	USEPA 1993a	EqP-based screening value
Aramite (total)	69.0	USEPA 1993a	EqP-based screening value
Benzoic acid	65	Buchman 1999	AET
Benzyl alcohol	52	Buchman 1999	AET
Bis(2-chloroethoxy)methane	255	USEPA 1993a	EqP-based screening value
Bis(2-chloroethyl)ether	29.6	USEPA 1993a	EqP-based screening value
Bis(2-chloroisopropyl)ether	NA	---	---
Bis(2-ethylhexyl)phthalate	182	MacDonald 1994	TEL
Butylbenzylphthalate	63	Buchman 1999	AET
Diallate (total)	4,467	USEPA 1993a	EqP-based screening value
Dibenzofuran	110	Buchman 1999	AET
Diethylphthalate	6	Buchman 1999	AET
Dimethylphthalate	6	Buchman 1999	AET
Di-n-butylphthalate	58	Buchman 1999	AET
Di-n-octylphthalate	61	Buchman 1999	AET
Dinoseb (2-Sec-butyl-4,6-dinitrophenol)	4.36	USEPA 1993a	EqP-based screening value
Ethyl methanesulfonate	NA	---	---
Hexachlorobenzene	6	Buchman 1999	AET
Hexachlorobutadiene	1.3	Buchman 1999	AET
Hexachlorocyclopentadiene	29.2	USEPA 1993a	EqP-based screening value
Hexachloroethane	73	Buchman 1999	AET
Hexachlorophene	477,312	USEPA 1993a	EqP-based screening value
Hexachloropropene	---	---	---
Isophorone	12.7	USEPA 1993a	EqP-based screening value
Isosafrole	---	---	---
m-Dinitrobenzene (1,3-Dinitrobenzene)	4.19	USEPA 1993a	EqP-based screening value
Methapyrilene	NA	---	---
Methyl methanesulfonate	NA	---	---
Nitrobenzene	21	Buchman 1999	AET
n-Nitrosodiethylamine	2,055	USEPA 1993a	EqP-based screening value
n-Nitrosodimethylamine	15.6	USEPA 1993a	EqP-based screening value
n-Nitroso-di-n-butylamine	162,197	USEPA 1993a	EqP-based screening value
n-Nitroso-di-n-propylamine	16,490	USEPA 1993a	EqP-based screening value
n-Nitrosodiphenylamine	28	Buchman 1999	AET
n-Nitrosomethylethylamine	529	USEPA 1993a	EqP-based screening value
n-Nitrosomorpholine	NA	---	---
n-Nitrosopiperidine	NA	---	---
n-Nitrosopyrrolidine	NA	---	---
o,o,o-Triethylphosphorothioate	NA	---	---
o-Toluidine	17.4	USEPA 1993a	EqP-based screening value

TABLE 3-11 (continued)
MARINE SEDIMENT SCREENING VALUES
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment Screening Value	Reference	Comment (1)
Semi-Volatile Organics (ug/kg) (continued.):			
p-Dimethylaminoazobenzene	NA	---	---
Pentachlorobenzene	40,148	USEPA 1993a	EqP-based screening value
Pentachloronitrobenzene	17.6	USEPA 1993a	EqP-based screening value
Pentachlorophenol	17	Buchman 1999	AET
Phenacetin	NA	---	---
Phenol	130	Buchman 1999	AET
Pronamide	207	USEPA 1993a	EqP-based screening value
Pryridine	4.79	USEPA 1993a	EqP-based screening value
Safrole	NA	---	---
PAHs (ug/kg):			
1-Methylnaphthalene	254	USEPA 1993a	EqP-based screening value
2-Methylnaphthalene	409	MacDonald 1994	TEL
Acenaphthene	6.71	MacDonald 1994	TEL
Acenaphthylene	927	MacDonald 1994	TEL
Anthracene	46.9	MacDonald 1994	TEL
Benzo(a)anthracene	74.8	MacDonald 1994	TEL
Benzo(a)pyrene	88.8	MacDonald 1994	TEL
Benzo(b)fluoranthene	1,800	Buchman 1999	AET
Benzo(g,h,i)perylene	670	Buchman 1999	AET
Benzo(k)fluoranthene	1,800	Buchman 1999	AET
Chrysene	108	MacDonald 1994	TEL
Dibenzo(a,h)anthracene	6.22	MacDonald 1994	TEL
Fluoranthene	113	MacDonald 1994	TEL
Fluorene	21.2	MacDonald 1994	TEL
Indeno(1,2,3-cd)pyrene	600	Buchman 1999	AET
Naphthalene	34.6	MacDonald 1994	TEL
Phenanthrene	86.7	MacDonald 1994	TEL
Pyrene	153	MacDonald 1994	TEL
Total PAHs (2)	1,684	MacDonald 1994	TEL
Inorganics (mg/kg):			
Antimony	2	Long and Morgan 1991	ER-L
Arsenic	7.24	MacDonald 1994	TEL
Barium	48	Buchman 1999	AET
Beryllium	NA	---	---
Cadmium	0.68	MacDonald 1994	TEL
Chromium (total)	52.3	MacDonald 1994	TEL
Cobalt	10	Buchman 1999	AET
Copper	18.7	MacDonald 1994	TEL
Lead	30.2	MacDonald 1994	TEL
Mercury	0.13	MacDonald 1994	TEL
Nickel	15.9	MacDonald 1994	TEL
Selenium	1.0	Buchman 1999	AET
Silver	0.73	MacDonald 1994	TEL
Thallium	NA	---	---
Tin	3.4	Buchman 1999	AET
Vanadium	57	Buchman 1999	AET
Zinc	124	MacDonald	TEL

TABLE 3-11 (continued)
MARINE SEDIMENT SCREENING VALUES
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Notes:

NA = Not Available
EqP = Equilibrium Partitioning
ER-L = Effects Range-Low
AET = Apparent Effects Threshold
TEL Threshold Effects Level

(1) EqP-based sediment screening values were calculated from the following equation: $SV_{sed} = (K_{oc})(f_{oc})(SV_{sw})$ where K_{oc} is the organic carbon partition coefficient (L/kg), f_{oc} is the fraction of organic carbon (unitless), and SV_{sed} is the surface water screening value (ug/L). An F_{oc} of 0.01 was assumed.

(2) Total PAH refers to the sum of the concentrations of thirteen PAHs (acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, naphthalene, 2-methylnaphthalene, phenanthrene, and pyrene [MacDonald 1994]).

TABLE 3-12
INGESTION-BASED SCREENING VALUES FOR BIRDS
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical (1)	Test Organism	Body Weight (kg)	Duration	Exposure Route	Effect/Endpoint	Test Material	LOAEL (mg/kg/day)	NOAEL (mg/kg/day)	Reference	Ecological Receptors
Volatile Organics:										
1,1,1,2-Tetrachloroethane	---	---	---	---	---	---	NA	NA	---	---
Carbon tetrachloride	---	---	---	---	---	---	NA	NA	---	---
Chlorobenzene	---	---	---	---	---	---	NA	NA	---	---
Chloroform	---	---	---	---	---	---	NA	NA	---	---
Ethylbenzene	---	---	---	---	---	---	NA	NA	---	---
Pentachloroethane	---	---	---	---	---	---	NA	NA	---	---
Styrene	---	---	---	---	---	---	NA	NA	---	---
Tetrachloroethene	---	---	---	---	---	---	NA	NA	---	---
Toluene	---	---	---	---	---	---	NA	NA	---	---
Trichloroethene	---	---	---	---	---	---	NA	NA	---	---
Xylenes (total)	Quail	0.191	Subacute	?	"Toxicity"	Not Applicable	405	40.5	Hill and Camardese 1986	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
Semi-Volatile Organics:										
1,2,4,5-Tetrachlorobenzene	---	---	---	---	---	---	NA	NA	---	---
1,2,4-Trichlorobenzene	---	---	---	---	---	---	NA	NA	---	---
1,2-Dichlorobenzene	Northern bobwhite	0.157	14 days	Oral (gavage)	Growth/mortality	Not Applicable	2,500	250	Grimes and Jaber 1989	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
1,3-Dichlorobenzene	Northern bobwhite	0.157	14 days	Oral (gavage)	Growth/mortality	Not Applicable	2,500	250	Grimes and Jaber 1989	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
1,4-Dichlorobenzene	Northern bobwhite	0.157	14 days	Oral (gavage)	Growth/mortality	Not Applicable	2,500	250	Grimes and Jaber 1989	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
2,3,4,6-Tetrachlorophenol	---	---	---	---	---	---	NA	NA	---	---
2,4,5-Trichlorophenol	---	---	---	---	---	---	NA	NA	---	---
2,4,6-Trichlorophenol	---	---	---	---	---	---	NA	NA	---	---
2,4-Dichlorophenol	---	---	---	---	---	---	NA	NA	---	---
2-Acetylaminofluorene	---	---	---	---	---	---	NA	NA	---	---
2-Chloronaphthalene	---	---	---	---	---	---	NA	NA	---	---
3,3'-Dichlorobenzidine	---	---	---	---	---	---	NA	NA	---	---
3,3-Dimethylbenzidine	---	---	---	---	---	---	NA	NA	---	---
3-Methylcholanthrene	---	---	---	---	---	---	NA	NA	---	---
4-Bromophenyl phenyl ether	---	---	---	---	---	---	NA	NA	---	---
4-Chloro-3-methylphenol	---	---	---	---	---	---	NA	NA	---	---
4-Chlorophenyl phenyl ether	---	---	---	---	---	---	NA	NA	---	---
7-12-Dimethyl benz(a)anthracene	---	---	---	---	---	---	NA	NA	---	---
Aramite (total)	---	---	---	---	---	---	NA	NA	---	---
Bis(2-Ethylhexyl)phthalate	Ringed dove	0.155	4 weeks	Oral in diet	Reproduction	Not Applicable	11	1.1	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
Butylbenzylphthalate	---	---	---	---	---	---	NA	NA	---	---

TABLE 3-12 (continued)
INGESTION-BASED SCREENING VALUES FOR BIRDS
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical (1)	Test Organism	Body Weight (kg)	Duration	Exposure Route	Effect/Endpoint	Test Material	LOAEL (mg/kg/day)	NOAEL (mg/kg/day)	Reference	Ecological Receptors
Semi-Volatile Organics (cont.):										
Diallate (total)	---	---	---	---	---	---	NA	NA	---	---
Dibenzofuran	---	---	---	---	---	---	NA	NA	---	---
Diethylphthalate	---	---	---	---	---	---	NA	NA	---	---
Di-n-butylphthalate	Ringed dove	0.155	4 weeks	Oral in diet	Reproduction	Not Applicable	1.1	0.11	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
Di-n-octylphthalate	Ring-necked pheasant	1	?	?	mortality	Not Applicable	500	50	TERRETOX 1998	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
Dinoseb (2-Sec-butyl-4,6-dinitrophenol)	---	---	---	---	---	---	NA	NA	---	---
Hexachlorobenzene	Japanese quail	0.19	90 days	Oral	Reproduction	Not Applicable	0.8	0.08	Coulston and Kolbye 1994	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
	Coturnix quail	?	5 days	Oral	?	Not Applicable	2,250	225	USEPA 1999a	---
Hexachlorobutadiene	Japanese quail	0.19	?	Oral	Reproduction	Not Applicable	8	2.5	Coulston and Kolbye 1994	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
	Japanese quail	?	3 months	Oral	?	Not Applicable	31,850	3,185	USEPA 1999a	---
Hexachlorocyclopentadiene	---	---	---	---	---	---	NA	NA	---	---
Hexachloroethane	---	---	---	---	---	---	NA	NA	---	---
Hexachlorophene	---	---	---	---	---	---	NA	NA	---	---
Hexachloropropene	---	---	---	---	---	---	NA	NA	---	---
Isosafrole	---	---	---	---	---	---	---	---	---	---
N-Nitrosodiphenylamine	---	---	---	---	---	---	NA	NA	---	---
p-Dimethylaminoazobenzene	---	---	---	---	---	---	NA	NA	---	---
Pentachlorobenzene	---	---	---	---	---	---	NA	NA	---	---
Pentachloronitrobenzene	Chicken	1.5	35 weeks	Oral in diet	Reproduction	Not Applicable	70.7	7.07	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
Pentachlorophenol	Chicken	1.5	8 weeks	Oral	Growth	Not Applicable	200	100	Eisler 1989	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
	Quail	?	5 days	Oral	?	Not Applicable	40,300	4,030	USEPA 1999a	---
Pronamide	---	---	---	---	---	---	NA	NA	---	---
PAHs:										
1-Methylnaphthalene	---	---	---	---	---	---	NA	NA	---	---
2-Methylnaphthalene	---	---	---	---	---	---	NA	NA	---	---
Acenaphthene	Chicken	1.5	34 days	Oral in diet	Reproduction	Not Applicable	395	39.5	Rigdon and Neal 1963	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
Acenaphthylene	Chicken	1.5	34 days	Oral in diet	Reproduction	Not Applicable	395	39.5	Rigdon and Neal 1963	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant

TABLE 3-12 (continued)
INGESTION-BASED SCREENING VALUES FOR BIRDS
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical (1)	Test Organism	Body Weight (kg)	Duration	Exposure Route	Effect/Endpoint	Test Material	LOAEL (mg/kg/day)	NOAEL (mg/kg/day)	Reference	Ecological Receptors
PAHs (continued):										
Anthracene	Mallard duck	1.043	7 months	Oral in diet	Hepatic	Not Applicable	228	22.8	Patton and Dieter 1980	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
Benzo(a)anthracene	Chicken	1.5	34 days	Oral in diet	Reproduction	Not Applicable	395	39.5	Rigdon and Neal 1963	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
Benzo(a)pyrene	Chicken	1.5	34 days	Oral in diet	Reproduction	Not Applicable	395	39.5	Rigdon and Neal 1963	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
Benzo(b)fluoranthene	Chicken	1.5	34 days	Oral in diet	Reproduction	Not Applicable	395	39.5	Rigdon and Neal 1963	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
Benzo(g,h,i)perylene	Chicken	1.5	34 days	Oral in diet	Reproduction	Not Applicable	395	39.5	Rigdon and Neal 1963	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
Benzo(k)fluoranthene	Chicken	1.5	34 days	Oral in diet	Reproduction	Not Applicable	395	39.5	Rigdon and Neal 1963	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
Chrysene	Chicken	1.5	34 days	Oral in diet	Reproduction	Not Applicable	395	39.5	Rigdon and Neal 1963	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
Dibenz(a,h)anthracene	Chicken	1.5	34 days	Oral in diet	Reproduction	Not Applicable	395	39.5	Rigdon and Neal 1963	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
Fluoranthene	Chicken	1.5	34 days	Oral in diet	Reproduction	Not Applicable	395	39.5	Rigdon and Neal 1963	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
Fluorene	Chicken	1.5	34 days	Oral in diet	Reproduction	Not Applicable	395	39.5	Rigdon and Neal 1963	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
Indeno(1,2,3-cd)pyrene	Chicken	1.5	34 days	Oral in diet	Reproduction	Not Applicable	395	39.5	Rigdon and Neal 1963	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
Naphthalene	Mallard duck	1.04	7 months	Oral in diet	Hepatic	Not Applicable	228	22.8	Patton and Dieter 1980	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
Phenanthrene	Chicken	1.5	34 days	Oral in diet	Reproduction	Not Applicable	395	39.5	Rigdon and Neal 1963	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
Pyrene	Chicken	1.5	34 days	Oral in diet	Reproduction	Not Applicable	395	39.5	Rigdon and Neal 1963	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant

TABLE 3-12 (continued)
INGESTION-BASED SCREENING VALUES FOR BIRDS
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical (1)	Test Organism	Body Weight (kg)	Duration	Exposure Route	Effect/Endpoint	Test Material	LOAEL (mg/kg/day)	NOAEL (mg/kg/day)	Reference	Ecological Receptors
Inorganics:										
Antimony	---	---	---	---	---	---	NA	NA	---	---
Arsenic	Brown-headed cowbird	0.049	7 months	Oral in diet	Mortality	Copper acetoarsenite	7.38	2.46	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
	Mallard duck	1.0	128 days	Oral in diet	Mortality	Sodium arsenite	12.84	5.14	Sample et al. 1996	---
Barium	One-day old chicks	0.121	4 weeks	Oral in diet	Mortality	Barium hydroxide	41.7	20.8	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
Beryllium	---	---	---	---	---	---	NA	NA	---	---
Cadmium	Mallard duck	1.153	90 days	Oral in diet	Reproduction	Cadmium chloride	20	1.45	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
Chromium (hexavalent)	American black duck	1.25	10 months	Oral in diet	Reproduction	Trivalent chromium $CrK(SO_4)_2$	5	1	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
Cobalt	Chicken	1.8	14 Days	Oral in diet	Growth	?	14.7	1.47	Diaz et al. 1994	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
Copper	One-day old chicks	0.534	10 weeks	Oral in diet	Growth/mortality	Copper oxide	61.7	47	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
Lead	Japanese quail	0.15	12 weeks	Oral in diet	Reproduction	Lead acetate	11.3	1.13	Sample et al. 1996	American robin, mourning dove, spotted sandpiper, and double-crested cormorant
	American kestrel	0.13	7 months	Oral in diet	Reproduction	Metallic lead	38.5	3.85	Sample et al. 1996	Red-tailed hawk
Mercury	Japanese quail	0.15	1 year	Oral in diet	Reproduction	Mercuric chloride	0.9	0.45	Sample et al. 1996	---
	Coturnix quail	?	5 days	Oral	Mortality	Mercuric chloride	32.5	3.25	USEPA 1999a	---
	Mallard duck	1	3 generations	Oral in diet	Reproduction	Methyl mercury dicyandiamide	0.064	0.0064	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
Nickel	Mallard duckling	0.782	90 days	Oral in diet	Growth/mortality	Nickel sulfate	107	77.4	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
	Coturnix quail	?	5 days	Oral	?	?	650	65	USEPA 1999a	---
Selenium	Mallard duck	1	100 days	Oral in diet	Reproduction	Selanomethionine	0.8	0.4	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
	Mallard duck	1	78 days	Oral in diet	Reproduction	Sodium Selenite	1	0.5	Sample et al. 1996	---
	Screech owl	0.2	13.7 weeks	Oral in diet	Reproduction	Selanomethionine	1.5	0.44	Sample et al. 1996	---
	Black-crowned night heron	0.883	94 days	Oral in diet	Rreproduction	Selanomethionine	11.8	1.8	Sample et al. 1996	---
Silver	Mallard duck	?	14 days	Oral	?	?	1,780	178	USEPA 1999a	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant

TABLE 3-12 (continued)
INGESTION-BASED SCREENING VALUES FOR BIRDS
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical (1)	Test Organism	Body Weight (kg)	Duration	Exposure Route	Effect/Endpoint	Test Material	LOAEL (mg/kg/day)	NOAEL (mg/kg/day)	Reference	Ecological Receptors
Inorganics (continued):										
Thallium	European starling	?	Acute	Oral	?	?	3.5	0.35	USEPA 1999a	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
Tin	Japanese quail	0.15	6 weeks	Oral in diet	Reproduction	bis(Tributyltin)-oxide	16.9	6.8	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
Vanadium	Mallard duck	1.17	12 weeks	Oral in diet	Growth/mortality	Vanadyl sulfate	114	11.4	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant
Zinc	White leghorn hen	1.935	44 weeks	Oral in diet	Reproduction	Zinc sulfate	131	14.5	Sample et al. 1996	American robin, mourning dove, red-tailed hawk, spotted sandpiper, and double-crested cormorant

Notes:

NA = Not Available
NOAEL = No Observed Adverse Effect Level
LOAEL = Lowest Observed Adverse Effect Level

TABLE 3-13
INGESTION-BASED SCREENING VALUES FOR MAMMALS
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Test Organism	Body Weight (kg)	Duration	Exposure Route	Effect/Endpoint	Test Material	LOAEL (mg/kg/day)	NOAEL (mg/kg/day)	Reference	Ecological Receptor [1]
Volatile Organics:										
1,1,1,2-Tetrachloroethane	---	---	---	---	---	---	NA	NA	---	---
Carbon Tetrachloride	Rat	0.35	2 years	Oral in diet	Reproduction	Not Applicable	160	16	Sample et al. 1996	West Indian manatee
Chlorobenzene	Dog	12.7	chronic	?	Liver	Not Applicable	273	27.3	IRIS 1998	West Indian manatee
Chloroform	Rat	0.35	13 weeks	Oral (intubation)	Systemic	Not Applicable	41	15	Sample et al. 1996	West Indian manatee
	Mouse	0.03	80 weeks	Oral in diet	?	Not Applicable	600	60	USEPA 1999a	---
Ethylbenzene	Rat	0.35	chronic	?	Liver/kidney	Not Applicable	971	97.1	Wolf et al. 1956	West Indian manatee
Pentachloroethane	---	---	---	---	---	---	NA	NA	---	---
Styrene	Rat	0.35	90 days	Oral	Reproduction	Not Applicable	350	35	Beliles et al. 1985	West Indian manatee
Tetrachloroethene	Mouse	0.03	6 weeks	Oral (gavage)	hepatotoxicity	Not Applicable	7	1.4	---	
Toluene	Mouse	0.03	GD 6-12	Oral (gavage)	Reproduction	Not Applicable	260	26	Sample et al. 1996	West Indian manatee
Trichloroethene	Mouse	0.03	6 weeks	Oral (gavage)	hepatotoxicity	Not Applicable	7	0.7	Sample et al. 1996	West Indian manatee
Xylenes (total)	Mouse	0.03	GD 6-15	Oral (gavage)	Reproduction	Not Applicable	2.6	2.1	Sample et al. 1996	West Indian manatee
Semi-Volatile Organics:										
1,2,4,5-Tetrachlorobenzene	---	---	---	---	---	---	NA	NA	---	---
1,2,4-Trichlorobenzene	Rat	0.35	3 generations	Oral in water	Reproduction	Not Applicable	106	53	Coulston and Kolbye 1994	West Indian manatee
1,2-Dichlorobenzene	Rat	0.35	chronic	Oral (gavage)	Liver/kidney	Not Applicable	857	85.7	Coulston and Kolbye 1994	West Indian manatee
1,3-Dichlorobenzene	Rat	0.35	chronic	Oral (gavage)	Liver/kidney	Not Applicable	857	85.7	Coulston and Kolbye 1994	West Indian manatee
1,4-Dichlorobenzene	Rat	0.35	GD 6-15	Oral (gavage)	Reproduction	Not Applicable	500	250	Coulston and Kolbye 1994	West Indian manatee
2,3,4,6-Tetrachlorophenol	---	---	---	---	---	---	NA	NA	---	---
2,4,5-Trichlorophenol	Rat	0.35	98 days	Oral in diet	Hepatic/renal	Not Applicable	800	80	McCollister et al. 1961	West Indian manatee
2,4,6-Trichlorophenol	Rat	0.35	98 days	Oral in diet	Hepatic/renal	Not Applicable	800	80	McCollister et al. 1961	West Indian manatee
2,4-Dichlorophenol	Rat	0.35	103 weeks	Oral in diet	Reproduction	Not Applicable	4,400	440	NTP 1989	West Indian manatee
2-Acetylaminofluorene	---	---	---	---	---	---	NA	NA	---	---
2-Chloronaphthalene	---	---	---	---	---	---	NA	NA	---	---
2-sec-butyl-4, 6-dinitrophenol	---	---	---	---	---	---	NA	NA	---	---
3,3'-Dichlorobenzidine	---	---	---	---	---	---	NA	NA	---	---
3,3'-Dimethylbenzidine	---	---	---	---	---	---	NA	NA	---	---
3-Methylcholanthrene	---	---	---	---	---	---	NA	NA	---	---
4-Bromophenyl-Phenylether	---	---	---	---	---	---	NA	NA	---	---
4-Chloro-3-Methylphenol	---	---	---	---	---	---	NA	NA	---	---
4-Chlorophenyl-Phenyl ether	---	---	---	---	---	---	NA	NA	---	---
7,12-Dimethylbenz(a)anthracene	---	---	---	---	---	---	NA	NA	---	---
Aramite	---	---	---	---	---	---	NA	NA	---	---
Bis(2-ethylhexyl)phthalate	Mouse	0.03	105 days	Oral in diet	Reproduction	Not Applicable	183.3	18.3	Sample et al. 1996	West Indian manatee
	Rat	0.35	2 years	Oral	?	Not Applicable	600	60	USEPA 1999a	
Butylbenzylphthalate	Rat	0.35	2 years	Oral in diet	Hepatic	Not Applicable	2,400	240	NTP 1997	West Indian manatee
Diallate	---	---	---	---	---	---	NA	NA	---	---
Dibenzofuran	Mouse	0.03	19 to 29 days	Oral in diet	Reproduction	Not Applicable	1,330	133	ATSDR 1995a	West Indian manatee
Diethylphthalate	Mouse	0.03	105 days	Oral in diet	Reproduction	Not Applicable	45,830	4,583	Sample et al. 1996	West Indian manatee
Di-n-butylphthalate	Mouse	0.03	105 days	Oral in diet	Reproduction	Not Applicable	1,833	550	Sample et al. 1996	West Indian manatee
Di-n-octylphthalate	Mouse	0.03	105 days	Oral in diet	Reproduction	Not Applicable	550	55	Sample et al. 1996	West Indian manatee
	Mouse	0.03	105 days	Oral	Reproduction	Not Applicable	75,000	7,500	USEPA 1999a	---
Dinoseb (2-Sec-butyl-4,6-dinitrophenol)	---	---	---	---	---	---	NA	NA	---	---
Hexachlorobenzene	Rat	0.35	2 years	Oral	Reproduction	Not Applicable	16	1.6	ATSDR 1989	West Indian manatee
Hexachlorobutadiene	Rat	0.35	90 days +	Oral	Reproduction	Not Applicable	20	2	IPCS 1994	West Indian manatee
Hexachlorocyclopentadiene	Rat	0.35	GD 6-15	Oral	Reproduction	Not Applicable	30	10	USEPA 1984	West Indian manatee
	Rat	0.35	13 weeks	Oral (gavage)	?	Not Applicable	38	3.8	USEPA 1999a	---

TABLE 3-13 (continued)
INGESTION-BASED SCREENING VALUES FOR MAMMALS
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Test Organism	Body Weight (kg)	Duration	Exposure Route	Effect/Endpoint	Test Material	LOAEL (mg/kg/day)	NOAEL (mg/kg/day)	Reference	Ecological Receptor [1]
Semi-Volatile Organics (continued):										
Hexachloroethane	---	---	---	---	---	---	NA	NA	---	---
Hexachlorophene	Rat	0.35	?	Oral	Mortality	Not Applicable	56	5.6	USEPA 1999a	West Indian manatee
Hexachloropropene	---	---	---	---	---	---	NA	NA	---	---
Isosafrole	---	---	---	---	---	---	NA	NA	---	---
N-Nitrosodiphenylamine	Rat	0.35	8 to 11 weeks	Oral in diet	Systemic	Not Applicable	1,500	150	ATSDR 1993a	West Indian manatee
p-Dimethylaminoazobenzene	---	---	---	---	---	---	NA	NA	---	---
Pentachlorobenzene	Rat	0.35	180 days	Oral	?	Not Applicable	72.5	7.25	USEPA 1999a	West Indian manatee
Pentachloronitrobenzene	Mouse	0.35	2 years	Oral	?	Not Applicable	4,583.3	458.3	USEPA 1999a	West Indian manatee
Pentachlorophenol	Rat	0.35	up to 24 months	Oral in diet	Reproduction	Not Applicable	2.4	0.24	Sample et al. 1996	West Indian manatee
Pronamide	---	---	---	---	---	---	NA	NA	---	---
PAHs:										
1-Methylnaphthalene	Mouse	0.03	81 weeks	Oral in diet	Systemic	Not Applicable	1,437	143.7	ATSDR 1995b	West Indian manatee
2-Methylnaphthalene	Mouse	0.03	81 weeks	Oral in diet	Systemic	Not Applicable	1,437	143.7	ATSDR 1995b	West Indian manatee
Acenaphthene	Mouse	0.03	13 weeks	Oral (gavage)	Reproduction	Not Applicable	3,500	350	ATSDR 1995a	West Indian manatee
Acenaphthylene	Mouse	0.03	13 weeks	Oral (gavage)	Reproduction	Not Applicable	2,500	350	ATSDR 1995a	West Indian manatee
Anthracene	Mouse	0.03	13 weeks	Oral (gavage)	Reproduction	Not Applicable	10,000	1000	ATSDR 1995a	West Indian manatee
Benzo(a)anthracene	Mouse	0.03	GD 7-16	Oral (intubation)	Reproduction	Not Applicable	10	1	Sample et al. 1996	West Indian manatee
Benzo(a)pyrene	Mouse	0.03	GD 7-16	Oral (intubation)	Reproduction	Not Applicable	10	1	Sample et al. 1996	West Indian manatee
Benzo(b)fluoranthene	Mouse	0.03	GD 7-16	Oral (intubation)	Reproduction	Not Applicable	10	1	Sample et al. 1996	West Indian manatee
Benzo(g,h,i)perylene	Mouse	0.03	19 to 29 days	Oral in diet	Reproduction	Not Applicable	1,330	133	ATSDR 1995a	West Indian manatee
Benzo(k)fluoranthene	Mouse	0.03	GD 7-16	Oral (intubation)	Reproduction	Not Applicable	10	1	Sample et al. 1996	West Indian manatee
Chrysene	Mouse	0.03	GD 7-16	Oral (intubation)	Reproduction	Not Applicable	10	1	Sample et al. 1996	West Indian manatee
Dibenz(a,h)anthracene	Mouse	0.03	GD 7-16	Oral (intubation)	Reproduction	Not Applicable	10	1	Sample et al. 1996	West Indian manatee
Fluoranthene	Mouse	0.03	13 weeks	Oral (gavage)	Hepatic	Not Applicable	1,250	125	ATSDR 1995a	West Indian manatee
Fluorene	Mouse	0.03	13 weeks	Oral (gavage)	Hematological	Not Applicable	1,250	125	ATSDR 1995a	West Indian manatee
Indeno(1,2,3-cd)pyrene	Mouse	0.03	GD 7-16	Oral (intubation)	Reproduction	Not Applicable	10	1	Sample et al. 1996	West Indian manatee
Naphthalene	Mouse	0.03	13 weeks	Oral (gavage)	Reproduction	Not Applicable	1,400	140	ATSDR 1995b	West Indian manatee
Phenanthrene	Mouse	0.03	19 to 29 days	Oral in diet	Reproduction	Not Applicable	1,330	133	ATSDR 1995a	West Indian manatee
Pyrene	Mouse	0.03	19 to 29 days	Oral in diet	Reproduction	Not Applicable	1,330	133	ATSDR 1995a	West Indian manatee
Inorganics:										
Antimony	Mouse	0.03	lifetime	Oral in water	Lifespan/longevity	Antimony Potassium Tartrate	1.25	0.125	Sample et al. 1996	---
	Rat	0.35	lifetime	Oral in water	Lifespan/longevity	?	0.66	0.066	USEPA 1999a	West Indian manatee
Arsenic	Mouse	0.03	3 generations	Oral in water	Reproduction	Arsentie (As^{+3})	1.26	0.126	Sample et al. 1996	West Indian manatee
	Dog	?	2 years	Oral	?	?	12.5	1.25	USEPA 1999a	---
Barium	Rat	0.435	16 months	Oral in water	Growth/hypertension	Barium Chloride	51	5.1	Sample et al. 1996	West Indian manatee
	Rat	0.35	10 days	Oral in water	Mortality	Barium Hydroxide	19.8	1.98	Sample et al. 1996	---
Beryllium	Rat	0.35	lifetime	Oral in water	Longevity/weight loss	Beryllium Sulfate	6.6	0.66	Sample et al. 1996	West Indian manatee
Cadmium	Rat	0.303	6 weeks	Oral (gavage)	Reproduction	Cadmium Chloride ($CdCl_2$)	10	1	Sample et al. 1996	---
	Dog	10	3 months	Oral (gavage)	Reproduction	?	7.5	0.75	ATSDR 1993b	---
	Mouse	0.03	2 generations	Oral in water	Reproduction	soluble salt	2.52	0.252	EPA 1999a	West Indian manatee
Chromium	Rat	0.35	2 years	Oral in diet	Reproduction and longevity	Cr^{+3} as Cr_2O_3	27,370	2,737	Sample et al. 1996	---
	Rat	0.35	1 year	Oral in water	Body weight and food consumption	Cr^{+6} as $K_2Cr_2O_4$	32.8	3.28	Sample et al. 1996	West Indian manatee
	Rat	0.35	3 months	Oral in water	Mortality	Cr^{+6}	13.14	1.314	Sample et al. 1996	---

TABLE 3-13 (continued)
INGESTION-BASED SCREENING VALUES FOR MAMMALS
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Test Organism	Body Weight (kg)	Duration	Exposure Route	Effect/Endpoint	Test Material	LOAEL (mg/kg/day)	NOAEL (mg/kg/day)	Reference	Ecological Receptor [1]
Inorganics (continued):										
Cobalt	Rat	0.35	69 days	Oral in diet	Reproduction	?	50	5	ATSDR 1992a	West Indian manatee
Copper	Mink	1	357 days	Oral in diet	Reproduction	Copper Sulfate	15.14	11.7	Sample et al. 1996	West Indian manatee
Lead	Rat	0.35	3 generations	Oral in diet	Reproduction	Lead Acetate	80	8	Sample et al. 1996	West Indian manatee
Mercury	Mink	1	6 months	Oral in diet	Reproduction	Mercuric Chloride	10	1.0	Sample et al. 1996	---
	Mouse	0.03	20 months	Oral in diet	Mortality, reproduction, and liver/kidney histology	Mercuric Sulfide	132	13.2	Sample et al. 1996	---
	Mink	1	93 days	Oral in diet	Mortality, weight loss, and ataxia	Methyl Mercury Chloride (CH3HgCl)	0.025	0.015	Sample et al. 1996	---
	Rat	0.35	3 generations	Oral in diet	Reproduction	Methyl Mercury Chloride (CH_3HgCl)	0.16	0.032	Sample et al. 1996	West Indian manatee
Nickel	Rat	0.35	3 generations	Oral in diet	Reproduction	Nickel Sulfate Hexahydrate	80	40	Sample et al. 1996	West Indian manatee
Selenium	Rat	0.35	1 year	Oral in water	Reproduction	Potassium Selenate (SeO_4)	0.33	0.2	Sample et al. 1996	West Indian manatee
	Mouse	0.03	3 genrations	Oral in water	Reproduction	Selanate (SeO_4)	0.76	0.076	USEPA 1999a	---
Silver	Rat	0.35	2 weeks	Oral in water	Mortality	?	181	18.1	ATSDR 1990	West Indian manatee
	Mouse	0.03	125 days	Oral	Hypoactivity	?	3.75	0.375	USEPA 1999a	---
Thallium	Rat	0.365	60 days	Oral in water	Reproduction	Thallium Sulfate	0.074	0.0074	Sample et al. 1996	West Indian manatee
Tin	Mouse	0.03	6-15 days	Oral intubation	Reproduction	bis(Tributyltin)oxide	35	23.4	Sample et al. 1996	West Indian manatee
Vanadium	Rat	0.26	>60 days	Oral intubation	Reproduction	Sodium Metavanadate ($NaVO_3$)	2.1	0.21	Sample et al. 1996	West Indian manatee
Zinc	Rat	0.35	GD 1-16	Oral in diet	Reproduction	Zinc Oxide	320	160	Sample et al. 1996	---
	Mink	1	25 weeks	Oral	Reproduction	?	208	20.8	ATSDR 1992b	West Indian manatee
	Mouse	0.03	13 weeks	Oral	?	?	100.4	10.4	USEPA 1999a	---

Notes:

NOAEL = No Observed Effect Level
LOAEL = Lowest Observed Effect Level
NA = Not Available

[1] When more than one study was available from the literature, the most appropriate study was selected based on study design, study methodology, study duration, and endpoint. When available, reproductive effects/endpoints were preferentially selected over non-reproductive effect endpoints (e.g., mortality, liver/kidney effects, hepatic function, and system effects)

TABLE 3-14
CONSERVATIVE SOIL BIOACCUMULATION FACTORS USED FOR TERRESTRIAL PLANTS AND INVERTEBRATES
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Soil-Plant BCF (dry weight)		Soil-Invertebrate BAF (dry weight)	
	Value	Reference	Value	Reference
Volatile Organics:				
1,1,1,2-Tetrachloroethane	1.1691	Travis and Arms 1988	1	Assumed
Carbon Tetrachloride	1.0234	Travis and Arms 1988	1	Assumed
Chlorobenzene	0.8608	Travis and Arms 1988	1	Assumed
Chloroform	3.0077	Travis and Arms 1988	1	Assumed
Ethylbenzene	0.5930	Travis and Arms 1988	1	Assumed
Pentachloroethane	0.6597	Travis and Arms 1988	1	Assumed
Styrene	0.7739	Travis and Arms 1988	1	Assumed
Tetrachloroethane	1.1085	Travis and Arms 1988	1	Assumed
Toluene	0.9966	Travis and Arms 1988	1	Assumed
Trichloroethene	1.0510	Travis and Arms 1988	1	Assumed
Xylenes (total)	0.6010	Travis and Arms 1988	1	Assumed
Semi-Volatile Organics:				
1,2,4,5-Tetrachlorobenzene	0.0806	Travis and Arms 1988	1	Assumed
1,2,4-Trichlorobenzene	0.1863	Travis and Arms 1988	0.56	Beyer 1996
1,2-Dichlorobenzene	0.4031	Travis and Arms 1988	1	Assumed
1,3-Dichlorobenzene	0.3624	Travis and Arms 1988	1	Assumed
1,4,-Dichlorobenzene	0.4085	Travis and Arms 1988	1	Assumed
1-Methylnaphthalene	0.2245	Travis and Arms 1989	0.23	Beyer and Stafford 1993
2,3,4,6-Tetrachlorophenol	0.1051	Travis and Arms 1988	1	Assumed
2,4,5-Trichlorophenol	0.2157	Travis and Arms 1988	8.4	van Gestel and Ma 1988
2,4,6-Trichlorophenol	0.2814	Travis and Arms 1988	1	Assumed
2,4-Dichlorophenol	0.6423	Travis and Arms 1988	1	Assumed
2-Acetylaminofluorene	0.6090	Travis and Arms 1988	1	Assumed
2-Chloronaphthalene	0.1567	Travis and Arms 1988	1	Assumed
2-Methylnaphthalene	0.2157	Travis and Arms 1988	0.2	Beyer and Stafford 1993
3,3'-Dichlorobenzidine	0.3624	Travis and Arms 1988	1	Assumed
3,3'-Dimethylbenzidine	1.0939	Travis and Arms 1988	1	Assumed
3-Methylcholanthrene	0.0075	Travis and Arms 1988	1	Assumed
4-Bromophenyl phenyl ether	0.0499	Travis and Arms 1988	1	Assumed
4-Chloro-3-methylphenol	0.6255	Travis and Arms 1988	1	Assumed
4-Chlorophenyl-Phenylether	0.0533	Travis and Arms 1988	1	Assumed
7,12-Dimethylbenz(a)anthracene	0.0058	Travis and Arms 1988	1	Assumed

TABLE 3-14 (continued)
CONSERVATIVE SOIL BIOACCUMULATION FACTORS USED FOR TERRESTRIAL PLANTS AND INVERTEBRATES
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Soil-Plant BCF (dry weight)		Soil-Invertebrate BAF (dry weight)	
	Value	Reference	Value	Reference
Semi-Volatile Organics (continued):				
Acenaphthene	0.2100	Travis and Arms 1988	0.3	Beyer and Stafford 1993
Acenaphthylene	0.3436	Travis and Arms 1988	0.22	Beyer and Stafford 1993
Anthracene	0.0908	Travis and Arms 1988	0.32	Beyer and Stafford 1993
Aramite (total)	0.0634	Travis and Arms 1988	1	Assumed
Benzo(a)anthracene	0.0197	Travis and Arms 1988	0.27	Beyer and Stafford 1993
Benzo(a)pyrene	0.0114	Travis and Arms 1988	0.34	Beyer and Stafford 1993
Benzo(b)fluoranthene	0.0101	Travis and Arms 1988	0.21	Beyer and Stafford 1993
Benzo(g,h,i)perylene	0.0052	Travis and Arms 1988	0.15	Beyer and Stafford 1993
Benzo(k)fluoranthene	0.0101	Travis and Arms 1988	0.21	Beyer and Stafford 1993
Bis(2-ethylhexyl)phthalate	0.0023	Travis and Arms 1988	1	Assumed
Butylbenzylphthalate	0.0617	Travis and Arms 1988	1	Assumed
Chrysene	0.0197	Travis and Arms 1988	0.44	Beyer and Stafford 1993
Diallate (total)	0.0984	Travis and Arms 1988	1	Assumed
Dibenzo(a,h)anthracene	0.0053	Travis and Arms 1988	0.49	Beyer and Stafford 1993
Dibenzofuran	0.1447	Travis and Arms 1988	1	Assumed
Diethylphthalate	1.3900	Travis and Arms 1988	1	Assumed
Di-n-butylphthalate	0.0838	Travis and Arms 1988	1	Assumed
Di-n-octylphthalate	0.0008	Travis and Arms 1988	1	Assumed
Dinoseb (2-Sec-butyl-4,6-dinitrophenol)	0.5930	Travis and Arms 1988	1	--
Fluoranthene	0.0425	Travis and Arms 1988	0.37	Beyer and Stafford 1993
Fluorene	0.1428	Travis and Arms 1988	0.2	Beyer and Stafford 1993
Hexachlorobenzene	0.0153	Travis and Arms 1988	1.69	Beyer 1996
Hexachlorobutadiene	0.0642	Travis and Arms 1988	1	Assumed
Hexachlorocyclopentadiene	0.0297	Travis and Arms 1988	1	Assumed
Hexachloroethane	0.1888	Travis and Arms 1988	1	Assumed
Hexachlorophene	0.0017	Travis and Arms 1988	1	Assumed
Hexachloropropene	0.1139	Travis and Arms 1988	1	Assumed
Indeno(1,2,3-cd)pyrene	0.0056	Travis and Arms 1988	0.41	Beyer and Stafford 1993
Isosafrole	0.4367	Travis and Arms 1988	1	Assumed
Naphthalene	0.4425	Travis and Arms 1988	0.21	Beyer and Stafford 1993
n-Nitrosodiphenylamine	0.5775	Travis and Arms 1988	1	Assumed
p-Dimethylaminoazobenzene	0.0872	Travis and Arms 1988	1	Assumed

TABLE 3-14 (continued)
CONSERVATIVE SOIL BIOACCUMULATION FACTORS USED FOR TERRESTRIAL PLANTS AND INVERTEBRATES
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Soil-Plant BCF (dry weight)		Soil-Invertebrate BAF (dry weight)	
	Value	Reference	Value	Reference
Semivolatile Organics (cont.):				
Pentachlorobenzene	0.0353	Travis and Arms 1988	1	Assumed
Pentachloronitrobenzene	0.0806	Travis and Arms 1988	1	Assumed
Pentachlorophenol	0.0443	Travis and Arms 1988	8	van Gestel and Ma 1988
Phenanthrene	0.0908	Travis and Arms 1988	0.28	Beyer and Stafford 1993
Pronamide	0.3624	Travis and Arms 1988	1	Assumed
Pyrene	0.0431	Travis and Arms 1988	0.39	Beyer and Stafford 1993
Inorganics:				
Antimony	0.2	Baes et al. 1984	1	Assumed
Arsenic	1.103	Bechtel Jacobs 1998a	0.523	Sample et al. 1998a
Barium	0.15	Baes et al. 1984	0.36	Beyer and Stafford 1993
Beryllium	0.01	Baes et al. 1984	1	Assumed
Cadmium	3.25	Bechtel Jacobs 1998a	40.69	Sample et al. 1998a
Chromium (total)	0.0075	Baes et al. 1984	3.162	Sample et al. 1998a
Cobalt	0.02	Baes et al. 1984	1	Assumed
Copper	0.625	Bechtel Jacobs 1998a	1.531	Sample et al. 1998a
Lead	0.468	Bechtel Jacobs 1998a	1.522	Sample et al. 1998a
Mercury	5	Bechtel Jacobs 1998a	20.63	Sample et al. 1998a
Nickel	1.411	Bechtel Jacobs 1998a	4.73	Sample et al. 1998a
Selenium	3.012	Bechtel Jacobs 1998a	1.34	Sample et al. 1998a
Silver	0.4	Baes et al. 1984	1	Assumed
Thallium	0.004	Baes et al. 1984	1	Assumed
Tin	0.03	Baes et al. 1984	1	Assumed
Vanadium	0.0055	Baes et al. 1984	0.088	Sample et al. 1998a
Zinc	1.82	Bechtel Jacobs 1998a	12.89	Sample et al. 1998a

Notes:

BCF = Bioconcentration Factor
BAF = Bioaccumulation Factor

TABLE 3-15
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
CONSERVATIVE SOIL BIOACCUMULATION FACTORS USED FOR SMALL MAMMAL PREY ITEMS
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Soil-Omnivore BCF (dry weight)	
	Value	Reference
Volatile Organics:		
1,1,1,2-Tetrachloroethane	---	see text
Carbon Tetrachloride	---	see text
Chlorobenzene	---	see text
Chloroform	---	see text
Ethylbenzene	---	see text
Pentachloroethane	---	see text
Styrene	---	see text
Tetrachloroethane	---	see text
Toluene	---	see text
Trichloroethene	---	see text
Xylenes (total)	---	see text
Semi-Volatile Organics:		
1,2,4,5-Tetrachlorobenzene	---	see text
1,2,4-Trichlorobenzene	---	see text
1,2-Dichlorobenzene	---	see text
1,3-Dichlorobenzene	---	see text
1,4,-Dichlorobenzene	---	see text
1-Methylnaphthalene	---	see text
2,3,4,6-Tetrachlorophenol	---	see text
2,4,5-Trichlorophenol	---	see text
2,4,6-Trichlorophenol	---	see text
2,4-Dichlorophenol	---	see text
2-Acetylaminofluorene	---	see text
2-Chloronaphthalene	---	see text
2-Methylnaphthalene	---	see text
3,3'-Dichlorobenzidine	---	see text
3,3'-Dimethylbenzidine	---	see text
3-Methylcholanthrene	---	see text
4-Bromophenyl phenyl ether	---	see text
4-Chloro-3-methylphenol	---	see text
4-Chlorophenyl-Phenylether	---	see text
7,12-Dimethylbenz(a)anthracene	---	see text
Acenaphthene	---	see text
Acenaphthylene	---	see text
Anthracene	---	see text
Aramite (total)	---	see text
Benzo(a)anthracene	---	see text
Benzo(a)pyrene	---	see text
Benzo(b)fluoranthene	---	see text
Benzo(g,h,i)perylene	---	see text
Benzo(k)fluoranthene	---	see text
Bis(2-ethylhexyl)phthalate	---	see text
Butylbenzylphthalate	---	see text
Chrysene	---	see text
Diallate (total)	---	see text
Dibenzo(a,h)anthracene	---	see text
Dibenzofuran	---	see text
Diethylphthalate	---	see text

TABLE 3-15 (continued)
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
CONSERVATIVE SOIL BIOACCUMULATION FACTORS USED FOR SMALL MAMMAL PREY ITEMS
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Soil-Omnivore BCF (dry weight)	
	Value	Reference
Semi-Volatile Organics (continued):		
Di-n-butylphthalate	---	see text
Di-n-octylphthalate	---	see text
Dinoseb (2-Sec-butyl-4,6-dinitrophenol)	---	see text
Fluoranthene	---	see text
Fluorene	---	see text
Hexachlorobenzene	---	see text
Hexachlorobutadiene	---	see text
Hexachlorocyclopentadiene	---	see text
Hexachloroethane	---	see text
Hexachlorophene	---	see text
Hexachloropropene	---	see text
Indeno(1,2,3-cd)pyrene	---	see text
Isosafrole	---	see text
Naphthalene	---	see text
n-Nitrosodiphenylamine	---	see text
p-Dimethylaminoazobenzene	---	see text
Pentachlorobenzene	---	see text
Pentachloronitrobenzene	---	see text
Pentachlorophenol	---	see text
Phenanthrene	---	see text
Pronamide	---	see text
Pyrene	---	see text
Inorganics:		
Antimony	---	see text
Arsenic	0.014	Sample et al. 1998b
Barium	0.069	Sample et al. 1998b
Beryllium	---	see text
Cadmium	0.462	Sample et al. 1998b
Chromium (total)	0.349	Sample et al. 1998b
Cobalt	0.025	Sample et al. 1998b
Copper	0.554	Sample et al. 1998b
Lead	0.286	Sample et al. 1998b
Mercury	0.13	Sample et al. 1998b
Nickel	0.589	Sample et al. 1998b
Selenium	1.263	Sample et al. 1998b
Silver	---	see text
Thallium	0.1227	Sample et al. 1998b
Tin	---	see text
Vanadium	---	see text
Zinc	2.7822	Sample et al. 1998b

Notes:

BCF = Bioconcentration Factor
BAF = Bioaccumulation Factor

TABLE 3-16
CONSERVATIVE SEDIMENT BIOACCUMULATION FACTORS USED FOR AQUATIC INVERTEBRATES AND FISH
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment-Invertebrate BAF (dry weight)		Sediment-Fish BAF (dry weight)	
	Value	Reference	Value	Reference
Volatile Organics:				
1,1,1,2-Tetrachloroethane	1	Assumed	1	Assumed
Carbon Tetrachloride	1	Assumed	1	Assumed
Chlorobenzene	1	Assumed	1	Assumed
Chloroform	1	Assumed	1	Assumed
Ethylbenzene	1	Assumed	1	Assumed
Pentachloroethane	1	Assumed	1	Assumed
Styrene	1	Assumed	1	Assumed
Tetrachloroethane	1	Assumed	1	Assumed
Toluene	1	Assumed	1	Assumed
Trichloroethene	1	Assumed	1	Assumed
Xylenes (total)	1	Assumed	1	Assumed
Semi-Volatile Organics:				
1,2,4,5-Tetrachlorobenzene	1	Assumed	1	Assumed
1,2,4-Trichlorobenzene	1	Assumed	1	Assumed
1,2-Dichlorobenzene	1	Assumed	1	Assumed
1,3-Dichlorobenzene	1	Assumed	1	Assumed
1,4,-Dichlorobenzene	1	Assumed	1	Assumed
1-Methylnapthalene	1	Assumed	1	Assumed
2,3,4,6-Tetrachlorophenol	1	Assumed	1	Assumed
2,4,5-Trichlorophenol	1	Assumed	1	Assumed
2,4,6-Trichlorophenol	1	Assumed	1	Assumed
2,4-Dichlorophenol	1	Assumed	1	Assumed
2-Acetylaminofluorene	1	Assumed	1	Assumed
2-Chloronaphthalene	1	Assumed	1	Assumed
2-Methylnaphthalene	1	Assumed	1	Assumed
3,3'-Dichlorobenzidine	1	Assumed	1	Assumed
3,3'-Dimethylbenzidine	1	Assumed	1	Assumed
3-Methylcholanthrene	1	Assumed	1	Assumed
4-Bromophenyl phenyl ether	1	Assumed	1	Assumed
4-Chloro-3-methylphenol	1	Assumed	1	Assumed
4-Chlorophenyl-Phenylether	1	Assumed	1	Assumed
7,12-Dimethylbenz(a)anthracene	1	Assumed	1	Assumed

TABLE 3-16 (continued)
CONSERVATIVE SEDIMENT BIOACCUMULATION FACTORS USED FOR AQUATIC INVERTEBRATES AND FISH
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment-Invertebrate BAF (dry weight)		Sediment-Fish BAF (dry weight)	
	Value	Reference	Value	Reference
Semi-Volatile Organics (continued):				
Acenaphthene	2.04	Maruya et al. 1997	1	Assumed
Acenaphthylene	1	Assumed	1	Assumed
Anthracene	0.271	Maruya et al. 1997	1	Assumed
Aramite (total)	1	Assumed	1	Assumed
Benzo(a)anthracene	1.4	Maruya et al. 1997	1	Assumed
Benzo(a)pyrene	0.191	Maruya et al. 1997	1	Assumed
Benzo(b)fluoranthene	0.16	Maruya et al. 1997	1	Assumed
Benzo(g,h,i)perylene	0.295	Maruya et al. 1997	1	Assumed
Benzo(k)fluoranthene	0.421	Maruya et al. 1997	1	Assumed
Bis(2-ethylhexyl)phthalate	1	Assumed	1	Assumed
Butylbenzylphthalate	1	Assumed	1	Assumed
Chrysene	0.335	Maruya et al. 1997	1	Assumed
Diallate (total)	1	Assumed	1	Assumed
Dibenzo(a,h)anthracene	1	Assumed	1	Assumed
Dibenzofuran	1	Assumed	1	Assumed
Diethylphthalate	1	Assumed	1	Assumed
Di-n-butylphthalate	1	Assumed	1	Assumed
Di-n-octylphthalate	1	Assumed	1	Assumed
Dinoseb (2-Sec-butyl-4,6-dinitrophenol)	1	Assumed	1	Assumed
Fluoranthene	0.312	Maruya et al. 1997	1	Assumed
Fluorene	1.13	Maruya et al. 1997	1	Assumed
Hexachlorobenzene	1	Assumed	1	Assumed
Hexachlorobutadiene	2.64	USEPA 1999a	1	Assumed
Hexachlorocyclopentadiene	1	Assumed	1	Assumed
Hexachloroethane	1	Assumed	1	Assumed
Hexachlorophene	1	Assumed	1	Assumed
Hexachloropropene	1	Assumed	1	Assumed
Indeno(1,2,3-cd)pyrene	0.355	Maruya et al. 1997	1	Assumed
Isosafrole	1	Assumed	1	Assumed
Naphthalene	1	Assumed	1	Assumed
n-Nitrosodiphenylamine	1	Assumed	1	Assumed
p-Dimethylaminoazobenzene	1	Assumed	1	Assumed

TABLE 3-16 (continued)
CONSERVATIVE SEDIMENT BIOACCUMULATION FACTORS USED FOR AQUATIC INVERTEBRATES AND FISH
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment-Invertebrate BAF (dry weight)		Sediment-Fish BAF (dry weight)	
	Value	Reference	Value	Reference
Semi-Volatile Organics (continued):				
Pentachlorobenzene	1.92	USEPA 1999a	1	Assumed
Pentachloronitrobenzene	1	Assumed	1	Assumed
Pentachlorophenol	1	Assumed	1	Assumed
Phenanthrene	0.652	Maruya et al. 1997	1	Assumed
Pronamide	1	Assumed	1	Assumed
Pyrene	0.803	Maruya et al. 1997	1	Assumed
Inorganics:				
Antimony	1	Assumed	1	Assumed
Arsenic	0.675	Bechtel Jacobs 1998b	0.126	Pascoe et al. 1996
Barium	1	Assumed	1	Assumed
Beryllium	1	Assumed	1	Assumed
Cadmium	3.073	Bechtel Jacobs 1998b	0.164	Pascoe et al. 1996
Chromium (total)	0.186	Bechtel Jacobs 1998b	0.038	Krantzberg and Boyd 1992
Cobalt	1	Assumed	1	Assumed
Copper	7.957	Bechtel Jacobs 1998b	0.1	Krantzberg and Boyd 1992
Lead	0.326	Bechtel Jacobs 1998b	0.07	Krantzberg and Boyd 1992
Mercury	1.735	Bechtel Jacobs 1998b	4.58	Cope et al. 1990
Nickel	0.214	Bechtel Jacobs 1998b	1	Assumed
Selenium	1	Assumed	1	Assumed
Silver	0.18	Hirsch 1998	1	Assumed
Thallium	1	Assumed	1	Assumed
Tin	1	Assumed	1	Assumed
Vanadium	1	Assumed	1	Assumed
Zinc	4.759	Bechtel Jacobs 1998b	0.147	Pascoe et al. 1996

Notes:

BAF = Bioaccumulation Factor

TABLE 3-17
CONSERVATIVE SURFACE WATER BIOACCUMULATION FACTORS USED FOR FISH
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical [(1)(2)]	Water-Fish BAF (dry weight)	
	Value [(3)]	Reference
Semi-Volatile Organics:		
Bis(2-ethylhexyl)phthalate	350	USEPA 1999a
PAHs:		
Acenaphthene	2,500 [(4)]	USEPA 1999a
Anthracene	2,500 [(4)]	USEPA 1999a
Fluoranthene	2,500 [(4)]	USEPA 1999a
Naphthalene	2,500 [(4)]	USEPA 1999a
Phenanathrene	2,500 [(4)]	USEPA 1999a
Pyrene	2,500 [(4)]	USEPA 1999a
Inorganics:		
Antimony	1	Sample et al. 1996
Arsenic	4	USEPA 1985a
Barium	95	SRC 2000
Cadmium	2,213	USEPA 1985b
Copper	290	Sample et al. 1996
Lead	45	Sample et al. 1996
Thallium	34	Sample et al. 1996
Tin	85	SRC 2000
Vanadium	153	SRC 2000
Zinc	966	Sample et al. 1996

Notes:

BAF = Bioaccumulation Factor.

(1) The organics shown are limited to those detected in surface water.

(2) The metals shown are limited to those detected in the dissolved (filtered) fraction.

(3) The BAF values shown are based on a surface water BCF and a food chain multiplier of 1.0.

(4) The value shown is a BAF for benzo(a)pyrene.

TABLE 3-18
CONSERVATIVE EXPOSURE PARAMETERS FOR UPPER TROPHIC LEVEL RECEPTORS
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Receptor	Habitat	Body Weight (kg)		Food Ingestion Rate (kg/day - dry)		Area Use Factor
		Value	Reference	Value	Reference	
Birds:						
American robin	Terrestrial	0.0635	USEPA 1993b	0.00735	Levey and Karasov 1989	1.0
Mourning dove	Terrestrial	0.105	Tomlinson et al. 1994	0.01787	Allometric equation from Nagy 1987 for all birds	1.0
Red-tailed hawk	Terrestrial	0.957	USEPA 1993b	0.04308	Sample and Suter II 1994	1.0
Spotted Sandpiper	Aquatic	0.0294	Dunning 1993	0.00930	Allometric equation from Nagy 1987 for all birds	1.0
Double-crested cormorant	Aquatic	1.825	Glahn and McCoy 1995	0.09250	Bivings et al. 1989	1.0
Mammals:						
West Indian manatee	Aquatic	800	USGS 2000	21.87	Etheridge et al. 1985	1.0

TABLE 3-19
DIETARY COMPOSITION FOR UPPER TROPHIC LEVEL RECEPTORS
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Receptor	Dietary Composition (percent)							Soil/ Sediment Ingestion (percent)	
	Terr. Plants	Soil Invert.	Small Mammals	Fish	Aquatic Plants	Aquatic Invert.	Reference	Value	Reference
Birds: American robin	12	78.9 [(1)]	0	0	0	0	Martin et al. 1951	9.1	Sample and Suter II 1994
Mourning dove	95	0	0	0	0	0	Tomlinson et al. 1994	5	Assumed
Red-tailed hawk	0	0	97.5	0	0	0	USEPA 1993b; Sample and Suter II 1994	2.5	Assumed
Spotted sandpiper	0	0	0	0	0	81.9	USEPA 1993b	18.1	Beyer et al. 1994
Double-crested cormorant	0	0	0	100	0	0	Bivings et al. 1989	0	Assumed
Mammals: West Indian manatee	0	0	0	0	99	0	USGS 1986 and Odell 1992	1	USGS 2000
Mammals (Prey Items): Small mammal omnivore	49	49	0	0	0	0	Assumed	2	Assumed

Notes:

[(1)] Dietary compositions were available for spring, summer, winter, and fall. For conservatism, the percentage of soil invertebrates shown represents the highest percentage of terrestrial insects reported for a given season (spring).

TABLE 3-20
FREQUENCY AND RANGE OF SURFACE SOIL DATA (MAXIMUM CONCENTRATIONS) COMPARED TO SURFACE SOIL SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					Surface Soil Screening Value (SSSV)		Max. HQ(2)	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen(1)					
Volatile Organics (ug/kg):										
1,1,1,2-Tetrachloroethane	0/23	NA	5.3U - 11U	4.1	11	---	---	NA	Yes	No SSSV
1,1,1-Trichloroethane	1/23	3.2J - 3.2J	5U - 7.6U	2.9	3.2	---	---	NA	Yes	No SSSV
1,1,2,2-Tetrachloroethane	0/23	NA	5U - 7.6U	2.9	7.6	---	---	NA	Yes	No SSSV
1,1,2-Trichloroethane	0/23	NA	5U - 7.6U	2.9	7.6	---	---	NA	Yes	No SSSV
1,1-Dichloroethane	0/23	NA	5U - 7.6U	2.9	7.6	---	---	NA	Yes	No SSSV
1,1-Dichloroethene	0/23	NA	5U - 7.6U	2.9	7.6	---	---	NA	Yes	No SSSV
1,2,3-Trichloropropane	0/23	NA	5.3U - 11U	4.1	11	---	---	NA	Yes	No SSSV
1,2-Dibromo-3-chloropropane	0/23	NA	11U - 23UJ	8.3	23	---	---	NA	Yes	No SSSV
1,2-Dibromoethane	0/23	NA	5.3U - 23U	6.8	23	---	---	NA	Yes	No SSSV
1,2-Dichloroethane	0/23	NA	5U - 7.6U	2.9	7.6	401	MHSPE 1994	0.02	No	HQ < 1.0
1,2-Dichloropropane	0/23	NA	5U - 7.6U	2.9	7.6	700,000	Efroymson et. al. 1997a	<0.01	No	HQ < 1.0
2-Butanone	2/23	5.4J - 5.9J	10UJ - 38U	9.8	5.9	---	---	NA	Yes	No SSSV
2-Hexanone	0/23	NA	10U - 38U	10.5	38	---	---	NA	Yes	No SSSV
3-Chloro-1-propene	0/23	NA	5.3U - 23U	6.8	23	---	---	NA	Yes	No SSSV
4-Methyl-2-pentanone	0/23	NA	10U - 38U	10.5	38	---	---	NA	Yes	No SSSV
Acetone	5/21	8.8J - 56J	10U - 76U	21.8	56	---	---	NA	Yes	No SSSV
Acetonitrile	0/23	NA	100UJ - 310U	89.3	310	---	---	NA	Yes	No SSSV
Acrolein	0/14	NA	110UJ - 570UJ	226.8	570	---	---	NA	Yes	No SSSV
Acrylonitrile	0/23	NA	100U - 150U	57.4	150	1,000,000	Efroymson et. al. 1997a	<0.01	No	HQ < 1.0
Benzene	0/23	NA	5U - 7.6U	2.9	7.6	105	MHSPE 1994	0.07	No	HQ < 1.0
Bromodichloromethane	0/23	NA	5U - 7.6U	2.9	7.6	---	---	NA	Yes	No SSSV
Bromoform	0/23	NA	5U - 7.6U	2.9	7.6	---	---	NA	Yes	No SSSV
Bromomethane	0/23	NA	10U - 15U	5.7	15	---	---	NA	Yes	No SSSV
Carbon disulfide	0/23	NA	5UJ - 7.6U	2.9	7.6	---	---	NA	Yes	No SSSV
Carbon tetrachloride	0/23	NA	5U - 7.6U	2.9	7.6	1000000	Efroymson et. al. 1997a	<0.01	No	HQ < 1.0
Chlorobenzene	0/23	NA	5U - 7.6U	2.9	7.6	40,000	Efroymson et. al. 1997a	<0.01	No	HQ < 1.0
Chloroethane	0/23	NA	10U - 15U	5.7	15	---	---	NA	Yes	No SSSV
Chloroform	0/23	NA	5U - 7.6U	2.9	7.6	1,000	MHSPE 1994	<0.01	No	HQ < 1.0
Chloromethane	0/23	NA	10U - 15U	5.7	15	---	---	NA	Yes	No SSSV
Chloroprene	0/23	NA	5.3U - 110U	27.2	110	---	---	NA	Yes	No SSSV
cis-1,3-Dichloropropene	0/23	NA	5U - 7.6U	2.9	7.6	---	---	NA	Yes	No SSSV
Dibromochloromethane	0/23	NA	5U - 7.6U	2.9	7.6	---	---	NA	Yes	No SSSV
Dibromomethane	0/23	NA	5.3U - 11UJ	4.1	11	---	---	NA	Yes	No SSSV
Dichlorodifluoromethane	0/23	NA	5.3U - 23UJ	6.8	23	---	---	NA	Yes	No SSSV
Ethyl methacrylate	0/23	NA	5.3U - 23U	6.8	23	---	---	NA	Yes	No SSSV
Ethylbenzene	0/23	NA	5U - 7.6U	2.9	7.6	5,005	MHSPE 1994	<0.01	No	HQ < 1.0
Iodomethane	0/23	NA	5.3U - 11UJ	4.1	11	---	---	NA	Yes	No SSSV
Isobutanol	0/5	NA	220U - 310U	128	310	---	---	NA	Yes	No SSSV
Methacrylonitrile	0/23	NA	20U - 150U	36.9	150	---	---	NA	Yes	No SSSV
Methyl methacrylate	0/23	NA	5.3U - 23U	6.8	23	---	---	NA	Yes	No SSSV
Methylene chloride	2/23	2.2J - 6.7	5UJ - 7.6U	3	6.7	1,001	MHSPE 1994	<0.01	No	HQ < 1.0

TABLE 3-20
FREQUENCY AND RANGE OF SURFACE SOIL DATA (MAXIMUM CONCENTRATIONS) COMPARED TO SURFACE SOIL SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					Surface Soil Screening Value (SSSV)		Max. HQ[2]	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]					
Volatile Organics (ug/kg) (cont.):										
Pentachloroethane	0/23	NA	20UJ - 38U	13.1	38	---	---	NA	Yes	No SSSV
Propionitrile	0/12	NA	110U - 150U	60.8	150	---	---	NA	Yes	No SSSV
Styrene	1/23	4.5J - 4.5J	5U - 7.6U	2.9	4.5	10,010	MHSPE 1994	<0.01	No	HQ < 1.0
Tetrachloroethene	0/23	NA	5U - 7.6U	2.9	7.6	401	MHSPE 1994	0.02	No	HQ < 1.0
Toluene	6/23	3.5J - 57	5U - 32U	10.9	57	13,005	MHSPE 1994	<0.01	No	HQ < 1.0
trans-1,2-Dichloroethene	0/12	NA	5.3U - 7.6U	3	7.6	---	---	NA	Yes	No SSSV
trans-1,3-Dichloropropene	0/23	NA	5U - 7.6U	2.9	7.6	---	---	NA	Yes	No SSSV
trans-1,4-Dichloro-2-butene	0/23	NA	11U - 23U	8.3	23	1,000,000	Efroymson et. al. 1997a	<0.01	No	HQ < 1.0
Trichloroethene	2/23	4.3J - 10	5U - 7.6U	3.3	10	6,000	MHSPE 1994	<0.01	No	HQ < 1.0
Trichlorofluoromethane	0/23	NA	5.3U - 11U	4.1	11	---	---	NA	Yes	No SSSV
Vinyl acetate	0/23	NA	10UJ - 15U	5.7	15	---	---	NA	Yes	No SSSV
Vinyl chloride	0/23	NA	10U - 15U	5.7	15	11	MHSPE 1994	1.36	Yes	HQ > 1.0
Xylene	4/23	2J - 5.4J	5U - 15U	3.8	5.4	2,505	MHSPE 1994	<0.01	No	HQ < 1.0
Semi-Volatile Organics (ug/kg):										
1,2,4,5-Tetrachlorobenzene	0/16	NA	350U - 470U	194.4	470	---	---	NA	Yes	No SSSV
1,2,4-Trichlorobenzene	0/23	NA	340U - 470U	189.1	470	20,000	Efroymson et. al. 1997a	0.02	No	HQ < 1.0
1,2-Dichlorobenzene	0/23	NA	340U - 470U	189.1	470	3,001	MHSPE 1994	0.16	No	Below SSSV
1,3,5-Trinitrobenzene	0/23	NA	350UJ - 3800UJ	956.1	3,800	---	---	NA	Yes	No SSSV
1,3-Dichlorobenzene	0/23	NA	340U - 470U	189.1	470	3,001	MHSPE 1994	0.16	No	HQ < 1.0
1,4,-Dichlorobenzene	0/23	NA	340U - 470U	189.1	470	20,000	Efroymson et. al. 1997a	0.02	No	HQ < 1.0
1,4-Dioxane	0/23	NA	350U - 760UJ	273.9	760	---	---	NA	Yes	No SSSV
1,4-Naphthoquinone	0/23	NA	350U - 1900UJ	527.8	1,900	---	---	NA	Yes	No SSSV
1,4-Phenylenediamine	0/19	NA	680UJ - 2400U	777.6	2,400	---	---	NA	Yes	No SSSV
1-Naphthylamine	0/23	NA	350U - 760U	266.1	760	---	---	NA	Yes	No SSSV
2,3,4,6-Tetrachlorophenol	0/23	NA	340U - 470U	189.1	470	1,000	MHSPE 1994	0.47	No	HQ < 1.0
2,4,5-Trichlorophenol	0/23	NA	350U - 1900U	527.8	1,900	4,000	Efroymson et. al. 1997b	0.48	No	HQ < 1.0
2,4,6-Trichlorophenol	0/23	NA	340U - 470U	189.1	470	10,000	Efroymson et. al. 1997a	0.05	No	HQ < 1.0
2,4-Dichlorophenol	0/23	NA	340U - 470U	189.1	470	---	---	NA	Yes	No SSSV
2,4-Dimethylphenol	0/23	NA	340U - 470U	189.1	470	---	---	NA	Yes	No SSSV
2,4-Dinitrophenol	0/23	NA	1700U - 2400U	958.7	2,400	20,000	Efroymson et. al. 1997b	0.12	No	HQ < 1.0
2,4-Dinitrotoluene	0/23	NA	340U - 470U	189.1	470	---	---	NA	Yes	No SSSV
2,6-Dichlorophenol	0/23	NA	340U - 470U	189.1	470	1,001	MHSPE 1994	0.47	No	HQ < 1.0
2,6-Dinitrotoluene	0/23	NA	340U - 470U	189.1	470	---	---	NA	Yes	No SSSV
2-Acetylaminofluorene	0/23	NA	350U - 760U	273.9	760	---	---	NA	Yes	No SSSV
2-Chloronaphthalene	0/23	NA	340U - 470U	189.1	470	1,033	MHSPE 1994	0.45	No	HQ < 1.0
2-Chlorophenol	0/23	NA	340U - 470U	189.1	470	---	---	NA	Yes	No SSSV
2-Methylphenol	0/23	NA	340U - 470U	189.1	470	---	---	NA	Yes	No SSSV
2-Naphthalamine	0/23	NA	350U - 940UJ	304.8	940	---	---	NA	Yes	No SSSV
2-Nitroaniline	0/23	NA	1700UJ - 2400U	958.7	2,400	---	---	NA	Yes	No SSSV
2-Nitrophenol	0/23	NA	340U - 470U	189.1	470	---	---	NA	Yes	No SSSV
2-Picoline	0/23	NA	340U - 470U	189.1	470	---	---	NA	Yes	No SSSV

TABLE 3-20
FREQUENCY AND RANGE OF SURFACE SOIL DATA (MAXIMUM CONCENTRATIONS) COMPARED TO SURFACE SOIL SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					Surface Soil Screening Value (SSSV)		Max. HQ[2]	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]					
Semi-Volatile Organics (ug/kg) (cont.):										
3&4-Methylphenol	0/23	NA	340U - 470U	189.1	470	---	---	NA	Yes	No SSSV
3,3'-Dichlorobenzidine	0/23	NA	680U - 940U	378.3	940	---	---	NA	Yes	No SSSV
3,3'-Dimethylbenzidine	0/23	NA	720U - 2400U	935.2	2,400	---	---	NA	Yes	No SSSV
3-Methylcholanthrene	0/23	NA	340U - 470U	189.1	470	---	---	NA	Yes	No SSSV
3-Nitroaniline	0/23	NA	1700U - 2400U	958.7	2,400	---	---	NA	Yes	No SSSV
4,6-Dinitro-2-methylphenol	0/23	NA	1700U - 2400U	958.7	2,400	---	---	NA	Yes	No SSSV
4-Aminobiphenyl	0/23	NA	350U - 760U	273.9	760	---	---	NA	Yes	No SSSV
4-Bromophenyl phenyl ether	0/23	NA	340U - 470U	189.1	470	---	---	NA	Yes	No SSSV
4-Chloro-3-methylphenol	0/23	NA	350U - 760U	273.9	760	---	---	NA	Yes	No SSSV
4-Chloroaniline	0/23	NA	680U - 940U	378.3	940	---	---	NA	Yes	No SSSV
4-Chlorophenyl-Phenylether	0/23	NA	340U - 470U	189.1	470	---	---	NA	Yes	No SSSV
4-Nitroaniline	0/23	NA	1700U - 2400U	956.5	2,400	---	---	NA	Yes	No SSSV
4-Nitrophenol	0/23	NA	1700UJ - 2400U	958.7	2,400	7,000	Efroymson et. al. 1997a	0.34	No	HQ < 1.0
5-Nitro-o-toluidine	0/23	NA	350U - 760U	273.9	760	---	---	NA	Yes	No SSSV
7,12-Dimethyl benz(a)anthracene	0/23	NA	350U - 760U	273.9	760	---	---	NA	Yes	No SSSV
A, A-Dimethylphenethylamine	0/23	NA	1700UJ - 96000U	21,576.1	96,000	---	---	NA	Yes	No SSSV
Acetophenone	0/23	NA	340U - 470U	189.1	470	---	---	NA	Yes	No SSSV
Aniline	0/23	NA	350U - 1900UJ	527.8	1,900	---	---	NA	Yes	No SSSV
Aramite	0/23	NA	350U - 760UJ	273.9	760	---	---	NA	Yes	No SSSV
Benzoic acid	0/11	NA	1700U - 1900U	886.4	1,900	---	---	NA	Yes	No SSSV
Benzyl alcohol	0/23	NA	340U - 470U	189.1	470	---	---	NA	Yes	No SSSV
Bis(2-chloroethoxy)methane	0/23	NA	340U - 470U	189.1	470	---	---	NA	Yes	No SSSV
Bis(2-chloroethyl)ether	0/23	NA	340U - 470U	189.1	470	---	---	NA	Yes	No SSSV
Bis(2-chloroisopropyl)ether	0/23	NA	340U - 470U	189.1	470	---	---	NA	Yes	No SSSV
Bis(2-ethylhexyl)phthalate	7/23	68J - 790	340U - 410U	189.2	790	6,010	MHSPE 1994	0.13	No	HQ < 1.0
Butylbenzylphthalate	0/23	NA	340U - 470U	189.1	470	6,010	MHSPE 1994	0.08	No	HQ < 1.0
Diallate	0/23	NA	340UJ - 470U	189.1	470	---	---	NA	Yes	No SSSV
Dibenzofuran	0/23	NA	340U - 470U	189.1	470	---	---	NA	Yes	No SSSV
Diethylphthalate	0/23	NA	340U - 470U	189.1	470	100,000	Efroymson et. al. 1997b	<0.01	No	HQ < 1.0
Dimethylphthalate	0/23	NA	340U - 470U	189.1	470	200,000	Efroymson et. al. 1997a	<0.01	No	HQ < 1.0
Di-n-butylphthalate	1/23	65J - 65J	340U - 460U	181.7	65	200,000	Efroymson et. al. 1997b	<0.01	No	HQ < 1.0
Di-n-octylphthalate	0/23	NA	340U - 470U	189.1	470	6,010	MHSPE 1994	0.08	No	HQ < 1.0
Dinoseb	0/23	NA	350U - 760U	273.9	760	---	---	NA	Yes	No SSSV
Ethyl methanesulfonate	0/23	NA	340U - 470U	189.1	470	---	---	NA	Yes	No SSSV
Hexachlorobenzene	0/23	NA	340U - 470U	189.1	470	---	---	NA	Yes	No SSSV
Hexachlorobutadiene	0/23	NA	340U - 470U	189.1	470	---	---	NA	Yes	No SSSV
Hexachlorocyclopentadiene	0/23	NA	340U - 470U	189.1	470	10,000	Efroymson et. al. 1997b	0.05	No	HQ < 1.0
Hexachloroethane	0/23	NA	340U - 470U	189.1	470	---	---	NA	Yes	No SSSV
Hexachlorophene	0/20	NA	3400U - 240000U	62,210.0	240,000	---	---	NA	Yes	No SSSV
Hexachloropropene	0/22	NA	350U - 1900U	510.9	1,900	---	---	NA	Yes	No SSSV
Isophorone	0/23	NA	340U - 470U	189.1	470	---	---	NA	Yes	No SSSV

TABLE 3-20
FREQUENCY AND RANGE OF SURFACE SOIL DATA (MAXIMUM CONCENTRATIONS) COMPARED TO SURFACE SOIL SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					Surface Soil Screening Value (SSSV)		Max. HQ(2)	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen(1)					
Semi-Volatile Organics (ug/kg) (cont.):										
Isosafrole	0/22	NA	340U - 460U	187	460	---	---	NA	Yes	No SSSV
m-Dinitrobenzene	0/23	NA	350U - 760U	273.9	760	---	---	NA	Yes	No SSSV
Methapyrilene	0/23	NA	850UJ - 96000U	21365	96,000	---	---	NA	Yes	No SSSV
Methyl methanesulfonate	0/23	NA	340U - 470U	189.1	470	---	---	NA	Yes	No SSSV
Nitrobenzene	0/23	NA	340U - 470U	189.1	470	40,000	Efroymson et. al. 1997a	0.01	No	HQ < 1.0
n-Nitrosodiethylamine	0/23	NA	340UJ - 470U	189.1	470	20,000	---	0.02	No	HQ < 1.0
n-Nitrosodimethylamine	0/23	NA	340UJ - 470U	189.1	470	20,000	---	0.02	No	HQ < 1.0
n-Nitroso-di-n-butylamine	0/23	NA	340U - 470U	189.1	470	20,000	---	0.02	No	HQ < 1.0
n-Nitroso-di-n-propylamine	0/23	NA	340U - 470U	189.1	470	20,000	---	0.02	No	HQ < 1.0
n-Nitrosodiphenylamine	0/23	NA	340U - 470U	189.1	470	20,000	Efroymson et. al. 1997a	0.02	No	HQ < 1.0
n-Nitrosomethylethylamine	0/23	NA	340U - 470U	189.1	470	20,000	---	0.02	No	HQ < 1.0
n-Nitrosomorpholine	0/23	NA	350U - 760U	273.9	760	---	---	NA	Yes	No SSSV
n-Nitrosopiperidine	0/23	NA	340UJ - 470U	189.1	470	---	---	NA	Yes	No SSSV
n-Nitrosopyrrolidine	0/23	NA	350U - 1900UJ	527.8	1,900	---	---	NA	Yes	No SSSV
o,o,o-Triethylphosphorothioate	0/12	NA	350U - 470U	199.2	470	---	---	NA	Yes	No SSSV
o-Toluidine	0/19	NA	340U - 470U	191.1	470	---	---	NA	Yes	No SSSV
p-Dimethylaminoazobenzene	0/23	NA	350U - 760U	273.9	760	---	---	NA	Yes	No SSSV
Pentachlorobenzene	0/23	NA	340U - 470U	189.1	470	20,000	Efroymson et. al. 1997a	0.02	No	HQ < 1.0
Pentachloronitrobenzene	0/23	NA	340U - 470U	189.1	470	---	---	NA	Yes	No SSSV
Pentachlorophenol	0/23	NA	1700U - 2400U	958.7	2,400	3000	Efroymson et. al. 1997b	0.80	No	HQ < 1.0
Phenacetin	0/23	NA	340U - 470U	189.1	470	---	---	NA	Yes	No SSSV
Phenol	0/23	NA	340U - 470U	189.1	470	30,000	Efroymson et. al. 1997a	0.02	No	HQ < 1.0
Pronamide	0/23	NA	340U - 470U	189.1	470	---	---	NA	Yes	No SSSV
Pryridine	0/23	NA	350U - 760UJ	273.9	760	60	MHSPE 1994	12.67	Yes	HQ > 1.0
Safrole	0/23	NA	340U - 470U	189.1	470	---	---	NA	Yes	No SSSV
PAHs (ug/kg):										
1-Methylnaphthalene	0/1	NA	8.4U - 8.4U	4.2	8.4	---	---	NA	Yes	No SSSV
2-Methylnaphthalene	0/23	NA	8.4U - 470U	180.4	470	---	---	NA	Yes	No SSSV
Acenaphthene	0/23	NA	8.4U - 470U	180.4	470	20,000	Efroymson et. al. 1997b	0.02	No	HQ < 1.0
Acenaphthylene	0/23	NA	8.4U - 470U	180.4	470	1,200	USEPA 1999a	0.39	No	HQ < 1.0
Anthracene	0/23	NA	8.4U - 470U	180.4	470	1,200	USEPA 1999a	0.39	No	HQ < 1.0
Benzo(a)anthracene	4/23	3.2J - 160J	340U - 470U	167.5	160	1,200	USEPA 1999a	0.13	No	HQ < 1.0
Benzo(a)pyrene	4/23	2.7J - 130J	340U - 470U	167.6	130	1,200	USEPA 1999a	0.11	No	HQ < 1.0
Benzo(b)fluoranthene	6/23	2.5J - 190J	340U - 470U	159.9	190	1,200	USEPA 1999a	0.16	No	HQ < 1.0
Benzo(g,h,i)perylene	6/23	3.2J - 110J	340U - 470U	154	110	1,200	USEPA 1999a	0.09	No	HQ < 1.0
Benzo(k)fluoranthene	2/23	3.6J - 100J	340U - 470U	177.3	100	1,200	USEPA 1999a	0.08	No	HQ < 1.0
Chrysene	5/23	3.3J - 210J	340U - 470U	165.1	210	1,200	USEPA 1999a	0.18	No	HQ < 1.0
Dibenzo(a,h)anthracene	0/23	NA	8.4U - 470U	180.4	470	1,200	USEPA 1999a	0.39	No	HQ < 1.0
Fluoranthene	5/23	6.2J - 360	340U - 470U	174	360	1,200	USEPA 1999a	0.30	No	HQ < 1.0
Fluorene	0/23	NA	8.4U - 470U	180.4	470	30,000	Efroymson et. al. 1997a	0.02	No	HQ < 1.0
Indeno(1,2,3-cd)pyrene	2/23	2.2J - 67J	340U - 470U	175.8	67	1,200	USEPA 1999a	0.06	No	HQ < 1.0

TABLE 3-20
FREQUENCY AND RANGE OF SURFACE SOIL DATA (MAXIMUM CONCENTRATIONS) COMPARED TO SURFACE SOIL SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					Surface Soil Screening Value (SSSV)		Max. HQ[2]	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]					
PAHs (ug/kg) (cont.):										
Naphthalene	0/23	NA	8.4U - 470U	180.4	470	1,200	USEPA 1999a	0.39	No	HQ < 1.0
Phenanthrene	4/23	3.4J - 46J	340U - 470U	160.8	46	1,200	USEPA 1999a	0.04	No	HQ < 1.0
Pyrene	4/23	4.3J - 320J	340U - 470U	177.4	320	1,200	USEPA 1999a	0.27	No	HQ < 1.0
Metals (mg/kg):										
Antimony	6/19	0.59J - 1.3J	1.3UJ - 2.6U	0.95	1.3	5	Efroymson et. al. 1997b	0.26	No	HQ < 1.0
Arsenic	20/23	0.75 - 3.2	0.52U - 0.97U	1.40	3.2	10	Efroymson et. al. 1997b	0.32	No	HQ < 1.0
Barium	23/23	27 - 342J	NA	89.62	342	500	Efroymson et. al. 1997b	0.68	No	HQ < 1.0
Beryllium	18/19	0.12J - 1.8	0.06U - 0.06U	0.37	1.8	10	Efroymson et. al. 1997b	0.18	No	HQ < 1.0
Cadmium	18/23	0.14J - 0.8	0.22U - 0.55U	0.38	0.8	4	Efroymson et. al. 1997b	0.20	No	HQ < 1.0
Chromium	23/23	7.2J - 65	NA	25.75	65	0.4	Efroymson et. al. 1997a	162.50	Yes	HQ > 1.0
Cobalt	19/19	7.3J - 38	NA	22.94	38	20	Efroymson et. al. 1997b	1.90	Yes	HQ > 1.0
Copper	19/19	23.1 - 120J	NA	83.45	120	50	Efroymson et. al. 1997a	2.40	Yes	HQ > 1.0
Lead	23/23	1.6 - 20.3	NA	8.49	20.3	50	Efroymson et. al. 1997b	0.41	No	HQ < 1.0
Mercury	12/23	0.0037J - 0.029	0.04U - 0.06U	0.02	0.029	0.10	Efroymson et. al. 1997a	0.29	No	HQ < 1.0
Nickel	19/19	4.3 - 25.4	NA	14.29	25.4	30	Efroymson et. al. 1997b	0.85	No	HQ < 1.0
Selenium	8/23	0.31J - 0.97J	0.12UJ - 1.3U	0.43	0.97	1.0	Efroymson et. al. 1997b	0.97	No	HQ < 1.0
Silver	0/23	NA	0.21U - 1.3U	0.36	1.3	2.0	Efroymson et. al. 1997b	0.65	No	HQ < 1.0
Thallium	11/19	0.79J - 2.5J	0.13U - 1.1U	0.98	2.5	1.0	Efroymson et. al. 1997b	2.50	Yes	HQ > 1.0
Tin	3/19	1.4 - 1.6	0.72U - 6.5U	2.10	1.6	50	Efroymson et. al. 1997b	0.03	No	HQ < 1.0
Vanadium	19/19	42.4 - 220	NA	131.49	220	2	Efroymson et. al. 1997b	110.00	Yes	HQ > 1.0
Zinc	19/19	48J - 290	NA	78.19	290	50	Efroymson et. al. 1997b	5.80	Yes	HQ > 1.0

Notes:

HQ = Hazard Quotient
COPC = Ecological Chemical of Potential Concern
NA = Not Applicable

J = Value is estimated
U = Not detected
UJ = Not detected, value is estimated

(1) Maximum detected concentration (or maximum reporting limit for non-detected chemicals).

(2) For a given chemical, the Hazard Quotient (HQ) is the maximum detected concentration (or maximum reporting limit for non-detected chemicals) divided by the surface soil screening value.

TABLE 3-21
FREQUENCY AND RANGE OF GROUNDWATER DATA (MAXIMUM CONCENTRATIONS) COMPARED TO SURFACE WATER SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					Surface Water Screening Value (SWSV)		Max. HQ[2]	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]					
Volatile Organics (ug/L) (cont.):										
1,1,1,2-Tetrachloroethane	0/20	NA	5U - 200U	7.4	200	902	Buchman 1999	0.22	No	HQ < 1.0
1,1,1-Trichloroethane	0/20	NA	5U - 200U	7.4	200	312	USEPA 2001	0.64	No	HQ < 1.0
1,1,2,2-Tetrachloroethane	0/20	NA	5U - 200U	7.4	200	90.2	USEPA 2001	2.22	Yes	HQ > 1.0
1,1,2-Trichloroethane	0/20	NA	5U - 200U	7.4	200	340	EPA 1996b	0.59	No	HQ < 1.0
1,1-Dichloroethane	0/20	NA	5U - 200U	7.4	200	47	USEPA 1996a	4.26	Yes	HQ > 1.0
1,1-Dichloroethene	1/20	1.7J - 1.7J	5U - 200U	7.3	1.7	2,240	USEPA 2001	<0.01	No	HQ < 1.0
1,2,3-Trichloropropane	0/20	NA	5U - 200U	7.4	200	274	USEPA 2000b	0.73	No	HQ < 1.0
1,2-Dibromo-3-chloropropane	0/20	NA	5UJ - 200UJ	7.4	200	100	USEPA 2000b	2.00	Yes	HQ > 1.0
1,2-Dibromoethane	0/20	NA	5U - 200U	7.4	200	48	USEPA 2000b	4.17	Yes	HQ > 1.0
1,2-Dichloroethane	0/20	NA	5U - 200U	7.4	200	1,130	USEPA 2001	0.18	No	HQ < 1.0
1,2-Dichloropropane	0/20	NA	5U - 200U	7.4	200	2,400	USEPA 2001	0.08	No	HQ < 1.0
2-Butanone	0/20	NA	25U - 2000U	61.9	2,000	40,000	USEPA 2000b	0.05	No	HQ < 1.0
2-Hexanone	0/20	NA	25U - 2000U	61.9	2,000	98.8	Suter II 1996	20.24	Yes	HQ > 1.0
3-Chloro-1-propene	0/20	NA	5U - 200U	7.4	200	3.4	USEPA 2000b	58.82	Yes	HQ > 1.0
4-Methyl-2-pentanone	0/20	NA	25U - 2000U	61.9	2,000	164	Suter II 1996	12.20	Yes	HQ > 1.0
Acetone	0/19	NA	50U - 5000U	155.3	5,000	1,000	USEPA 2000b	5.00	Yes	HQ > 1.0
Acetonitrile	0/20	NA	200UJ - 8000UJ	295	8,000	160,000	USEPA 2000b	0.05	No	HQ < 1.0
Acrylonitrile	0/20	NA	100UJ - 4000UJ	147.5	4,000	58.1	USEPA 2000b	68.85	Yes	HQ > 1.0
Benzene	0/20	NA	5U - 200U	7.4	200	109	USEPA 2001	1.83	Yes	HQ > 1.0
Bromodichloromethane	1/20	2.9J - 2.9J	5U - 200U	7.4	2.9	6,400	Buchman 1999	<0.01	No	HQ < 1.0
Bromoform	0/20	NA	5U - 200U	7.4	200	640	USEPA 2001	0.31	No	HQ < 1.0
Bromomethane	0/20	NA	10UJ - 200UJ	9.8	200	120	USEPA 2000b	1.67	Yes	HQ > 1.0
Carbon disulfide	0/20	NA	5U - 200U	7.4	200	650	USEPA 2000b	0.31	No	HQ < 1.0
Carbon tetrachloride	0/20	NA	5U - 200U	7.4	200	1,500	USEPA 2001	0.13	No	HQ < 1.0
Chlorobenzene	0/20	NA	5U - 200U	7.4	200	105	USEPA 2001	1.90	Yes	HQ > 1.0
Chloroethane	0/20	NA	10U - 200U	9.8	200	---	---	NA	Yes	No SWSV
Chloroform	1/20	75 - 75	5U - 200U	11	75	815	USEPA 2001	0.09	No	HQ < 1.0
Chloromethane	0/20	NA	10U - 200U	9.8	200	2,700	USEPA 2000b	0.07	No	HQ < 1.0
Chloroprene	0/20	NA	5U - 200U	7.4	200	---	---	NA	Yes	No SWSV
cis-1,3-Dichloropropene	0/20	NA	5U - 200U	7.4	200	7.9	USEPA 2001	25.32	Yes	HQ > 1.0
Dibromochloromethane	0/20	NA	5U - 200U	7.4	200	6,400	Buchman 1999	0.03	No	HQ < 1.0
Dibromomethane	0/20	NA	5U - 200U	7.4	200	6,400	Buchman 1999	0.03	No	HQ < 1.0
Dichlorodifluoromethane	0/20	NA	10U - 200U	9.8	200	6,400	Buchman 1999	0.03	No	HQ < 1.0
Ethyl methacrylate	0/20	NA	5U - 200U	7.4	200	---	---	NA	Yes	No SWSV
Ethylbenzene	0/20	NA	5U - 200U	7.4	200	4.3	USEPA 2001	46.51	Yes	HQ > 1.0
Iodomethane	0/20	NA	5U - 200U	7.4	200	---	---	NA	Yes	No SWSV
Isobutanol	2/13	270J - 2700J	200U - 200U	313.1	2,700	10,000	USEPA 2000b	0.27	No	HQ < 1.0
Methacrylonitrile	0/20	NA	100UJ - 4000UJ	147.5	4,000	---	---	NA	Yes	No SWSV
Methyl methacrylate	0/20	NA	5U - 200U	7.4	200	1,300	USEPA 2000b	0.15	No	HQ < 1.0

TABLE 3-21
FREQUENCY AND RANGE OF GROUNDWATER DATA (MAXIMUM CONCENTRATIONS) COMPARED TO SURFACE WATER SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					Surface Water Screening Value (SWSV)		Max. HQ[2]	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]					
Volatile Organics (ug/L) (cont.):										
Methylene chloride	2/20	1.6J - 95J	5U - 5U	7.1	95	2,560	USEPA 2001	0.04	No	HQ < 1.0
Pentachloroethane	0/13	NA	25UJ - 1000UJ	50	1,000	281	Buchman 1999	3.56	Yes	HQ > 1.0
Propionitrile	1/20	12J - 12J	100U - 4000U	145.6	12	15,200	USEPA 2000b	<0.01	No	HQ < 1.0
Styrene	0/20	NA	5U - 200U	7.4	200	510	USEPA 2000b	0.39	No	HQ < 1.0
Tetrachloroethene	0/20	NA	5U - 200U	7.4	200	45	USEPA 2001	4.44	Yes	HQ > 1.0
Toluene	1/20	200J - 200J	5U - 5U	12.4	200	37	USEPA 2001	5.41	Yes	HQ > 1.0
trans-1,2-Dichloroethene	0/20	NA	5U - 200U	7.4	200	22,400	Buchman 1999	<0.01	No	HQ < 1.0
trans-1,3-Dichloropropene	0/20	NA	5U - 200U	7.4	200	7.9	USEPA 2001	25.32	Yes	HQ > 1.0
trans-1,4-Dichloro-2-butene	0/20	NA	10U - 400U	14.8	400	---	---	NA	Yes	No SWSV
Trichloroethene	2/20	0.35J - 28000J	5U - 5U	1,402	28,000	200	Buchman 1999	140.00	Yes	HQ > 1.0
Trichlorofluoromethane	0/20	NA	5U - 200U	7.4	200	6,400	Buchman 1999	0.03	No	HQ < 1.0
Vinyl acetate	0/20	NA	10U - 400U	14.8	400	10,000	USEPA 2000b	0.04	No	HQ < 1.0
Vinyl chloride	0/20	NA	10U - 200U	9.8	200	87.8	Suter II 1996	2.28	Yes	HQ > 1.0
Xylene	0/20	NA	10U - 400U	14.8	400	41	USEPA 2000b	9.76	Yes	HQ > 1.0
Semi-Volatile Organics (ug/L):										
1,2,4,5-Tetrachlorobenzene	0/20	NA	10U - 10U	5	10	30	USEPA 2000b	0.33	No	HQ < 1.0
1,2,4-Trichlorobenzene	0/20	NA	10U - 10U	5	10	4.5	USEPA 2001	2.22	Yes	HQ > 1.0
1,2-Dichlorobenzene	0/20	NA	10U - 10U	5	10	19.7	USEPA 2001	0.51	No	HQ < 1.0
1,3,5-Trinitrobenzene	0/15	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
1,3-Dichlorobenzene	0/20	NA	10U - 10U	5	10	28.5	USEPA 2001	0.35	No	HQ < 1.0
1,4,-Dichlorobenzene	0/20	NA	10U - 10U	5	10	19.9	USEPA 2001	0.50	No	HQ < 1.0
1,4-Dioxane	0/20	NA	10U - 10U	5	10	67,000	USEPA 2000b	<0.01	No	HQ < 1.0
1,4-Naphthoquinone	0/20	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
1,4-Phenylenediamine	0/20	NA	2000U - 2000U	1,000	2,000	200	USEPA 2000b	10.00	Yes	HQ > 1.0
1-Naphthylamine	0/20	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
2,3,4,6-Tetrachlorophenol	0/19	NA	10U - 10U	5	10	44	Buchman 1999	0.23	No	HQ < 1.0
2,4,5-Trichlorophenol	0/19	NA	10U - 10U	5	10	11	Buchman 1999	0.91	No	HQ < 1.0
2,4,6-Trichlorophenol	0/19	NA	10U - 10U	5	10	12.1	USEPA 2000b	0.83	No	HQ < 1.0
2,4-Dichlorophenol	0/19	NA	10U - 10U	5	10	5	USEPA 2000b	2.00	Yes	HQ > 1.0
2,4-Dimethylphenol	0/19	NA	10U - 10U	5	10	131	USEPA 2000b	0.08	No	HQ < 1.0
2,4-Dinitrophenol	0/19	NA	50UJ - 50UJ	25	50	48.5	USEPA 2001	1.03	Yes	HQ > 1.0
2,4-Dinitrotoluene	0/20	NA	10U - 10U	5	10	370	Buchman 1999	0.03	No	HQ < 1.0
2,6-Dichlorophenol	0/20	NA	10U - 10U	5	10	54	USEPA 2000b	0.19	No	HQ < 1.0
2,6-Dinitrotoluene	0/20	NA	10UJ - 10UJ	5	10	370	Assumed	0.03	No	HQ < 1.0
2-Acetylaminofluorene	0/20	NA	10U - 10U	5	10	100	USEPA 2000b	0.10	No	HQ < 1.0
2-Chloronaphthalene	0/20	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
2-Chlorophenol	0/19	NA	10U - 10U	5	10	53	USEPA 2000b	0.19	No	HQ < 1.0
2-Methylphenol	0/19	NA	10U - 10U	5	10	102	USEPA 2000b	0.10	No	HQ < 1.0
2-Naphthalamine	0/20	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
2-Nitroaniline	0/20	NA	50U - 50U	25	50	48.9	USEPA 2000b	1.02	Yes	HQ > 1.0

TABLE 3-21
FREQUENCY AND RANGE OF GROUNDWATER DATA (MAXIMUM CONCENTRATIONS) COMPARED TO SURFACE WATER SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					Surface Water Screening Value (SWSV)		Max. HQ[2]	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]					
Semi-Volatile Organics (ug/L) (cont.):										
2-Nitrophenol	0/19	NA	10U - 10U	5	10	10,000	USEPA 2000b	<0.01	No	HQ < 1.0
2-Picoline	0/20	NA	10U - 10U	5	10	8,979	USEPA 2000b	<0.01	No	HQ < 1.0
3&4-Methylphenol	0/19	NA	10U - 10U	5	10	50	USEPA 2000b	0.20	No	HQ < 1.0
3,3'-Dichlorobenzidine	0/20	NA	20U - 20U	10	20	10.5	USEPA 2000b	1.90	Yes	HQ > 1.0
3,3'-Dimethylbenzidine	0/20	NA	20U - 20U	10	20	160	USEPA 2000b	0.13	No	HQ < 1.0
3-Methylcholanthrene	0/20	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
3-Nitroaniline	0/20	NA	50U - 50U	25	50	9.8	USEPA 2000b	5.10	Yes	HQ > 1.0
4,6-Dinitro-2-methylphenol	0/19	NA	50UJ - 50UJ	25	50	183	USEPA 2000b	0.27	No	HQ < 1.0
4-Aminobiphenyl	0/20	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
4-Bromophenyl phenyl ether	0/20	NA	10U - 10U	5	10	3.6	USEPA 2000b	2.78	Yes	HQ > 1.0
4-Chloro-3-methylphenol	0/19	NA	10U - 10U	5	10	1,300	USEPA 2000b	<0.01	No	HQ < 1.0
4-Chloroaniline	0/20	NA	20U - 20U	10	20	129	Buchman 1999	0.16	No	HQ < 1.0
4-Chlorophenyl-Phenylether	0/20	NA	10U - 10U	5	10	7.3	USEPA 2000b	1.37	Yes	HQ > 1.0
4-Nitroaniline	0/20	NA	50U - 50U	25	50	170	USEPA 2000b	0.29	No	HQ < 1.0
4-Nitrophenol	0/19	NA	50U - 50U	25	50	71.7	USEPA 2001	0.70	No	HQ < 1.0
4-Nitroquinoline-1-oxide	0/1	NA	20UJ - 20UJ	10	20	---	---	NA	Yes	No SWSV
5-Nitro-o-toluidine	0/20	NA	10U - 10U	5	10	225	USEPA 2000b	0.04	No	HQ < 1.0
7,12-Dimethyl benz(a)anthracene	0/20	NA	10U - 10U	5	10	30	Buchman 1999	0.33	No	HQ < 1.0
A, A-Dimethylphenethylamine	0/20	NA	2000UJ - 2000UJ	1000	2000	---	---	NA	Yes	No SWSV
Acetophenone	1/20	4.8J - 4.8J	10U - 10U	5	4.8	1,550	USEPA 2000b	<0.01	No	HQ < 1.0
Aniline	0/20	NA	20U - 20U	10	20	294	USEPA 2000b	0.07	No	HQ < 1.0
Aramite	0/20	NA	10U - 10U	5	10	0.6	USEPA 2000b	16.67	Yes	HQ > 1.0
Benzyl alcohol	0/19	NA	10U - 10U	5	10	150	USEPA 2000b	0.07	No	HQ < 1.0
Bis(2-chloroethoxy)methane	0/20	NA	10U - 10U	5	10	6,400	Buchman 1999	<0.01	No	HQ < 1.0
Bis(2-chloroethyl)ether	0/20	NA	10U - 10U	5	10	910	USEPA 2000b	0.01	No	HQ < 1.0
Bis(2-chloroisopropyl)ether	0/20	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
Bis(2-ethylhexyl)phthalate	7/20	0.88J - 15	10U - 10U	4.4	15	360	Buchman 1999	0.04	No	HQ < 1.0
Butylbenzylphthalate	0/20	NA	10U - 10U	5	10	29.4	USEPA 2001	0.34	No	HQ < 1.0
Diallate	0/20	NA	10U - 10U	5	10	82	USEPA 2000b	0.12	No	HQ < 1.0
Dibenzofuran	1/20	0.54J - 0.54J	10U - 10U	4.8	0.54	100	USEPA 2000b	<0.01	No	HQ < 1.0
Diethylphthalate	1/20	0.66J - 0.66J	10U - 10U	4.8	0.66	75.9	USEPA 2001	<0.01	No	HQ < 1.0
Dimethylphthalate	2/20	0.5J - 1.8J	10U - 10U	4.6	1.8	580	USEPA 2001	<0.01	No	HQ < 1.0
Di-n-butylphthalate	6/20	0.28J - 1.6J	10U - 10U	3.8	1.6	3.4	USEPA 2001	0.47	No	HQ < 1.0
Di-n-octylphthalate	0/20	NA	10U - 10U	5	10	3,450	USEPA 2000b	<0.01	No	HQ < 1.0
Dinoseb	0/20	NA	10U - 10U	5	10	1.7	USEPA 2000b	5.88	Yes	HQ > 1.0
Ethyl methanesulfonate	0/20	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
Hexachlorobenzene	0/20	NA	10U - 10U	5	10	10	USEPA 2000b	1.00	Yes	HQ > 1.0
Hexachlorobutadiene	0/20	NA	10U - 10U	5	10	0.32	USEPA 2001	31.25	Yes	HQ > 1.0
Hexachlorocyclopentadiene	0/20	NA	10U - 10U	5	10	0.07	USEPA 2001	142.86	Yes	HQ > 1.0
Hexachloroethane	0/20	NA	10U - 10U	5	10	9.4	USEPA 2001	1.06	Yes	HQ > 1.0

TABLE 3-21
FREQUENCY AND RANGE OF GROUNDWATER DATA (MAXIMUM CONCENTRATIONS) COMPARED TO SURFACE WATER SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					Surface Water Screening Value (SWSV)		Max. HQ[2]	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]					
Semi-Volatile Organics (ug/L) (cont.):										
Hexachlorophene	0/20	NA	5000U - 5000U	2,500	5,000	8.8	USEPA 2000b	568.18	Yes	HQ > 1.0
Hexachloropropene	0/20	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
Isophorone	0/20	NA	10U - 10U	5	10	129	USEPA 2001	0.08	No	HQ < 1.0
Isosafrole	0/8	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
m-Dinitrobenzene	0/20	NA	10U - 10U	5	10	66.8	Assumed	0.15	No	HQ < 1.0
Methapyrilene	0/20	NA	2000U - 2000U	1,000	2,000	---	---	NA	Yes	No SWSV
Methyl methanesulfonate	0/20	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
Nitrobenzene	0/20	NA	10U - 10U	5	10	66.8	USEPA 2001	0.15	No	HQ < 1.0
n-Nitrosodiethylamine	0/20	NA	10U - 10U	5	10	330,000	Buchman 1999	<0.01	No	HQ < 1.0
n-Nitrosodimethylamine	0/20	NA	10U - 10U	5	10	27,000	USEPA 2000b	<0.01	No	HQ < 1.0
n-Nitroso-di-n-butylamine	0/20	NA	10U - 10U	5	10	330,000	Buchman 1999	<0.01	No	HQ < 1.0
n-Nitroso-di-n-propylamine	0/20	NA	10U - 10U	5	10	330,000	Assumed	<0.01	No	HQ < 1.0
n-Nitrosodiphenylamine	0/20	NA	10U - 10U	5	10	33,000	USEPA 2001	<0.01	No	HQ < 1.0
n-Nitrosomethylethylamine	0/20	NA	10U - 10U	5	10	330,000	Assumed	<0.01	No	HQ < 1.0
n-Nitrosomorpholine	0/20	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
n-Nitrosopiperidine	0/20	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
n-Nitrosopyrrolidine	0/20	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
o,o,o-Triethylphosphorothioate	0/20	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
o-Toluidine	0/20	NA	10U - 10U	5	10	400	USEPA 2000b	0.03	No	HQ < 1.0
p-Dimethylaminoazobenzene	0/20	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
Pentachlorobenzene	0/20	NA	10U - 10U	5	10	129	USEPA 2001	0.08	No	HQ < 1.0
Pentachloronitrobenzene	0/20	NA	10U - 10U	5	10	0.23	USEPA 2000b	43.48	Yes	HQ > 1.0
Pentachlorophenol	0/19	NA	50U - 50U	25	50	7.9	USEPA 1999b	6.33	Yes	HQ > 1.0
Phenacetin	0/20	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
Phenol	0/19	NA	10U - 10U	5	10	58	USEPA 2001	0.17	No	HQ < 1.0
Pronamide	0/20	NA	10U - 10U	5	10	35	USEPA 2000b	0.29	No	HQ < 1.0
Pryridine	0/20	NA	50U - 50U	25	50	500	USEPA 2000b	0.10	No	HQ < 1.0
Pyrene	0/20	NA	10U - 10U	5	10	30	Buchman 1999	0.33	No	HQ < 1.0
Safrole	0/20	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
PAHs (ug/L):										
2-Methylnaphthalene	2/20	6.2J - 96	10U - 10U	9.6	96	6	USEPA 2000b	16.00	Yes	HQ > 1.0
Acenaphthene	1/20	0.95J - 0.95J	10U - 10U	4.8	0.95	9.7	USEPA 2001	0.10	No	HQ < 1.0
Acenaphthylene	0/20	NA	10U - 10U	5	10	30	Buchman 1999	0.33	No	HQ < 1.0
Anthracene	0/20	NA	10U - 10U	5	10	50	EPA 1996b	0.20	No	HQ < 1.0
Benzo(a)anthracene	0/20	NA	10U - 10U	5	10	30	Buchman 1999	0.33	No	HQ < 1.0
Benzo(a)pyrene	0/20	NA	10U - 10U	5	10	10	EPA 1996b	1.00	Yes	HQ > 1.0
Benzo(b)fluoranthene	0/20	NA	10U - 10U	5	10	30	Buchman 1999	0.33	No	HQ < 1.0
Benzo(g,h,i)perylene	2/20	1.4J - 1.4J	10U - 10U	4.6	1.4	30	Buchman 1999	0.05	No	HQ < 1.0
Benzo(k)fluoranthene	0/20	NA	10U - 10U	5	10	30	Buchman 1999	0.33	No	HQ < 1.0
Chrysene	0/20	NA	10U - 10U	5	10	10	EPA 1996b	1.00	Yes	HQ > 1.0

TABLE 3-21
FREQUENCY AND RANGE OF GROUNDWATER DATA (MAXIMUM CONCENTRATIONS) COMPARED TO SURFACE WATER SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					Surface Water Screening Value (SWSV)		Max. HQ[2]	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]					
PAH (ug/L) (cont.):										
Dibenzo(a,h)anthracene	0/20	NA	10U - 10U	5	10	30	Buchman 1999	0.33	No	HQ < 1.0
Fluoranthene	0/20	NA	10U - 10U	5	10	11	USEPA 1996a	0.91	No	HQ < 1.0
Fluorene	2/20	1.3J - 2.7J	10U - 10U	4.7	2.7	10	USEPA 2000b	0.27	No	HQ < 1.0
Indeno(1,2,3-cd)pyrene	1/20	0.58J - 0.58J	10U - 10U	4.8	0.58	30	Buchman 1999	0.02	No	HQ < 1.0
Naphthalene	0/20	NA	10U - 10U	5	10	23.5	USEPA 2001	0.43	No	HQ < 1.0
Phenanthrene	1/20	0.5J - 0.5J	10U - 10U	4.8	0.5	8.3	USEPA 1996a	0.06	No	HQ < 1.0
Total Metals (ug/L):										
Antimony	0/20	NA	20U - 20U	10	20	500	Buchman 1999	0.04	No	HQ < 1.0
Arsenic	6/20	3.4J - 18	10UJ - 10UJ	6	18	36	USEPA 1999b	0.50	No	HQ < 1.0
Barium	19/20	1.5J - 900	10U - 10U	148.8	900	50,000	USEPA 2000b	0.02	No	HQ < 1.0
Beryllium	0/20	NA	4U - 4U	2	4	310	USEPA 2000b	0.01	No	HQ < 1.0
Cadmium	2/20	0.97J - 2.9J	5U - 5U	2.4	2.9	9.36	USEPA 1999b	0.31	No	HQ < 1.0
Chromium	4/20	1.9J - 8.2J	10U - 10U	4.8	8.2	50.4	USEPA 1999b	0.16	No	HQ < 1.0
Cobalt	7/20	2J - 18	10U - 10U	6.2	18	45	USEPA 2000b	0.40	No	HQ < 1.0
Copper	13/20	0.95J - 53	20U - 20U	9.4	53	3.7	USEPA 1999b	14.32	Yes	HQ > 1.0
Lead	2/20	1.7J - 6.7J	5UJ - 5UJ	2.7	6.7	8.5	USEPA 1999b	0.79	No	HQ < 1.0
Mercury	2/20	0.22J - 2.4J	0.2UJ - 0.4UJ	0.2	2.4	1.1	USEPA 1999b	2.18	Yes	HQ > 1.0
Nickel	3/20	5.7J - 7.7J	40U - 40U	18	7.7	8.3	USEPA 1999b	0.93	No	HQ < 1.0
Selenium	3/20	5.1J - 8.3J	10UJ - 10UJ	5.2	8.3	71.1	USEPA 1999b	0.12	No	HQ < 1.0
Silver	1/20	2J - 2J	10U - 10U	4.9	2	0.23	USEPA 2001	8.70	Yes	HQ > 1.0
Thallium	4/20	5.6J - 13	10U - 10U	5.8	13	21.3	USEPA 2001	0.61	No	HQ < 1.0
Tin	0/20	NA	50U - 50U	25	50	---	---	NA	Yes	No SWSV
Vanadium	16/20	2.6J - 140	10U - 10U	25	140	---	---	NA	Yes	No SWSV
Zinc	6/20	6.7J - 110	20U - 20U	15.1	110	85.6	USEPA 1999b	1.29	Yes	HQ > 1.0

Notes:

HQ = Hazard Quotient
COPC = Ecological Chemical of Potential Concern
NA = Not Applicable

J = Value is estimated
U = Not detected
UJ = Not detected, value is estimated

(1) Maximum detected concentration (or maximum reporting limit for non-detected chemicals).

(2) For a given chemical, the Hazard Quotient (HQ) is the maximum detected concentration (or maximum reporting limit for non-detected chemicals) divided by the surface water screening value.

TABLE 3-22
FREQUENCY AND RANGE OF SURFACE WATER DATA (MAXIMUM CONCENTRATIONS) COMPARED TO SURFACE WATER SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					Surface Water Screening Value (SWSV)		Max. HQ[2]	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]					
Volatile Organics (ug/L):										
1,1,1,2-Tetrachloroethane	0/9	NA	5U - 5U	2.5	5	902	Buchman 1999	<0.01	No	HQ < 1.0
1,1,1-Trichloroethane	0/9	NA	5U - 5U	2.5	5	312	USEPA 2001	0.02	No	HQ < 1.0
1,1,2,2-Tetrachloroethane	0/9	NA	5U - 5U	2.5	5	90.2	USEPA 2001	0.06	No	HQ < 1.0
1,1,2-Trichloroethane	0/9	NA	5U - 5U	2.5	5	340	EPA 1996b	0.01	No	HQ < 1.0
1,1-Dichloroethane	0/9	NA	5U - 5U	2.5	5	47	USEPA 1996a	0.11	No	HQ < 1.0
1,1-Dichloroethene	0/9	NA	5U - 5U	2.5	5	2,240	USEPA 2001	<0.01	No	HQ < 1.0
1,2,3-Trichloropropane	0/9	NA	5U - 5U	2.5	5	274	USEPA 2000b	0.02	No	HQ < 1.0
1,2-Dibromo-3-chloropropane	0/9	NA	5U - 5U	2.5	5	100	USEPA 2000b	0.05	No	HQ < 1.0
1,2-Dibromoethane	0/9	NA	5U - 5U	2.5	5	48	USEPA 2000b	0.10	No	HQ < 1.0
1,2-Dichloroethane	0/9	NA	5U - 5U	2.5	5	1,130	USEPA 2001	<0.01	No	HQ < 1.0
1,2-Dichloropropane	0/9	NA	5U - 5U	2.5	5	2,400	USEPA 2001	<0.01	No	HQ < 1.0
2-Butanone	0/9	NA	25U - 25U	12.5	25	40,000	USEPA 2000b	<0.01	No	HQ < 1.0
2-Hexanone	0/9	NA	25U - 25U	12.5	25	98.8	Suter II 1996	0.25	No	HQ < 1.0
3-Chloro-1-propene	0/9	NA	5U - 5U	2.5	5	3.4	USEPA 2000b	1.47	Yes	HQ > 1.0
4-Methyl-2-pentanone	0/9	NA	25U - 25U	12.5	25	164	Suter II 1996	0.15	No	HQ < 1.0
Acetone	0/9	NA	50U - 50U	25	50	1,000	USEPA 2000b	0.05	No	HQ < 1.0
Acetonitrile	0/9	NA	200UJ - 200UJ	100	200	160,000	USEPA 2000b	<0.01	No	HQ < 1.0
Acrylonitrile	0/9	NA	100U - 100U	50	100	58.1	USEPA 2000b	1.72	Yes	HQ > 1.0
Benzene	0/9	NA	5U - 5U	2.5	5	109	USEPA 2001	0.05	No	HQ < 1.0
Bromodichloromethane	0/9	NA	5U - 5U	2.5	5	6,400	Buchman 1999	<0.01	No	HQ < 1.0
Bromoform	0/9	NA	5U - 5U	2.5	5	640	USEPA 2001	<0.01	No	HQ < 1.0
Bromomethane	0/9	NA	10U - 10U	5	10	120	USEPA 2000b	0.08	No	HQ < 1.0
Carbon disulfide	2/9	2.9J - 3.3J	5U - 5U	2.6	3.3	650	USEPA 2000b	<0.01	No	HQ < 1.0
Carbon tetrachloride	0/9	NA	5U - 5U	2.5	5	1,500	USEPA 2001	<0.01	No	HQ < 1.0
Chlorobenzene	0/9	NA	5U - 5U	2.5	5	105	USEPA 2001	0.05	No	HQ < 1.0
Chloroethane	0/9	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
Chloroform	0/9	NA	5U - 5U	2.5	5	815	USEPA 2001	<0.01	No	HQ < 1.0
Chloromethane	0/9	NA	10U - 10U	5	10	2,700	USEPA 2000b	<0.01	No	HQ < 1.0
Chloroprene	0/9	NA	5U - 5U	2.5	5	---	---	NA	Yes	No SWSV
cis-1,3-Dichloropropene	0/9	NA	5U - 5U	2.5	5	7.9	USEPA 2001	0.63	No	HQ < 1.0
Dibromochloromethane	0/9	NA	5U - 5U	2.5	5	6,400	Buchman 1999	<0.01	No	HQ < 1.0
Dibromomethane	0/9	NA	5U - 5U	2.5	5	6,400	Buchman 1999	<0.01	No	HQ < 1.0
Dichlorodifluoromethane	0/9	NA	10U - 10U	5	10	6400	Buchman 1999	<0.01	No	HQ < 1.0
Ethyl methacrylate	0/9	NA	5U - 5U	2.5	5	---	---	NA	Yes	No SWSV
Ethylbenzene	0/9	NA	5U - 5U	2.5	5	4.3	USEPA 2001	1.16	Yes	HQ > 1.0
Iodomethane	0/9	NA	5U - 5U	2.5	5	---	---	NA	Yes	No SWSV
Methacrylonitrile	0/9	NA	100U - 100U	50	100	---	---	NA	Yes	No SWSV
Methyl methacrylate	0/9	NA	5U - 5U	2.5	5	1,300	USEPA 2000b	<0.01	No	HQ < 1.0
Methylene chloride	0/9	NA	5U - 5U	2.5	5	2,560	USEPA 2001	<0.01	No	HQ < 1.0
Pentachloroethane	0/9	NA	25U - 25U	12.5	25	281	Buchman 1999	0.09	No	HQ < 1.0

TABLE 3-22
FREQUENCY AND RANGE OF SURFACE WATER DATA (MAXIMUM CONCENTRATIONS) COMPARED TO SURFACE WATER SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					Surface Water Screening Value (SWSV)		Max. HQ[2]	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]					
Volatile Organics (ug/L) (cont.):										
Propionitrile	0/9	NA	100U - 100U	50	100	15,200	USEPA 2000b	<0.01	No	HQ < 1.0
Styrene	0/9	NA	5U - 5U	2.5	5	510	USEPA 2000b	<0.01	No	HQ < 1.0
Tetrachloroethene	0/9	NA	5U - 5U	2.5	5	45	USEPA 2001	0.11	No	HQ < 1.0
Toluene	0/9	NA	5U - 5U	2.5	5	37	USEPA 2001	0.14	No	HQ < 1.0
trans-1,2-Dichloroethene	0/9	NA	5U - 5U	2.5	5	22,400	Buchman 1999	<0.01	No	HQ < 1.0
trans-1,3-Dichloropropene	0/9	NA	5U - 5U	2.5	5	7.9	USEPA 2001	0.63	No	HQ < 1.0
trans-1,4-Dichloro-2-butene	0/9	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
Trichloroethene	0/9	NA	5U - 5U	2.5	5	200	Buchman 1999	0.03	No	HQ < 1.0
Trichlorofluoromethane	0/9	NA	5U - 5U	2.5	5	6400	Buchman 1999	<0.01	No	HQ < 1.0
Vinyl acetate	0/9	NA	10U - 10U	5	10	10,000	USEPA 2000b	<0.01	No	HQ < 1.0
Vinyl chloride	0/9	NA	10U - 10U	5	10	87.8	Suter II 1996	0.11	No	HQ < 1.0
Xylene	0/9	NA	10U - 10U	5	10	41	USEPA 2000b	0.24	No	HQ < 1.0
Semi-Volatile Organics (ug/L):										
1,2,4,5-Tetrachlorobenzene	0/9	NA	10U - 10U	5	10	30	USEPA 2000b	0.33	No	HQ < 1.0
1,2,4-Trichlorobenzene	0/9	NA	10U - 10U	5	10	4.5	USEPA 2001	2.22	Yes	HQ > 1.0
1,2-Dichlorobenzene	0/9	NA	10U - 10U	5	10	19.7	USEPA 2001	0.51	No	HQ < 1.0
1,3,5-Trinitrobenzene	0/9	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
1,3-Dichlorobenzene	0/9	NA	10U - 10U	5	10	28.5	USEPA 2001	0.35	No	HQ < 1.0
1,4,-Dichlorobenzene	0/9	NA	10U - 10U	5	10	19.9	USEPA 2001	0.50	No	HQ < 1.0
1,4-Dioxane	0/9	NA	10U - 10U	5	10	67,000	USEPA 2000b	<0.01	No	HQ < 1.0
1,4-Naphthoquinone	0/9	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
1,4-Phenylenediamine	0/9	NA	2000U - 2000U	1,000	2,000	200	USEPA 2000b	10.00	Yes	HQ > 1.0
1-Naphthylamine	0/9	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
2,3,4,6-Tetrachlorophenol	0/9	NA	10U - 10U	5	10	44	Buchman 1999	0.23	No	HQ < 1.0
2,4,5-Trichlorophenol	0/9	NA	10U - 10U	5	10	11	Buchman 1999	0.91	No	HQ < 1.0
2,4,6-Trichlorophenol	0/9	NA	10U - 10U	5	10	12.1	USEPA 2000b	0.83	No	HQ < 1.0
2,4-Dichlorophenol	0/9	NA	10U - 10U	5	10	5	USEPA 2000b	2.00	Yes	HQ > 1.0
2,4-Dimethylphenol	0/9	NA	10U - 10U	5	10	131	USEPA 2000b	0.08	No	HQ < 1.0
2,4-Dinitrophenol	0/9	NA	50U - 50U	25	50	48.5	USEPA 2001	1.03	Yes	HQ > 1.0
2,4-Dinitrotoluene	0/9	NA	10U - 10U	5	10	370	Buchman 1999	0.03	No	HQ < 1.0
2,6-Dichlorophenol	0/9	NA	10U - 10U	5	10	54	USEPA 2000b	0.19	No	HQ < 1.0
2,6-Dinitrotoluene	0/9	NA	10U - 10U	5	10	370	Assumed	0.03	No	HQ < 1.0
2-Acetylaminofluorene	0/9	NA	10U - 10U	5	10	100	USEPA 2000b	0.10	No	HQ < 1.0
2-Chloronaphthalene	0/9	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
2-Chlorophenol	0/9	NA	10U - 10U	5	10	53	USEPA 2000b	0.19	No	HQ < 1.0
2-Methylphenol	0/9	NA	10U - 10U	5	10	102	USEPA 2000b	0.10	No	HQ < 1.0
2-Naphthalamine	0/9	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
2-Nitroaniline	0/9	NA	50U - 50U	25	50	48.9	USEPA 2000b	1.02	Yes	HQ > 1.0
2-Nitrophenol	0/9	NA	10U - 10U	5	10	10,000	USEPA 2000b	<0.01	No	HQ < 1.0
2-Picoline	0/9	NA	10U - 10U	5	10	8,979	USEPA 2000b	<0.01	No	HQ < 1.0

TABLE 3-22
FREQUENCY AND RANGE OF SURFACE WATER DATA (MAXIMUM CONCENTRATIONS) COMPARED TO SURFACE WATER SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					Surface Water Screening Value (SWSV)		Max. HQ[2]	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]					
Semi-Volatile Organics (ug/L) (cont.):										
3&4-Methylphenol	0/9	NA	10U - 10U	5	10	50	USEPA 2000b	0.20	No	HQ < 1.0
3,3'-Dichlorobenzidine	0/9	NA	20U - 20U	10	20	10.5	USEPA 2000b	1.90	Yes	HQ > 1.0
3,3'-Dimethylbenzidine	0/9	NA	20U - 20U	10	20	160	USEPA 2000b	0.13	No	HQ < 1.0
3-Methylcholanthrene	0/9	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
3-Nitroaniline	0/9	NA	50U - 50U	25	50	9.8	USEPA 2000b	5.10	Yes	HQ > 1.0
4,6-Dinitro-2-methylphenol	0/9	NA	50U - 50U	25	50	183	USEPA 2000b	0.27	No	HQ < 1.0
4-Aminobiphenyl	0/9	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
4-Bromophenyl phenyl ether	0/9	NA	10U - 10U	5	10	3.6	USEPA 2000b	2.78	Yes	HQ > 1.0
4-Chloro-3-methylphenol	0/9	NA	10U - 10U	5	10	1,300	USEPA 2000b	<0.01	No	HQ < 1.0
4-Chloroaniline	0/9	NA	20U - 20U	10	20	129	Buchman 1999	0.16	No	HQ < 1.0
4-Chlorophenyl-Phenylether	0/9	NA	10U - 10U	5	10	7.3	USEPA 2000b	1.37	Yes	HQ > 1.0
4-Nitroaniline	0/9	NA	50U - 50U	25	50	170	USEPA 2000b	0.29	No	HQ < 1.0
4-Nitrophenol	0/9	NA	50U - 50U	25	50	71.7	USEPA 2001	0.70	No	HQ < 1.0
5-Nitro-o-toluidine	0/9	NA	10U - 10U	5	10	225	USEPA 2000b	0.04	No	HQ < 1.0
7,12-Dimethyl benz(a)anthracene	0/9	NA	10U - 10U	5	10	30	Buchman 1999	0.33	No	HQ < 1.0
A, A-Dimethylphenethylamine	0/9	NA	2000U - 2000U	1,000	2,000	---	---	NA	Yes	No SWSV
Acetophenone	0/9	NA	10U - 10U	5	10	1,550	USEPA 2000b	<0.01	No	HQ < 1.0
Aniline	0/9	NA	20U - 20U	10	20	294	USEPA 2000b	0.07	No	HQ < 1.0
Aramite	0/9	NA	10U - 10U	5	10	0.6	USEPA 2000b	16.67	Yes	HQ > 1.0
Benzyl alcohol	0/9	NA	10U - 10U	5	10	150	USEPA 2000b	0.07	No	HQ < 1.0
Bis(2-chloroethoxy)methane	0/9	NA	10U - 10U	5	10	6,400	Buchman 1999	<0.01	No	HQ < 1.0
Bis(2-chloroethyl)ether	0/9	NA	10U - 10U	5	10	910	USEPA 2000b	0.01	No	HQ < 1.0
Bis(2-chloroisopropyl)ether	0/9	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
Bis(2-ethylhexyl)phthalate	1/9	12 - 12	10U - 10U	5.8	12	360	Buchman 1999	0.03	No	HQ < 1.0
Butylbenzylphthalate	0/9	NA	10U - 10U	5	10	29.4	USEPA 2001	0.34	No	HQ < 1.0
Diallate	0/9	NA	10U - 10U	5	10	82	USEPA 2000b	0.12	No	HQ < 1.0
Dibenzofuran	0/9	NA	10U - 10U	5	10	100	USEPA 2000b	0.10	No	HQ < 1.0
Diethylphthalate	0/9	NA	10U - 10U	5	10	75.9	USEPA 2001	0.13	No	HQ < 1.0
Dimethylphthalate	0/9	NA	10U - 10U	5	10	580	USEPA 2001	0.02	No	HQ < 1.0
Di-n-butylphthalate	0/9	NA	10U - 10U	5	10	3.4	USEPA 2001	2.94	Yes	HQ > 1.0
Di-n-octylphthalate	0/9	NA	10U - 10U	5	10	3,450	USEPA 2000b	<0.01	No	HQ < 1.0
Dinoseb	0/9	NA	10U - 10U	5	10	1.7	USEPA 2000b	5.88	Yes	HQ > 1.0
Ethyl methanesulfonate	0/9	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
Hexachlorobenzene	0/9	NA	10U - 10U	5	10	10	USEPA 2000b	1.00	Yes	HQ > 1.0
Hexachlorobutadiene	0/9	NA	10U - 10U	5	10	0.32	USEPA 2001	31.25	Yes	HQ > 1.0
Hexachlorocyclopentadiene	0/9	NA	10U - 10U	5	10	0.07	USEPA 2001	142.86	Yes	HQ > 1.0
Hexachloroethane	0/9	NA	10U - 10U	5	10	9.4	USEPA 2001	1.06	Yes	HQ > 1.0
Hexachlorophene	0/9	NA	5000U - 5000U	2,500	5,000	8.8	USEPA 2000b	568.18	Yes	HQ > 1.0
Hexachloropropene	0/9	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV

TABLE 3-22
FREQUENCY AND RANGE OF SURFACE WATER DATA (MAXIMUM CONCENTRATIONS) COMPARED TO SURFACE WATER SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					Surface Water Screening Value (SWSV)		Max. HQ[2]	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]					
Semi-Volatile Organics (ug/L) (cont.):										
Isophorone	0/9	NA	10U - 10U	5	10	129	USEPA 2001	0.08	No	HQ < 1.0
Isosafrole	0/4	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
m-Dinitrobenzene	0/9	NA	10U - 10U	5	10	66.8	Assumed	0.15	No	HQ < 1.0
Methapyrilene	0/9	NA	2000U - 2000U	1,000	2,000	---	---	NA	Yes	No SWSV
Methyl methanesulfonate	0/9	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
Nitrobenzene	0/9	NA	10U - 10U	5	10	66.8	USEPA 2001	0.15	No	HQ < 1.0
n-Nitrosodiethylamine	0/9	NA	10U - 10U	5	10	330,000	Buchman 1999	<0.01	No	HQ < 1.0
n-Nitrosodimethylamine	0/9	NA	10U - 10U	5	10	27,000	USEPA 2000b	<0.01	No	HQ < 1.0
n-Nitroso-di-n-butylamine	0/9	NA	10U - 10U	5	10	330,000	Buchman 1999	<0.01	No	HQ < 1.0
n-Nitroso-di-n-propylamine	0/9	NA	10U - 10U	5	10	330,000	Assumed	<0.01	No	HQ < 1.0
n-Nitrosodiphenylamine	0/9	NA	10U - 10U	5	10	33,000	USEPA 2001	<0.01	No	HQ < 1.0
n-Nitrosomethylethylamine	0/9	NA	10U - 10U	5	10	330,000	Assumed	<0.01	No	HQ < 1.0
n-Nitrosomorpholine	0/9	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
n-Nitrosopiperidine	0/9	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
n-Nitrosopyrrolidine	0/9	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
o,o,o-Triethylphosphorothioate	0/9	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
o-Toluidine	0/9	NA	10U - 10U	5	10	400	USEPA 2000b	0.03	No	HQ < 1.0
p-Dimethylaminoazobenzene	0/9	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
Pentachlorobenzene	0/9	NA	10U - 10U	5	10	129	USEPA 2001	0.08	No	HQ < 1.0
Pentachloronitrobenzene	0/9	NA	10U - 10U	5	10	0.23	USEPA 2000b	43.48	Yes	HQ > 1.0
Pentachlorophenol	0/9	NA	50U - 50U	25	50	7.9	USEPA 1999b	6.33	Yes	HQ > 1.0
Phenacetin	0/9	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
Phenol	0/9	NA	10U - 10U	5	10	58	USEPA 2001	0.17	No	HQ < 1.0
Pronamide	0/9	NA	10U - 10U	5	10	35	USEPA 2000b	0.29	No	HQ < 1.0
Pryridine	0/9	NA	50U - 50U	25	50	500	USEPA 2000b	0.10	No	HQ < 1.0
Safrole	0/9	NA	10U - 10U	5	10	---	---	NA	Yes	No SWSV
PAHs (ug/L):										
1-Methylnaphthalene	0/9	NA	0.2U - 0.2U	0.1	0.2	19	USEPA 2000b	0.01	No	HQ < 1.0
2-Methylnaphthalene	0/9	NA	0.2U - 0.2U	0.1	0.2	6	USEPA 2000b	0.03	No	HQ < 1.0
Acenaphthene	1/9	0.12J - 0.12J	0.2U - 0.2U	0.1	0.12	9.7	USEPA 2001	0.01	No	HQ < 1.0
Acenaphthylene	0/9	NA	0.2U - 0.2U	0.1	0.2	30	Buchman 1999	<0.01	No	HQ < 1.0
Anthracene	2/9	0.08J - 0.08J	0.2U - 0.2U	0.1	0.08	50	EPA 1996b	<0.01	No	HQ < 1.0
Benzo(a)anthracene	0/9	NA	0.2U - 0.2U	0.1	0.2	30	Buchman 1999	<0.01	No	HQ < 1.0
Benzo(a)pyrene	0/9	NA	0.2U - 0.2U	0.1	0.2	10	EPA 1996b	0.02	No	HQ < 1.0
Benzo(b)fluoranthene	0/9	NA	0.2U - 0.2U	0.1	0.2	30	Buchman 1999	<0.01	No	HQ < 1.0
Benzo(g,h,i)perylene	0/9	NA	0.2U - 0.2U	0.1	0.2	30	Buchman 1999	<0.01	No	HQ < 1.0
Benzo(k)fluoranthene	0/9	NA	0.2U - 0.2U	0.1	0.2	30	Buchman 1999	<0.01	No	HQ < 1.0
Chrysene	0/9	NA	0.2U - 0.2U	0.1	0.2	10	EPA 1996b	0.02	No	HQ < 1.0
Dibenzo(a,h)anthracene	0/9	NA	0.2U - 0.2U	0.1	0.2	30	Buchman 1999	<0.01	No	HQ < 1.0
Fluoranthene	3/9	0.05J - 0.17J	0.2U - 0.2U	0.1	0.17	11	USEPA 1996a	0.02	No	HQ < 1.0

TABLE 3-22
FREQUENCY AND RANGE OF SURFACE WATER DATA (MAXIMUM CONCENTRATIONS) COMPARED TO SURFACE WATER SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					Surface Water Screening Value (SWSV)		Max. HQ[2]	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]					
PAHs (ug/L) (cont.):										
Fluorene	0/9	NA	0.2U - 0.2U	0.1	0.2	10	USEPA 2000b	0.02	No	HQ < 1.0
Indeno(1,2,3-cd)pyrene	0/9	NA	0.2U - 0.2U	0.1	0.2	30	Buchman 1999	<0.01	No	HQ < 1.0
Naphthalene	1/9	0.11J - 0.11J	0.2U - 0.2U	0.1	0.11	23.5	USEPA 2001	<0.01	No	HQ < 1.0
Phenanthrene	1/9	0.17J - 0.17J	0.2U - 0.2U	0.1	0.17	8.3	USEPA 1996a	0.02	No	HQ < 1.0
Pyrene	1/9	0.09J - 0.09J	0.2U - 0.2U	0.1	0.09	30	Buchman 1999	<0.01	No	HQ < 1.0
Total Metals (ug/L):										
Antimony	2/9	5.4J - 5.7J	20U - 20U	9	5.7	500	Buchman 1999	0.01	No	HQ < 1.0
Arsenic	6/9	3.9J - 7J	10U - 10U	5	7	36	USEPA 1999b	0.19	No	HQ < 1.0
Barium	9/9	8.4J - 21	NA	10.5	21	50,000	USEPA 2000b	<0.01	No	HQ < 1.0
Beryllium	0/9	NA	4U - 4U	2	4	310	USEPA 2000b	0.01	No	HQ < 1.0
Cadmium	1/9	0.72J - 0.72J	5U - 5U	2.3	0.72	9.36	USEPA 1999b	0.08	No	HQ < 1.0
Chromium	0/9	NA	10U - 10U	5	10	50.4	USEPA 1999b	0.20	No	HQ < 1.0
Cobalt	0/9	NA	10U - 10U	5	10	45	USEPA 2000b	0.22	No	HQ < 1.0
Copper	9/9	2.1J - 14J	NA	4.2	14	3.7	USEPA 1999b	3.78	Yes	HQ > 1.0
Lead	1/9	1.7J - 1.7J	5U - 5U	2.4	1.7	8.5	USEPA 1999b	0.20	No	HQ < 1.0
Mercury	1/9	0.08J - 0.08J	0.2U - 0.2U	0.1	0.08	1.1	USEPA 1999b	0.07	No	HQ < 1.0
Nickel	0/9	NA	40U - 40U	20	40	8.3	USEPA 1999b	4.82	Yes	HQ > 1.0
Selenium	1/9	6.3J - 6.3J	10U - 10U	5.1	6.3	71.1	USEPA 1999b	0.09	No	HQ < 1.0
Silver	0/9	NA	10U - 10U	5	10	0.23	USEPA 2001	43.48	Yes	HQ > 1.0
Thallium	0/9	NA	10U - 10U	5	10	21.3	USEPA 2001	0.47	No	HQ < 1.0
Tin	2/9	6.8J - 11J	50U - 50U	21.4	11	---	---	NA	Yes	No SWSV
Vanadium	9/9	4.6J - 12J	NA	8	12	---	---	NA	Yes	No SWSV
Zinc	1/9	6.5J - 6.5J	20U - 20U	9.6	6.5	85.6	USEPA 1999b	0.08	No	HQ < 1.0

Notes:

HQ = Hazard Quotient
COPC = Ecological Chemical of Potential Concern
NA = Not Applicable

J = Value is estimated
U = Not detected
UJ = Not detected, value is estimated

(1) Maximum detected concentration (or maximum reporting limit for non-detected chemicals).

(2) For a given chemical, the Hazard Quotient (HQ) is the maximum detected concentration (or maximum reporting limit for non-detected chemicals) divided by the surface water screening value.

TABLE 3-23
FREQUENCY AND RANGE OF SEDIMENT DATA (MAXIMUM CONCENTRATIONS) COMPARED TO SEDIMENT SCREENING VALUES
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

	Chemical Frequency/Range									
Chemical	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]	Sediment Screening Value (SSV)		Max. HQ[2]	COPC?	Comments
Volatile Organics (ug/kg)										
1,1,1,2-Tetrachloroethane	0/13	NA	6.6U - 13U	4.5	13	729.5	USEPA 1993a	0.02	No	HQ < 1.0
1,1,1-Trichloroethane	0/13	NA	6.6U - 13U	4.5	13	179.7	USEPA 1993a	0.07	No	HQ < 1.0
1,1,2,2-Tetrachloroethane	0/13	NA	6.6U - 13U	4.5	13	42.4	USEPA 1993a	0.31	No	HQ < 1.0
1,1,2-Trichloroethane	0/13	NA	6.6U - 13U	4.5	13	74.0	USEPA 1993a	0.18	No	HQ < 1.0
1,1-Dichloroethane	0/13	NA	6.6U - 13U	4.5	13	5.7	USEPA 1993a	2.29	Yes	HQ > 1.0
1,1-Dichloroethene	0/13	NA	6.6U - 13U	4.5	13	584.2	USEPA 1993a	0.02	No	HQ < 1.0
1,2,3-Trichloropropane	0/13	NA	6.6U - 13U	4.5	13	93.8	USEPA 1993a	0.14	No	HQ < 1.0
1,2-Dibromo-3-chloropropane	0/13	NA	13U - 26U	8.8	26	41.9	USEPA 1993a	0.62	No	HQ < 1.0
1,2-Dibromoethane	0/13	NA	6.6U - 13U	4.5	13	8.5	USEPA 1993a	1.53	Yes	HQ > 1.0
1,2-Dichloroethane	0/13	NA	6.6U - 13U	4.5	13	66.2	USEPA 1993a	0.20	No	HQ < 1.0
1,2-Dichloropropane	0/13	NA	6.6U - 13U	4.5	13	435.7	USEPA 1993a	0.03	No	HQ < 1.0
2-Butanone	12/13	5.8J - 40J	41U - 41U	17.2	40	158.4	USEPA 1993a	0.25	No	HQ < 1.0
2-Hexanone	0/13	NA	33U - 65U	22.2	65	4.8	USEPA 1993a	13.47	Yes	HQ > 1.0
3-Chloro-1-propene	0/13	NA	6.6U - 13U	4.5	13	0.6	USEPA 1993a	23.06	Yes	HQ > 1.0
4-Methyl-2-pentanone	0/13	NA	33U - 65U	22.2	65	5.1	USEPA 1993a	12.76	Yes	HQ > 1.0
Acetone	4/13	36J - 120J	9.2U - 190U	54.5	120	1.2	USEPA 1993a	98.31	Yes	HQ > 1.0
Acetonitrile	0/13	NA	260U - 520UJ	177.7	520	155.7	USEPA 1993a	3.34	Yes	HQ > 1.0
Acrylonitrile	0/13	NA	130U - 260U	88.5	260	0.2	USEPA 1993a	1209.34	Yes	HQ > 1.0
Benzene	0/13	NA	6.6U - 13U	4.5	13	28.4	USEPA 1993a	0.46	No	HQ < 1.0
Bromodichloromethane	0/13	NA	6.6U - 13U	4.5	13	1,559.5	USEPA 1993a	<0.01	No	HQ < 1.0
Bromoform	0/13	NA	6.6U - 13U	4.5	13	274.6	USEPA 1993a	0.05	No	HQ < 1.0
Bromomethane	0/13	NA	13U - 26U	8.8	26	3.7	USEPA 1993a	6.97	Yes	HQ > 1.0
Carbon disulfide	1/13	4.9J - 4.9J	6.6U - 13U	4.5	4.9	126.3	USEPA 1993a	0.04	No	HQ < 1.0
Carbon tetrachloride	0/13	NA	6.6U - 13U	4.5	13	1,521.2	USEPA 1993a	<0.01	No	HQ < 1.0
Chlorobenzene	0/13	NA	6.6U - 13U	4.5	13	142.9	USEPA 1993a	0.09	No	HQ < 1.0
Chloroethane	0/13	NA	13U - 26U	8.8	26	---	---	NA	Yes	No SSV
Chloroform	0/13	NA	6.6U - 13U	4.5	13	132.1	USEPA 1993a	0.10	No	HQ < 1.0
Chloromethane	0/13	NA	13U - 26U	8.8	26	44.5	USEPA 1993a	0.58	No	HQ < 1.0
Chloroprene	0/13	NA	6.6U - 13U	4.5	13	---	---	NA	Yes	No SSV
cis-1,3-Dichloropropene	0/13	NA	6.6U - 13U	4.5	13	1.5	USEPA 1993a	8.47	Yes	HQ > 1.0
Dibromochloromethane	0/13	NA	6.6U - 13U	4.5	13	1,827.2	USEPA 1993a	<0.01	No	HQ < 1.0
Dibromomethane	0/13	NA	6.6U - 13U	4.5	13	526.2	USEPA 1993a	0.02	No	HQ < 1.0
Dichlorodifluoromethane	0/13	NA	6.6U - 13U	4.5	13	1,786.3	USEPA 1993a	<0.01	No	HQ < 1.0
Ethyl methacrylate	0/13	NA	6.6U - 13U	4.5	13	---	---	NA	Yes	No SSV
Ethylbenzene	0/13	NA	6.6U - 13U	4.5	13	4.0	Buchman 1999	3.25	Yes	HQ > 1.0
Iodomethane	0/13	NA	6.6U - 13U	4.5	13	---	---	NA	Yes	No SSV
Methacrylonitrile	0/13	NA	130U - 260U	88.5	260	---	---	NA	Yes	No SSV
Methyl methacrylate	0/13	NA	6.6U - 13U	4.5	13	62.1	USEPA 1993a	0.21	No	HQ < 1.0
Methylene chloride	1/13	2.7J - 2.7J	6.6U - 13U	4.4	2.7	91.1	USEPA 1993a	0.03	No	HQ < 1.0
Pentachloroethane	0/13	NA	33U - 65U	22.2	65	601.4	USEPA 1993a	0.11	No	HQ < 1.0

TABLE 3-23
FREQUENCY AND RANGE OF SEDIMENT DATA (MAXIMUM CONCENTRATIONS) COMPARED TO SEDIMENT SCREENING VALUES
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					Sediment Screening Value (SSV)		Max. HQ[2]	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]					
Volatile Organics (ug/kg) (cont.):										
Propionitrile	0/13	NA	130U - 260U	88.5	260	45.9	USEPA 1993a	5.67	Yes	HQ > 1.0
Styrene	4/13	3.1J - 9.8	6.6U - 13U	4.8	9.8	831.9	USEPA 1993a	0.01	No	HQ < 1.0
Tetrachloroethene	0/13	NA	6.6U - 13U	4.5	13	57.0	Buchman 1999	0.23	No	HQ < 1.0
Toluene	5/13	5.8J - 31J	7U - 13U	7.9	31	39.3	USEPA 1993a	0.79	No	HQ < 1.0
trans-1,2-Dichloroethene	0/13	NA	6.6U - 13U	4.5	13	5,099.8	USEPA 1993a	<0.01	No	HQ < 1.0
trans-1,3-Dichloropropene	0/13	NA	6.6U - 13U	4.5	13	1.5	USEPA 1993a	8.47	Yes	HQ > 1.0
trans-1,4-Dichloro-2-butene	0/13	NA	13U - 26U	8.8	26	---	---	NA	Yes	No SSV
Trichloroethene	0/13	NA	6.6U - 13U	4.5	13	41.0	Buchman 1999	0.32	No	HQ < 1.0
Trichlorofluoromethane	0/13	NA	6.6U - 13U	4.5	13	4,127.3	USEPA 1993a	<0.01	No	HQ < 1.0
Vinyl acetate	0/13	NA	13U - 26U	8.8	26	109.7	USEPA 1993a	0.24	No	HQ < 1.0
Vinyl chloride	0/13	NA	13U - 26U	8.8	26	5.5	USEPA 1993a	4.73	Yes	HQ > 1.0
Xylene	1/13	6.2J - 6.2J	6.6U - 13U	4.7	6.2	4.0	Buchman 1999	1.55	Yes	HQ > 1.0
Semi-Volatile Organics (ug/kg):										
1,2,4,5-Tetrachlorobenzene	0/13	NA	480U - 820U	306.2	820	2,294.8	USEPA 1993a	0.36	No	HQ < 1.0
1,2,4-Trichlorobenzene	0/13	NA	480U - 820U	306.2	820	4.8	Buchman 1999	170.83	Yes	HQ > 1.0
1,2-Dichlorobenzene	0/13	NA	480U - 820U	306.2	820	---	---	NA	Yes	No SSV
1,3,5-Trinitrobenzene	0/12	NA	480UJ - 820UJ	307.5	820	13.0	Buchman 1999	63.08	Yes	HQ > 1.0
1,3-Dichlorobenzene	0/13	NA	480U - 820U	306.2	820	168.9	USEPA 1993a	4.85	Yes	HQ > 1.0
1,4,-Dichlorobenzene	0/13	NA	480U - 820U	306.2	820	110.0	Buchman 1999	7.45	Yes	HQ > 1.0
1,4-Dioxane	1/13	40 - 40	480U - 820U	287.3	40	58.2	USEPA 1993a	0.69	No	HQ < 1.0
1,4-Naphthoquinone	0/13	NA	480U - 820U	306.2	820	---	---	NA	Yes	No SSV
1,4-Phenylenediamine	0/13	NA	2500U - 4200U	1,569.2	4,200	0.2	USEPA 1993a	19706.98	Yes	HQ > 1.0
1-Naphthylamine	0/13	NA	480U - 820U	306.2	820	---	---	NA	Yes	No SSV
2,3,4,6-Tetrachlorophenol	0/13	NA	480U - 820U	306.2	820	2,140.3	USEPA 1993a	0.38	No	HQ < 1.0
2,4,5-Trichlorophenol	0/13	NA	480U - 820U	306.2	820	750.5	Buchman 1999	1.09	Yes	HQ > 1.0
2,4,6-Trichlorophenol	0/13	NA	480U - 820U	306.2	820	6.0	Buchman 1999	136.67	Yes	HQ > 1.0
2,4-Dichlorophenol	0/13	NA	480U - 820U	306.2	820	5.0	Buchman 1999	164.00	Yes	HQ > 1.0
2,4-Dimethylphenol	0/13	NA	480U - 820U	306.2	820	18.0	Buchman 1999	45.56	Yes	HQ > 1.0
2,4-Dinitrophenol	0/13	NA	2500U - 4200U	1,569.2	4,200	3.4	USEPA 1993a	1234.12	Yes	HQ > 1.0
2,4-Dinitrotoluene	0/13	NA	480U - 820U	306.2	820	73.5	USEPA 1993a	11.15	Yes	HQ > 1.0
2,6-Dichlorophenol	0/13	NA	480U - 820U	306.2	820	57.3	USEPA 1993a	14.31	Yes	HQ > 1.0
2,6-Dinitrotoluene	0/13	NA	480U - 820U	306.2	820	53.6	USEPA 1993a	15.31	Yes	HQ > 1.0
2-Acetylaminofluorene	0/13	NA	480U - 820U	306.2	820	245.2	USEPA 1993a	3.34	Yes	HQ > 1.0
2-Chloronaphthalene	0/13	NA	480U - 820U	306.2	820	---	USEPA 1993a	NA	Yes	No SSV
2-Chlorophenol	0/13	NA	480U - 820U	306.2	820	8.0	Buchman 1999	102.50	Yes	HQ > 1.0
2-Methylphenol	0/13	NA	480U - 820U	306.2	820	8.0	Buchman 1999	102.50	Yes	HQ > 1.0
2-Naphthalamine	0/13	NA	480U - 820U	306.2	820	---	---	NA	Yes	No SSV
2-Nitroaniline	0/13	NA	2500U - 4200U	1,569.2	4,200	6.9	USEPA 1993a	606.82	Yes	HQ > 1.0
2-Nitrophenol	0/13	NA	480U - 820U	306.2	820	1,154.5	USEPA 1993a	0.71	No	HQ < 1.0
2-Picoline	0/13	NA	480U - 820U	306.2	820	232.7	USEPA 1993a	3.52	Yes	HQ > 1.0

TABLE 3-23
FREQUENCY AND RANGE OF SEDIMENT DATA (MAXIMUM CONCENTRATIONS) COMPARED TO SEDIMENT SCREENING VALUES
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					Sediment Screening Value (SSV)		Max. HQ[2]	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]					
Semi-Volatile Organics (ug/kg) (cont.):										
3&4-Methylphenol	0/13	NA	480U - 820U	306.2	820	8.7	USEPA 1993a	94.51	Yes	HQ > 1.0
3,3'-Dichlorobenzidine	0/13	NA	960U - 1600U	613.8	1,600	62.2	USEPA 1993a	25.71	Yes	HQ > 1.0
3,3'-Dimethylbenzidine	0/13	NA	2500U - 4200U	1,569.2	4,200	144.9	USEPA 1993a	28.99	Yes	HQ > 1.0
3-Methylcholanthrene	0/13	NA	480U - 820U	306.2	820	---	---	NA	Yes	No SSV
3-Nitroaniline	0/13	NA	2500U - 4200U	1,569.2	4,200	0.5	USEPA 1993a	9179.39	Yes	HQ > 1.0
4,6-Dinitro-2-methylphenol	0/13	NA	2500U - 4200U	1,569.2	4,200	48.8	USEPA 1993a	86.04	Yes	HQ > 1.0
4-Aminobiphenyl	0/13	NA	480U - 820U	306.2	820	---	---	NA	Yes	No SSV
4-Bromophenyl phenyl ether	0/13	NA	480U - 820U	306.2	820	622.0	USEPA 1993a	1.32	Yes	HQ > 1.0
4-Chloro-3-methylphenol	0/13	NA	480U - 820U	306.2	820	3,046.1	USEPA 1993a	0.27	No	HQ < 1.0
4-Chloroaniline	0/13	NA	960U - 1600U	613.8	1,600	17.9	USEPA 1993a	89.64	Yes	HQ > 1.0
4-Chlorophenyl-Phenylether	0/13	NA	480U - 820U	306.2	820	1,126.3	USEPA 1993a	0.73	No	HQ < 1.0
4-Nitroaniline	0/13	NA	2500U - 4200U	1,569.2	4,200	8.3	USEPA 1993a	505.74	Yes	HQ > 1.0
4-Nitrophenol	0/13	NA	2500U - 4200U	1,569.2	4,200	12.2	USEPA 1993a	345.31	Yes	HQ > 1.0
5-Nitro-o-toluidine	0/13	NA	480U - 820U	306.2	820	32.6	USEPA 1993a	25.17	Yes	HQ > 1.0
7,12-Dimethyl benz(a)anthracene	0/13	NA	480U - 820U	306.2	820	202,805.9	USEPA 1993a	<0.01	No	HQ < 1.0
A, A-Dimethylphenethylamine	0/13	NA	97000U - 170000U	62,576.9	170,000	---	---	NA	Yes	No SSV
Acetophenone	0/13	NA	480U - 820U	306.2	820	133.3	USEPA 1993a	6.15	Yes	HQ > 1.0
Aniline	0/13	NA	480U - 820U	306.2	820	5.7	USEPA 1993a	144.42	Yes	HQ > 1.0
Aramite	0/13	NA	480U - 820U	306.2	820	69.0	USEPA 1993a	11.89	Yes	HQ > 1.0
Benzyl alcohol	0/13	NA	480U - 820U	306.2	820	52.0	Buchman 1999	15.77	Yes	HQ > 1.0
Bis(2-chloroethoxy)methane	0/13	NA	480U - 820U	306.2	820	255.0	USEPA 1993a	3.22	Yes	HQ > 1.0
Bis(2-chloroethyl)ether	0/13	NA	480U - 820U	306.2	820	29.6	USEPA 1993a	27.72	Yes	HQ > 1.0
Bis(2-chloroisopropyl)ether	0/13	NA	480U - 820U	306.2	820	---	---	NA	Yes	No SSV
Bis(2-ethylhexyl)phthalate	3/13	180J - 250J	480U - 690U	275.0	250	182.0	MacDonald 1994	1.37	Yes	HQ > 1.0
Butylbenzylphthalate	0/13	NA	480U - 820U	306.2	820	63.0	Buchman 1999	13.02	Yes	HQ > 1.0
Diallate	0/13	NA	480U - 820U	306.2	820	4,466.7	USEPA 1993a	0.18	No	HQ < 1.0
Dibenzofuran	0/13	NA	480U - 820U	306.2	820	110.0	Buchman 1999	7.45	Yes	HQ > 1.0
Diethylphthalate	0/13	NA	480U - 820U	306.2	820	6.0	Buchman 1999	136.67	Yes	HQ > 1.0
Dimethylphthalate	0/13	NA	480U - 820U	306.2	820	6.0	Buchman 1999	136.67	Yes	HQ > 1.0
Di-n-butylphthalate	0/13	NA	480U - 820U	306.2	820	58.0	Buchman 1999	14.14	Yes	HQ > 1.0
Di-n-octylphthalate	0/13	NA	480U - 820U	306.2	820	61.0	Buchman 1999	13.44	Yes	HQ > 1.0
Dinoseb	0/13	NA	480U - 820UJ	306.2	820	4.4	USEPA 1993a	188.04	Yes	HQ > 1.0
Ethyl methanesulfonate	0/13	NA	480U - 820U	306.2	820	---	---	NA	Yes	No SSV
Hexachlorobenzene	0/13	NA	480U - 820U	306.2	820	6.0	Buchman 1999	136.67	Yes	HQ > 1.0
Hexachlorobutadiene	0/13	NA	480U - 820U	306.2	820	1.3	Buchman 1999	630.77	Yes	HQ > 1.0
Hexachlorocyclopentadiene	0/13	NA	480U - 820U	306.2	820	29.2	USEPA 1993a	28.04	Yes	HQ > 1.0
Hexachloroethane	0/13	NA	480U - 820U	306.2	820	73.0	Buchman 1999	11.23	Yes	HQ > 1.0
Hexachlorophene	0/13	NA	250000U - 420000U	156,923.1	420,000	477,311.6	USEPA 1993a	0.88	No	HQ < 1.0
Hexachloropropene	0/13	NA	480U - 820U	306.2	820	---	---	NA	Yes	No SSV
Isophorone	0/13	NA	480U - 820U	306.2	820	12.7	USEPA 1993a	64.51	Yes	HQ > 1.0

TABLE 3-23
FREQUENCY AND RANGE OF SEDIMENT DATA (MAXIMUM CONCENTRATIONS) COMPARED TO SEDIMENT SCREENING VALUES
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					Sediment Screening Value (SSV)		Max. HQ[2]	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]					
Semi-Volatile Organics (ug/kg) (cont.):										
Isosafrole	0/10	NA	480U - 820U	302.0	820	---	---	NA	Yes	No SSV
m-Dinitrobenzene	0/13	NA	480U - 820U	306.2	820	4.2	USEPA 1993a	195.90	Yes	HQ > 1.0
Methapyrilene	0/13	NA	97000U - 170000U	62,576.9	170,000	---	---	NA	Yes	No SSV
Methyl methanesulfonate	0/13	NA	480U - 820U	306.2	820	---	---	NA	Yes	No SSV
Nitrobenzene	0/13	NA	480U - 820U	306.2	820	21.0	Buchman 1999	39.05	Yes	HQ > 1.0
n-Nitrosodiethylamine	0/13	NA	480U - 820U	306.2	820	2,055.2	USEPA 1993a	0.40	No	HQ < 1.0
n-Nitrosodimethylamine	0/13	NA	480U - 820U	306.2	820	15.6	USEPA 1993a	52.51	Yes	HQ > 1.0
n-Nitroso-di-n-butylamine	0/13	NA	480U - 820U	306.2	820	162,197.2	USEPA 1993a	<0.01	No	HQ < 1.0
n-Nitroso-di-n-propylamine	0/13	NA	480U - 820U	306.2	820	16,489.7	USEPA 1993a	0.05	No	HQ < 1.0
n-Nitrosodiphenylamine	0/13	NA	480U - 820U	306.2	820	28.0	Buchman 1999	29.29	Yes	HQ > 1.0
n-Nitrosomethylethylamine	0/13	NA	480U - 820U	306.2	820	528.5	USEPA 1993a	1.55	Yes	HQ > 1.0
n-Nitrosomorpholine	0/13	NA	480U - 820U	306.2	820	---	---	NA	Yes	No SSV
n-Nitrosopiperidine	0/13	NA	480U - 820U	306.2	820	---	---	NA	Yes	No SSV
n-Nitrosopyrrolidine	0/13	NA	480U - 820U	306.2	820	---	---	NA	Yes	No SSV
o,o,o-Triethylphosphorothioate	0/13	NA	480U - 820U	306.2	820	---	---	NA	Yes	No SSV
o-Toluidine	0/13	NA	480U - 820U	306.2	820	17.4	USEPA 1993a	46.99	Yes	HQ > 1.0
p-Dimethylaminoazobenzene	0/13	NA	480U - 820U	306.2	820	---	---	NA	Yes	No SSV
Pentachlorobenzene	0/13	NA	480U - 820U	306.2	820	40,148.5	USEPA 1993a	0.02	No	HQ < 1.0
Pentachloronitrobenzene	0/13	NA	480U - 820U	306.2	820	17.6	USEPA 1993a	46.61	Yes	HQ > 1.0
Pentachlorophenol	0/13	NA	2500U - 4200U	1,569.2	4200	17.0	Buchman 1999	247.06	Yes	HQ > 1.0
Phenacetin	0/13	NA	480U - 820U	306.2	820	---	---	NA	Yes	No SSV
Phenol	0/13	NA	480U - 820U	306.2	820	130.0	Buchman 1999	6.31	Yes	HQ > 1.0
Pronamide	0/13	NA	480U - 820U	306.2	820	207.4	USEPA 1993a	3.95	Yes	HQ > 1.0
Pryridine	0/13	NA	480U - 820U	306.2	820	4.8	USEPA 1993a	171.29	Yes	HQ > 1.0
Safrole	0/13	NA	480U - 820U	306.2	820	---	---	NA	Yes	No SSV
PAHs (ug/kg):										
1-Methylnaphthalene	0/13	NA	6.7U - 340U	20.5	340	254.4	USEPA 1993a	1.34	Yes	HQ > 1.0
2-Methylnaphthalene	1/13	1.6J - 1.6J	6.7U - 340U	20.1	1.6	409.4	MacDonald 1994	<0.01	No	HQ < 1.0
Acenaphthene	4/13	3.8J - 140J	6.7U - 58U	18.3	140	6.7	MacDonald 1994	20.86	Yes	HQ > 1.0
Acenaphthylene	9/13	3J - 32	9.7U - 340U	21.7	32	926.9	MacDonald 1994	0.03	No	HQ < 1.0
Anthracene	10/13	2.8J - 250	9.7U - 11U	46.6	250	46.9	MacDonald 1994	5.33	Yes	HQ > 1.0
Benzo(a)anthracene	12/13	6.6J - 1700	11U - 11U	206	1,700	74.8	MacDonald 1994	22.73	Yes	HQ > 1.0
Benzo(a)pyrene	12/13	6.2J - 2200	11U - 11U	295.6	2,200	88.8	MacDonald 1994	24.77	Yes	HQ > 1.0
Benzo(b)fluoranthene	12/13	14J - 2400	11U - 11U	367.9	2,400	1,800.0	Buchman 1999	1.33	Yes	HQ > 1.0
Benzo(g,h,i)perylene	12/13	3.8J - 1400	11U - 11U	163.3	1,400	670.0	Buchman 1999	2.09	Yes	HQ > 1.0
Benzo(k)fluoranthene	12/13	13J - 2500	11U - 11U	375.3	2,500	1,800.0	Buchman 1999	1.39	Yes	HQ > 1.0
Chrysene	12/13	10 - 2600	11U - 11U	321	2,600	108.0	MacDonald 1994	24.07	Yes	HQ > 1.0
Dibenzo(a,h)anthracene	10/13	2.7J - 530	9.7U - 11U	68.9	530	6.2	MacDonald 1994	85.21	Yes	HQ > 1.0
Fluoranthene	11/13	8.5J - 5800	9.7U - 11U	594.4	5,800	113.0	MacDonald 1994	51.33	Yes	HQ > 1.0
Fluorene	5/13	3J - 140J	9.7U - 58U	18.3	140	21.2	MacDonald 1994	6.60	Yes	HQ > 1.0

TABLE 3-23
FREQUENCY AND RANGE OF SEDIMENT DATA (MAXIMUM CONCENTRATIONS) COMPARED TO SEDIMENT SCREENING VALUES
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					Sediment Screening Value (SSV)		Max. HQ[2]	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]					
PAHs (ug/kg) (cont.):										
Indeno(1,2,3-cd)pyrene	12/13	3.3J - 1300	11U - 11U	149.5	1,300	600.0	Buchman 1999	2.17	Yes	HQ > 1.0
Naphthalene	0/13	NA	6.7U - 340U	20.5	340	34.6	MacDonald 1994	9.83	Yes	HQ > 1.0
Phenanthrene	9/13	13 - 2800	9.7U - 11U	261.1	2,800	86.7	MacDonald 1994	32.30	Yes	HQ > 1.0
Pyrene	12/13	3.8J - 4700	11U - 11U	484.3	4,700	153.0	MacDonald 1994	30.72	Yes	HQ > 1.0
Total PAHs [3]	NA	NA	NA	2,449.0	21,840 [4]	1,680.0	MacDonald 1994	13.00	Yes	HQ > 1.0
Metals (mg/kg):										
Antimony	4/13	0.89J - 15J	2.4U - 3.8UJ	2.65	15	2.0	ong and Morgan 199	7.50	Yes	HQ > 1.0
Arsenic	13/13	2.9J - 46	NA	9.72	46	7.2	MacDonald 1994	6.35	Yes	HQ > 1.0
Barium	13/13	15 - 100	NA	31.23	100	48	Buchman 1999	2.08	Yes	HQ > 1.0
Beryllium	13/13	0.11J - 0.39J	NA	0.18	0.39	---	---	NA	Yes	No SSV
Cadmium	11/13	0.16J - 1.3	0.91U - 0.95U	0.49	1.3	0.7	MacDonald 1994	1.91	Yes	HQ > 1.0
Chromium	13/13	11 - 47J	NA	24.85	47	52.3	MacDonald 1994	0.90	No	HQ < 1.0
Cobalt	13/13	3.6 - 31	NA	10.33	31	10	Buchman 1999	3.10	Yes	HQ > 1.0
Copper	13/13	10 - 210J	NA	71.23	210	18.7	MacDonald 1994	11.23	Yes	HQ > 1.0
Lead	13/13	1.3J - 1300J	NA	157.67	1300	30.2	MacDonald 1994	43.05	Yes	HQ > 1.0
Mercury	12/13	0.0092J - 0.075	0.028U - 0.028U	0.04	0.075	0.1	MacDonald 1994	0.58	No	HQ < 1.0
Nickel	13/13	3.1J - 21	NA	9.78	21	15.9	MacDonald 1994	1.32	Yes	HQ > 1.0
Selenium	2/13	0.8J - 1.3J	1.4U - 2.3UJ	0.90	1.3	1.0	Buchman 1999	1.30	Yes	HQ > 1.0
Silver	0/13	NA	1.2U - 2.3UJ	0.84	2.3	0.7	MacDonald 1994	3.15	Yes	HQ > 1.0
Thallium	2/13	0.96J - 1.6J	1.4U - 2.3UJ	0.93	1.6	---	---	NA	Yes	No SSV
Tin	1/13	9.3J - 9.3J	6U - 11UJ	4.52	9.3	3.4	Buchman 1999	2.74	Yes	HQ > 1.0
Vanadium	13/13	33 - 200	NA	87.85	200	57	Buchman 1999	3.51	Yes	HQ > 1.0
Zinc	13/13	11 - 600	NA	137.54	600	124.0	MacDonald 1994	4.84	Yes	HQ > 1.0

Notes:

HQ = Hazard Quotient
COPC = Ecological Chemical of Potential Concern
NA = Not Applicable

J = Value is estimated
U = Not detected
UJ = Not detected, value is estimated

(1) Maximum detected concentration (or maximum reporting limit for non-detected chemicals).

(2) For a given chemical, the Hazard Quotient (HQ) is the maximum detected concentration (or maximum reporting limit for non-detected chemicals) divided by the sediment screening value.

(3) Total PAH refers to the sum of the concentrations of thirteen PAHs (acenaphthene, acenaphthylene, anthracene, benzo9a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene fluoranthene, fluorene, naphthalene, 2-methylnaphthalene, phenanthrene, and pyrene [MacDonald 1994])

(4) The reporting limit was used to sum the concentration of total PAHs if a given PAH was not detected.

TABLE 3-34
FREQUENCY AND RANGE OF SEDIMENT DATA (MEAN CONCENTRATIONS) COMPARED TO SEDIMENT SCREENING VALUES
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					Sediment Screening Value (SSV)		Mean HQ[2]	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]					
Volatile Organics (ug/L):										
1,1-Dichloroethane	0/13	NA	6.6U - 13U	4.5	4.5	5.7	USEPA 1993a	0.79	No	HQ<1.0
1,2-Dibromoethane	0/13	NA	6.6U - 13U	4.5	4.5	8.5	USEPA 1993a	0.53	No	HQ<1.0
2-Hexanone	0/13	NA	33U - 65U	22.2	22.2	4.8	USEPA 1993a	4.60	No	Not Detected
3-Chloro-1-propene	0/13	NA	6.6U - 13U	4.5	4.5	0.6	USEPA 1993a	7.98	No	Not Detected
4-Methyl-2-pentanone	0/13	NA	33U - 65U	22.2	22.2	5.1	USEPA 1993a	4.36	No	Not Detected
Acetone	4/13	36J - 120J	9.2U - 190U	54.5	54.5	1.2	USEPA 1993a	44.65	Yes	HQ > 1.0
Acetonitrile	0/13	NA	260U - 520UJ	177.7	177.7	155.7	USEPA 1993a	1.14	No	Not Detected
Acrylonitrile	0/13	NA	130U - 260U	88.5	88.5	0.2	USEPA 1993a	411.64	No	Not Detected
Bromomethane	0/13	NA	13U - 26U	8.8	8.8	3.7	USEPA 1993a	2.36	No	Not Detected
cis-1,3-Dichloropropene	0/13	NA	6.6U - 13U	4.5	4.5	1.5	USEPA 1993a	3.00	No	Not Detected
Dibromomethane	0/13	NA	6.6U - 13U	4.5	4.5	526.2	USEPA 1993a	0.01	No	HQ<1.0
Ethylbenzene	0/13	NA	6.6U - 13U	4.5	4.5	4.0	Buchman 1999	1.13	No	Not Detected
Methyl methacrylate	0/13	NA	6.6U - 13U	4.5	4.5	62.1	USEPA 1993a	0.07	No	HQ<1.0
Methylene chloride	1/13	2.7J - 2.7J	6.6U - 13U	4.4	2.7	91.1	USEPA 1993a	0.03	No	HQ<1.0
Pentachloroethane	0/13	NA	33U - 65U	22.2	22.2	601.4	USEPA 1993a	0.04	No	HQ<1.0
Propionitrile	0/13	NA	130U - 260U	88.5	88.5	45.9	USEPA 1993a	1.93	No	Not Detected
trans-1,3-Dichloropropene	0/13	NA	6.6U - 13U	4.5	4.5	1.5	USEPA 1993a	2.93	No	Not Detected
Vinyl chloride	0/13	NA	13U - 26U	8.8	8.8	5.5	USEPA 1993a	1.60	No	Not Detected
Xylene	1/13	6.2J - 6.2J	6.6U - 13U	4.7	4.7	4.0	Buchman 1999	1.18	Yes	HQ > 1.0
Semi-Volatile Organics (ug/kg):										
1,2,4-Trichlorobenzene	0/13	NA	480U - 820U	306.2	306.2	4.8	Buchman 1999	63.79	No	Not Detected
1,3,5-Trinitrobenzene	0/12	NA	480UJ - 820UJ	307.5	307.5	13.0	Buchman 1999	23.65	No	Not Detected
1,3-Dichlorobenzene	0/13	NA	480U - 820U	306.2	306.2	168.9	USEPA 1993a	1.81	No	Not Detected
1,4,-Dichlorobenzene	0/13	NA	480U - 820U	306.2	306.2	110.0	Buchman 1999	2.78	No	Not Detected
1,4-Phenylenediamine	0/13	NA	2500U - 4200U	1569.2	1569.2	0.2	USEPA 1993a	7362.90	No	Not Detected
2,4,5-Trichlorophenol	0/13	NA	480U - 820U	306.2	306.2	750.5	Buchman 1999	0.41	No	HQ < 1.0
2,4,6-Trichlorophenol	0/13	NA	480U - 820U	306.2	306.2	6.0	Buchman 1999	51.03	No	Not Detected
2,4-Dichlorophenol	0/13	NA	480U - 820U	306.2	306.2	5.0	Buchman 1999	61.24	No	Not Detected
2,4-Dimethylphenol	0/13	NA	480U - 820U	306.2	306.2	18.0	Buchman 1999	17.01	No	Not Detected
2,4-Dinitrophenol	0/13	NA	2500U - 4200U	1569.2	1569.2	3.4	USEPA 1993a	461.09	No	Not Detected
2,4-Dinitrotoluene	0/13	NA	480U - 820U	306.2	306.2	73.5	USEPA 1993a	4.16	No	Not Detected
2,6-Dichlorophenol	0/13	NA	480U - 820U	306.2	306.2	57.3	USEPA 1993a	5.34	No	Not Detected
2,6-Dinitrotoluene	0/13	NA	480U - 820U	306.2	306.2	53.6	USEPA 1993a	5.72	No	Not Detected
2-Acetylaminofluorene	0/13	NA	480U - 820U	306.2	306.2	245.2	USEPA 1993a	1.25	No	Not Detected
2-Chlorophenol	0/13	NA	480U - 820U	306.2	306.2	8.0	Buchman 1999	38.28	No	Not Detected
2-Methylphenol	0/13	NA	480U - 820U	306.2	306.2	8.0	Buchman 1999	38.28	No	Not Detected
2-Nitroaniline	0/13	NA	2500U - 4200U	1569.2	1569.2	6.9	USEPA 1993a	226.72	No	Not Detected
3&4-Methylphenol	0/13	NA	480U - 820U	306.2	306.2	8.7	USEPA 1993a	35.29	No	Not Detected
3,3'-Dichlorobenzidine	0/13	NA	960U - 1600U	613.8	613.8	62.2	USEPA 1993a	9.86	No	Not Detected
3,3'-Dimethylbenzidine	0/13	NA	2500U - 4200U	1569.2	1569.2	144.9	USEPA 1993a	10.83	No	Not Detected
3-Nitroaniline	0/13	NA	2500U - 4200U	1569.2	1569.2	0.5	USEPA 1993a	3429.60	No	Not Detected

TABLE 3-34
FREQUENCY AND RANGE OF SEDIMENT DATA (MEAN CONCENTRATIONS) COMPARED TO SEDIMENT SCREENING VALUES
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					Sediment Screening Value (SSV)		Mean HQ[2]	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]					
Semi-Volatile Organics (ug/kg) (cont.):										
4,6-Dinitro-2-methylphenol	0/13	NA	2500U - 4200U	1569.2	1569.2	48.8	USEPA 1993a	32.14	No	Not Detected
4-Chloroaniline	0/13	NA	960U - 1600U	613.8	613.8	17.9	USEPA 1993a	34.39	No	Not Detected
4-Nitroaniline	0/13	NA	2500U - 4200U	1569.2	1569.2	8.3	USEPA 1993a	188.96	No	Not Detected
4-Nitrophenol	0/13	NA	2500U - 4200U	1569.2	1569.2	12.2	USEPA 1993a	129.01	No	Not Detected
5-Nitro-o-toluidine	0/13	NA	480U - 820U	306.2	306.2	32.6	USEPA 1993a	9.40	No	Not Detected
Acetophenone	0/13	NA	480U - 820U	306.2	306.2	133.3	USEPA 1993a	2.30	No	Not Detected
Aniline	0/13	NA	480U - 820U	306.2	306.2	5.7	USEPA 1993a	53.93	No	Not Detected
Aramite	0/13	NA	480U - 820U	306.2	306.2	69.0	USEPA 1993a	4.44	No	Not Detected
Benzyl alcohol	0/13	NA	480U - 820U	306.2	306.2	52.0	Buchman 1999	5.89	No	Not Detected
Bis(2-chloroethoxy)methane	0/13	NA	480U - 820U	306.2	306.2	255.0	USEPA 1993a	1.20	No	Not Detected
Bis(2-chloroethyl)ether	0/13	NA	480U - 820U	306.2	306.2	29.6	USEPA 1993a	10.35	No	Not Detected
Bis(2-ethylhexyl)phthalate	3/13	180J - 250J	480U - 690U	275.0	250.0	182.0	MacDonald 1994	1.37	Yes	HQ > 1.0
Butylbenzylphthalate	0/13	NA	480U - 820U	306.2	306.2	63.0	Buchman 1999	4.86	No	Not Detected
Dibenzofuran	0/13	NA	480U - 820U	306.2	306.2	110.0	Buchman 1999	2.78	No	Not Detected
Diethylphthalate	0/13	NA	480U - 820U	306.2	306.2	6.0	Buchman 1999	51.03	No	Not Detected
Dimethylphthalate	0/13	NA	480U - 820U	306.2	306.2	6.0	Buchman 1999	51.03	No	Not Detected
Di-n-butylphthalate	0/13	NA	480U - 820U	306.2	306.2	58.0	Buchman 1999	5.28	No	Not Detected
Di-n-octylphthalate	0/13	NA	480U - 820U	306.2	306.2	61.0	Buchman 1999	5.02	No	Not Detected
Dinoseb	0/13	NA	480U - 820UJ	306.2	306.2	4.4	USEPA 1993a	70.22	No	Not Detected
Hexachlorobenzene	0/13	NA	480U - 820U	306.2	306.2	6.0	Buchman 1999	51.03	No	Not Detected
Hexachlorobutadiene	0/13	NA	480U - 820U	306.2	306.2	1.3	Buchman 1999	235.54	No	Not Detected
Hexachlorocyclopentadiene	0/13	NA	480U - 820U	306.2	306.2	29.2	USEPA 1993a	10.47	No	Not Detected
Hexachloroethane	0/13	NA	480U - 820U	306.2	306.2	73.0	Buchman 1999	4.19	No	Not Detected
Isophorone	0/13	NA	480U - 820U	306.2	306.2	12.7	USEPA 1993a	24.09	No	Not Detected
m-Dinitrobenzene	0/13	NA	480U - 820U	306.2	306.2	4.2	USEPA 1993a	73.15	No	Not Detected
Nitrobenzene	0/13	NA	480U - 820U	306.2	306.2	21.0	Buchman 1999	14.58	No	Not Detected
n-Nitrosodimethylamine	0/13	NA	480U - 820U	306.2	306.2	15.6	USEPA 1993a	19.61	No	Not Detected
n-Nitrosodiphenylamine	0/13	NA	480U - 820U	306.2	306.2	28.0	Buchman 1999	10.94	No	Not Detected
o-Toluidine	0/13	NA	480U - 820U	306.2	306.2	17.4	USEPA 1993a	17.55	No	Not Detected
Pentachloronitrobenzene	0/13	NA	480U - 820U	306.2	306.2	17.6	USEPA 1993a	17.40	No	Not Detected
Pentachlorophenol	0/13	NA	2500U - 4200U	1569.2	1569.2	17.0	Buchman 1999	92.31	No	Not Detected
Phenol	0/13	NA	480U - 820U	306.2	306.2	130.0	Buchman 1999	2.36	No	Not Detected
Pryridine	0/13	NA	480U - 820U	306.2	306.2	4.8	USEPA 1993a	63.96	No	Not Detected
PAHs (ug/kg):										
1-Methylnaphthalene	0/13	NA	6.7U - 340U	20.5	20.5	254.4	USEPA 1993a	0.08	No	HQ<1.0
Acenaphthene	4/13	3.8J - 140J	6.7U - 58U	18.3	18.3	6.7	MacDonald 1994	2.73	Yes	HQ > 1.0
Anthracene	10/13	2.8J - 250	9.7U - 11U	46.6	46.6	46.9	MacDonald 1994	0.99	No	HQ < 1.0
Benzo(a)anthracene	12/13	6.6J - 1700	11U - 11U	206.0	206.0	74.8	MacDonald 1994	2.75	Yes	HQ > 1.0
Benzo(a)pyrene	12/13	6.2J - 2200	11U - 11U	295.6	295.6	88.8	MacDonald 1994	3.33	Yes	HQ > 1.0
Benzo(b)fluoranthene	12/13	14J - 2400	11U - 11U	367.9	367.9	1800.0	Buchman 1999	0.20	No	HQ < 1.0

TABLE 3-34
FREQUENCY AND RANGE OF SEDIMENT DATA (MEAN CONCENTRATIONS) COMPARED TO SEDIMENT SCREENING VALUES
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					Sediment Screening Value (SSV)		Mean HQ[2]	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]					
PAHs (ug/kg) (cont.):										
Benzo(g,h,i)perylene	12/13	3.8J - 1400	11U - 11U	163.3	163.3	670.0	Buchman 1999	0.24	No	HQ < 1.0
Benzo(k)fluoranthene	12/13	13J - 2500	11U - 11U	375.3	375.3	1800.0	Buchman 1999	0.21	No	HQ < 1.0
Chrysene	12/13	10 - 2600	11U - 11U	321.0	321.0	108.0	MacDonald 1994	2.97	Yes	HQ > 1.0
Dibenzo(a,h)anthracene	10/13	2.7J - 530	9.7U - 11U	68.9	68.9	6.2	MacDonald 1994	11.08	Yes	HQ > 1.0
Fluoranthene	11/13	8.5J - 5800	9.7U - 11U	594.4	594.4	113.0	MacDonald 1994	5.26	Yes	HQ > 1.0
Fluorene	5/13	3J - 140J	9.7U - 58U	18.3	18.3	21.2	MacDonald 1994	0.86	No	HQ < 1.0
Fluoranthene	11/13	8.5J - 5800	9.7U - 11U	594.4	594.4	113.0	MacDonald 1994	5.26	Yes	HQ > 1.0
Indeno(1,2,3-cd)pyrene	12/13	3.3J - 1300	11U - 11U	149.5	149.5	600.0	Buchman 1999	0.25	No	HQ < 1.0
Naphthalene	0/13	NA	6.7U - 340U	20.5	20.5	34.6	MacDonald 1994	0.59	No	HQ < 1.0
Phenanthrene	9/13	13 - 2800	9.7U - 11U	261.1	261.1	86.7	MacDonald 1994	3.01	Yes	HQ > 1.0
Pyrene	12/13	3.8J - 4700	11U - 11U	484.3	484.3	153.0	MacDonald 1994	3.17	Yes	HQ > 1.0
Total PAHs [3]	NA	NA	NA	2.4	2,449 (4)	1,680.0	MacDonald 1994	1.46	Yes	HQ > 1.0
Metals (ug/kg):										
Antimony	4/13	0.89J - 15J	2.4U - 3.8UJ	2.6	2.6	2.0	Long and Morgan 1991	1.32	Yes	HQ > 1.0
Arsenic	13/13	2.9J - 46	NA	9.7	9.7	7.2	MacDonald 1994	1.34	Yes	HQ > 1.0
Barium	13/13	15 - 100	NA	31.2	31.2	48	Buchman 1999	0.65	No	HQ < 1.0
Beryllium	13/13	0.11J - 0.39J	NA	0.18	0.18	---	---	NA	Yes	Detected, No SSV
Cadmium	11/13	0.16J - 1.3	0.91U - 0.95U	0.49	0.49	0.7	MacDonald 1994	0.71	No	HQ < 1.0
Cobalt	13/13	3.6 - 31	NA	10.3	10.3	10	Buchman 1999	1.03	Yes	HQ > 1.0
Copper	13/13	10 - 210J	NA	71.2	71.2	18.7	MacDonald 1994	3.81	Yes	HQ > 1.0
Lead	13/13	1.3J - 1300J	NA	158	158	30.2	MacDonald 1994	5.22	Yes	HQ > 1.0
Nickel	13/13	3.1J - 21	NA	9.8	9.8	15.9	MacDonald 1994	0.61	No	HQ < 1.0
Selenium	2/13	0.8J - 1.3J	1.4U - 2.3UJ	0.9	0.9	1.0	Buchman 1999	0.90	No	HQ < 1.0
Silver	0/13	NA	1.2U - 2.3UJ	0.84	0.84	0.7	MacDonald 1994	1.15	No	Not Detected
Thallium	2/13	0.96J - 1.6J	1.4U - 2.3UJ	0.93	0.93	---	---	NA	Yes	Detected, No SSV
Tin	1/13	9.3J - 9.3J	6U - 11UJ	4.5	4.5	3.4	Buchman 1999	1.33	Yes	HQ > 1.0
Vanadium	13/13	33 - 200	NA	87.8	87.8	57	Buchman 1999	1.54	Yes	HQ > 1.0
Zinc	13/13	11 - 600	NA	137.5	137.5	124.0	MacDonald 1994	1.11	Yes	HQ > 1.0

Notes:

HQ = Hazard Quotient
COPC = Ecological Chemical of Potential Concern
NA = Not Applicable

J = Value is estimated
U = Not detected
UJ = Not detected, value is estimated

(1) Mean concentration unless the mean exceeds the maximum concentration.

(2) The mean HQ value is the mean (half non-detects) divided by the screening value. If the mean concentration exceeds the maximum concentration, the maximum concentration is used.

(3) Total PAHs refers to the sum of the concentrations of thirteen PAHs (acenaphthene, acenaphthylene, anthracene, benzo9a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene fluoranthene, fluorene, naphthalene, 2-methylnaphthalene, phenanthrene, and pyrene [MacDonald 1994])

(4) For a given PAH, one-half the reporting limit was used to sum the concentration of total PAHs if that PAH was not detected.

TABLE 3-25
SUMMARY OF HAZARD QUOTIENTS FOR CONSERVATIVE FOOD WEB EXPOSURES - AQUATIC RECEPTORS
SWMU 7/8 - TOW WAY FUEL FARM
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Spotted Sandpiper			Double-Crested Cormorant			West Indian Manatee		
	NOAEL	LOAEL	MATC	NOAEL	LOAEL	MATC	NOAEL	LOAEL	MATC
Inorganics:									
Antimony	NA	NA	NA	NA	NA	NA	1.29	0.13	0.41
Arsenic	4.34	1.45	2.51	0.12	0.04	0.07	11.00	1.10	3.48
Barium	1.52	0.76	1.07	0.25	0.12	0.18	0.08	<0.01	0.03
Beryllium	NA	NA	NA	NA	NA	NA	<0.01	<0.01	<0.01
Cadmium	0.77	0.06	0.21	0.08	<0.01	0.02	0.46	0.05	0.14
Chromium	4.11	0.82	1.84	0.09	0.02	0.04	<0.01	<0.01	<0.01
Cobalt	6.67	0.67	2.11	1.07	0.11	0.34	<0.01	<0.01	<0.01
Copper	5.86	4.46	5.11	0.03	0.02	0.02	0.31	0.24	0.27
Lead	2.13	0.21	0.67	4.09	0.41	1.29	2.10	0.21	0.66
Mercury	2.85	0.29	0.90	2.72	0.27	0.86	0.32	0.06	0.14
Nickel	0.03	0.02	0.03	0.01	<0.01	0.01	0.02	0.01	0.01
Selenium	1.03	0.51	0.73	0.16	0.08	0.12	0.53	0.32	0.41
Silver	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Thallium	1.45	0.14	0.46	0.26	0.03	0.08	0.08	<0.01	0.03
Tin	0.40	0.16	0.26	0.08	0.03	0.05	<0.01	<0.01	<0.01
Vanadium	5.55	0.55	1.75	0.90	0.09	0.28	0.40	0.04	0.13
Zinc	6.85	0.76	2.28	0.34	0.04	0.11	1.43	0.14	0.45
Semi-Volatile Organics:									
1,2,4,5-Tetrachlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,4-Trichlorobenzene	NA	NA	NA	NA	NA	NA	<0.01	<0.01	<0.01
1,2-Dichlorobenzene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
1,3-Dichlorobenzene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
1,4-Dichlorobenzene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,3,4,6-Tetrachlorophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,4,5-Trichlorophenol	NA	NA	NA	NA	NA	NA	<0.01	<0.01	<0.01
2,4,6-Trichlorophenol	NA	NA	NA	NA	NA	NA	<0.01	<0.01	<0.01
2,4-Dichlorophenol	NA	NA	NA	NA	NA	NA	<0.01	<0.01	<0.01
2-Acetylaminofluorene	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-Chloronaphthalene	NA	NA	NA	NA	NA	NA	NA	NA	NA
3,3'-Dichlorobenzidine	NA	NA	NA	NA	NA	NA	NA	NA	NA
3,3'-Dimethylbenzidine	NA	NA	NA	NA	NA	NA	NA	NA	NA
3-Methylcholanthrene	NA	NA	NA	NA	NA	NA	NA	NA	NA
4-Bromophenyl-phenylether	NA	NA	NA	NA	NA	NA	NA	NA	NA

TABLE 3-25
SUMMARY OF HAZARD QUOTIENTS FOR CONSERVATIVE FOOD WEB EXPOSURES - AQUATIC RECEPTORS
SWMU 7/8 - TOW WAY FUEL FARM
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Spotted Sandpiper			Double-Crested Cormorant			West Indian Manatee		
	NOAEL	LOAEL	MATC	NOAEL	LOAEL	MATC	NOAEL	LOAEL	MATC
4-Chloro-3-methylphenol	NA	NA	NA	NA	NA	NA	NA	NA	NA
4-Chlorophenyl-phenylether	NA	NA	NA	NA	NA	NA	NA	NA	NA
7,12-Dimethylbenz(a)anthracene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Aramite	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bis(2-ethylhexyl)phthalate	0.18	0.02	0.06	0.21	0.02	0.06	<0.01	<0.01	<0.01
Butylbenzylphthalate	NA	NA	NA	NA	NA	NA	<0.01	<0.01	<0.01
Diallate	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzofuran	NA	NA	NA	NA	NA	NA	<0.01	<0.01	<0.01
Diethylphthalate	NA	NA	NA	NA	NA	NA	<0.01	<0.01	<0.01
Di-n-butylphthalate	1.81	0.18	0.57	0.38	0.04	0.12	<0.01	<0.01	<0.01
Di-n-octylphthalate	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dinoseb	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hexachlorobenzene	2.49	0.25	0.79	0.52	0.05	0.16	<0.01	<0.01	<0.01
Hexachlorobutadiene	0.19	0.06	0.10	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
Hexachlorocyclopentadiene	NA	NA	NA	NA	NA	NA	<0.01	<0.01	<0.01
Hexachloroethane	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hexachlorophene	NA	NA	NA	NA	NA	NA	<0.01	<0.01	<0.01
Hexachloropropene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Isosafrole	NA	NA	NA	NA	NA	NA	NA	NA	NA
N-Nitrosodiphenylamine	NA	NA	NA	NA	NA	NA	<0.01	<0.01	<0.01
p-Dimethylaminoazobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pentachlorobenzene	NA	NA	NA	NA	NA	NA	<0.01	<0.01	<0.01
Pentachloronitrobenzene	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pentachlorophenol	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01
Pronamide	NA	NA	NA	NA	NA	NA	NA	NA	NA
PAHs:									
1-Methylnaphthalene	NA	NA	NA	NA	NA	NA	<0.01	<0.01	<0.01
2-Methylnaphthalene	NA	NA	NA	NA	NA	NA	<0.01	<0.01	<0.01
Acenaphthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Acenaphthylene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Anthracene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)anthracene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)pyrene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(b)fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

TABLE 3-25
SUMMARY OF HAZARD QUOTIENTS FOR CONSERVATIVE FOOD WEB EXPOSURES - AQUATIC RECEPTORS
SWMU 7/8 - TOW WAY FUEL FARM
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Spotted Sandpiper			Double-Crested Cormorant			West Indian Manatee		
	NOAEL	LOAEL	MATC	NOAEL	LOAEL	MATC	NOAEL	LOAEL	MATC
PAHs (continued):									
Benzo(g,h,i)perylene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(k)fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chrysene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dibenz(a,h)anthracene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluorene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Indeno(1,2,3-cd)pyrene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Naphthalene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenanthrene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pyrene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Volatile Organics:									
1,1,2,2-Tetrachloroethane	NA	NA	NA	NA	NA	NA	NA	NA	NA
Carbon Tetrachloride	NA	NA	NA	NA	NA	NA	<0.01	<0.01	<0.01
Chlorobenzene	NA	NA	NA	NA	NA	NA	<0.01	<0.01	<0.01
Chloroform	NA	NA	NA	NA	NA	NA	<0.01	<0.01	<0.01
Ethylbenzene	NA	NA	NA	NA	NA	NA	<0.01	<0.01	<0.01
Pentachloroethane	NA	NA	NA	NA	NA	NA	NA	NA	NA
Styrene	NA	NA	NA	NA	NA	NA	<0.01	<0.01	<0.01
Tetrachloroethene	NA	NA	NA	NA	NA	NA	<0.01	<0.01	<0.01
Toluene	NA	NA	NA	NA	NA	NA	<0.01	<0.01	<0.01
Trichloroethene	NA	NA	NA	NA	NA	NA	<0.01	<0.01	<0.01
Xylenes (total)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Notes:

NA = HQ value could not be calculated due to the lack of an ingestion-based screening value

TABLE 3-26
SUMMARY OF PRELIMINARY ECOLOGICAL CHEMICALS OF POTENTIAL CONCERN
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

	Media-Specific Screening Evaluation				Food Web Exposure Models	
Chemical	**Groundwater**	**Surface Soil**	**Surface Water**	**Sediment**	**Terrestrial Receptors (Max. HQ)**	**Aquatic Receptors (Max.HQ)**
Volatile Organics:						
1,1,1,2-Tetrachloroethane		No SSSV				
1,1,1-Trichloroethane		No SSSV				
1,1,2,2-Tetrachloroethane	2.22	No SSSV				
1,1,2-Trichloroethane		No SSSV				
1,1-Dichloroethane	4.26	No SSSV		2.29		
1,1-Dichloroethene		No SSSV				
1,2,3-Trichloropropane		No SSSV				
1,2-Dibromo-3-chloropropane	2.00	No SSSV				
1,2-Dibromoethane	4.17	No SSSV		1.53		
2-Butanone		No SSSV				
2-Hexanone	20.24	No SSSV		13.47		
3-Chloro-1-propene	58.82	No SSSV	1.47	23.06		
4-Methyl-2-pentanone	12.20	No SSSV		12.76		
Acetone	5.00	No SSSV		98.31		
Acetonitrile		No SSSV		3.34		
Acrolein		No SSSV				
Acrylonitrile	68.85		1.72	1209.34		
Benzene	1.83					
Bromodichloromethane		No SSSV				
Bromoform		No SSSV				
Bromomethane	1.67	No SSSV		6.97		
Carbon disulfide		No SSSV				
Chlorobenzene	1.90					
Chloroethane	No SWSV	No SSSV	No SWSV	No SSV		
Chloroform	HQ < 1.0					
Chloromethane	HQ < 1.0	No SSSV				
Chloroprene	No SWSV	No SSSV	No SWSV	No SSV		
cis-1,3-Dichloropropene	25.32	No SSSV		8.47		
Dibromochloromethane		No SSSV				
Dibromomethane		No SSSV				
Dichlorodifluoromethane		No SSSV				
Ethylbenzene	46.51		1.16	3.25		
Ethyl methacrylate	No SWSV	No SSSV	No SWSV	No SSV		
Iodomethane	No SWSV	No SSSV	No SWSV	No SSV		
Isobutanol		No SSSV				
Methacrylonitrile	No SWSV	No SSSV	No SWSV	No SSV		
Methyl methacrylate		No SSSV				
Pentachloroethane	3.56	No SSSV				
Propionitrile		No SSSV		5.67		
Tetrachloroethene	4.44					
Toluene	5.41					
trans-1,2-Dichloroethene		No SSSV				
trans-1,3-Dichloropropene	25.32	No SSSV		8.47		
trans-1,4-Dichloro-2-butene	No SWSV		No SWSV	No SSV		
Trichloroethene	140					
Trichlorofluoromethane		No SSSV				
Vinyl acetate		No SSSV				
Vinyl chloride	2.28	1.36		4.73		
Xylene	9.76			1.55		
Semi-Volatile Organics:						
1,2,4,5-Tetrachlorobenzene		No SSSV				
1,2,4-Trichlorobenzene	2.22		2.22	170.83		
1,3,5-Trinitrobenzene	No SWSV	No SSSV	No SWSV	63.08		
1,2-Dichlorobenzene				No SSV		
1,3-Dichlorobenzene				4.85		
1,4,-Dichlorobenzene				7.45		
1,4-Dioxane		No SSSV				
1,4-Naphthoquinone	No SWSV	No SSSV	No SWSV	No SSV		
1,4-Phenylenediamine	10.00	No SSSV	10.00	19706.98		
1-Naphthylamine	No SWSV	No SSSV	No SWSV	No SSV		
2,4,5-Trichlorophenol				1.09		

TABLE 3-26
SUMMARY OF PRELIMINARY ECOLOGICAL CHEMICALS OF POTENTIAL CONCERN
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Media-Specific Screening Evaluation				Food Web Exposure Models	
	Groundwater	Surface Soil	Surface Water	Sediment	Terrestrial Receptors (Max. HQ)	Aquatic Receptors (Max.HQ)
Semi-Volatile Organics (cont.):						
2,4,6-Trichlorophenol				136.67		
2,4-Dichlorophenol	2.00	No SSSV	2.00	164.00		
2,4-Dimethylphenol		No SSSV		45.56		
2,4-Dinitrophenol	1.03		1.03	1234.12		
2,4-Dinitrotoluene		No SSSV		11.15		
2,6-Dichlorophenol				14.31		
2,6-Dinitrotoluene		No SSSV		15.31		
2-Acetylaminofluorene		No SSSV		3.34		
2-Chloronaphthalene	No SWSV		No SWSV	No SSV		
2-Chlorophenol		No SSSV	HQ < 1.0	102.50		
2-Methylphenol		No SSSV	HQ < 1.0	102.50		
2-Naphthalamine	No SWSV	No SSSV	No SWSV	No SSV		
2-Nitroaniline	1.02	No SSSV	1.02	606.82		
2-Nitrophenol		No SSSV				
2-Picoline		No SSSV		3.52		
3,3'-Dichlorobenzidine	1.90	No SSSV	1.90	25.71		
3,3'-Dimethylbenzidine		No SSSV		28.99		
3-Methylcholanthrene	No SWSV	No SSSV	No SWSV	No SSV		
3&4-Methylphenol		No SSSV		94.51		
3-Nitroaniline	5.10	No SSSV	5.10	9179.39		
4,6-Dinitro-2-methylphenol		No SSSV		86.04		
4-Aminobiphenyl	No SWSV	No SSSV	No SWSV	No SSV		
4-Bromophenyl phenyl ether	2.78	No SSSV	2.78	1.32		
4-Chloro-3-methylphenol		No SSSV				
4-Chloroaniline		No SSSV		89.64		
4-Chlorophenyl-Phenylether	1.37	No SSSV	1.37			
4-Nitroaniline		No SSSV		505.74		
4-Nitrophenol				345.31		
4-Nitroquinoline-1-oxide	No SWSV	No SSSV	No SWSV	No SSV		
5-Nitro-o-toluidine		No SSSV		25.17		
7,12-Dimethyl benz(a)anthracene		No SSSV				
Acetophenone		No SSSV		6.15		
A, A-Dimethylphenethylamine	No SWSV	No SSSV	No SWSV	No SSV		
Aniline		No SSSV		144.42		
Aramite	16.67	No SSSV	16.67	11.89		
Benzoic acid	Not Analyzed	No SSSV	Not Analyzed	Not Analyzed		
Benzyl alcohol		No SSSV		15.77		
Bis(2-chloroethoxy)methane		No SSSV		3.22		
Bis(2-chloroethyl)ether		No SSSV		27.72		
Bis(2-chloroisopropyl)ether	No SWSV	No SSSV	No SWSV	No SSV		
Bis(2-ethylhexyl)phthalate				1.37		
Butylbenzylphthalate				13.02		
Diallate		No SSSV				
Dibenzofuran		No SSSV		7.45		
Diethylphthalate				136.67		
Dimethylphthalate				136.67		
Di-n-butylphthalate			2.94	14.14		1.81, sandpiper
Di-n-octylphthalate				13.44		
Dinoseb	5.88	No SSSV	5.88	188.04		
Ethyl methanesulfonate	No SWSV	No SSSV	No SWSV	No SSV		
Hexachlorobenzene	1.00	No SSSV	1.00	136.67		2.49, sandpiper
Hexachlorobutadiene	31.25	No SSSV	31.25	630.77		
Hexachlorocyclopentadiene	142.86		142.86	28.04		
Hexachloroethane	1.06	No SSSV	1.06	11.23		
Hexachlorophene	568.18	No SSSV	568.18			
Hexachloropropene	No SWSV	No SSSV	No SWSV	No SSV		
Isophorone		No SSSV		64.51		
Isosafrole	No SWSV	No SSSV	No SWSV	No SSV		
m-Dinitrobenzene		No SSSV		195.90		
Methapyrilene	No SWSV	No SSSV	No SWSV	No SSV		

TABLE 3-26
SUMMARY OF PRELIMINARY ECOLOGICAL CHEMICALS OF POTENTIAL CONCERN
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Media-Specific Screening Evaluation				Food Web Exposure Models	
	Groundwater	Surface Soil	Surface Water	Sediment	Terrestrial Receptors (Max. HQ)	Aquatic Receptors (Max.HQ)
Semi-Volatile Organics (cont.):						
Methyl methanesulfonate	No SWSV	No SSSV	No SWSV	No SSV		
Nitrobenzene				39.05		
n-Nitrosodimethylamine				52.51		
n-Nitrosodiphenylamine				29.29		
n-Nitrosomethylethylamine				1.55		
n-Nitrosomorpholine	No SWSV	No SSSV	No SWSV	No SSV		
n-Nitrosopiperidine	No SWSV	No SSSV	No SWSV	No SSV		
n-Nitrosopyrrolidine	No SWSV	No SSSV	No SWSV	No SSV		
o,o,o-Triethylphosphorothioate	No SWSV	No SSSV	No SWSV	No SSV		
o-Toluidine		No SSSV		46.99		
p-Dimethylaminoazobenzene	No SWSV	No SSSV	No SWSV	No SSV		
Pentachloronitrobenzene	43.48	No SSSV	43.48	46.61		
Pentachlorophenol	6.33		6.33	247.06		
Phenacetin	No SWSV	No SSSV	No SWSV	No SSV		
Phenol				6.31		
Pronamide		No SSSV		3.95		
Pryridine		12.67		171.29		
Safrole	No SWSV	No SSSV	No SWSV	No SSV		
PAHs:						
1-Methylnaphthalene	Not Analyzed	No SSSV		1.34		
2-Methylnaphthalene	16.00	No SSSV				
Acenaphthene				20.86		
Anthracene				5.33		
Benzo(a)anthracene				22.73		
Benzo(a)pyrene	1.00			24.77		
Benzo(b)fluoranthene				1.33		
Benzo(g,h,i)perylene				2.09		
Benzo(k)fluoranthene				1.39		
Chrysene	1.00			24.07		
Dibenzo(a,h)anthracene				85.21		
Fluoranthene				51.33		
Fluorene				6.60		
Indeno(1,2,3-cd)pyrene				2.17		
Naphthalene				9.83		
Phenanthrene				32.30		
Pyrene				30.72		
Total PAHs	NA	NA	NA	13.00	NA	NA
Metals:						
Antimony				7.50		1.29, manatee
Arsenic				6.35		11.0, manatee
Barium				2.08		1.52, sandpiper
Beryllium				No SSV		
Cadmium				1.91	1.61, robin	
Chromium		162.50			15.02, robin	4.11, sandpiper
Cobalt		1.90		3.10	2.04, robin	6.67, sandpiper
Copper	14.32	2.40	3.78	11.23		5.86, sandpiper
Lead				43.05	2.16, robin	4.09, cormorant
Mercury	2.18				6.87, robin	2.85, sandpiper
Nickel			4.82	1.32		
Selenium				1.30	1.20, dove	1.03, sandpiper
Silver	8.70		43.48	3.15		
Thallium		2.50		No SSV		1.45, sandpiper
Tin	No SWSV		No SWSV	2.74		
Vanadium	No SWSV	110.00	No SWSV	3.51		5.55, sandpiper
Zinc	1.29	5.80		4.84	18.72, robin	6.85, sandpiper

Shaded cell indicates that the chemical was detected.

Notes:

Number = HQ value

NA = Not applicable (total PAHs were evaluated in the media screening only for sediment)

TABLE 3-27
LESS CONSERVATIVE SOIL BIOACCUMULATION FACTORS USED FOR TERRESTRIAL PLANTS AND INVERTEBRATES
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Soil-Plant BCF (dry weight)		Soil-Invertebrate BAF (dry weight)	
	Value	Reference	Value	Reference
Volatile Organics:				
Styrene	0.7739	Travis and Arms 1988	1	Assumed
Toluene	0.9966	Travis and Arms 1988	1	Assumed
Trichloroethene	1.0510	Travis and Arms 1988	1	Assumed
Semi-Volatile Organics:				
Inorganics:				
Antimony	0.2	Baes et al. 1984	0.063	Helmke et al. 1979
Beryllium	0.01	Baes et al. 1984	1	Assumed
Cadmium	0.514	Bechtel Jacobs 1998a	7.66	Sample et al. 1998a
Chromium (total)	0.0075	Baes et al. 1984	0.32	Sample et al. 1998a
Cobalt	0.02	Baes et al. 1984	0.38	Helmke et al. 1979
Lead	0.0377	Bechtel Jacobs 1998a	0.307	Sample et al. 1998a
Mercury	0.344	Bechtel Jacobs 1998a	1.186	Sample et al. 1998a
Selenium	0.567	Bechtel Jacobs 1998a	0.982	Sample et al. 1998a
Zinc	0.358	Bechtel Jacobs 1998a	2.482	Sample et al. 1998a

Notes:

BCF = Bioconcentration Factor
BAF = Bioaccumulation Factor

(1) The chemicals listed are limited to those which were identified as preliminary ecological COPCs for the American robin and/or mourning dove and retained for evaluation in Step 3b.

TABLE 3-28
LESS CONSERVATIVE SOIL BIOACCUMULATION FACTORS USED FOR SMALL MAMMAL PREY ITEMS
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical [1]	Soil-Omnivore BCF (dry weight)	
	Value	Reference
Volatile Organics:		
Styrene	---	see text
Toluene	---	see text
Trichloroethene	---	see text
Semi-Volatile Organics:		
Inorganics:		
Antimony	---	see text
Beryllium	---	see text
Chromium (total)	0.092	Sample et al. 1998b
Zinc	0.5092	Sample et al. 1998b

Notes:

BCF = Bioconcentration Factor
BAF = Bioaccumulation Factor

[1] The chemicals listed are limited to those identified as preliminary ecological chemicals of potential concern in the screening-level ecological risk assessment for the red-tailed hawk and retained for evaluation in Step 3b.

TABLE 3-29
LESS CONSERVATIVE SEDIMENT BIOACCUMULATION FACTORS USED FOR AQUATIC INVERTEBRATES AND FISH
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Sediment-Invertebrate BAF (dry weight)		Sediment-Fish BAF (dry weight)	
	Value	Reference	Value	Reference
Semi-Volatile Organics:				
Bis(2-ethylhexyl)phthalate	---	---	1	Assumed
Di-n-butylphthalate	1	Assumed	---	---
Hexachlorobenzene	1	Assumed	---	---
Inorganics:				
Antimony	1	Assumed	1	Assumed
Arsenic	0.437	Bechtel Jacobs 1998b	---	---
Barium	1	Assumed	---	---
Beryllium	1	Assumed	1	Assumed
Chromium (total)	0.09	Bechtel Jacobs 1998b	---	---
Cobalt	1	Assumed	1	Assumed
Copper	0.919	Bechtel Jacobs 1998b	---	---
Lead	0.338	Bechtel Jacobs 1998b	0.07	Krantzberg and Boyd 1992
Mercury	1.022	Bechtel Jacobs 1998b	3.25	Cope et al. 1990
Selenium	1	Assumed	---	---
Thallium	1	Assumed	---	---
Vanadium	1	Assumed	---	---
Zinc	0.954	Bechtel Jacobs 1998b	---	---

Notes:

BAF = Bioaccumulation Factor

(1) The chemicals listed are limited to those which were identified as preliminary ecological COPCs for the spotted sandpiper and/or double crested cormorant and retained for evaluation in Step 3b.

TABLE 3-30
LESS CONSERVATIVE EXPOSURE PARAMETERS FOR UPPER TROPHIC LEVEL RECEPTORS
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Receptor	Habitat	Body Weight (kg)		Food Ingestion Rate (kg/day - dry)		Area Use Factor
		Value	Reference	Value	Reference	
Birds:						
American robin	Terrestrial	0.0773	USEPA 1993b	0.00426	Levey and Karasov 1989	1.0
Mourning dove	Terrestrial	0.1265	Tomlinson et al. 1994	0.01515	Allometric equation from Nagy 1987 for all birds	1.0
Red-tailed hawk	Terrestrial	1.126	Sample and Suter II 1996	0.03927	Sample and Suter II 1994	1.0
Spotted Sandpiper	Aquatic	0.0404	Dunning 1993	0.00721	Allometric equation from Nagy 1987 for all birds	1.0
Double-crested cormorant	Aquatic	2.33	Glahn and McCoy 1995	0.09250	Bivings et al. 1989	1.0
Mammals:						
West Indian manatee	Aquatic	1,000	USGS 2000	9.75	Etheridge et al. 1985	1.0
Small Mammal Omnivore	Terrestrial	0.275	Jackson 1992	0.01477	Allometric equation from Nagy 1987 for rodents	1.0

TABLE 3-31
FREQUENCY AND RANGE OF SURFACE SOIL DATA (MEAN CONCENTRATIONS) COMPARED TO SURFACE SOIL SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					Surface Soil Screening Value (SSV)		Mean HQ[2]	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]					
Volatile Organics (ug/kg):										
1,1,1-Trichloroethane	1/23	3.2J - 3.2J	5U - 7.6U	2.9	2.9	---	---	NA	Yes	Detected, No SSSV
2-Butanone	2/23	5.4J - 5.9J	10UJ - 38U	9.8	5.9	---	---	NA	Yes	Detected, No SSSV
Acetone	5/21	8.8J - 56J	10U - 76U	21.8	21.8	---	---	NA	Yes	Detected, No SSSV
Vinyl chloride	0/23	NA	10U - 15U	5.7	5.7	11	MHSPE 1994	0.52	No	HQ , 1.0
Semi-Volatile Organics (ug/kg) (cont.):										
Pryridine	0/23	NA	350U - 760UJ	273.9	274	60	MHSPE 1994	4.57	Yes	HQ > 1.0
Metals (mg/kg):										
Chromium	23/23	7.2J - 65	NA	25.75	26	0.4	Efroymson et. al. 1997a	64.37	Yes	HQ > 1.0
Cobalt	19/19	7.3J - 38	NA	22.94	23	20	Efroymson et. al. 1997b	1.15	Yes	HQ > 1.0
Copper	19/19	23.1 - 120J	NA	83.45	83	50	Efroymson et. al. 1997a	1.67	Yes	HQ > 1.0
Thallium	11/19	0.79J - 2.5J	0.13U - 1.1U	0.98	1.0	1.0	Efroymson et. al. 1997b	0.98	No	HQ < 1.0
Vanadium	19/19	42.4 - 220	NA	131.49	131	2	Efroymson et. al. 1997b	65.75	Yes	HQ > 1.0
Zinc	19/19	48J - 290	NA	78.19	78	50	Efroymson et. al. 1997b	1.56	Yes	HQ > 1.0

Notes:

HQ = Hazard Quotient
COPC = Ecological Chemical of Potential Concern
NA = Not Applicable

J = Value is estimated
U = Not detected
UJ = Not detected, value is estimated

(1) Mean concentration unless the mean exceeds the maximum concentration.

(2) The mean HQ value is the mean (half non-detects) divided by the screening value. If the mean concentration exceeds the maximum concentration, the maximum concentration is used.

TABLE 3-32
FREQUENCY AND RANGE OF GROUNDWATER DATA (MEAN CONCENTRATIONS) COMPARED TO SURFACE WATER SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range						Surface Water Screening Value (SWSV)		Mean HQ[2]	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Max Value	Value used in Screen[1]					
Volatile Organics (ug/L):											
1,1,2,2-Tetrachloroethane	0/20	NA	5U - 200U	7.4	200	7.4	90.2	USEPA 2001	0.08	No	HQ < 1.0
1,1-Dichloroethene	1/20	1.7J - 1.7J	5U - 200U	7.3	1.7	1.7	2,240	USEPA 2001	0.00	No	HQ < 1.0
1,2-Dibromo-3-chloropropane	0/20	NA	5UJ - 200UJ	7.4	200	7.4	100	USEPA 2000b	0.07	No	HQ < 1.0
1,2-Dibromoethane	0/20	NA	5U - 200U	7.4	200	7.4	48	USEPA 2000b	0.15	No	HQ < 1.0
2-Hexanone	0/20	NA	25U - 2000U	61.9	2,000	61.9	98.8	Suter II 1996	0.63	No	HQ < 1.0
3-Chloro-1-propene	0/20	NA	5U - 200U	7.4	200	7.4	3.4	USEPA 2000b	2.18	No	Not Detected
4-Methyl-2-pentanone	0/20	NA	25U - 2000U	61.9	2,000	61.9	164	Suter II 1996	0.38	No	HQ < 1.0
Acetone	0/19	NA	50U - 5000U	155.3	5,000	155.3	1,000	USEPA 2000b	0.16	No	HQ < 1.0
Acrylonitrile	0/20	NA	100UJ - 4000UJ	147.5	4,000	147.5	58.1	USEPA 2000b	2.54	No	Not Detected
Benzene	0/20	NA	5U - 200U	7.4	200	7.4	109	USEPA 2001	0.07	No	HQ < 1.0
Bromomethane	0/20	NA	10UJ - 200UJ	9.8	200	9.8	120	USEPA 2000b	0.08	No	HQ < 1.0
Chlorobenzene	0/20	NA	5U - 200U	7.4	200	7.4	105	USEPA 2001	0.07	No	HQ < 1.0
cis-1,3-Dichloropropene	0/20	NA	5U - 200U	7.4	200	7.4	7.9	USEPA 2001	0.94	No	HQ < 1.0
Ethylbenzene	0/20	NA	5U - 200U	7.4	200	7.4	4.3	USEPA 2001	1.72	No	Not Detected
Pentachloroethane	0/13	NA	25UJ - 1000UJ	50	1,000	50	281	Buchman 1999	0.18	No	HQ < 1.0
Tetrachloroethene	0/20	NA	5U - 200U	7.4	200	7.4	45	USEPA 2001	0.16	No	HQ < 1.0
Toluene	1/20	200J - 200J	5U - 5U	12.4	200	12.4	37	USEPA 2001	0.34	No	HQ < 1.0
trans-1,3-Dichloropropene	0/20	NA	5U - 200U	7.4	200	7.4	7.9	USEPA 2001	0.94	No	HQ < 1.0
Trichloroethene	2/20	0.35J - 28000J	5U - 5U	1,402.3	28,000	1,402.3	200	Buchman 1999	7.01	Yes	HQ > 1.0
Vinyl chloride	0/20	NA	10U - 200U	9.8	200	9.8	87.8	Suter II 1996	0.11	No	HQ < 1.0
Xylene	0/20	NA	10U - 400U	14.8	400	14.8	41	USEPA 2000b	0.36	No	HQ < 1.0
PAHs (ug/L):											
2-Methylnaphthalene	2/20	6.2J - 96	10U - 10U	9.6	96	9.6	6	USEPA 2000b	1.60	Yes	HQ > 1.0
Benzo(a)pyrene	0/20	NA	10U - 10U	5	10	5	10	USEPA 1996b	0.50	No	HQ < 1.0
Chrysene	0/20	NA	10U - 10U	5	10	5	10	USEPA 1996b	0.50	No	HQ < 1.0
Semi-Volatile Organics (ug/L):											
1,2,4-Trichlorobenzene	0/20	NA	10U - 10U	5	10	5	4.5	USEPA 2001	1.11	No	Not Detected
1,4-Phenylenediamine	0/20	NA	2000U - 2000U	1,000	2,000	1,000	200	USEPA 2000b	5.00	No	Not Detected
2,4-Dichlorophenol	0/19	NA	10U - 10U	5	10	5	5	USEPA 2000b	1.00	No	Not Detected
2,4-Dinitrophenol	0/19	NA	50UJ - 50UJ	25	50	25	48.5	USEPA 2001	0.52	No	HQ < 1.0
2-Nitroaniline	0/20	NA	50U - 50U	25	50	25	48.9	USEPA 2000b	0.51	No	HQ < 1.0
3,3'-Dichlorobenzidine	0/20	NA	20U - 20U	10	20	10	10.5	USEPA 2000b	0.95	No	HQ < 1.0
3-Nitroaniline	0/20	NA	50U - 50U	25	50	25	9.8	USEPA 2000b	2.55	No	Not Detected
4-Bromophenyl phenyl ether	0/20	NA	10U - 10U	5	10	5	3.6	USEPA 2000b	1.39	No	Not Detected
4-Chlorophenyl-Phenylether	0/20	NA	10U - 10U	5	10	5	7.3	USEPA 2000b	0.68	No	HQ < 1.0
Aramite	0/20	NA	10U - 10U	5	10	5	0.6	USEPA 2000b	8.33	No	Not Detected
Dinoseb	0/20	NA	10U - 10U	5	10	5	1.7	USEPA 2000b	2.94	No	Not Detected
Hexachlorobenzene	0/20	NA	10U - 10U	5	10	5	10	USEPA 2000b	0.50	No	HQ < 1.0
Hexachlorobutadiene	0/20	NA	10U - 10U	5	10	5	0.32	USEPA 2001	15.63	No	Not Detected
Hexachlorocyclopentadiene	0/20	NA	10U - 10U	5	10	5	0.07	USEPA 2001	71.43	No	Not Detected
Hexachloroethane	0/20	NA	10U - 10U	5	10	5	9.4	USEPA 2001	0.53	No	HQ < 1.0
Hexachlorophene	0/20	NA	5000U - 5000U	2,500	5,000	2,500	8.8	USEPA 2000b	284.09	No	Not Detected
Pentachloronitrobenzene	0/20	NA	10U - 10U	5	10	5	0.23	USEPA 2000b	21.74	No	Not Detected
Pentachlorophenol	0/19	NA	50U - 50U	25	50	25	7.9	USEPA 1999b	3.16	No	Not Detected

TABLE 3-32
FREQUENCY AND RANGE OF GROUNDWATER DATA (MEAN CONCENTRATIONS) COMPARED TO SURFACE WATER SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range						Surface Water Screening Value (SWSV)		Mean HQ[2]	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Max Value	Value used in Screen[1]					
Total Metals (ug/L):											
Copper	13/20	0.95J - 53	20U - 20U	9.4	53	9.4	3.7	USEPA 1999b	2.54	Yes	HQ > 1.0
Mercury	2/20	0.22J - 2.4J	0.2UJ - 0.4UJ	0.2	2.4	0.2	1.1	USEPA 1999b	0.18	No	HQ < 1.0
Silver	1/20	2J - 2J	10U - 10U	4.9	2	2	0.23	USEPA 2001	8.70	Yes	HQ > 1.0
Vanadium	16/20	2.6J - 140	10U - 10U	25	140	25	---	---	NA	Yes	Detected, No SWSV
Zinc	6/20	6.7J - 110	20U - 20U	15.1	110	15.1	85.6	USEPA 1999b	0.18	No	HQ < 1.0

Notes:

HQ = Hazard Quotient
COPC = Ecological Chemical of Potential Concern
NA = Not Applicable

J = Value is estimated
U = Not detected
UJ = Not detected, value is estimated

(1) Mean concentration unless the mean exceeds the maximum concentration.

(2) The mean HQ value is the mean (half non-detects) divided by the screening value. If the mean concentration exceeds the maximum concentration, the maximum concentration is used.

TABLE 3-33
FREQUENCY AND RANGE OF SURFACE WATER DATA (MEAN CONCENTRATIONS) COMPARED TO SURFACE WATER SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					Surface Water Screening Value (SWSV)		Mean HQ[2]	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]					
Volatile Organics (ug/L):										
3-Chloro-1-propene	0/9	NA	5U - 5U	2.5	2.5	3.4	USEPA 2000b	0.74	No	HQ < 1.0
Acrylonitrile	0/9	NA	100U - 100U	50	50	58.1	USEPA 2000b	0.86	No	HQ < 1.0
Ethylbenzene	0/9	NA	5U - 5U	2.5	2.5	4.3	USEPA 2001	0.58	No	HQ < 1.0
Semi-Volatile Organics (ug/L)										
1,2,4-Trichlorobenzene	0/9	NA	10U - 10U	5	5	4.5	USEPA 2001	1.11	No	Not Detected
1,4-Phenylenediamine	0/9	NA	2000U - 2000U	1,000	1,000	200	USEPA 2000b	5.00	No	Not Detected
2,4-Dichlorophenol	0/9	NA	10U - 10U	5	5	5	USEPA 2000b	1.00	No	Not Detected
2,4-Dinitrophenol	0/9	NA	50U - 50U	25	25	48.5	USEPA 2001	0.52	No	HQ < 1.0
2-Nitroaniline	0/9	NA	50U - 50U	25	25	48.9	USEPA 2000b	0.51	No	HQ < 1.0
3,3'-Dichlorobenzidine	0/9	NA	20U - 20U	10	10	10.5	USEPA 2000b	0.95	No	HQ < 1.0
3-Nitroaniline	0/9	NA	50U - 50U	25	25	9.8	USEPA 2000b	2.55	No	Not Detected
4-Bromophenyl phenyl ether	0/9	NA	10U - 10U	5	5	3.6	USEPA 2000b	1.39	No	Not Detected
4-Chlorophenyl-Phenylether	0/9	NA	10U - 10U	5	5	7.3	USEPA 2000b	0.68	No	HQ < 1.0
Aramite	0/9	NA	10U - 10U	5	5	0.6	USEPA 2000b	8.33	No	Not Detected
Di-n-butylphthalate	0/9	NA	10U - 10U	5	5	3.4	USEPA 2001	1.47	No	Not Detected
Dinoseb	0/9	NA	10U - 10U	5	5	1.7	USEPA 2000b	2.94	No	Not Detected
Hexachlorobenzene	0/9	NA	10U - 10U	5	5	10	USEPA 2000b	0.50	No	HQ < 1.0
Hexachlorobutadiene	0/9	NA	10U - 10U	5	5	0.32	USEPA 2001	15.63	No	Not Detected
Hexachlorocyclopentadiene	0/9	NA	10U - 10U	5	5	0.07	USEPA 2001	71.43	No	Not Detected
Hexachloroethane	0/9	NA	10U - 10U	5	5	9.4	USEPA 2001	0.53	No	HQ < 1.0
Hexachlorophene	0/9	NA	5000U - 5000U	2,500	2,500	8.8	USEPA 2000b	284.09	No	Not Detected
Pentachloronitrobenzene	0/9	NA	10U - 10U	5	5	0.23	USEPA 2000b	21.74	No	Not Detected
Pentachlorophenol	0/9	NA	50U - 50U	25	25	7.9	USEPA 1999b	3.16	No	Not Detected
Total Metals (ug/L):										
Copper	9/9	2.1J - 14J	NA	4.2	4.2	3.7	USEPA 1999b	1.14	Yes	HQ > 1.0
Nickel	0/9	NA	40U - 40U	20	20	8.3	USEPA 1999b	2.41	No	Not Detected
Silver	0/9	NA	10U - 10U	5	5	0.23	USEPA 2001	21.74	No	Not Detected
Tin	2/9	6.8J - 11J	50U - 50U	21.4	11	---	---	NA	Yes	Detected, No SWSV
Vanadium	9/9	4.6J - 12J	NA	8	8	---	---	NA	Yes	Detected, No SWSV

Notes:

HQ = Hazard Quotient
COPC = Ecological Chemical of Potential Concern
NA = Not Applicable

J = Value is estimated
U = Not detected
UJ = Not detected, value is estimated

(1) Mean concentration unless the mean exceeds the maximum concentration.

(2) The mean HQ value is the mean (half non-detects) divided by the screening value. If the mean concentration exceeds the maximum concentration, the maximum concentration is used.

TABLE 3-34
FREQUENCY AND RANGE OF SEDIMENT DATA (MEAN CONCENTRATIONS) COMPARED TO SEDIMENT SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					Sediment Screening Value (SSV)		Mean HQ[2]	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]					
Volatile Organics (ug/L):										
1,1-Dichloroethane	0/13	NA	6.6U - 13U	4.5	4.5	5.7	USEPA 1993a	0.79	No	HQ<1.0
1,2-Dibromoethane	0/13	NA	6.6U - 13U	4.5	4.5	8.5	USEPA 1993a	0.53	No	HQ<1.0
2-Hexanone	0/13	NA	33U - 65U	22.2	22.2	4.8	USEPA 1993a	4.60	No	Not Detected
3-Chloro-1-propene	0/13	NA	6.6U - 13U	4.5	4.5	0.6	USEPA 1993a	7.98	No	Not Detected
4-Methyl-2-pentanone	0/13	NA	33U - 65U	22.2	22.2	5.1	USEPA 1993a	4.36	No	Not Detected
Acetone	4/13	36J - 120J	9.2U - 190U	54.5	54.5	1.2	USEPA 1993a	44.65	Yes	HQ > 1.0
Acetonitrile	0/13	NA	260U - 520UJ	177.7	177.7	155.7	USEPA 1993a	1.14	No	Not Detected
Acrylonitrile	0/13	NA	130U - 260U	88.5	88.5	0.2	USEPA 1993a	411.64	No	Not Detected
Bromomethane	0/13	NA	13U - 26U	8.8	8.8	3.7	USEPA 1993a	2.36	No	Not Detected
cis-1,3-Dichloropropene	0/13	NA	6.6U - 13U	4.5	4.5	1.5	USEPA 1993a	3.00	No	Not Detected
Dibromomethane	0/13	NA	6.6U - 13U	4.5	4.5	526.2	USEPA 1993a	0.01	No	HQ<1.0
Ethylbenzene	0/13	NA	6.6U - 13U	4.5	4.5	4.0	Buchman 1999	1.13	No	Not Detected
Methyl methacrylate	0/13	NA	6.6U - 13U	4.5	4.5	62.1	USEPA 1993a	0.07	No	HQ<1.0
Methylene chloride	1/13	2.7J - 2.7J	6.6U - 13U	4.4	2.7	91.1	USEPA 1993a	0.03	No	HQ<1.0
Pentachloroethane	0/13	NA	33U - 65U	22.2	22.2	601.4	USEPA 1993a	0.04	No	HQ<1.0
Propionitrile	0/13	NA	130U - 260U	88.5	88.5	45.9	USEPA 1993a	1.93	No	Not Detected
trans-1,3-Dichloropropene	0/13	NA	6.6U - 13U	4.5	4.5	1.5	USEPA 1993a	2.93	No	Not Detected
Vinyl chloride	0/13	NA	13U - 26U	8.8	8.8	5.5	USEPA 1993a	1.60	No	Not Detected
Xylene	1/13	6.2J - 6.2J	6.6U - 13U	4.7	4.7	4.0	Buchman 1999	1.18	Yes	HQ > 1.0
Semi-Volatile Organics (ug/kg):										
1,2,4-Trichlorobenzene	0/13	NA	480U - 820U	306.2	306.2	4.8	Buchman 1999	63.79	No	Not Detected
1,3,5-Trinitrobenzene	0/12	NA	480UJ - 820UJ	307.5	307.5	13.0	Buchman 1999	23.65	No	Not Detected
1,3-Dichlorobenzene	0/13	NA	480U - 820U	306.2	306.2	168.9	USEPA 1993a	1.81	No	Not Detected
1,4,-Dichlorobenzene	0/13	NA	480U - 820U	306.2	306.2	110.0	Buchman 1999	2.78	No	Not Detected
1,4-Phenylenediamine	0/13	NA	2500U - 4200U	1569.2	1569.2	0.2	USEPA 1993a	7362.90	No	Not Detected
2,4,5-Trichlorophenol	0/13	NA	480U - 820U	306.2	306.2	750.5	Buchman 1999	0.41	No	HQ < 1.0
2,4,6-Trichlorophenol	0/13	NA	480U - 820U	306.2	306.2	6.0	Buchman 1999	51.03	No	Not Detected
2,4-Dichlorophenol	0/13	NA	480U - 820U	306.2	306.2	5.0	Buchman 1999	61.24	No	Not Detected
2,4-Dimethylphenol	0/13	NA	480U - 820U	306.2	306.2	18.0	Buchman 1999	17.01	No	Not Detected
2,4-Dinitrophenol	0/13	NA	2500U - 4200U	1569.2	1569.2	3.4	USEPA 1993a	461.09	No	Not Detected
2,4-Dinitrotoluene	0/13	NA	480U - 820U	306.2	306.2	73.5	USEPA 1993a	4.16	No	Not Detected
2,6-Dichlorophenol	0/13	NA	480U - 820U	306.2	306.2	57.3	USEPA 1993a	5.34	No	Not Detected
2,6-Dinitrotoluene	0/13	NA	480U - 820U	306.2	306.2	53.6	USEPA 1993a	5.72	No	Not Detected
2-Acetylaminofluorene	0/13	NA	480U - 820U	306.2	306.2	245.2	USEPA 1993a	1.25	No	Not Detected
2-Chlorophenol	0/13	NA	480U - 820U	306.2	306.2	8.0	Buchman 1999	38.28	No	Not Detected
2-Methylphenol	0/13	NA	480U - 820U	306.2	306.2	8.0	Buchman 1999	38.28	No	Not Detected
2-Nitroaniline	0/13	NA	2500U - 4200U	1569.2	1569.2	6.9	USEPA 1993a	226.72	No	Not Detected
3&4-Methylphenol	0/13	NA	480U - 820U	306.2	306.2	8.7	USEPA 1993a	35.29	No	Not Detected
3,3'-Dichlorobenzidine	0/13	NA	960U - 1600U	613.8	613.8	62.2	USEPA 1993a	9.86	No	Not Detected
3,3'-Dimethylbenzidine	0/13	NA	2500U - 4200U	1569.2	1569.2	144.9	USEPA 1993a	10.83	No	Not Detected
3-Nitroaniline	0/13	NA	2500U - 4200U	1569.2	1569.2	0.5	USEPA 1993a	3429.60	No	Not Detected

TABLE 3-34
FREQUENCY AND RANGE OF SEDIMENT DATA (MEAN CONCENTRATIONS) COMPARED TO SEDIMENT SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					Sediment Screening Value (SSV)		Mean HQ[2]	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]					
Semi-Volatile Organics (ug/kg) (cont.):										
4,6-Dinitro-2-methylphenol	0/13	NA	2500U - 4200U	1569.2	1569.2	48.8	USEPA 1993a	32.14	No	Not Detected
4-Chloroaniline	0/13	NA	960U - 1600U	613.8	613.8	17.9	USEPA 1993a	34.39	No	Not Detected
4-Nitroaniline	0/13	NA	2500U - 4200U	1569.2	1569.2	8.3	USEPA 1993a	188.96	No	Not Detected
4-Nitrophenol	0/13	NA	2500U - 4200U	1569.2	1569.2	12.2	USEPA 1993a	129.01	No	Not Detected
5-Nitro-o-toluidine	0/13	NA	480U - 820U	306.2	306.2	32.6	USEPA 1993a	9.40	No	Not Detected
Acetophenone	0/13	NA	480U - 820U	306.2	306.2	133.3	USEPA 1993a	2.30	No	Not Detected
Aniline	0/13	NA	480U - 820U	306.2	306.2	5.7	USEPA 1993a	53.93	No	Not Detected
Aramite	0/13	NA	480U - 820U	306.2	306.2	69.0	USEPA 1993a	4.44	No	Not Detected
Benzyl alcohol	0/13	NA	480U - 820U	306.2	306.2	52.0	Buchman 1999	5.89	No	Not Detected
Bis(2-chloroethoxy)methane	0/13	NA	480U - 820U	306.2	306.2	255.0	USEPA 1993a	1.20	No	Not Detected
Bis(2-chloroethyl)ether	0/13	NA	480U - 820U	306.2	306.2	29.6	USEPA 1993a	10.35	No	Not Detected
Bis(2-ethylhexyl)phthalate	3/13	180J - 250J	480U - 690U	275.0	250.0	182.0	MacDonald 1994	1.37	Yes	HQ > 1.0
Butylbenzylphthalate	0/13	NA	480U - 820U	306.2	306.2	63.0	Buchman 1999	4.86	No	Not Detected
Dibenzofuran	0/13	NA	480U - 820U	306.2	306.2	110.0	Buchman 1999	2.78	No	Not Detected
Diethylphthalate	0/13	NA	480U - 820U	306.2	306.2	6.0	Buchman 1999	51.03	No	Not Detected
Dimethylphthalate	0/13	NA	480U - 820U	306.2	306.2	6.0	Buchman 1999	51.03	No	Not Detected
Di-n-butylphthalate	0/13	NA	480U - 820U	306.2	306.2	58.0	Buchman 1999	5.28	No	Not Detected
Di-n-octylphthalate	0/13	NA	480U - 820U	306.2	306.2	61.0	Buchman 1999	5.02	No	Not Detected
Dinoseb	0/13	NA	480U - 820UJ	306.2	306.2	4.4	USEPA 1993a	70.22	No	Not Detected
Hexachlorobenzene	0/13	NA	480U - 820U	306.2	306.2	6.0	Buchman 1999	51.03	No	Not Detected
Hexachlorobutadiene	0/13	NA	480U - 820U	306.2	306.2	1.3	Buchman 1999	235.54	No	Not Detected
Hexachlorocyclopentadiene	0/13	NA	480U - 820U	306.2	306.2	29.2	USEPA 1993a	10.47	No	Not Detected
Hexachloroethane	0/13	NA	480U - 820U	306.2	306.2	73.0	Buchman 1999	4.19	No	Not Detected
Isophorone	0/13	NA	480U - 820U	306.2	306.2	12.7	USEPA 1993a	24.09	No	Not Detected
m-Dinitrobenzene	0/13	NA	480U - 820U	306.2	306.2	4.2	USEPA 1993a	73.15	No	Not Detected
Nitrobenzene	0/13	NA	480U - 820U	306.2	306.2	21.0	Buchman 1999	14.58	No	Not Detected
n-Nitrosodimethylamine	0/13	NA	480U - 820U	306.2	306.2	15.6	USEPA 1993a	19.61	No	Not Detected
n-Nitrosodiphenylamine	0/13	NA	480U - 820U	306.2	306.2	28.0	Buchman 1999	10.94	No	Not Detected
o-Toluidine	0/13	NA	480U - 820U	306.2	306.2	17.4	USEPA 1993a	17.55	No	Not Detected
Pentachloronitrobenzene	0/13	NA	480U - 820U	306.2	306.2	17.6	USEPA 1993a	17.40	No	Not Detected
Pentachlorophenol	0/13	NA	2500U - 4200U	1569.2	1569.2	17.0	Buchman 1999	92.31	No	Not Detected
Phenol	0/13	NA	480U - 820U	306.2	306.2	130.0	Buchman 1999	2.36	No	Not Detected
Pryridine	0/13	NA	480U - 820U	306.2	306.2	4.8	USEPA 1993a	63.96	No	Not Detected
PAHs (ug/kg):										
1-Methylnaphthalene	0/13	NA	6.7U - 340U	20.5	20.5	254.4	USEPA 1993a	0.08	No	HQ<1.0
Acenaphthene	4/13	3.8J - 140J	6.7U - 58U	18.3	18.3	6.7	MacDonald 1994	2.73	Yes	HQ > 1.0
Anthracene	10/13	2.8J - 250	9.7U - 11U	46.6	46.6	46.9	MacDonald 1994	0.99	No	HQ < 1.0
Benzo(a)anthracene	12/13	6.6J - 1700	11U - 11U	206.0	206.0	74.8	MacDonald 1994	2.75	Yes	HQ > 1.0
Benzo(a)pyrene	12/13	6.2J - 2200	11U - 11U	295.6	295.6	88.8	MacDonald 1994	3.33	Yes	HQ > 1.0
Benzo(b)fluoranthene	12/13	14J - 2400	11U - 11U	367.9	367.9	1800.0	Buchman 1999	0.20	No	HQ < 1.0
Benzo(g,h,i)perylene	12/13	3.8J - 1400	11U - 11U	163.3	163.3	670.0	Buchman 1999	0.24	No	HQ < 1.0

TABLE 3-34
FREQUENCY AND RANGE OF SEDIMENT DATA (MEAN CONCENTRATIONS) COMPARED TO SEDIMENT SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					Sediment Screening Value (SSV)		Mean HQ[2]	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]					
PAHs (ug/kg) (cont.):										
Benzo(k)fluoranthene	12/13	13J - 2500	11U - 11U	375.3	375.3	1800.0	Buchman 1999	0.21	No	HQ < 1.0
Chrysene	12/13	10 - 2600	11U - 11U	321.0	321.0	108.0	MacDonald 1994	2.97	Yes	HQ > 1.0
Dibenzo(a,h)anthracene	10/13	2.7J - 530	9.7U - 11U	68.9	68.9	6.2	MacDonald 1994	11.08	Yes	HQ > 1.0
Fluoranthene	11/13	8.5J - 5800	9.7U - 11U	594.4	594.4	113.0	MacDonald 1994	5.26	Yes	HQ > 1.0
Fluorene	5/13	3J - 140J	9.7U - 58U	18.3	18.3	21.2	MacDonald 1994	0.86	No	HQ < 1.0
Fluoranthene	11/13	8.5J - 5800	9.7U - 11U	594.4	594.4	113.0	MacDonald 1994	5.26	Yes	HQ > 1.0
Indeno(1,2,3-cd)pyrene	12/13	3.3J - 1300	11U - 11U	149.5	149.5	600.0	Buchman 1999	0.25	No	HQ < 1.0
Naphthalene	0/13	NA	6.7U - 340U	20.5	20.5	34.6	MacDonald 1994	0.59	No	HQ < 1.0
Phenanthrene	9/13	13 - 2800	9.7U - 11U	261.1	261.1	86.7	MacDonald 1994	3.01	Yes	HQ > 1.0
Pyrene	12/13	3.8J - 4700	11U - 11U	484.3	484.3	153.0	MacDonald 1994	3.17	Yes	HQ > 1.0
Metals (ug/kg):										
Antimony	4/13	0.89J - 15J	2.4U - 3.8UJ	2.6	2.6	2.0	Long and Morgan 1991	1.32	Yes	HQ > 1.0
Arsenic	13/13	2.9J - 46	NA	9.7	9.7	7.2	MacDonald 1994	1.34	Yes	HQ > 1.0
Barium	13/13	15 - 100	NA	31.2	31.2	48	Buchman 1999	0.65	No	HQ < 1.0
Beryllium	13/13	0.11J - 0.39J	NA	0.18	0.18	---	---	NA	Yes	Detected, No SSV
Cadmium	11/13	0.16J - 1.3	0.91U - 0.95U	0.49	0.49	0.7	MacDonald 1994	0.71	No	HQ < 1.0
Cobalt	13/13	3.6 - 31	NA	10.3	10.3	10	Buchman 1999	1.03	Yes	HQ > 1.0
Copper	13/13	10 - 210J	NA	71.2	71.2	18.7	MacDonald 1994	3.81	Yes	HQ > 1.0
Lead	13/13	1.3J - 1300J	NA	158	158	30.2	MacDonald 1994	5.22	Yes	HQ > 1.0
Nickel	13/13	3.1J - 21	NA	9.8	9.8	15.9	MacDonald 1994	0.61	No	HQ < 1.0
Selenium	2/13	0.8J - 1.3J	1.4U - 2.3UJ	0.9	0.9	1.0	Buchman 1999	0.90	No	HQ < 1.0
Silver	0/13	NA	1.2U - 2.3UJ	0.84	0.84	0.7	MacDonald 1994	1.15	No	Not Detected
Thallium	2/13	0.96J - 1.6J	1.4U - 2.3UJ	0.93	0.93	---	---	NA	Yes	Detected, No SSV
Tin	1/13	9.3J - 9.3J	6U - 11UJ	4.5	4.5	3.4	Buchman 1999	1.33	Yes	HQ > 1.0
Vanadium	13/13	33 - 200	NA	87.8	87.8	57	Buchman 1999	1.54	Yes	HQ > 1.0
Zinc	13/13	11 - 600	NA	137.5	137.5	124.0	MacDonald 1994	1.11	Yes	HQ > 1.0

Notes:

HQ = Hazard Quotient
COPC = Ecological Chemical of Potential Concern
NA = Not Applicable

J = Value is estimated
U = Not detected
UJ = Not detected, value is estimated

(1) Mean concentration unless the mean exceeds the maximum concentration.

(2) The mean HQ value is the mean (half non-detects) divided by the screening value. If the mean concentration exceeds the maximum concentration, the maximum concentration is used.

TABLE 3-35
SUMMARY OF HAZARD QUOTIENTS FOR LESS CONSERVATIVE FOOD WEB EXPOSURES - TERRESTRIAL RECEPTORS
SWMU 7/8 - TOW WAY FUEL FARM
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical [1]	American Robin			Mourning Dove			Red-Tailed Hawk		
	NOAEL	LOAEL	MATC	NOAEL	LOAEL	MATC	NOAEL	LOAEL	MATC
Inorganics:									
Cadmium	0.09	<0.01	0.02	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
Chromium	0.49	0.10	0.22	0.18	0.04	0.08	0.10	0.02	0.05
Cobalt	0.34	0.03	0.11	0.13	0.01	0.04	0.02	<0.01	<0.01
Lead	0.14	0.01	0.04	0.08	<0.01	0.02	0.02	<0.01	<0.01
Mercury	0.17	0.02	0.05	0.13	0.01	0.04	<0.01	<0.01	<0.01
Selenium	0.06	0.03	0.04	0.08	0.04	0.05	0.01	<0.01	<0.01
Zinc	0.62	0.07	0.21	0.25	0.03	0.08	0.10	0.01	0.03

Notes:

[1] The chemicals listed are those retained as preliminary ecological COPCs for one or more of the terrestrial avian receptors.

TABLE 3-36
SUMMARY OF HAZARD QUOTIENTS FOR LESS CONSERVATIVE FOOD WEB EXPOSURES - AQUATIC RECEPTORS
SWMU 7/8 - TOW WAY FUEL FARM
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical [1]	Spotted Sandpiper			Double-Crested Cormorant			West Indian Manatee		
	NOAEL	LOAEL	MATC	NOAEL	LOAEL	MATC	NOAEL	LOAEL	MATC
Inorganics:									
Antimony	NA	NA	NA	NA	NA	NA	0.59	0.06	0.19
Arsenic	0.46	0.15	0.27	0.02	<0.01	0.01	0.48	0.05	0.15
Barium	0.38	0.19	0.27	0.06	0.03	0.04	0.07	<0.01	0.02
Chromium	1.06	0.21	0.47	0.04	<0.01	0.02	<0.01	<0.01	<0.01
Cobalt	1.65	0.16	0.52	0.28	0.03	0.09	<0.01	<0.01	<0.01
Copper	0.16	0.13	0.14	<0.01	<0.01	<0.01	0.04	0.03	0.04
Lead	0.51	0.05	0.16	0.39	0.04	0.12	0.07	<0.01	0.02
Mercury	0.49	0.05	0.16	0.72	0.07	0.23	0.03	<0.01	0.01
Selenium	0.39	0.20	0.28	0.09	0.04	0.06	0.18	0.11	0.14
Thallium	0.48	0.05	0.15	0.12	0.01	0.04	0.12	0.01	0.04
Vanadium	1.97	0.20	0.62	0.31	0.03	0.10	0.50	0.05	0.16
Zinc	0.44	0.05	0.15	0.08	<0.01	0.03	0.13	0.01	0.04
Semi-Volatile Organics:									
Di-n-butylphthalate	0.44	0.04	0.14	0.11	0.01	0.03	<0.01	<0.01	<0.01
Hexachlorobenzene	0.61	0.06	0.19	0.15	0.02	0.05	<0.01	<0.01	<0.01

Notes:

NA = HQ value could not be calculated due to the lack of an ingestion-based screening value

[1] The chemicals listed are those retained as preliminary ecological COPCs for one or more of the aquatic receptors.

TABLE 3-37
FREQUENCY AND RANGE OF SURFACE SOIL DATA COMPARED TO BACKGROUND
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

	SWMU 7/8 Surface Soil						Background Surface Soil[1]					
Appendix IX Metal	No. of Positive Detects/ No. of Samples	Range of Non-Detects	Range of Positive Detections	Max. Detected Conc.	Arithmetic Mean (half Non-detects)	Standard Deviation	No. of Positive Detects/ No. of Samples	Range of Non-Detects	Range of Positive Detections	Max. Detected Conc.	Arithmetic Mean (half Non-detects)	Standard Deviation
Antimony	6/19	1.3UJ - 2.6U	0.59J - 1.3J	1.3	0.95	0.21	0/4	2.2UJ - 2.4UJ	NA	NA	1.15	0.04
Arsenic	20/23	0.52U - 0.97U	0.75 - 3.2	3.2	1.40	0.74	4/4	NA	0.35J - 1.8	1.8	1.21	0.63
Barium	23/23	NA	27 - 342J	342	89.62	65.82	4/4	NA	35.6 - 169	169	90.60	57.47
Beryllium	18/19	0.06U - 0.06U	0.12J - 1.8	1.8	0.37	0.37	3/4	0.1U - 0.1U	0.21 - 0.36	0.36	0.23	0.13
Cadmium	18/23	0.22U - 0.55U	0.14J - 0.8	0.8	0.38	0.22	0/4	0.26U - 0.28U	NA	NA	0.14	0.00
Chromium	23/23	NA	7.2J - 65	65	25.75	15.19	4/4	NA	11J - 44.1J	44.1	29.65	13.81
Cobalt	19/19	NA	7.3J - 38	38	22.94	7.45	4/4	NA	9.5 - 30.2	30.2	21.98	9.11
Copper	19/19	NA	23.1 - 120J	120	83.45	27.36	4/4	NA	57 - 250	250	117.10	90.48
Lead	23/23	NA	1.6 - 20.3	20	8.49	5.05	4/4	NA	2.4 - 11.9	11.9	7.63	4.10
Mercury	12/23	0.04U - 0.06U	0.0037J - 0.029	0.029	0.02	0.01	3/4	0.04U - 0.04U	0.06 - 0.07	0.07	0.06	0.02
Nickel	19/19	NA	4.3 - 25.4	25.4	14.29	5.84	4/4	NA	5.8 - 10.9	10.9	8.28	2.11
Selenium	8/23	0.12UJ - 1.3U	0.31J - 0.97J	0.97	0.43	0.26	3/4	0.13UJ - 0.13UJ	0.56J - 1.2J	1.2	0.73	0.53
Silver	0/23	0.21U - 1.3U	NA	NA	0.36	0.21	0/4	0.35U - 0.39U	NA	NA	0.19	0.01
Thallium	11/19	0.13U - 1.1U	0.79J - 2.5J	2.5	0.98	0.90	1/4	0.08U - 0.09UJ	0.1J - 0.1J	0.1	0.06	0.03
Tin	3/19	0.72U - 6.5U	1.4 - 1.6	1.6	2.10	1.01	2/4	1.2U - 1.3U	1.4 - 2.2	2.2	1.21	0.75
Vanadium	19/19	NA	42.4 - 220	220	131.49	43.66	4/4	NA	123 - 227	227	177.25	43.24
Zinc	19/19	NA	48J - 290	290	78.19	53.11	4/4	NA	34.2J - 106J	106	62.58	31.90

Notes:

NA = Not Applicable
U = Not Detected
J = Estimated Value
UJ = Reported detection limit is qualified as estimated
[1] - Baker Environmental, Inc., 2003. Final CMS Investigation Report for SWMU 9, April 25, 2003, Section 3.0.

TABLE 3-38
FREQUENCY AND RANGE OF GROUNDWATER DATA COMPARED TO BACKGROUND
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

	SWMU 7/8 Groundwater						Background Groundwater					
Appendix IX Metal	No. of Positive Detects/ No. of Samples	Range of Non-Detects	Range of Positive Detections	Max. Detected Conc.	Arithmetic Mean (Half Non-Detects)	Standard Deviation	No. of Positive Detects/ No. of Samples	Range of Non-Detects	Range of Positive Detections	Max. Detected Conc.	Arithmetic Mean (Half Non-Detects)	Standard Deviation
Antimony	0/20	20U - 20U	NA	0	10	0	0/4	24.6UJ - 24.6UJ	NA	NA	12.3	0.01
Arsenic	6/20	10UJ - 10UJ	3.4J - 18	18	6	3.50	2/4	1.8U - 1.8U	1.7J - 3.6	3.6	1.8	0.00
Barium	19/20	10U - 10U	1.5J - 900	900	148.8	252.60	4/4	NA	212 - 612	612	353	0.56
Beryllium	0/20	4U - 4U	NA	0	2	0	2/4	1.1U - 1.1U	2 - 2.3	2.3	1.4	0.00
Cadmium	2/20	5U - 5U	0.97J - 2.9J	3	2.4	0.40	1/4	2.9U - 2.9U	7.5 - 7.5	7.5	3	0.01
Chromium	4/20	10U - 10U	1.9J - 8.2J	8	4.8	1.20	3/3	NA	29.4 - 92	92	58.5	0.11
Cobalt	7/20	10U - 10U	2J - 18	18	6.2	4.40	4/4	NA	54.3 - 91.8	91.8	71.2	0.09
Copper	13/20	20U - 20U	0.95J - 53	53	9.4	11.20	4/4	NA	24 - 352	352	149.5	0.32
Lead	2/20	5UJ - 5UJ	1.7J - 6.7J	7	2.7	1.00	3/4	0.9UJ - 0.9UJ	2.5J - 7J	7	3.6	0.01
Mercury	2/20	0.2UJ - 0.4UJ	0.22J - 2.4J	2	0.2	0.50	0/4	0.1U - 0.1U	NA	NA	0.1	0.00
Nickel	3/20	40U - 40U	5.7J - 7.7J	8	18	4.80	4/4	NA	26.4 - 73.7	73.7	44.9	0.07
Selenium	3/20	10UJ - 10UJ	5.1J - 8.3J	8	5.2	0.80	1/4	1.4UJ - 2.8UJ	3.1J - 3.1J	3.1	1.5	0.00
Silver	1/20	10U - 10U	2J - 2J	2	4.9	0.70	0/4	4U - 4U	NA	NA	2	0.00
Thallium	4/20	10U - 10U	5.6J - 13	13	5.8	2.00	0/4	1U - 1.6UJ	NA	NA	0.7	0.00
Tin	0/20	50U - 50U	NA	0	25	0	0/4	13.5U - 13.5U	NA	NA	6.8	0.01
Vanadium	16/20	10U - 10U	2.6J - 140	140	25	35.70	4/4	NA	26.8 - 549	549	209.5	0.48
Zinc	6/20	20U - 20U	6.7J - 110	110	15.1	22.60	4/4	NA	95.7 - 320	320	180.4	0.30

Notes:

NA = Not Applicable
J = Estimated Value
U = Not Detected
UJ = Reported detection limit is qualified as estimated

TABLE 3-39
FREQUENCY AND RANGE OF SEDIMENT DATA (MEAN CONCENTRATIONS) COMPARED TO EQUILIBRIUM PARTITIONING-BASED SEDIMENT SCREENING VALUES
CALCULATED USING THE AVERAGE TOC CONCENTRATION FOR ENSENADA HONDA SEDIMENT SAMPLES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					EqP-Based Sediment Screening Screening Value (SSV)		Mean HQ[2]	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]					
Volatile Organics (ug/L)										
Acetone	4/13	36J - 120J	9.2U - 190U	54.5	54.5	5.9	USEPA 1993a	9.31	Yes	HQ > 1.0
Xylene	1/13	6.2J - 6.2J	6.6U - 13U	4.7	4.7	493.0	USEPA 1993a	<0.01	No	HQ<1.0
Semi-Volatile Organics (ug/kg):										
Bis(2-ethylhexyl)phthalate	3/13	180J - 250J	480U - 690U	275.0	250.0	54,383,711.3	USEPA 1993a	<0.01	No	HQ<1.0
PAHs (ug/kg):										
Acenaphthene	4/13	3.8J - 140J	6.7U - 58U	18.3	18.3	697.3	USEPA 1993a	0.03	No	HQ<1.0
Benzo(a)anthracene	12/13	6.6J - 1700	11U - 11U	206.0	206.0	121,195.8	USEPA 1993a	<0.01	No	HQ<1.0
Benzo(a)pyrene	12/13	6.2J - 2200	11U - 11U	295.6	295.6	102,187.2	USEPA 1993a	<0.01	No	HQ<1.0
Chrysene	12/13	10 - 2600	11U - 11U	321.0	321.0	40,398.6	USEPA 1993a	<0.01	No	HQ<1.0
Dibenzo(a,h)anthracene	10/13	2.7J - 530	9.7U - 11U	68.9	68.9	1,139,351.2	USEPA 1993a	<0.01	No	HQ<1.0
Fluoranthene	11/13	8.5J - 5800	9.7U - 11U	594.4	594.4	11,956.9	USEPA 1993a	0.05	No	HQ<1.0
Phenanthrene	9/13	13 - 2800	9.7U - 11U	261.1	261.1	2,483.1	USEPA 1993a	0.11	No	HQ<1.0
Pyrene	12/13	3.8J - 4700	11U - 11U	484.3	484.3	31,879.9	USEPA 1993a	0.02	No	HQ<1.0

Notes:

HQ = Hazard Quotient
COPC = Ecological Chemical of Potential Concern
EqP = Equilibrium Partitioning

J = Value is estimated
U = Not detected

(2) Mean concentration unless the mean exceeds the maximum concentration.

(3) The mean HQ value is the mean (half non-detects) divided by the screening value. If the mean concentration exceeds the maximum concentration, the maximum concentration is used. Values were calculated using the average total organic carbon concentration for Ensenada Honda sediments (10,069 mg/kg).

Table 3-39a
COMPARISON OF MAXIMUM AND MEAN PAH SEDIMENT CONCENTRATIONS TO EqP-BASED SEDIMENT BENCHMARKS DEVELOPED USING A TARGET LIPID MODEL
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

PAH Compound [1]	Maximum Concentration (ug/kg)	Mean Concentration (ug/kg)	EqP-Based Benchmark [2] (ug/kg)
Acenaphthene	140 J	18.3	8,312
Benzo(a)anthracene	1,700	206	14,222
Benzo(a)pyrene	2,200	296	16,324
Chrysene	2,600	321	14,268
Dibenz(a,h)anthracene	530	68.9	18,983
Fluoranthene	5,800	594	11,974
Phenanthrene	2,800	261	9,747
Pyrene	4,700	484	11,792

Notes:

(1) The PAH compounds listed are limited to those detected in one or more of the sediment samples collected froom the Ensenada Honda and retained as ecological COPCs in Step 2 of the ERA.

(2) The EqP-based benchmarks were derived by Di Toro and McGrath (2000) assuming one percent organic carbon.

TABLE 3-40
FREQUENCY AND RANGE OF SEDIMENT DATA (MEAN CONCENTRATIONS) COMPARED TO EQUILIBRIUM PARTITIONING-BASED SEDIMENT SCREENING VALUES CALCULATED USING THE MINIMUM TOC CONCENTRATION FOR ENSENADA HONDA SEDIMENT SAMPLES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					EqP-Based Sediment Screening Screening Value (SSV)		Mean HQ[2]	COPC?	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]					
Volatile Organics (ug/L)										
Acetone	4/13	36J - 120J	9.2U - 190U	54.5	54.5	1.2	USEPA 1993a	44.65	Yes	HQ > 1.0
Xylene	1/13	6.2J - 6.2J	6.6U - 13U	4.7	4.7	102.8	USEPA 1993a	0.05	No	HQ<1.0
Semi-Volatile Organics (ug/kg):										
Bis(2-ethylhexyl)phthalate	3/13	180J - 250J	480U - 690U	275.0	250.0	11,342,317.4	USEPA 1993a	<0.01	No	HQ<1.0
PAHs (ug/kg):										
Acenaphthene	4/13	3.8J - 140J	6.7U - 58U	18.3	18.3	145.4	USEPA 1993a	0.13	No	HQ<1.0
Benzo(a)anthracene	12/13	6.6J - 1700	11U - 11U	206.0	206.0	25,276.7	USEPA 1993a	<0.01	No	HQ<1.0
Benzo(a)pyrene	12/13	6.2J - 2200	11U - 11U	295.6	295.6	21,312.2	USEPA 1993a	0.01	No	HQ<1.0
Chrysene	12/13	10 - 2600	11U - 11U	321.0	321.0	8,425.6	USEPA 1993a	0.04	No	HQ<1.0
Dibenzo(a,h)anthracene	10/13	2.7J - 530	9.7U - 11U	68.9	68.9	237,624.1	USEPA 1993a	<0.01	No	HQ<1.0
Fluoranthene	11/13	8.5J - 5800	9.7U - 11U	594.4	594.4	2,493.7	USEPA 1993a	0.24	No	HQ<1.0
Phenanthrene	9/13	13 - 2800	9.7U - 11U	261.1	261.1	517.9	USEPA 1993a	0.50	No	HQ<1.0
Pyrene	12/13	3.8J - 4700	11U - 11U	484.3	484.3	6,648.9	USEPA 1993a	0.07	No	HQ<1.0

Notes:

HQ = Hazard Quotient
COPC = Ecological Chemical of Potential Concern
EqP = Equilibrium Partitioning

J = Value is estimated
U = Not detected

(2) Mean concentration unless the mean exceeds the maximum concentration.

(3) The mean HQ value is the mean (half non-detects) divided by the screening value. If the mean concentration exceeds the maximum concentration, the maximum concentration is used. Values were calculated using the minimum total organic carbon concentration for Ensenada Honda sediments (2,100 mg/kg).

TABLE 3-41
FREQUENCY AND RANGE OF SEDIMENT METALS DATA (MEAN CONCENTRATIONS, EXCLUDING 7SD9, 7SD10, AND 7SD11)
COMPARED TO SEDIMENT SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					Sediment Screening Value (SSV)		Mean HQ[2]	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]				
Metals (ug/kg):									
Antimony	1/10	0.89J	2.4U - 3.8UJ	0.89	0.89	2.0	Long and Morgan 1991	0.45	HQ < 1.0
Arsenic	10/10	2.9J - 46	NA	9.45	9.45	7.2	MacDonald 1994	1.30	HQ > 1.0
Barium	10/10	15 - 100	NA	34.60	34.60	48	Buchman 1999	0.72	HQ < 1.0
Beryllium	10/10	0.11J - 0.39J	NA	0.20	0.20	---	---	NA	Detected, No SSV
Cadmium	8/10	0.16J - 1.3	0.91U - 0.95U	0.48	0.48	0.7	MacDonald 1994	0.71	HQ < 1.0
Chromium	10/10	11 - 39	NA	22.40	22.40	52.3	MacDonald 1994	0.43	HQ < 1.0
Cobalt	10/10	3.6 - 31	NA	11.66	11.66	10	Buchman 1999	1.17	HQ > 1.0
Copper	10/10	10 - 130J	NA	51.80	51.80	18.7	MacDonald 1994	2.77	HQ > 1.0
Lead	10/10	1.3J - 55	NA	15.97	15.97	30.2	MacDonald 1994	0.53	HQ < 1.0
Mercury	9/10	0.0092J - 0.075	0.028U	0.03	0.03	0.1	MacDonald 1994	0.22	HQ < 1.0
Nickel	10/10	3.1J - 21	NA	8.63	8.63	15.9	MacDonald 1994	0.54	HQ < 1.0
Selenium	2/10	0.8J - 1.3J	1.4U - 1.9U	0.88	0.88	1.0	Buchman 1999	0.88	HQ < 1.0
Silver	0/10	NA	1.2U - 1.9U	0.80	0.80	0.7	MacDonald 1994	1.09	HQ > 1.0, Not Detected
Thallium	2/10	0.96J - 1.6J	1.4U - 1.9U	0.83	0.83	---	---	NA	Detected, No SSV
Tin	0/10	NA	6U - 9.5U	3.96	3.96	3.4	Buchman 1999	1.16	HQ > 1.0, Not Detected
Vanadium	10/10	43J - 200	NA	101.80	101.80	57	Buchman 1999	1.79	HQ > 1.0
Zinc	10/10	11 - 82	NA	49.80	49.80	124.0	MacDonald 1994	0.40	HQ < 1.0

Notes:

HQ = Hazard Quotient
COPC = Ecological Chemical of Potential Concern
NA = Not Applicable

J = Value is estimated
U = Not detected
UJ = Not detected, value is estimated

(1) Mean concentration unless the mean exceeds the maximum concentration.

(2) The mean HQ value is the mean (half non-detects) divided by the screening value. If the mean concentration exceeds the maximum concentration, the maximum concentration is used.

TABLE 3-42
FREQUENCY AND RANGE OF 7SD5 and 7SD6 METALS DATA (MEAN CONCENTRATIONS) COMPARED TO SEDIMENT SCREENING VALUES
DRAFT FINAL TASK 1 CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Chemical	Chemical Frequency/Range					Sediment Screening Value (SSV)		Mean HQ[2]	Comments
	No. of Positive Detects/No. of Samples	Range of Positive Detections	Range of Non-Detects	Arithmetic Mean (Half Non-Detects)	Value used in Screen[1]				
Metals (ug/kg):									
Antimony	0/2	NA	3.2UJ - 3.5UJ	3.35	3.35	2.0	Long and Morgan 1991	1.68	HQ > 1.0, Not Detected
Arsenic	2/2	4.9 J	NA	4.90	4.90	7.2	MacDonald 1994	0.68	HQ < 1.0
Barium	2/2	20 - 48	NA	34.00	34.00	48	Buchman 1999	0.71	HQ < 1.0
Beryllium	2/2	0.16J - 0.19J	NA	0.18	0.18	---	---	NA	Detected, No SSV
Cadmium	2/2	0.17J - 0.4J	NA	0.29	0.29	0.7	MacDonald 1994	0.42	HQ < 1.0
Chromium	2/2	22J - 24J	NA	23.00	23.00	52.3	MacDonald 1994	0.44	HQ < 1.0
Cobalt	2/2	15	NA	15.00	15.00	10	Buchman 1999	1.50	HQ > 1.0
Copper	2/2	76J - 130J	NA	103.00	103.00	18.7	MacDonald 1994	5.51	HQ > 1.0
Lead	2/2	11J - 17J	NA	14.00	14.00	30.2	MacDonald 1994	0.46	HQ < 1.0
Mercury	2/2	0.013J - 0.036	NA	0.02	0.02	0.1	MacDonald 1994	0.19	HQ < 1.0
Nickel	2/2	10	NA	10.00	10.00	15.9	MacDonald 1994	0.63	HQ < 1.0
Selenium	0/2	NA	1.6U - 1.7U	1.65	1.65	1.0	Buchman 1999	1.65	HQ > 1.0, Not Detected
Silver	0/2	NA	1.6U - 1.7U	1.65	1.65	0.7	MacDonald 1994	2.26	HQ > 1.0, Not Detected
Thallium	1/2	1.6J	1.7U	1.65	1.60	---	---	NA	Detected, No SSV
Tin	0/2	NA	8.1U - 8.7U	8.40	8.40	3.4	Buchman 1999	2.47	HQ > 1.0, Not Detected
Vanadium	2/2	97 - 130	NA	113.50	113.50	57	Buchman 1999	1.99	HQ > 1.0
Zinc	2/2	71 - 77	NA	74.00	74.00	124.0	MacDonald 1994	0.60	HQ < 1.0

Notes:

HQ = Hazard Quotient
COPC = Ecological Chemical of Potential Concern
NA = Not Applicable

J = Value is estimated
U = Not detected
UJ = Not detected, value is estimated

(1) Mean concentration unless the mean exceeds the maximum concentration.

(2) The mean HQ value is the mean (half non-detects) divided by the screening value. If the mean concentration exceeds the maximum concentration, the maximum concentration is used.

Revised: April 22, 2003

TABLE 4-1

TOTAL SITE INCREMENTAL LIFETIME CANCER RISKS (ILCRs) AND HAZARD INDICES (HIs) FROM RFI FOR CURRENT AND FUTURE POTENTIAL HUMAN RECEPTORS CORRECTIVE MEASURES STUDY - TASK I REPORT TOW WAY FUEL FARM NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Receptors	SWMU 7/8	
	Total ILCR	Total HI
Current On-Site Commercial/Maintenance Workers[1]	3.4×10^{-4}	0.08
Future Construction Workers [2]	7.6×10^{-5}	0.29
Future On-Site Residents [3]	1.4×10^{-3}	12

Notes:

[1] Current on-site workers were evaluated for exposures to surface soil COPCs at SWMU 7/8.

[2] Future construction workers were evaluated for exposures to subsurface soil COPCs at SWMU 7/8.

[3] Future on-site residents were evaluated for exposures to surface soil and groundwater COPCs at SWMU 7/8. Total HI and ICR values presented for residents are the sums of the resident adult and resident child HI and ILCR values, respectively

Shading indicates exceedence of USEPA acceptable target risk criteria by total risk value.

TABLE 4-2

INCREMENTAL LIFETIME CANCER RISKS (ILCRs) AND HAZARD INDICES (HIs) FROM RFI FOR CURRENT ON-SITE WORKERS
CORRECTIVE MEASURES STUDY - TASK 1 REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Medium/Pathway	Current On-Site Worker	
	ILCR	HI
Surface Soil		
Ingestion	1.7×10^{-5}	0.02
Dermal Contact	3.2×10^{-4}	0.06
Inhalation[1]	6.9×10^{-8}	<0.01
TOTAL	3.4×10^{-4}[2]	0.08

Notes:

[1] Inhalation of fugitive dusts from soil.

[2] Total ILCR exceeded USEPA=s target risk range due to dermal exposures to carcinogenic PAHs and beryllium (75% and 18% risk contributions, respectively) in surface soil. The slope factor for beryllium has since been removed from IRIS.

Shading indicates exceedence of USEPA acceptable target risk criteria by total risk value.

Revised: April 22, 2003

TABLE 4-3

INCREMENTAL CANCER RISKS (ILCRs) AND HAZARD INDICES (HIs) FROM RFI FOR FUTURE ADULT AND YOUNG CHILD RESIDENTS CORRECTIVE MEASURES STUDY - TASK I REPORT TOW WAY FUEL FARM NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

	Future Residents			
	Adult		Young Child	
Pathway	ICR	HI	ICR	HI
Surface Soil				
Ingestion	4.6×10^{-5}	0.05	1.1×10^{-4}	0.44
Dermal Contact	5.5×10^{-4}	0.11	2.4×10^{-4}	0.2
Inhalation (1)	1.9×10^{-7}	--	2.2×10^{-7}	--
Subtotal	6.0×10^{-4}	0.16	3.5×10^{-4}	0.64
Groundwater				
Ingestion	2.6×10^{-4}	2.9	1.5×10^{-4}	6.7
Dermal Contact	1.4×10^{-5}	0.5	6.5×10^{-6}	0.93
Inhalation (2)	4.6×10^{-7}	<0.01	NE	NE
Subtotal	2.7×10^{-4}	3.4	1.6×10^{-4}	7.6
TOTAL	8.7×10^{-4} (3)	3.6 (4)	5.1×10^{-4} (3)	8.2(4)

Notes:

(1) Inhalation of fugitive dust.

(2) Inhalation of volatilized organics while showering.

(3) Total ILCR exceeded USEPA=s target risk range because of ingestion exposures to benzo(a)pyrene (86% risk contribution) and dermal exposures to benzo(a)pyrene and beryllium (75% and 18% risk contribution, respectively) in surface soil, and to ingestion exposures to benzene and dissolved arsenic (88% and 11% risk contribution, respectively) in groundwater. The carcinogenic slope factor for beryllium has since been removed from IRIS.

(4) Total HI exceeded USEPA=s acceptable target value of 1.0 because of ingestion exposures to ethylbenzene in groundwater (54% risk contribution). The HI for this chemical was also greater than 1.0.

-- COPCs and/or toxicity criteria not available for evaluation.

NE - No evaluation performed since exposure pathway is not applicable to receptor.

Shading indicates exceedence of USEPA acceptable target risk criteria by total risk value.

TABLE 4-4

SURFACE SOIL DATA AND COPC SELECTION SUMMARY
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Contaminant	Region III Criteria [1]	Contaminant Frequency / Range / Location				Comparison to Criteria	COPC Selection	
	Residential RBC Value	Range of Detection Limits	No. of Positive Detects / No. of Samples	Range of Positive Detections	Location of Maximum Detection	Positive Detects Above Residential RBC Value	Selected as a COPC?	Rationale for Selection or Deletion
Volatiles (ug/kg)								
1,1,1-Trichloroethane	2,190,000 N	5 U - 760 U	1/28	3.2 J - 3.2 J	7SB24-00	0	No	BSL
2-Butanone	4,692,857 N	10 UJ - 1500 U	3/28	5.4 J - 140 J	8TP07-00	0	No	BSL
Acetone	782,143 N	10 U - 1500 U	6/26	8.8 J - 440	8TP07-00	0	No	BSL
Benzene	11,613 C	1.1 U - 760 U	1/57	13 J - 13 J	8TP07-00	0	No	BSL
Carbon disulfide	782,143 N	5 UJ - 760 UJ	2/28	7 J - 14 J	8TP07-00	0	No	BSL
Ethylbenzene	782,143 N	1.1 U - 760 U	2/57	99 J - 1300 J	7DP25-01	0	No	BSL
Methylene chloride	85,163 C	5 UJ - 760 U	2/28	2.2 J - 6.7	7SB30-00	0	No	BSL
Styrene	1,564,286 N	5 U - 760 U	1/28	4.5 J - 4.5 J	7SB30-00	0	No	BSL
Toluene	1,564,286 N	1.1 U - 760 U	8/57	1.2 J - 57	7SB30-00	0	No	BSL
Trichloroethene	1,597 C	5 U - 760 U	2/28	4.3 J - 10	7SB30-00	0	No	BSL
Xylene	15,642,857 N	1.1 U - 760 U	14/57	0.17 J - 820 J	7DP25-01	0	No	BSL
Semivolatiles (ug/kg)								
2-Methylnaphthalene	156,429 N	8.4 U - 470 U	5/28	2400 J - 50000 J	8TP07-01	0	No	BSL
7,12-Dimethyl benz(a)anthracene	NE	350 U - 78000 U	1/28	53000 J - 53000 J	8TP02-01	NA	No	NTX
Acenaphthene	469,286 N	8.4 U - 98000 U	1/28	6000 J - 6000 J	8TP03-00	0	No	BSL
Anthracene	2,346,429 N	8.4 U - 98000 U	1/28	1200 J - 1200 J	8TP07-01	0	No	BSL
Benzo(a)anthracene	875 C	340 U - 39000 U	7/28	3.2 J - 17000 J	8TP02-01	3	Yes	ASL
Benzo(a)pyrene	87.5 C	340 U - 4600 U	8/28	2.7 J - 23000 J	8TP02-01	5	Yes	ASL
Benzo(b)fluoranthene	875 C	340 U - 98000 U	8/28	2.5 J - 5900 J	8TP03-01	2	Yes	ASL
Benzo(g,h,i)perylene	NE	340 U - 98000 U	8/28	3.2 J - 4800 J	8TP03-01	NA	No	NTX
Benzo(k)fluoranthene	8,750 C	340 U - 98000 U	2/28	3.6 J - 100 J	7MW03-00	0	No	BSL
Bis(2-ethylhexyl)phthalate	45,623 C	340 U - 98000 U	7/28	68 J - 790	7SB23-00	0	No	BSL
Chrysene	87,497 C	340 U - 39000 U	9/28	3.3 J - 35000 J	8TP02-01	0	No	BSL
Fluoranthene	312,857 N	340 U - 98000 U	6/28	6.2 J - 4600 J	8TP03-01	0	No	BSL
Fluorene	312,857 N	8.4 U - 98000 U	1/28	4300 J - 4300 J	8TP07-01	0	No	BSL
Indeno(1,2,3-cd)pyrene	875 C	340 U - 98000 U	3/28	2.2 J - 5300 J	8TP03-01	1	Yes	ASL
Naphthalene	156,429 N	8.4 U - 98000 U	3/28	5400 J - 12000	8TP07-01	0	No	BSL
Phenanthrene	NE	340 U - 470 U	9/28	3.4 J - 31000 J	8TP02-01	NA	No	NTX
Pyrene	234,643 N	340 U - 470 U	9/28	4.3 J - 76000 J	8TP02-01	0	No	BSL

TABLE 4-4

SURFACE SOIL DATA AND COPC SELECTION SUMMARY
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Contaminant	Region III Criteria (1)	Contaminant Frequency / Range / Location				Comparison to Criteria	COPC Selection	
	Residential RBC Value	Range of Detection Limits	No. of Positive Detects / No. of Samples	Range of Positive Detections	Location of Maximum Detection	Positive Detects Above Residential RBC Value	Selected as a COPC?	Rationale for Selection or Deletion
Inorganics (mg/kg)								
Antimony	3.13 N	1.3 UJ - 2.6 U	6/19	0.59 J - 1.3 J	7SB23-00	0	No	BSL
Arsenic	0.426 C	0.52 U - 0.97 U	25/28	0.4 J - 3.7	8TP07-01	24	Yes	ASL
Barium	548 N	NA	28/28	11.5 - 342 J	7MW03-00	0	No	BSL
Beryllium	15.6 N	0.06 U - 0.06 U	18/19	0.12 J - 1.8	7MW03-00	0	No	BSL
Cadmium	3.91 N	0.22 U - 0.55 U	19/28	0.14 J - 0.8	7SB27-00	0	No	BSL
Chromium	23.5 N (2)	NA	28/28	4.4 J - 65	7SB25-00	10	Yes	ASL
Cobalt	156 N	NA	19/19	7.3 J - 38	7SB28-00	0	No	BSL
Copper	313 N	NA	19/19	23.1 - 120 J	7MW17-00	0	No	BSL
Lead	400 N (3)	NA	28/28	0.65 J - 55.7	8TP02-01	0	No	BSL
Mercury	2.35 N (4)	0.04 U - 0.06 U	13/28	0.0037 J - 0.12	8TP07-00	0	No	BSL
Nickel	156.4 N	NA	19/19	4.3 - 25.4	7MW03-00	0	No	BSL
Selenium	39.107 N	0.12 UJ - 1.3 U	11/28	0.26 J - 0.97 J	7SB29-00	0	No	BSL
Thallium	0.548 N	0.13 U - 1.1 U	11/19	0.79 J - 2.5 J	7SB29-00,7SB30-00	11	Yes	ASL
Tin	4,693 N	0.72 U - 6.5 U	3/19	1.4 - 1.6	7SB02-00,7SB03-00	0	No	BSL
Vanadium	54.8 N	NA	19/19	42.4 - 220	7MW17-00,7SB25-00	18	Yes	ASL
Zinc	2,346 N	NA	19/19	48 J - 96 J	7SB28-00	0	No	BSL

Notes:

NA - Not Applicable
NE - Not Established
RBC - Risk-Based Concentration
COPC - Chemical of Potential Concern
ug/kg - microgram per kilogram
mg/kg - milligram per kilogram
C = Carcinogenic
N = Non-Carcinogenic

J - Analyte present - Reported value is estimated

Shaded constituents were identified as COPCs for quantitative risk evaluation.

(1) USEPA Region III Risk Based Concentration Table, April, 2002 (USEPA, 2002)
(2) Screening value for chromium VI used.
(3) Action level for lead.
(4) Screening values for mercuric chloride used as a surrogate.

Rationale Codes:

(ASL) Above Screening Level
(BSL) Below Screening Level
(NTX) No Toxicity Information

TABLE 4-5

SUBSURFACE SOIL DATA AND COPC SELECTION SUMMARY
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Contaminant	Region III Criteria [1]		Contaminant Frequency / Range / Location				Comparison to Criteria	COPC Selection	
	Residential RBC Value		Range of Detection Limits	No. of Positive Detects / No. of Samples	Range of Positive Detections	Location of Maximum Detection	Positive Detects Above Residential RBC Value	Selected as a COPC?	Rationale for Selection or Deletion
Volatiles (ug/kg)									
1,1,1-Trichloroethane	2,190,000	N	5 U - 1500 U	1/39	3.2 J - 3.2 J	7SB24-00	0	No	BSL
2-Butanone	4,692,857	N	10 UJ - 3100 U	3/39	5.4 J - 140 J	8TP07-00	0	No	BSL
Acetone	782,143	N	10 U - 3100 U	9/37	8.8 J - 440	8TP07-00	0	No	BSL
Benzene	11,613	C	1.1 U - 1500 U	7/106	4.5 - 210	443BO02C	0	No	BSL
Carbon disulfide	782,143	N	5 UJ - 1500 UJ	2/39	7 J - 14 J	8TP07-00	0	No	BSL
Ethylbenzene	782,143	N	1.1 U - 760 U	21/106	3.8 - 12000	7DP07-04	0	No	BSL
Methylene chloride	85,163	C	5 UJ - 1500 U	2/39	2.2 J - 6.7	7SB30-00	0	No	BSL
Styrene	1,564,286	N	5 U - 1500 U	1/39	4.5 J - 4.5 J	7SB30-00	0	No	BSL
Toluene	1,564,286	N	1.1 U - 1500 U	24/106	0.68 J - 680	7DP15-02	0	No	BSL
Trichloroethene	1,597	C	5 U - 1500 U	2/39	4.3 J - 10	7SB30-00	0	No	BSL
Xylene	15,642,857	N	1.1 U - 760 U	42/106	0.17 J - 5800	8TP06-01	0	No	BSL
Semivolatiles (ug/kg)									
1-Methylnaphthalene	NE		7.3 U - 380 U	2/12	3.9 J - 6.1 J	7MW18-03	NA	No	NTX
2-Methylnaphthalene	156,429	N	7.3 U - 20000 UJ	15/49	6 J - 980000 J	8TP07-04	3	Yes	ASL
5-Nitro-o-toluidine	19,355	C	350 U - 400000 U	1/47	31 J - 31 J	7SB26-07	0	No	BSL
7,12-Dimethyl benz(a)anthracene	NE		350 U - 400000 U	2/47	140 J - 53000 J	8TP02-01	NA	No	NTX
Acenaphthene	469,286	N	7.3 U - 98000 U	3/50	750 J - 26000 J	8TP07-04	0	No	BSL
Anthracene	2,346,429	N	7.3 U - 98000 U	5/50	6.8 J - 20000 J	8TP07-04	0	No	BSL
Benzo(a)anthracene	875	C	7.3 U - 200000 U	9/50	2.1 J - 17000 J	8TP02-01	3	Yes	ASL
Benzo(a)pyrene	87.5	C	7.3 U - 200000 U	10/50	2.7 J - 23000 J	8TP02-01	6	Yes	ASL
Benzo(b)fluoranthene	875	C	7.3 U - 200000 U	10/50	2.5 J - 5900 J	8TP03-01	2	Yes	ASL
Benzo(g,h,i)perylene	NE		7.3 U - 200000 U	9/50	3.2 J - 4800 J	8TP03-01	NA	No	NTX
Benzo(k)fluoranthene	8,750	C	7.3 U - 200000 U	5/50	2 J - 220 J	7SB02-03	0	No	BSL
Bis(2-ethylhexyl)phthalate	45,623	C	340 U - 200000 U	11/47	52 J - 790	7SB23-00	0	No	BSL
Chrysene	87,497	C	7.3 U - 41000 U	12/50	3.3 J - 35000 J	8TP02-01	0	No	BSL
Dibenzofuran	31,286	N	340 U - 200000 U	2/47	250 J - 1400 J	8TP01-04	0	No	BSL
Fluoranthene	312,857	N	7.3 U - 200000 U	8/50	4.4 J - 4600 J	8TP03-01	0	No	BSL
Fluorene	312,857	N	7.3 U - 98000 U	7/50	2.9 J - 69000 J	8TP07-04	0	No	BSL
Indeno(1,2,3-cd)pyrene	875	C	7.3 U - 200000 U	4/50	2.1 J - 5300 J	8TP03-01	1	Yes	ASL
Naphthalene	156,429	N	7.3 U - 98000 U	11/50	66 J - 310000	8TP07-04	1	Yes	ASL
Phenanthrene	NE		7.3 U - 20000 U	18/50	2.1 J - 250000	8TP07-04	NA	No	NTX
Pyrene	234,643	N	7.3 U - 41000 U	13/50	3.9 J - 76000 J	8TP02-01	0	No	BSL
p-Dimethylaminoazobenzene	NE		350 U - 400000 U	1/47	61 J - 61 J	7SB26-07	NA	No	NTX

TABLE 4-5

SUBSURFACE SOIL DATA AND COPC SELECTION SUMMARY
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Contaminant	Region III Criteria (1)		Contaminant Frequency / Range / Location				Comparison to Criteria	COPC Selection	
	Residential RBC Value		Range of Detection Limits	No. of Positive Detects / No. of Samples	Range of Positive Detections	Location of Maximum Detection	Positive Detects Above Residential RBC Value	Selected as a COPC?	Rationale for Selection or Deletion
Inorganics (mg/kg)									
Antimony	3.13	N	1.3 UJ - 2.6 U	6/19	0.59 J - 1.3 J	7SB23-00	0	No	BSL
Arsenic	0.426	C	0.07 UJ - 0.97 U	35/39	0.16 J - 3.7	8TP07-01	30	Yes	ASL
Barium	548	N	NA	39/39	11.5 - 342 J	7MW03-00	0	No	BSL
Beryllium	15.6	N	0.06 U - 0.06 U	18/19	0.12 J - 1.8	7MW03-00	0	No	BSL
Cadmium	3.91	N	0.22 U - 0.55 U	21/39	0.14 J - 0.8	7SB27-00	0	No	BSL
Chromium	23.5	N (2)	NA	39/39	4.1 J - 120 J	8TP02-02	14	Yes	ASL
Cobalt	156	N	NA	19/19	7.3 J - 38	7SB28-00	0	No	BSL
Copper	313	N	NA	19/19	23.1 - 120 J	7MW17-00	0	No	BSL
Lead	400	N (3)	NA	39/39	0.65 J - 70	8TP07-04	0	No	BSL
Mercury	2.35	N (4)	0.04 U - 0.07 U	17/39	0.0037 J - 0.53	8TP07-04	0	No	BSL
Nickel	156	N	NA	19/19	4.3 - 25.4	7MW03-00	0	No	BSL
Selenium	39.1	N	0.1 UJ - 1.3 U	14/39	0.26 J - 1.7 J	8TP01-04	0	No	BSL
Thallium	0.548	N	0.13 U - 1.1 U	11/19	0.79 J - 2.5 J	7SB29-00,7SB30-00	11	Yes	ASL
Tin	4,693	N	0.72 U - 6.5 U	3/19	1.4 - 1.6	7SB02-00,7SB03-00	0	No	BSL
Vanadium	54.8	N	NA	19/19	42.4 - 220	7MW17-00,7SB25-00	18	Yes	ASL
Zinc	2,346	N	NA	19/19	48 J - 96 J	7SB28-00	0	No	BSL

Notes:

NA - Not Applicable
NE - Not Established

ug/kg - microgram per kilogram
mg/kg - milligram per kilogram

C = Carcinogenic
N = Non-Carcinogenic

J - Analyte present - Reported value is estimated

Shaded constituents were identified as COPCs for quantitative risk evaluation.

(1) USEPA Region III Risk Based Concentration Table, April, 2002 (USEPA, 2002)
(2) Screening value for chromium VI used.
(3) Action level for lead.
(4) Screening values for mercuric chloride used as a surrogate.

Rationale Codes:

(ASL) Above Screening Level
(BSL) Below Screening Level
(NTX) No Toxicity Information

TABLE 4-6

GROUNDWATER DATA AND COPC SELECTION SUMMARY
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Contaminant	Region III Criteria [1]		Contaminant Frequency / Range / Location				Comparison to Criteria	COPC Selection	
	Tap Water RBC Value		Range of Detection Limits	No. of Positive Detects / No. of Samples	Range of Positive Detections	Location of Maximum Detection	Positive Detects Above Residential RBC Value	Selected as a COPC?	Rationale for Selection or Deletion
Volatiles (ug/L)									
1,1,2-Trichloroethane	0.188	C	0.5 U - 500 U	1/116	0.5 - 0.5	7MW07	1	Yes	ASL
1,1-Dichloroethene	0.0436	C	0.5 U - 500 U	5/116	1.7 J - 5	7TCEAd	5	Yes	ASL
1,2,3-Trichlorobenzene	NE		0.5 U - 250 U	1/52	530 - 530	UGW13	NA	No	NTX
1,2,4-Trimethylbenzene	1.23	N	0.4 U - 50 U	15/52	5 J - 4600	470MW3	15	Yes	ASL
1,2-Dibromo-3-chloropropane	0.0474	C	0.5 U - 1000 U	1/99	5 J - 5 J	7MW08	1	No	FOD
1,3,5-Trimethylbenzene	1.23	N	0.5 U - 250 U	13/41	1 J - 1100	470MW1	12	Yes	ASL
2-Butanone	191	N	10 U - 2500 U	1/64	810 J - 810 J	470MW01	1	No	FOD
Acetone	60.8	N	10 UJ - 5000 U	1/50	16 J - 16 J	7MW16	0	No	BSL
Acetonitrile	12.4	N	100 UJ - 20000 U	1/47	1700 J - 1700 J	470MW01	1	No	FOD
Acrolein	0.0042	N	500 U - 25000 U	1/12	100 J - 100 J	7MW08	1	No	BKG
Acrylonitrile	0.0367	C	100 UJ - 10000 U	1/47	400 J - 400 J	470MW01	1	No	FOD
Benzene	0.319	C	0.5 U - 250 U	63/202	0.52 J - 26000	470MW1	63	Yes	ASL
Bromodichloromethane	0.170	C	0.5 U - 250 U	2/116	0.8 - 2.9 J	UGW09	2	Yes	ASL
Carbon tetrachloride	0.162	C	0.5 U - 500 U	1/116	0.6 J - 0.6 J	7MW18	1	No	FOD
Chloroform	0.063	C	0.5 U - 500 U	3/116	2 - 75	UGW09	3	Yes	ASL
Chloromethane	2.11	C	0.5 U - 1000 U	2/116	9 J - 13	7TCE1s	2	Yes	ASL
cis-1,2-Dichloroethene	6.08	N	0.5 U - 250 U	2/69	1.1 - 6	7MW07	0	No	BSL
Ethylbenzene	3.25	C	0.5 U - 250 U	79/202	1 - 23864.6	UGW13	67	Yes	ASL
Isobutanol	183	N	200 U - 2000 UJ	4/16	33 J - 2700 J	7MW07	3	Yes	ASL
Isopropylbenzene	65.8	N	0.5 U - 250 U	18/52	0.5 J - 130	470MW1	3	Yes	ASL
m/p-Xylene	1,217	N	0.5 U - 250 U	12/42	0.6 - 13000	470MW3	2	Yes	ASL
Methyl methacrylate	141.94	N	5 U - 1000 U	1/47	4.4 J - 4.4 J	7MW15	0	No	BSL
Methyl tert-butyl ether	2.64	C	10 U - 10 U	1/18	80 J - 80 J	UGW22	1	Yes	ASL
Methylene chloride	4.10	C	0.5 U - 500 U	4/116	1.6 J - 95 J	7MW07	3	Yes	ASL
Naphthalene	0.651	N	0.5 U - 250 U	16/52	7 J - 970	470MW1	16	Yes	ASL
n-Butylbenzene	24.3	N	0.5 U - 250 U	10/52	2 - 360 J	UGW13	5	Yes	ASL
n-Propylbenzene	24.3	N	0.5 U - 250 U	16/52	0.8 J - 360 J	UGW05	8	Yes	ASL
o-Xylene	1,217	N	0.5 U - 250 U	5/50	7 - 5900	470MW3	2	Yes	ASL
Pentachloroethane	NE		20 U - 2500 U	1/31	25 J - 25 J	7MW08	NA	No	NTX
p-Isopropyltoluene	NE		0.5 U - 250 U	10/52	0.6 J - 170 J	UGW13	NA	No	NTX

TABLE 4-6

GROUNDWATER DATA AND COPC SELECTION SUMMARY
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Contaminant	Region III Criteria [1]	Contaminant Frequency / Range / Location				Comparison to Criteria	COPC Selection	
	Tap Water RBC Value	Range of Detection Limits	No. of Positive Detects / No. of Samples	Range of Positive Detections	Location of Maximum Detection	Positive Detects Above Residential RBC Value	Selected as a COPC?	Rationale for Selection or Deletion
Volatiles (ug/L) (Cont)								
Propionitrile	NE	50 U - 10000 U	2/37	12 J - 720 J	470MW01	NA	No	NTX
sec-Butylbenzene	24.3 N	0.5 U - 250 U	16/52	1 J - 160 J	UGW13	8	Yes	ASL
Styrene	162 N	0.5 U - 250 U	2/116	1.2 - 2.1	UGW08	0	No	BSL
tert-Butylbenzene	24.3 N	0.5 U - 250 U	1/52	1 - 1	7MW02	0	No	BSL
Toluene	74.7 N	0.5 U - 500 U	48/202	0.5 - 7800	470MW1	9	Yes	ASL
Trichloroethene	0.0264 C	0.5 U - 500 U	17/116	0.35 J - 28000 J	7MW07	17	Yes	ASL
Trichlorofluoromethane	129 N	0.5 U - 500 U	1/99	11 - 11	7MW19	0	No	BSL
Xylene	1,217 N	1 U - 400 U	61/151	2.5 J - 40739.2	UGW13	7	Yes	ASL
Semivolatiles (ug/L)								
1-Methylnaphthalene	NE	10 U - 10 U	2/4	30 - 220	UGW22	NA	No	NTX
2,4-Dimethylphenol	73.0 N	10 U - 210 U	2/46	26 - 36	470MW03	0	No	BSL
2-Methylnaphthalene	12.2 N	10 U - 11 UJ	14/51	0.58 J - 790 J	UGW2	9	Yes	ASL
2-Methylphenol	183 N	10 U - 210 U	2/46	5.1 J - 13	470MW01	0	No	BSL
3&4-Methylphenol	18.3 N [2]	10 U - 210 U	3/46	7.4 J - 73	470MW01	1	Yes	ASL
Acenaphthene	36.5 N	10 U - 210 U	4/51	0.6 J - 1 J	UGW10	0	No	BSL
Acenaphthylene	NE	10 U - 210 U	1/51	1.2 J - 1.2 J	470MW03	NA	No	NTX
Acetophenone	0.0042 N	10 U - 210 U	2/47	4 J - 4.8 J	7MW12	2	No	FOD
Anthracene	183 N	10 U - 11 U	1/47	15 J - 15 J	UGW2	0	No	BSL
Benzo(g,h,i)perylene	NE	10 U - 120 U	2/51	1.4 J - 1.4 J	UGW08,UGW26	NA	No	NTX
Benzyl alcohol	1,095 N	10 U - 210 U	1/46	4.4 J - 4.4 J	7MW17	0	No	BSL
Bis(2-ethylhexyl)phthalate	4.78 C	6 UJ - 210 U	19/47	0.55 J - 15	GW04	3	Yes	ASL
Dibenzofuran	2.43 N	10 U - 210 U	3/47	0.54 J - 1.2 J	7MW16	0	No	BSL
Diethylphthalate	2,920 N	10 U - 210 U	4/47	0.66 J - 2 J	UGW10,UGW16	0	No	BSL
Dimethylphthalate	36,500 N	10 U - 210 U	6/47	0.5 J - 5 J	7GW04	0	No	BSL
Di-n-butylphthalate	365 N	10 U - 210 U	11/47	0.28 J - 1.6 J	7MW11	0	No	BSL
Fluoranthene	146 N	10 U - 210 U	1/51	0.39 J - 0.39 J	7MW15	0	No	BSL
Fluorene	24.3 N	10 U - 210 U	7/51	0.7 J - 5 J	UGW03	0	No	BSL

TABLE 4-6

GROUNDWATER DATA AND COPC SELECTION SUMMARY
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Contaminant	Region III Criteria [1]		Contaminant Frequency / Range / Location				Comparison to Criteria	COPC Selection	
	Tap Water RBC Value		Range of Detection Limits	No. of Positive Detects / No. of Samples	Range of Positive Detections	Location of Maximum Detection	Positive Detects Above Residential RBC Value	Selected as a COPC?	Rationale for Selection or Deletion
Semivolatiles (ug/L) (Cont)									
Indeno(1,2,3-cd)pyrene	0.0917	C	10 U - 210 U	1/51	0.58 J - 0.58 J	7MW12	1	No	FOD
Isophorone	70.5	C	10 U - 120 U	1/47	1 J - 1 J	UGW10	0	No	BSL
Naphthalene	0.651	N	0.5 U - 250 U	16/52	7 J - 970	470MW1	7	Yes	ASL
Phenanthrene	NE		10 U - 210 U	5/51	0.5 J - 140	UGW2	NA	No	NTX
Phenol	2,190.0	N	10 U - 210 U	3/46	2 J - 72	470MW01	0	No	BSL
Dissolved Inorganics (ug/L)									
Arsenic	0.0446	C	1.2 U - 10 U	11/47	3.8 J - 11 J	470MW01	11	Yes	ASL
Barium	256	N	1.4 U - 10 U	45/47	1.4 J - 1070	UGW20	8	Yes	ASL
Beryllium	7.30	N	4 U - 4 U	2/36	0.57 J - 0.62 J	470MW03	0	No	BSL
Cadmium	1.83	N	2.2 U - 5 U	7/47	0.77 J - 5.8	UGW2	5	Yes	ASL
Chromium	11.0	N [3]	2.4 U - 10 U	1/47	4.5 J - 4.5 J	7MW09	0	No	BSL
Cobalt	73.0	N	10 U - 10 U	16/36	1.5 J - 20	7MW14	0	No	BSL
Copper	146	N	20 U - 20 U	22/36	1.1 J - 11 J	7MW03	0	No	BSL
Lead	15.0	N [4]	0.8 U - 5 UJ	5/47	1.7 J - 22	470MW01	1	Yes	ASL
Mercury	1.10	N [5]	0.1 U - 4 U	5/47	0.11 J - 2.2 J	UGW16	2	Yes	ASL
Nickel	73.0	N	40 U - 40 U	8/36	5.3 J - 13 J	7MW03,7MW17	0	No	BSL
Selenium	18.3	N	1.4 UJ - 10 U	5/47	4.4 J - 5.3 J	UGW18	0	No	BSL
Silver	18.3	N	3.1 U - 10 U	1/47	2.9 J - 2.9 J	7MW19	0	No	BSL
Thallium	0.256	N	10 U - 10 U	2/36	5 J - 11 J	470MW01	2	Yes	ASL
Vanadium	25.6	N	2.2 UJ - 10 U	27/36	2.2 J - 620	7MW05	10	Yes	ASL
Zinc	1,095	N	20 U - 20 U	11/36	6.4 J - 22	7MW17	0	No	BSL
Total Inorganics (ug/L)									
Antimony	1.46	N	20 U - 20 U	1/36	7.5 J - 7.5 J	7MW19	1	No	FOD
Arsenic	0.0446	C	10 UJ - 10 UJ	11/47	3.2 J - 3709	UGW05	11	Yes	ASL
Barium	256	N	10 U - 10 U	45/47	1 - 900	UGW20R	7	Yes	ASL
Beryllium	7.30	N	4 U - 4 U	2/36	0.62 J - 0.7 J	470MW01	0	No	BSL
Cadmium	1.83	N	5 U - 5 U	7/47	0.97 J - 19	UGW05	4	Yes	ASL
Chromium	11.0	N [3]	5 U - 10 U	1/47	1.7 J - 49	7MW19	3	Yes	ASL
Cobalt	73.0	N	10 U - 10 U	16/36	1.8 J - 30	7MW03	0	No	BSL
Copper	146	N	20 U - 20 U	22/36	0.9 J - 83	7MW19	0	No	BSL

TABLE 4-6

GROUNDWATER DATA AND COPC SELECTION SUMMARY
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Contaminant	Region III Criteria [1]	Contaminant Frequency / Range / Location				Comparison to Criteria	COPC Selection	
	Tap Water RBC Value	Range of Detection Limits	No. of Positive Detects / No. of Samples	Range of Positive Detections	Location of Maximum Detection	Positive Detects Above Residential RBC Value	Selected as a COPC?	Rationale for Selection or Deletion
Total Inorganics (ug/L)								
Iron	1,095 N	NA	51/51	230 - 596000	AW1	50	Yes	ASL
Lead	15.0 N [4]	1.2 UJ - 25 U	5/47	0.06 - 167	UGW15	32	Yes	ASL
Mercury	1.10 N [5]	0.2 U - 5 U	5/47	0.08 J - 2.4 J	UGW16	1	Yes	ASL
Nickel	73.0 N	40 U - 40 U	8/36	5 J - 35 J	7MW19	0	No	BSL
Selenium	18.3 N	10 U - 10 U	5/47	4.3 J - 8.3 J	UGW15	0	No	BSL
Silver	18.3 N	10 U - 10 U	1/47	2 J - 8	UGW05	0	No	BSL
Thallium	0.256 N	10 UJ - 10 UJ	2/36	5.5 J - 13	UGW15	2	Yes	ASL
Vanadium	25.6 N	10 U - 10 U	27/36	2.6 J - 580	7MW05	14	Yes	ASL
Zinc	1,095.0 N	20 U - 20 U	11/36	6.7 J - 110	UGW20R	0	No	BSL

Notes:

NA - Not Applicable
NE - Not Established
RBC - Risk-Based Concentration
COPC - Chemical of Potential Concern
ug/kg - microgram per kilogram
mg/kg - milligram per kilogram
C = Carcinogenic
N = Non-Carcinogenic

J - Analyte present - Reported value is estimated

Shaded constituents were identified as COPCs for quantitative risk evaluation.

(1) USEPA Region III Risk Based Concentration Table, April, 2002 (USEPA, 2002)
(2) Screening value for p-Cresol used.
(3) Screening value for chromium VI used.
(4) Action level for lead.
(5) Screening values for mercuric chloride used as a surrogate.

Rationale Codes:

(ASL) Above Screening Level
(BKG) Anthropogenic background (CNO, 2000)
(BSL) Below Screening Level
(FOD) Frequency of detection <5%, not detected previously
(NTX) No Toxicity Information

TABLE 4-7

SUMMARY OF QUANTITATIVE CAO CALCULATIONS
EXPOSURE VIA INGESTION OF CHEMICALS IN SOIL
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

CAO Equations:

$$CAO = \frac{Risk \times BW \times AT_c}{SF \times IR \times CF \times FI \times EF \times ED} \quad \text{(carcinogens)}$$

$$CAO = \frac{HQ \times RfD \times BW \times AT_{nc}}{IR \times CF \times FI \times EF \times ED} \quad \text{(noncarcinogens)}$$

Supporting Equations:

$$Intake = \frac{CS \times IR \times CF \times FI \times EF \times ED}{BW \times AT}$$

$$Risk = Intake \times SF$$

$$HQ = Intake/RfD$$

where:

CAO = Corrective Action Objective (CS, µg/g)
Risk = Target risk level (unitless)
HQ = Target hazard quotient (unitless)
Intake = Average daily intake (mg/kg-day)
SF = Slope factor $(mg/kg\text{-}day)^{-1}$
RfD = Reference dose (mg/kg-day)
CS = Exposure point chemical concentration in soil (mg/kg)
IR = Ingestion rate (mg soil/day)
CF = Conversion factor (10^{-6} g/µg)
FI = Fraction ingested at site (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged, in days)

Industrial Workers

Variable	Value	Rationale/Source
Risk	10^{-6}	Conservative point of departure (NCP; USEPA, 1991a)
HQ	1	Standard default (USEPA, 1991a)
IR	50 mg/day	Standard default for commercial/industrial workers (USEPA, 1991b)
FI	1	Standard default for commercial/industrial workers (USEPA, 1991b)
EF	250 days/year	Standard default for commercial/industrial workers (USEPA, 1991b)
ED	25 years	95th percentile for employment at one location (USEPA, 1991b)
BW	70 kg	Adult average weight (USEPA, 1989a)
AT_c	25,550 days	70-year lifetime (70 years x 365 days/year; USEPA, 1991b)
AT_{nc}	9,125 days	ED x 365 days/year (USEPA, 1991b)

TABLE 4-7

SUMMARY OF QUANTITATIVE CAO CALCULATIONS
EXPOSURE VIA INGESTION OF CHEMICALS IN SOIL
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Construction Workers

Variable	Value	Rationale/Source
Risk	10^{-6}	Conservative point of departure (NCP; USEPA, 1991a)
HQ	1	Standard default (USEPA, 1991a)
IR	100 mg/day	EPA Region 2 recommendation (Maddaloni and Rogovin, 2000)
FI	1	Standard default for commercial/industrial workers (USEPA, 1989a)
EF	180 days/year	Professional judgement
ED	1 year	Professional judgement
BW	70 kg	Adult average weight (USEPA, 1989a)
AT_c	25,550 days	70- year lifetime (70 years x 365 days; USEPA, 1991b)
AT_{nc}	365 days	ED x 365 days/year (USEPA, 1989a)

Revised: January 3, 2003

TABLE 4-8

SUMMARY OF QUANTITATIVE SOIL CAO CALCULATIONS -- EXPOSURE VIA INHALATION OF CHEMICALS IN PARTICULATES CORRECTIVE MEASURES STUDY - TASK I REPORT TOW WAY FUEL FARM NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

CAO EQUATIONS:

$$CAO = \frac{Risk \times BW \times AT_c}{SF \times IR \times FI \times ET \times EF \times ED \times (1/PEF)} \quad \text{(carcinogens)}$$

$$CAO = \frac{HQ \times RfD \times BW \times AT_{nc}}{IR \times FI \times ET \times EF \times ED \times (1/PEF)} \quad \text{(noncarcinogens)}$$

Supporting Equations:

$$Intake = \frac{CS \times IR \times FI \times ET \times EF \times ED \times (1/PEF)}{BW \times AT}$$

Risk = Intake x SF

HQ = Intake/RfD

where:

CAO = Corrective Action Objective (CS, µg/g)
Risk = Target risk level (unitless)
HQ = Target hazard quotient (unitless)
Intake = Average daily intake (mg/kg-day)
SF = Slope factor $(mg/kg\text{-}day)^{-1}$
RfD = Reference dose (mg/kg-day)
CS = Exposure point chemical concentration in soil (µg/g)
IR = Inhalation rate (m^3/hour)
FI = Fraction inhaled from site (unitless)
ET = Exposure time (hours/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
PEF = Particulate emission factor (m^3/kg)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged, in days)

Industrial Worker

Variable	Value	Rationale/Source
Risk	10^{-6}	Conservative point of departure (NCP; USEPA, 1991a)
HQ	1	Standard default (USEPA, 1991a)
IR	1.3 m^3/hour	Recommended average value for adult outside workers (USEPA, 1997a)
FI	1	Standard default for commercial/industrial workers (USEPA, 1991b)
ET	8 hours/day	Standard default for commercial/industrial workers (USEPA, 1991b)
EF	250 days/year	Standard default for commercial/industrial workers (USEPA, 1991b)
ED	25 years	95th percentile for employment at one location (USEPA, 1991b)
PEF	1.08×10^9 m^3/kg	Calculated for typical site in Zone IX, Miami (USEPA, 2001b)
BW	70 kg	Adult average weight (USEPA, 1989a)
AT_c	25,550 days	70-year lifetime (70 years x 365 days/year; USEPA, 1991b)
AT_{nc}	9,125 days	ED x 365 days/year (USEPA, 1991b)

Revised: January 3, 2003

TABLE 4-8

SUMMARY OF QUANTITATIVE SOIL CAO CALCULATIONS -- EXPOSURE VIA INHALATION OF CHEMICALS IN PARTICULATES CORRECTIVE MEASURES STUDY - TASK I REPORT TOW WAY FUEL FARM NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Construction Workers

Variable	Value	Rationale/Source
Risk	10^{-6}	Conservative point of departure (NCP; USEPA, 1991a)
HQ	1	Standard default (USEPA, 1991a)
IR	1.3 m^3/hour	Recommended average value for adult outside workers (USEPA, 1997a)
FI	1	Standard default (USEPA, 1989a)
ET	8 hours/day	Standard default work day (USEPA, 1991b)
EF	180 days/year	Professional judgement
ED	1 year	Professional judgement
PEF	1.08×10^9 m^3/kg	Calculated for typical site in Zone IX, Miami (USEPA, 2001b)
BW	70 kg	Adult average weight (USEPA, 1989a)
AT_c	25,550 days	70-year lifetime (70 years x 365 days/year; USEPA, 1991b)
AT_{nc}	1,825 days	ED x 365 days/year (USEPA, 1991b)

Revised: January 3, 2003

TABLE 4-9

**SUMMARY OF QUANTITATIVE SOIL CAO CALCULATIONS --
EXPOSURE VIA INHALATION OF VOLATILES EMITTED FROM SOIL
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO**

CAO EQUATIONS:

$$CAO = \frac{Risk \times BW \times AT_c}{SF \times IR \times FI \times ET \times EF \times ED \times (1/VF)} \quad \text{(carcinogens)}$$

$$CAO = \frac{HQ \times RfD \times BW \times AT_{nc}}{IR \times FI \times ET \times EF \times ED \times (1/VF)} \quad \text{(noncarcinogens)}$$

Supporting Equations:

$$Intake = \frac{CS \times IR \times FI \times ET \times EF \times ED \times (1/VF)}{BW \times AT}$$

$$Risk = Intake \times SF$$

$$HQ = Intake/RfD$$

where:

CAO = Corrective Action Objective (CS, µg/g)
Risk = Target risk level (unitless)
HQ = Target hazard quotient (unitless)
Intake = Average daily intake (mg/kg-day)
SF = Slope factor $(mg/kg\text{-}day)^{-1}$
RfD = Reference dose (mg/kg-day)
CS = Exposure point chemical concentration in soil (µg/g)
IR = Inhalation rate (m^3/hour)
FI = Fraction inhaled from site (unitless)
ET = Exposure time (hours/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
VF = Volatilization factor (m^3/kg)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged, in days)

Industrial Worker

Variable	Value	Rationale/Source
Risk	10^{-6}	Conservative point of departure (NCP; USEPA, 1991a)
HQ	1	Standard default (USEPA, 1991a)
IR	1.3 m^3/hour	Recommended average value for adult outside workers (USEPA, 1997a)
FI	1	Standard default for commercial/industrial workers (USEPA, 1989a)
ET	8 hours/day	Standard default for commercial/industrial workers (USEPA, 1991b)
EF	250 days/year	Standard default for commercial/industrial workers (USEPA, 1991b)
ED	25 years	95th percentile for employment at one location (USEPA, 1991b)
VF	Chemical-specific	See Table 3-10 for summary of calculation.
BW	70 kg	Adult average weight (USEPA, 1989a)
AT_c	25,550 days	70-year lifetime (70 years x 365 days/year; USEPA, 1991b)
AT_{nc}	9,125 days	ED x 365 days/year (USEPA, 1991b)

TABLE 4-9

**SUMMARY OF QUANTITATIVE SOIL CAO CALCULATIONS --
EXPOSURE VIA INHALATION OF VOLATILES EMITTED FROM SOIL
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO**

Construction Workers

Variable	Value	Rationale/Source
Risk	10^{-6}	Conservative point of departure (NCP; USEPA, 1991a)
HQ	1	Standard default (USEPA, 1991a)
IR	1.3 m^3/hour	Recommended average value for adult outside workers (USEPA, 1997a)
FI	1	Standard default (USEPA, 1989a)
ET	8 hours/day	Standard default work day (USEPA, 1991b)
EF	180 days/year	Professional judgement
ED	1 year	Professional judgement
VF	Chemical-specific	See Table 3-10 for summary of calculation.
BW	70 kg	Adult average weight (USEPA, 1989a)
AT_c	25,550 days	70-year lifetime (70 years x 365 days/year; USEPA, 1991b)
AT_{nc}	1,825 days	ED x 365 days/year (USEPA, 1991b)

TABLE 4-10 Revised: January 3, 2003

SUMMARY OF SOIL-TO-AIR VOLATIZATION FACTOR (VF) CALCULATION
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Equations:

$$VF = \frac{Q/C \times (3.14 \times D_A \times T)^{1/2} \times CF}{2 \times \rho_b \times D_A} \qquad \text{Eq. 1}$$

$$D_A = \frac{[(\Theta_a^{3.33} \times D_i \times H' + \Theta_w^{3.33} \times D_w) / n^2]}{\rho_b \times K_d + \Theta_w + \Theta_a \times H'} \qquad \text{Eq. 2}$$

$$K_d = K_{oc} \times f_{oc} \qquad \text{Eq. 3}$$

$$C_{sat} = (S/\rho_b) \times [(K_d \times \rho_b) + \Theta_w + (H' \times \Theta_a)] \qquad \text{Eq. 4}$$

where:

Equation 1

VF = Volatilization factor (m^3/kg)
Q/C = Inverse of the mean concentration, at the center of a square 0.5-acre-square source (g/m^2-s per kg/m^3)
= 74.70 (Zone IX, Miami; USEPA, 2001c)
T = Exposure interval (s)
= 7.9E+08 industrial (25 years in s)
= 3.15E+07 construction (1 year in s)
CF = Conversion factor (1E-04 m^2/cm^2)
D_A = Apparent diffusivity (chemical-specific, cm^2/s)
ρ_b = Dry soil bulk density (g/cm^3)
= 1.5 (Default value, USEPA, 1996a)

Equation 2

Θ_a = air-filled soil porosity (L_{air} / L_{soil})
= 0.23 (Default for Johnson and Ettinger model; USEPA, 2000b)
Θ_w = Water-filled soil porosity (L_{water} / L_{soil})
= 0.20 (Default for Johnson and Ettinger model; USEPA, 2000b)
n = Total soil porosity (L_{pore} / L_{soil})
= 0.43 (Default value; USEPA, 1996a)
D_i = Diffusivity in air (chemical-specific, cm^2/sec)
D_w = Diffusivity in water (chemical-specific, cm^2/sec)
H' = Dimensionless Henry's Law Constant (chemical-specific)
K_d = Soil-water partition coefficient (chemical-specific, cm^3/g)

Equation 3

K_{oc} = Organic carbon partition coefficient (chemical-specific, cm^3/g)
f_{oc} = Organic carbon content of soil (g/g)
= 0.02 (Site-specific value)

Equation 4

C_{sat} = Soil saturation concentration (see text, chemical-specific, mg/kg)
S = Solubility in water (chemical-specific, mg/L-water)

TABLE 4-11

CHEMICAL-SPECIFIC VOLATIZATION FACTOR DATA
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

COPC Name	Solubility (1)		Di		Dw		H'		Koc	
	(mg/L)	Ref.	(cm^2/s)	Ref.	(cm^2/s)	Ref.	(atm-m^3/mol)	Ref.	(ml/g)	Ref.
SVOCs										
Benzo(a)pyrene	1.62E-03	1	4.30E-02	1	9.00E-06	1	4.63E-05	1	1.02E+06	1
Naphthalene	3.10E+01	1	5.90E-02	1	7.50E-06	1	1.98E-02	1	2.00E+03	1

Notes

1 - Solubility is used in computing Csat, the soil saturation constant, which is used to check the validity of the volatilization calculation (USEPA, 1996b).

TABLE 4-12

SUMMARY OF QUANTITATIVE CAO CALCULATIONS -- EXPOSURE VIA DERMAL ABSORPTION OF CHEMICALS IN SOIL CORRECTIVE MEASURES STUDY - TASK I REPORT TOW WAY FUEL FARM NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

CAO Equations:

$$CAO = \frac{Risk \times BW \times AT_c}{SF_d \times SA \times AF \times ABS \times CF \times FI \times EF \times ED} \quad \text{(carcinogens)}$$

$$CAO = \frac{HQ \times RfD_d \times BW \times AT_{nc}}{SA \times AF \times ABS \times CF \times FI \times EF \times ED} \quad \text{(noncarcinogens)}$$

Supporting Equations:

$$\text{Absorbed dose} = \frac{CS \times SA \times AF \times ABS \times CF \times FI \times EF \times ED}{BW \times AT}$$

$$Risk = \text{Absorbed dose} \times SF_d$$

$$HQ = \text{Absorbed dose}/RfD_d$$

where:

CAO = Corrective Action Objective (CS, µg/g)
Risk = Target risk level (unitless)
HQ = Target hazard quotient (unitless)
Absorbed dose = (mg/kg-day)
SF_d = Slope factor, modified for absorption $(mg/kg\text{-}day)^{-1}$
RfD_d = Reference dose, modified for absorption (mg/kg-day)
CS = Exposure point chemical concentration in soil (µg/g)
SA = Exposed skin surface area (cm²)
AF = Soil-to-skin adherence factor (mg/cm^2-event)
ABS = Adult skin absorption factor (unitless)
CF = Conversion factor (10^{-6} g/µg)
FI = Fraction contacted at site (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged, in days)

Industrial Workers

Variable	Value	Rationale/Source
Risk	10^{-6}	Conservative point of departure (NCP; USEPA, 1991a)
HQ	1	Standard default (USEPA, 1991a)
SA	3,300	Recommended average value for working adults (USEPA, 2001a; 1997a)
AF	0.2	Recommended average value for working adults (USEPA, 2001a; 1997a)
ABS	Chem. Spec.	USEPA recommendations (USEPA, 2001a), see Appendix H for values used
FI	1	Standard default for commercial/industrial workers (USEPA, 1989a)
EF	250 days/year	Standard default for commercial/industrial workers (USEPA, 1991b)
ED	25 years	95th percentile for employment at one location (USEPA, 1991b)
BW	70 kg	Adult average weight (USEPA, 1989a)
AT_c	25,550 days	70-year lifetime (70 years x 365 days/year; USEPA, 1991b)
AT_{nc}	9,125 days	ED x 365 days/year (USEPA, 1991b)

TABLE 4-12

**SUMMARY OF QUANTITATIVE CAO CALCULATIONS --
EXPOSURE VIA DERMAL ABSORPTION OF CHEMICALS IN SOIL
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO**

Construction Workers

Variable	Value	Rationale/Source
Risk	10^{-6}	Conservative point of departure (NCP; USEPA, 1991a)
HQ	1	Standard default (USEPA, 1991a)
SA	3,300 cm^2	Recommended average value for working adults (USEPA, 2001a; 1997a)
AF	0.2	Recommended average value for working adults (USEPA, 2001a; 1997a)
ABS	Chem. Spec.	USEPA recommendations (USEPA, 2001a), see Appendix H for values used
FI	1	Standard default for commercial/industrial workers (USEPA, 1989a)
EF	180 days/year	Professional judgement
ED	1 year	Professional judgement
BW	70 kg	Adult average weight (USEPA, 1989a)
AT_c	25,550 days	70-year lifetime (70 years x 365 days/year; USEPA, 1991b)
AT_{nc}	365 days	ED x 365 days/year (USEPA, 1991b)

TABLE 4-12

**SUMMARY OF QUANTITATIVE CAO CALCULATIONS --
EXPOSURE VIA DERMAL ABSORPTION OF CHEMICALS IN SOIL
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO**

Construction Workers

Variable	Value	Rationale/Source
Risk	10^{-6}	Conservative point of departure (NCP; USEPA, 1991a)
HQ	1	Standard default (USEPA, 1991a)
SA	3,300 cm^2	Recommended average value for working adults (USEPA, 2001a; 1997a)
AF	0.2	Recommended average value for working adults (USEPA, 2001a; 1997a)
ABS	Chem. Spec.	USEPA recommendations (USEPA, 2001a), see Appendix D for values used
FI	1	Standard default for commercial/industrial workers (USEPA, 1989a)
EF	180 days/year	Professional judgement
ED	1 year	Professional judgement
BW	70 kg	Adult average weight (USEPA, 1989a)
AT_c	25,550 days	70-year lifetime (70 years x 365 days/year; USEPA, 1991b)
AT_{nc}	365 days	ED x 365 days/year (USEPA, 1991b)

TABLE 4-13
SUMMARY OF QUANTITATIVE CAO CALCULATIONS --
EXPOSURE VIA INGESTION OF CHEMICALS IN GROUNDWATER
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

CAO Equations:

$$CAO = \frac{Risk \times BW \times AT_c}{SF \times IR \times CF \times FI \times EF \times ED} \quad \text{(carcinogens)}$$

$$CAO = \frac{HQ \times RfD \times BW \times AT_{nc}}{IR \times CF \times FI \times EF \times ED} \quad \text{(noncarcinogens)}$$

Supporting Equations:

$$Intake = \frac{CW \times IR \times CF \times FI \times EF \times ED}{BW \times AT}$$

$$Risk = Intake \times SF$$

$$HQ = Intake/RfD$$

where:

CAO = Corrective Action Objective (CW, µg/L)
Risk = Target risk level (unitless)
HQ = Target hazard quotient (unitless)
Intake = Average daily intake (mg/kg-day)
SF = Slope factor $(mg/kg\text{-}day)^{-1}$
RfD = Reference dose (mg/kg-day)
CW = Exposure point chemical concentration in water (µg/L)
IR = Ingestion rate (L water/day)
CF = Conversion factor (10^{-3} mg/µg)
FI = Fraction ingested at site (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged, in days)

Construction Workers

Variable	Value	Rationale/Source
Risk	10^{-6}	Conservative point of departure (NCP; USEPA, 1991a)
HQ	1	Standard default (USEPA, 1991a)
IR	0.05 L/day	Estimate of volume of one swallow of water (USEPA, 1989a)
FI	1	Standard default (USEPA, 1989a)
EF	18 days/year	Professional judgement, 10% of total EF of 180 days/yr assumed to be in physical contact with groundwater
ED	1 year	Professional judgement
BW	70 kg	Adult average weight (USEPA, 1989a)
AT_c	25,550 days	70-year lifetime (70 years x 365 days/year; USEPA, 1991b)
AT_{nc}	365 days	ED x 365 days/year (USEPA, 1991b)

TABLE 4-14

SUMMARY OF QUANTITATIVE CAO CALCULATIONS -- EXPOSURE VIA INHALATION OF VOLATILES IN GROUNDWATER CORRECTIVE MEASURES STUDY - TASK I REPORT TOW WAY FUEL FARM NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

CAO Equations:

$$CAO = \frac{Risk \times BW \times AT_c}{SF \times IR \times CF \times FI \times EF \times ED \times K \times EV \times ET} \quad \text{(carcinogens)}$$

$$CAO = \frac{HQ \times RfD \times BW \times AT_{nc}}{IR \times CF \times FI \times EF \times ED \times K \times EV \times ET} \quad \text{(noncarcinogens)}$$

Supporting Equations:

$$Intake = \frac{CW \times IR \times CF \times FI \times EF \times ED \times K \times EV \times ET}{BW \times AT}$$

$$Risk = Intake \times SF$$

$$HQ = Intake/RfD$$

where:

CAO = Corrective Action Objective (CW, µg/L)
Risk = Target risk level (unitless)
HQ = Target hazard quotient (unitless)
Intake = Average daily intake (mg/kg-day)
SF = Slope factor $(mg/kg\text{-}day)^{-1}$
RfD = Reference dose (mg/kg-day)
CW = Exposure point chemical concentration in water (µg/L)
IR = Inhalation rate (m^3/hour)
CF = Conversion factor (10^{-3} mg/µg)
FI = Fraction ingested at site (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
K = Volatilization factor (unitless)
EV = Event frequency (event/day)
ET = Exposure time (hour/event)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged, in days)

Construction Workers

Variable	Value	Rationale/Source
Risk	10^{-6}	Conservative point of departure (NCP; USEPA, 1991a)
HQ	1	Standard default (USEPA, 1991a)
IR	1.3m^3/hour	Recommended average value for adult outside workers (USEPA, 1997a)
FI	1	Standard default for commercial/industrial workers (USEPA, 1989a)
EF	18 days/year	Professional judgement, 10% of total EF of 180 days/yr assumed to be in physical contact with groundwater
ED	1 year	Professional judgement
K	0.0005 x 1000 L/m^3	Default constant (USEPA, 1991a)
EV	1 event/day	Professional judgement
ET	1 hour/day	Professional judgement
BW	70 kg	Adult average weight (USEPA, 1989a)
AT_c	25,550 days	70-year lifetime (70 years x 365 days/year; USEPA, 1991b)
AT_{nc}	365 days	ED x 365 days/year (USEPA, 1991b)

TABLE 4-15

SUMMARY OF QUANTITATIVE CAO CALCULATIONS -- DERMAL ABSORPTION OF CHEMICALS IN GROUNDWATER CORRECTIVE MEASURES STUDY - TASK I REPORT TOW WAY FUEL FARM NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

CAO Equations:

$$CAO = \frac{Risk \times BW \times AT_c}{SF_d \times DAF \times SA \times EV \times EF \times ED \times CF_m \times CF_v} \quad \text{(carcinogens)}$$

$$CAO = \frac{HQ \times RfD_d \times BW \times AT_{nc}}{DAF \times SA \times EV \times EF \times ED \times CF_m \times CF_v} \quad \text{(noncarcinogens)}$$

Supporting Equations:

$$\text{Absorbed dose} = \frac{CW \times DAF \times SA \times EV \times EF \times ED \times CF_m \times CF_v}{BW \times AT}$$

$$Risk = \text{Absorbed dose} \times SF_d$$

$$HQ = \text{Absorbed dose}/RfD_d$$

For inorganics:

$$DAF = K_p \times T$$

For organics: six-step procedure outlined in Tables 3-16 and 3-17 used to calculate DAF, where:

CAO = Corrective Action Objective (CW, µg/L)
Risk = Target risk level (unitless)
HQ = Target hazard quotient (unitless)
Absorbed dose = (mg/kg-day)
SF_d = Slope factor, modified for absorption $(mg/kg\text{-}day)^{-1}$
RfD_d = Reference dose, modified for absorption (mg/kg-day)
CW = Exposure-point chemical concentration in water (µg/L)
DAF = Dermal absorption factor (cm/event)
SA = Exposed skin surface area (cm^2)
EV = Event frequency (events/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
CF_m = Mass conversion factor (1E-03 mg/µg)
CF_v = Volumetric conversion factor (1E-03 L/cm^3)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged, in days)
K_p = Chemical-specific dermal permeability constant
T = Duration of event (hours/event)

Construction Workers

Variable	Value	Rationale/Source
SA	10,000 cm^2	Professional judgement, assuming one-half adult body SA in contact with water (USEPA, 1992)
EV	1 event/day	Professional judgement
EF	18 days/year	Professional judgement, 10% of total EF of 180 days/yr assumed to be in physical contact with groundwater
ED	1 year	Professional judgement
BW	70 kg	Adult average weight (USEPA, 1989a)
T	1 hour/event	Professional judgement
AT_c	25,550 days	70-year lifetime (70 years x 365 days/year)
AT_{nc}	365 days	ED x 365 days/year

TABLE 4-16

DETERMINATION OF DERMAL ABSORPTION FACTOR (DAF) FOR USE IN CALCULATING DERMAL ABSORPTION OF ORGANIC CHEMICALS FROM WATER
CMS - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

This six-step algorithm is derived from EPA's *Risk Assessment Guidance for Superfund, Part E*, (USEPA, 2001a).

STEP 1: Calculate the permeability coefficient for a chemical from water through the skin (K_p; cm/hr):

$K_p = 10^{(-2.80 + 0.66 \log Kow - 0.0056 MW)}$

where:

K_{ow} = Chemical-specific partition coefficient between water and octanol (dimensionless).
MW = Chemical-specific molecular weight (g/gmole)

STEP 2: Calculate B (dimensionless):

$B = K_p \times (MW)^{1/2} / 2.6$

STEP 3: Calculate the diffusivity of a chemical within the dermal stratum corneum (D_{sc}; cm²/hr).

$\log (D_{sc} / l_{sc}) = -2.80 - 0.0056 MW$

where:

l_{sc} = Thickness of the dermal stratum corneum (1E-03 cm)

STEP 4: Calculate the lag time (TAU; hours) using an assumed value of 1E-03 cm for l_{sc}

$TAU = l_{sc}^2 / (6 \times D_{sc})$

STEP 5: Calculate the time to reach steady state (T*; hours)

If B <= 0.6, then $T^* = 2.4 \times TAU$

If B > 0.6, then $T^* = 6 \times (b - (b^2 - c^2)^{1/2}) \times TAU$

where:

$b = 2/PI \times (1 + B)^2 - c$

and:

PI = 3.14159

$c = (1 + (3 \times B) + (3 \times B^2)) / 3 \times (1 + B)$

STEP 6: Calculate the dermal absorption factor (DAF; cm/event)
using the estimated duration of the event (T; hr/event):

If $T <= T^*$, then $DAF = 2 \times FA \times K_p \times [6 \times TAU \times T / PI]^{1/2}$

If $T > T^*$, then $DAF = FA \times K_p \times [(T/(1 + B)) + (2 \times TAU \times (1 + (3 \times B) + (3 \times B^2))/(1 + B)^2)]$

where: FA = Chemical-specific fraction absorbed (dimensionless).

TABLE 4-17

DERMAL ABSORPTION FACTOR PARAMETER VALUES FOR GROUNDWATER COPCs
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, PUERTO RICO

COPC	DAF (cm/event)	K_p (cm/hr)	K_{ow}		MW	B	Dsc (cm^2/hr)	TAU (hr)	T* (hr)	b	c	FA
Volatiles:												
1,1-Dichloroethene	2.07E-02	1.16E-02	1.35E+02	(1)	96.90	4.38E-02	4.54E-07	3.67E-01	8.80E-01	3.30E-01	3.63E-01	1.0
1,1,2-Trichloroethane	1.35E-02	6.40E-03	1.12E+02	(1)	133.40	2.84E-02	2.84E-07	5.87E-01	1.41E+00	3.21E-01	3.53E-01	1.0
1,2,4-Trimethylbenzene	2.05E-01	1.05E-01	6.03E+03	(2)	120.20	4.43E-01	3.36E-07	4.95E-01	1.19E+00	6.52E-01	6.74E-01	1.0
1,3,5-Trimethylbenzene	1.18E-01	6.08E-02	2.63E+03	(2)	120.19	2.57E-01	3.36E-07	4.95E-01	1.19E+00	4.83E-01	5.22E-01	1.0
Acrolein	9.47E-04	6.60E-04	7.94E-01	(1)	56.10	1.90E-03	7.69E-07	2.17E-01	5.20E-01	3.04E-01	3.35E-01	1.0
Benzene	2.39E-02	1.47E-02	1.35E+02	(1)	78.10	5.01E-02	5.79E-07	2.88E-01	6.91E-01	3.34E-01	3.68E-01	1.0
Bromodichloromethane	1.18E-02	4.59E-03	1.23E+02	(1)	163.80	2.26E-02	1.92E-07	8.69E-01	2.09E+00	3.17E-01	3.49E-01	1.0
n-Butylbenzene	3.99E-01	1.88E-01	1.91E+04	(3)	134.20	8.36E-01	2.81E-07	5.93E-01	2.28E+00	1.13E+00	1.02E+00	1.0
Chloroform	1.31E-02	6.78E-03	9.33E+01	(1)	119.40	2.85E-02	3.40E-07	4.90E-01	1.18E+00	3.21E-01	3.53E-01	1.0
Chloromethane	4.63E-03	3.30E-03	8.13E+00	(1)	50.50	9.01E-03	8.26E-07	2.02E-01	4.84E-01	3.09E-01	3.39E-01	1.0
Ethylbenzene	1.07E-01	4.84E-02	1.41E+03	(1)	106.20	1.92E-01	4.03E-07	4.13E-01	9.92E-01	4.33E-01	4.71E-01	1.0
Isobutanol	2.96E-03	1.91E-03	5.62E+00	(2)	74.00	6.31E-03	6.10E-07	2.73E-01	6.55E-01	3.07E-01	3.38E-01	1.0
Isopropylbenzene	1.34E-01	6.87E-02	3.16E+03	(2)	120.19	2.90E-01	3.36E-07	4.95E-01	1.19E+00	5.11E-01	5.48E-01	1.0
Methylene chloride	5.81E-03	3.54E-03	1.78E+01	(1)	84.90	1.26E-02	5.30E-07	3.14E-01	7.54E-01	3.11E-01	3.42E-01	1.0
Methyl tert-butyl ether	1.54E-02	9.13E-03	7.94E+01	(2)	88.15	3.30E-02	5.09E-07	3.28E-01	7.87E-01	3.24E-01	3.56E-01	1.0
n-Propylbenzene	1.63E-01	8.37E-02	4.27E+03	(3)	120.20	3.53E-01	3.36E-07	4.95E-01	1.19E+00	5.66E-01	5.99E-01	1.0
sec-Butylbenzene	4.00E-01	1.88E-01	1.91E+04	(3)	134.00	8.37E-01	2.82E-07	5.92E-01	2.28E+00	1.13E+00	1.02E+00	1.0
Toluene	5.28E-02	2.88E-02	5.37E+02	(1)	92.13	1.06E-01	4.83E-07	3.45E-01	8.28E-01	3.72E-01	4.08E-01	1.0
Trichloroethene	2.41E-02	1.15E-02	2.63E+02	(1)	131.40	5.08E-02	2.91E-07	5.72E-01	1.37E+00	3.35E-01	3.68E-01	1.0
Xylenes	1.17E-01	5.22E-02	1.58E+03	(1)	106.20	2.07E-01	4.03E-07	4.13E-01	9.92E-01	4.44E-01	4.83E-01	1.0
Semivolatiles:												
2-Methylnaphthalene	3.02E-01	1.35E-01	1.35E+04	(2)	142.20	6.18E-01	2.53E-07	6.58E-01	2.63E+00	8.43E-01	8.24E-01	1.0
3&4-Methylphenol (4)	1.31E-02	7.27E-03	8.32E+01	(1)	108.13	2.91E-02	3.93E-07	4.24E-01	1.02E+00	3.21E-01	3.53E-01	1.0
Bis(2-ethylhexyl) phthalate	2.15E-01	2.42E-02	1.29E+05	(1)	391.00	1.84E-01	1.02E-08	1.63E+01	3.91E+01	4.27E-01	4.65E-01	0.8
Naphthalene	9.36E-02	4.57E-02	2.00E+03	(1)	128.20	1.99E-01	3.03E-07	5.49E-01	1.32E+00	4.38E-01	4.77E-01	1.0

COPC	DAF (cm/event)	K_p (cm/hr)	FA (Unitless)
Inorganics (5)	1.00E-03	1.00E-03	1.0
Chromium (+6)	2.00E-03	2.00E-03	0.5

(1) - K_{ow} values are from USEPA (1992)

(2) - K_{ow} values are from RAIS (2002)

(3) - K_{ow} values are from "Properties of Some Organic Chemicals" website, http://blues.fd1.uc.edu/www/geology/org-cont/refer/propert.html

(4) - All values are for 4-Methylphenol

(5) - A default value of 0.001 cm/hr for K_p is assigned for all inorganics except those listed (USEPA, 2001a).

TABLE 4-18 Revised: April 22, 2003

TOXICOLOGICAL DATA SUMMARY
CORRECTIVE MEASURES STUDY - TASK 1 REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

	Carcinogenic			Noncarcinogenic					
	Oral	Inhalation	Inhalation	Oral	Oral	Inhalation	Inhalation	Inhalation	Inhalation
Analyte	**SF** $(mg/kg\text{-}d)^{-1}$	**SF** $(mg/kg\text{-}d)^{-1}$	**URF** $(mg/m^3)^{-1}$	**RFD (c)** mg/kg-d	**RFD (s)** mg/kg-d	**RFD (c)** mg/kg-d	**RFD (s)** mg/kg-d	**RFC (c)** mg/m^3	**RFC (s)** mg/m^3
Metals									
Arsenic	1.50E+00 I	1.51E+01 I	4.30E+00 I	3.00E-04 I	3.00E-04 I	--	--	--	--
Barium	--	--	--	7.00E-02 I	7.00E-02 H	1.40E-04 H	1.40E-03 E	5.00E-04 H	5.00E-03 H
Cadmium	--	6.30E+00 I	1.80E+00 I	5.00E-04 I	5.00E-04 I	5.70E-05 E	2.60E-04 E	2.00E-04 E	9.00E-04 E
Chromium (+3)	--	--	--	1.50E+00 I	1.00E+00 H	--	--	--	--
Chromium (+6)	--	4.10E+01 H	1.20E+01 I	3.00E-03 I	2.00E-02 H	2.86E-05 E	2.86E-05 E	1.00E-04 I	--
Thallium	--	--	--	8.00E-05 I	8.00E-04 H	--	--	--	--
Vanadium	--	--	--	7.00E-03 H	7.00E-03 H	--	--	--	--
Volatiles:									
1,1-Dichloroethene	6.00E-01 I	1.75E-01 I	5.00E-02 I	9.00E-03 I	9.00E-03 I	--	--	--	--
1,1,2-Trichloroethane	5.70E-02 I	5.60E-02 I	1.60E-02 I	4.00E-03 I	4.00E-02 H	--	--	--	--
1,2,4-Trimethylbenzene	--	--	--	5.00E-02 E	5.00E-02 E	1.70E-03 E	1.70E-03 E	6.00E-03 E	6.00E-03 E
1,3,5-Trimethylbenzene	--	--	--	5.00E-02 E	5.00E-02 E	1.70E-03 E	1.70E-03 E	6.00E-03 E	6.00E-03 E
Acrolein	--	--	--	2.00E-02 H	2.00E-02 H	5.71E-06 I	5.71E-06	2.00E-05 I	2.00E-05
Benzene	5.50E-02 I	2.90E-02 I	7.80E-03 I	3.00E-03 E	3.00E-03 E	1.70E-03 E	1.70E-03 E	5.95E-03 E	5.95E-03 E
Bromodichloromethane	6.20E-02 I	--	--	2.00E-02 I	2.00E-02 I	--	--	--	--
n-Butylbenzene	--	--	--	4.00E-02 E	4.00E-02 E	--	--	--	--
sec-Butylbenzene	--	--	--	4.00E-02 E	4.00E-02 E	--	--	--	--
Chloroform	6.10E-03 I	8.10E-02 I	2.30E-02 I	1.00E-02 I	1.00E-02 I	8.60E-05 E	8.60E-05 E	3.01E-04 E	3.01E-04 E
Chloromethane	1.30E-02 H	3.50E-03 E	1.80E-03 H	--	--	8.60E-02 E	8.60E-02 E	3.01E-01 E	3.01E-01 E
Ethylbenzene	--	--	3.85E-03 E	1.00E-01 I	1.00E-01 I	2.90E-01 I	2.90E-01 E	1.00E+00 I	1.00E+00 E
Isobutanol	--	--	--	3.00E-01 I	3.00E-01	--	--	--	--
Isopropylbenzene	--	--	--	1.00E-01 I	4.00E-01 H	1.10E-01 I	2.62E-02 H	4.00E-01 I	9.00E-02 H
Methylene chloride	7.50E-03 I	1.65E-03 I	4.74E-04 I	6.00E-02 I	6.00E-02 H	8.60E-01 H	8.60E-01 H	3.00E+00 H	3.00E+00 H
Methyl tert-butyl ether	--	--	--	--	--	8.57E-01 I	8.57E-01	--	--
n-Propylbenzene	--	--	--	4.00E-02 E	4.00E-02 E	--	--	--	--
Toluene	--	--	--	2.00E-01 I	2.00E+00 H	1.14E-01 I	2.60E-01 E	4.00E-01 I	9.23E-01 E
Trichloroethene	4.00E-01 E	4.00E-01 E	1.14E-01 E	3.00E-04 E	3.00E-04 E	1.00E-02 E	1.00E-02 E	3.50E-02 E	3.50E-02 E
Xylenes	--	--	--	2.00E+00 I	3.57E-01 E	--	--	--	--
Semivolatiles:									
Benzo(a)anthracene	7.30E-01 R	--	--	--	--	--	--	--	--
Benzo(a)pyrene	7.30E+00 I	3.10E+00 E	8.80E-01 E	--	--	--	--	--	--
Benzo(b)fluoranthene	7.30E-01 R	--	--	--	--	--	--	--	--
Bis(2-ethylhexyl) phthalate	1.40E-02 I	1.40E-02 E	4.00E-04 I	2.00E-02 I	2.00E-02	--	--	--	--
Indeno(1,2,3-cd)pyrene	7.30E-01 R	--	--	--	--	--	--	--	--
2-Methylnaphthalene	--	--	--	2.00E-02 E	2.00E-02 E	--	--	--	--
3&4-Methylphenol	--	--	--	5.00E-03 H	5.00E-03 H	--	--	--	--
Naphthalene	--	--	--	2.00E-02 I	2.00E-02 I	9.00E-04 I	9.00E-04 I	3.00E-03 I	3.00E-03 I

I = IRIS (USEPA, 2002)
H = HEAST (USEPA, 1997b)
E = EPA-NCEA provisional value

-- = Relevant toxicity data are unavailable
(c) = Chronic
(s) = Subchronic

R = Based on relative potency to Benzo(a)pyrene (USEPA, 1993)

TABLE 4-19 Revised: January 3, 2003

QUANTITATIVE SOIL CAOs FOR TWFF
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Surface Soil (mg/kg)		**Total Soil (mg/kg)**	
COPCs	**Industrial**	**COPCs**	**Construction**
Metals		*Metals*	
Arsenic	2.7E+00	Arsenic	5.5E+01
Chromium (+3)	(a)	Chromium (+3)	(a)
Chromium (+6)	7.3E+02	Chromium (+6)	2.8E+04
Thallium	1.6E+02	Thallium	1.1E+03
Vanadium	1.4E+04	Vanadium	9.9E+03
Semivolatiles		*Semivolatiles*	
Benzo(a)anthracene	2.9E+00	Benzo(a)anthracene	7.3E+01
Benzo(a)pyrene	2.9E+00	Benzo(a)pyrene	7.3E+00
Benzo(b)fluoranthene	2.9E+00	Benzo(b)fluoranthene	7.3E+01
Indeno(1,2,3-cd)pyrene	2.9E+00	Indeno(1,2,3-cd)pyrene	7.3E+01
		2-Methylnaphthalene	1.5E+04
		Naphthalene	3.4E+02

COPCs in **bold** are identified in subsurface soil but not in surface soil.
(a) - Calculated value is greater than one million parts per million.

TABLE 4-20 Revised: January 3, 2003

QUANTITATIVE GROUNDWATER CAOs FOR TWFF
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

	Groundwater (ug/L)	
COPCs	**Construction**	**Industrial**
Metals		
Arsenic	1.1E+03	N/A
Barium	5.2E+05	N/A
Cadmium	1.6E+03	N/A
Chromium (+3)	1.7E+06	N/A
Chromium (+6)	8.7E+03	N/A
Lead	15 (1)	N/A
Mercury	7.1E+03	N/A
Thallium	1.9E+04	N/A
Vanadium	2.3E+04	N/A
Volatiles		
1,1-Dichloroethene	3.7E+02	1.6E+01
1,1,2-Trichloroethane	2.1E+03	1.7E+03
1,2,4-Trimethylbenzene	3.3E+03	1.3E+04
1,3,5-Trimethylbenzene	3.5E+03	9.5E+03
Benzene	2.9E+03	5.5E+02
Bromodichloromethane	9.5E+03	1.1E+03
n-Butylbenzene	1.4E+04	--
sec-Butylbenzene	1.4E+04	--
Chloroform	1.9E+02	2.5E+02
Chloromethane	2.8E+04	4.1E+04
Ethylbenzene	4.0E+04	1.0E+03
Isobutanol	5.3E+06	--
Isopropylbenzene	5.0E+04	6.1E+04 (2)
Methylene chloride	5.3E+04	1.9E+04
Methyl tert-butyl ether	1.9E+06	3.6E+07
n-Propylbenzene	3.4E+04	--
Toluene	5.1E+05	5.3E+05 (2)
Trichloroethene	2.6E+02	2.2E+01
Xylenes	4.6E+05	--
Semivolatiles		
2-Methylnaphthalene	9.3E+03	--
3&4-Methylphenol	4.0E+04	--
Bis(2-ethylhexyl) phthalate	2.5E+03	3.4E+02 (2)
Naphthalene	1.8E+03	3.1E+04 (2)

(1) Value is interim CAO based on Maximum Contamination Limit (MCL); 40 CFR 161
(2) The calculated risk-based CAO exceeds the solubility, so the solubility is the CAO.
N/A - Not applicable because volatilization model only applies to organics.
-- Indicates that the relevant health effects criteria are unavailable.

TABLE 5-1 Revised: April 22, 2003

GROUNDWATER COCs AND CAOs
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Groundwater (ug/L)	
COCs	**CAOs**
Volatiles	
1,2,4-Trimethylbenzene	3.3E+03
Benzene	5.5E+02
Ethylbenzene	1.0E+03
Trichloroethene	2.2E+01

TABLE 5-2 Revised: January 3, 2003

SOIL COCs AND CAOs
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Surface Soil (mg/kg)		**Total Soil (mg/kg)**	
COC	**CAO**	**COC**	**CAO**
Metals		*Semivolatiles*	
Arsenic	2.7E+00	Benzo(a)pyrene	7.30E+00
Semivolatiles			
Benzo(a)anthracene	2.9E+00		
Benzo(a)pyrene	2.9E+00		
Benzo(b)fluoranthene	2.9E+00		
Indeno(1,2,3-cd)pyrene	2.9E+00		

TABLE 6-1

POTENTIALLY APPLICABLE CORRECTIVE MEASURE TECHNOLOGIES
SOIL MATRIX
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Technology	Tow Way Fuel Farm
No Action	X
Institutional Controls	X
Containment:	
Capping	X
Excavation and Disposal:	
Excavation	X
On-Site Disposal	X
Off-Site Disposal	X
Treatment Technologies:	
In-situ Biological Treatment	
Biodegradation	X
Bioventing	X
Oxygen Enhancement with Hydrogen Peroxide (CleanOx®)	X
In-situ Physical/Chemical Treatment	
Soil Vapor Extraction	X
Ex-situ Biological Treatment (assuming excavation)	
Composting	X
Controlled Solid Phase Biological Treatment	X
Land Farming	X
Slurry Phase Biological Treatment	X
Ex-situ Physical/Chemical Treatment (assuming excavation)	
Soil Washing	X
Ex-situ Thermal Treatment (assuming excavation)	
Incineration	X
Low Temperature Thermal Desorption	X
High Temperature Thermal Desorption	X
Vitrification	X
Natural Attenuation	X
Asphalt Incorporation	X
Electro Chemical Geo Oxidation (ECGO[7])	X

X – Retained for further evaluation

TABLE 6-2

CORRECTIVE MEASURES TREATMENT TECHNOLOGY DESCRIPTIONS
SOIL MATRIX
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Technology	Description
SOIL	
In Situ Biological Treatment	
Biodegradation	The activity of naturally occurring microbes is stimulated by circulating water-based solutions through contaminated soils to enhance in situ biological degradation of organic contaminants. Nutrients, oxygen, or other amendments may be used to enhance biodegradation and contaminant desorption from subsurface materials.
Bioventing	Oxygen is delivered to contaminated unsaturated soils by forced air movement (either extraction or injection of air) to increase oxygen concentrations and stimulate biodegradation.
Oxygen Enhancement with Hydrogen Peroxide (CleanOx®)	The CleanOX® technology is an in-situ process utilizing the injection of hydrogen peroxide liquid chemical formulations through monitoring wells into the contaminated portion of the aquifer to increase the available oxygen supply for degredation.
In Situ Physical/Chemical Treatment	
Soil Vapor Extraction	Vacuum is applied through extraction wells to create a pressure/concentration gradient that induces gas-phase volatiles to diffuse through soil to extraction wells. The process includes a system for handling off-gases. This technology also is known as in situ soil venting, in situ volatilization, enhanced volatilization, or soil vacuum extraction.
Ex Situ Biological Treatment (assuming excavation)	
Composting	Contaminated soil is excavated and mixed with bulking agents and organic amendments such as wood chips, animal and vegetative wastes, which are added to enhance the porosity and organic content of the mixture to be decomposed.
Controlled Solid Phase Biological Treatment	Excavated soils are mixed with soil amendments and placed in aboveground enclosures. Processes include prepared treatment beds, biotreatment cells, soil piles, and composting.
Land farming	Contaminated soils are applied onto the soil surface and periodically turned over or tilled into the soil to aerate the waste.
Slurry Phase Biological Treatment	An aqueous slurry is created by combining soil or sludge with water and other additives. The slurry is mixed to keep solids suspended and microorganisms in contact with the soil contaminants. Upon completion of the process, the slurry is dewatered and the treated soil is disposed of.

TABLE 6-2

CORRECTIVE MEASURES TREATMENT TECHNOLOGY DESCRIPTIONS
SOIL MATRIX
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Ex Situ Physical/Chemical Treatment (assuming excavation)	
Soil Washing	Contaminants sorbed onto fine soil particles are separated from bulk soil in an aqueous-based system on the basis of particle size. The wash water may be augmented with a basic leaching agent, surfactant, pH adjustment, or chelating agent to help remove organics and heavy metals.
Ex Situ Thermal Treatment (assuming excavation)	
Incineration	High temperatures, 817 - 1,204 EC (1,600 2,200 EF), are used to combust (in the presence of oxygen) organic constituents in hazardous wastes.
Low-Temperature Thermal Desorption	Wastes are heated to 93 - 315 EC (200 - 600 EF) to volatize water and organic contaminants. A carrier gas or vacuum system transports volatized water and organics to the gas treatment system.
High-Temperature Thermal Desorption	Wastes are heated to 320 to 560 °C (600 to 1,000 °F) to volatize water and organic contaminants. A carrier gas or vacuum system transports volatized water and organics to the gas treatment system.
Vitrification	Contaminated soils and sludges are melted at high temperatures to form a glass and crystalline structure with very low leaching characteristics.
Other Treatment	
Natural Attenuation	Natural subsurface processes - such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials - are allowed to reduce contaminant concentrations to acceptable levels.
Asphalt Incorporation	Contaminated soils and sludges are mixed into hot asphalt. The process stabilizes the contaminants within the asphalt mixture.
ECGO[7]	In Situ process that uses induced electric current to create oxidation-reduction (Redox) reactions leading to complete mineralization of organic constituents (or mobilization of inorganic constituents) present in a volume of soil and groundwater between the electrode locations.

TABLE 6-3

POTENTIALLY APPLICABLE CORRECTIVE MEASURE TECHNOLOGIES
GROUNDWATER MATRIX
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Technology	Tow Way Fuel Farm
No Action	X
Institutional Controls:	
Alternate Water	Already Available
Relocation	X
Containment/Collection:	
Capping	X
Barriers	X
Trenches	X
Extraction Wells	X
Subsurface Drains	X
In-situ Biological Treatment	
Nitrate Enhancement	X
Oxygen Enhancement with Air Sparging	X
Oxygen Enhancement with Hydrogen Peroxide (CleanOx[7])	X
In-situ Physical/Chemical Treatment	
Air Sparging	X
Dual Phase Extraction	X
Steam Stripping/Flushing	X
Vacuum Vapor Extraction	X
Pneumatic Fracturing	X
Ex-situ Biological Treatment (Assuming Pumping)	
Bioreactors	X
Ex-situ Physical/Chemical Treatment (Assuming Pumping)	
Air Stripping	X
Ultraviolet Oxidation	X
Discharge	
NPDES	X
Infiltration	X
Re-injection	X
Waste Water Treatment Plant (WWTP)	X
Monitored Natural Attenuation	X
Electro Chemical GeoOxidation (ECGO®)	X

X – Retained for further evaluation

TABLE 6-4

CORRECTIVE MEASURES TREATMENT TECHNOLOGY DESCRIPTIONS
GROUNDWATER MATRIX
CORRECTIVE MEASURES STUDY – TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Technology	Description
GROUNDWATER	
In Situ Biological Treatment	
aNitrate Enhancement	Nitrate is circulated throughout groundwater contamination zones as an alternative electron acceptor for biological oxidation of organic contaminants by microbes.
Oxygen Enhancement with Air Sparging	Air is injected under pressure below the water table to increase groundwater oxygen concentrations and enhance the rate of biological degradation of organic contaminants by naturally occurring microbes.
Oxygen Enhancement with Hydrogen Peroxide (CleanOx[7])	CleanOX is a patented technology to remediate hydrocarbon and other organic contamination in groundwater and saturated soil. The CleanOX technology is an in-situ process utilizing the injection of proprietary liquid chemical formulations through monitoring wells into the contaminated portion of an aquifer. The technology involves the application of a Fenton-like chemistry to create and migrate hydroxyl radicals, which in turn degrade organic contamination to carbon dioxide and water.
In Situ Physical/Chemical Treatment	
Air Sparging	Air is injected into saturated matrices to remove contaminants through volatilization.
Dual Phase Extraction	A high vacuum system is applied to simultaneously remove liquid and gas from low permeability or heterogeneous formations.
Hot Water or Steam Flushing/Stripping	Steam is forced into an aquifer through injection wells to vaporize volatile and semivolatile contaminants. Vaporized components rise to the unsaturated zone where they are removed by vacuum extraction and then treated.
Vacuum Vapor Extraction	Air is injected into a well, lifting contaminated groundwater in the well and allowing additional groundwater flow into the well. Once inside the well, some of the VOCs in the contaminated groundwater are transferred from the water to air bubbles, which rise and are collected at the top of the well by vapor extraction.
Pneumatic Fracturing	Pneumatic Fracturing can best be described as a process whereby a gas is injected into the subsurface at pressures exceeding the natural in-situ pressures present in the soil / rock interface (i.e. overburden pressure, cohesive stresses, etc.) and at flow volumes exceeding the natural permeability of the subsurface. The fractures create preferable pathways for groundwater to travel.

TABLE 6-4

CORRECTIVE MEASURES TREATMENT TECHNOLOGY DESCRIPTIONS
GROUNDWATER MATRIX
CORRECTIVE MEASURES STUDY – TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Ex Situ Biological Treatment (assuming pumping)	
Bioreactors	Contaminants in extracted groundwater are put into contact with microorganisms in attached or suspended growth biological reactors. In suspended systems, such as activated sludge, contaminated groundwater is circulated in an aeration basin. In attached systems, such as rotating biological contractors and trickling filters, microorganisms are established on an inert support matrix.
Ex Situ Physical/Chemical Treatment (assuming pumping)	
Air Stripping	The air stripping treatment process relies on the transfer of volatile organic compounds from water into air. Contaminated water enters the top of the air stripping tower and flows down through the packing material in a thin film. An air stream is forced upward through the tower. Within the tower, the contaminants are transferred from the thin film of contaminated water into the flowing air stream. Treated water exits from the bottom of the tower, while air containing the volatilized contaminants is exhausted through the top of the tower.
UV Oxidation	Ultraviolet (UV) radiation, ozone, and/or hydrogen peroxide are used to destroy organic contaminants as water flows into a treatment tank. An ozone destruction unit is used to treat off-gases from the treatment tank.
Other Treatment	
Monitored Natural Attenuation	Natural subsurface processes - such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials - are allowed to reduce contaminant concentrations to acceptable levels.
ECGO[7]	In Situ process that uses induced electric current to create oxidation-reduction (Redox) reactions leading to complete mineralization of organic constituents (or mobilization of inorganic constituents) present in a volume of soil and groundwater between the electrode locations.

TABLE 6-5

POTENTIALLY APPLICABLE CORRECTIVE MEASURE TECHNOLOGIES
PHASE SEPARATED HYDROCARBON
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Technology	Tow Way Fuel Farm
No Action	X
Institutional Controls	X
Containment/Collection:	
Barriers	X
Interceptor Trenches	X
Extraction Wells *	X
Dual Phase Extraction	X
Three Phase Extraction	X
Floating Skimmer/Filter Pumps	X
Surface Oil/Water Separators	X
CleanOx[7]	X
Pneumatic Fracturing	X
Electro Chemical Geo Oxidation (ECGO[7])	X

Note:

*Includes the various combinations of skimming, groundwater table depression and reinjection of water upgradient to enhance head differentials

X – Retained for further evaluation

TABLE 7-1 Revised: January 3, 2003

TREATMENT TECHNOLOGIES SCREENING MATRIX
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

	Development Status	Availability	Residuals Produced	Treatment Train (excludes off-gas treatment)	Contaminants Treated					System Reliability/ Maintainability	Cleanup Time	Overall Cost	O&M or Capital Intensive
					VOCs	SVOCs	Fuels	Inorganic	Explosives				
SOIL													
In Situ Biological Treatment													
Biodegradation	Full	■	None	No	■	■	■	△	■	△	△	○	O&M
Bioventing	Full	■	None	No	■	■	■	△	I	■	○	■	Neither
Oxygen Enhancement (CleanOx)	Full	■	None	No	○	○	△	△	○	○	■	○	O&M
In Situ Physical/Chemical Treatment													
Soil Vapor Extraction (in Situ)	Full	■	Liquid	Yes	■	△	■	△	△	■	○	■	O&M
Ex Situ Biological Treatment													
Composting	Full	■	None	No	○	○	■	△	■	■	○	■	Neither
Controlled Solid Phase Bio. Treatment	Full	■	S, L, V	Yes	■	■	■	△	■	○	○	○	Both
Land Farming	Full	■	None	No	■	○	■	△	○	■	△	■	Neither
Slurry Phase Bio. Treatment	Full	■	S, L, V	Yes	■	■	■	△	■	○	○	○	Both
Ex Situ Physical/Chemical Treatment (assuming excavation)													
Soil Washing	Full	■	Solid. Liquid	Yes	○	○	○	○	○	■	■	○	Both
Ex Situ Thermal Treatment (assuming excavation)													
Incineration	Full	■	L, S, V	No	■	■	■	△	■	■	■	△	Both
Low Temperature Thermal Desorption	Full	■	Liquid, Solid	No	■	■	■	△	■	○	■	○	Both
High Temperature Thermal Desorption	Full	■	Liquid, Solid	No	■	■	■	△	■	○	■	○	Both
Vitrification	Full	○	Liquid	No	○	○	○	■	△	○	○	△	Both
Other Treatment													
Natural Attenuation	NA	■	None	No	■	■	■	△	△	■	△	■	Neither
Asphalt Incorporation	NA	■	None	No	■	■	■	△	NA	■	△	■	Neither
ECGO	Full	○	Liquid	Yes	○	○	△	■	△	○	○	△	O&M
GROUNDWATER													
In Situ Biological Treatment													
Nitrate Enhancement	Full	■	None	No	■	■	■	△	○	○	○	■	O&M
Oxygen Enhancement with Air Sparging	Full	■	None	No	■	■	■	△	○	○	○	■	O&M
Oxygen Enhancement with H_2O_2	Full	■	None	No	■	■	■	△	○	○	○	■	O&M
In Situ Physical/Chemical Treatment													
Air Sparging	Full	■	Vapor	No	■	○	■	△	△	■	■	■	Neither
Dual Phase Extraction	Full	■	Liquid, Vapor	Yes	■	■	■	△	△	○	○	○	Both
Hot Water or Steam Flushing/Stripping	Full	■	Liquid, Vapor	Yes	○	■	■	△	△	○	■	○	Both
Vacuum Vapor Extraction	Pilot	△	Liquid, Vapor	No	■	○	■	I	△	■	○	○	CAP
Ex Situ Biological Treatment (assuming pumping)													
Bioreactors	Full	■	Solid	No	■	■	■	△	■	○	○	■	CAP
Ex Situ Physical/Chemical Treatment (assuming pumping)													
UV Oxidation	Full	■	Vapor	Yes	■	■	■	△	■	○	△	○	Both
Other Treatment													
Natural Attenuation	NA	■	None	No	■	■	■	△	△	■	△	■	Neither

Rating Codes

■	Better	I	Inadequate Information	S	Solid
○	Average	NA	Not Applicable	L	Liquid
△	Worse			V	Vapor

Source: Remediation Technologies Screening Matrix and Reference Guide, Version 4.0, www.frtr.gov/matrix 2/section 3/table 3_2.html

TABLE 7-2

APPLICABLE CORRECTIVE MEASURE TECHNOLOGIES
SOIL MATRIX
CORRECTIVE MEASURES STUDY – TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Technology	Applicable	Reason for Exclusion
No Action	X	
Institutional Controls	X	
Containment:		
Capping		Surface soils not significantly impacted
Excavation and Disposal:		
Excavation	X	
On-Site Disposal		Limited space available in on-site landfill
Off-Site Disposal	X	
Treatment Technologies:		
In-situ Biological Treatment		
Biodegradation	X	transfer limitations
Bioventing	X	
Oxygen Enhancement with H_2O_2 (CleanOx®)		Pilot test shoed limited effectiveness
In-situ Physical/Chemical Treatment		
Soil Vapor Extraction	X	
Ex-situ Biological Treatment (assuming excavation)		
Composting	X	
Controlled Solid Phase Bio Treatment		Complex implementation, produces residuals
Land Farming	X	
Slurry Phase Bio Treatment		Complex implementation, produces residuals
Ex-situ Physical/Chemical Treatment (assuming excavation)		
Soil Washing		Limited effectiveness with clayey soils

TABLE 7-2

APPLICABLE CORRECTIVE MEASURE TECHNOLOGIES
SOIL MATRIX
CORRECTIVE MEASURES STUDY – TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Technology	Applicable	Reason for Exclusion
Ex Situ Thermal Treatment (assuming excavation)		
Incineration		Complex implementation, off gass treatment required
Low Temperature Thermal Desorption		Limited effectiveness on PAHs
High Temperature Thermal Desorption	X	
Vitrification		Complex implementation, required equipment not located on island
Natural Attenuation	X	
Asphalt Incorporation		Additional treatment of soil required to remove large rocks
Electro Chemical Geo Oxidation (ECGO[7])	X	

TABLE 7-3

APPLICABLE CORRECTIVE MEASURE TECHNOLOGIES
GROUNDWATER MATRIX
CORRECTIVE MEASURES STUDY – TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Technology	Applicable	Reason for Exclusion
No Action	X	
Institutional Controls:		
Alternate Water	X	
Relocation		Unfeasible
Containment/Collection:		
Capping		Surface soils not significantly impacted
Barriers	X	
Trenches		Geology (near surface bedrock) not
Extraction Wells	X	
Subsurface Drains		Unacceptable to Regulators
In-situ Biological Treatment		
Nitrate Enhancement		Nitrate injection into groundwater is prohibited
Oxygen Enhancement with Air Sparging	X	
Oxygen Enhancement with H_2O_2 (CleanOx®)	X	
In-situ Physical/Chemical Treatment		
Air Sparging	X	
Dual Phase Extraction	X	
Hot Water or Steam Flushing/Stripping	X	
Vacuum Vapor Extraction	X	
Pneumatic Fracturing		Pilot test had mixed results
Ex-situ Biological Treatment (Assuming Pumping)		
Bioreactors	X	
Ex-situ Physical/Chemical Treatment (Assuming Pumping)		
Air Stripping	X	
Ultraviolet Oxidation		Aqueous stream should be from oil and grease
Discharge		
NPDES	X	
Infiltration		Infiltration rates are not favorable
Re-injection	X	
Waste Water Treatment Plant (WWTP) Chemical	X	
Monitored Natural Attenuation	X	
Electro Chemical GeoOxidation (ECGO®)	X	

TABLE 7-4

APPLICABLE CORRECTIVE MEASURE TECHNOLOGIES
PHASE SEPARATED HYDROCARBON
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Technology	Applicable	Reason for Exclusion
No Action	X	
Institutional Controls	X	
Containment/Collection:		
Barriers	X	
Interceptor Trenches		Geology (near surface bedrock) not conducive to trenching
Extraction Wells *	X	
Dual Phase Extraction	X	
Three Phase Extraction	X	
Floating Skimmer/Filter Pumps	X	
Surface Oil/Water Separators	X	
CleanOx[7]	X	
Pneumatic Fracturing		Pilot test had mixed results

Note:

*Includes the various combinations of skimming, groundwater table depression, and reinjection of water upgradient to enhance head differentials

TABLE 7-4

APPLICABLE CORRECTIVE MEASURE TECHNOLOGIES
PHASE SEPARATED HYDROCARBON
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

Technology	Applicable	Reason for Exclusion
No Action	X	
Institutional Controls	X	
Containment/Collection:		
Barriers	X	
Interceptor Trenches		Geology (near surface bedrock) not conducive to trenching
Extraction Wells *	X	
Dual Phase Extraction	X	
Three Phase Extraction	X	
Floating Skimmer/Filter Pumps	X	
Surface Oil/Water Separators	X	
CleanOx[7]	X	
Pneumatic Fracturing		Pilot test had mixed results
Electro Chemical Geo Oxidation (ECGO[7])	X	

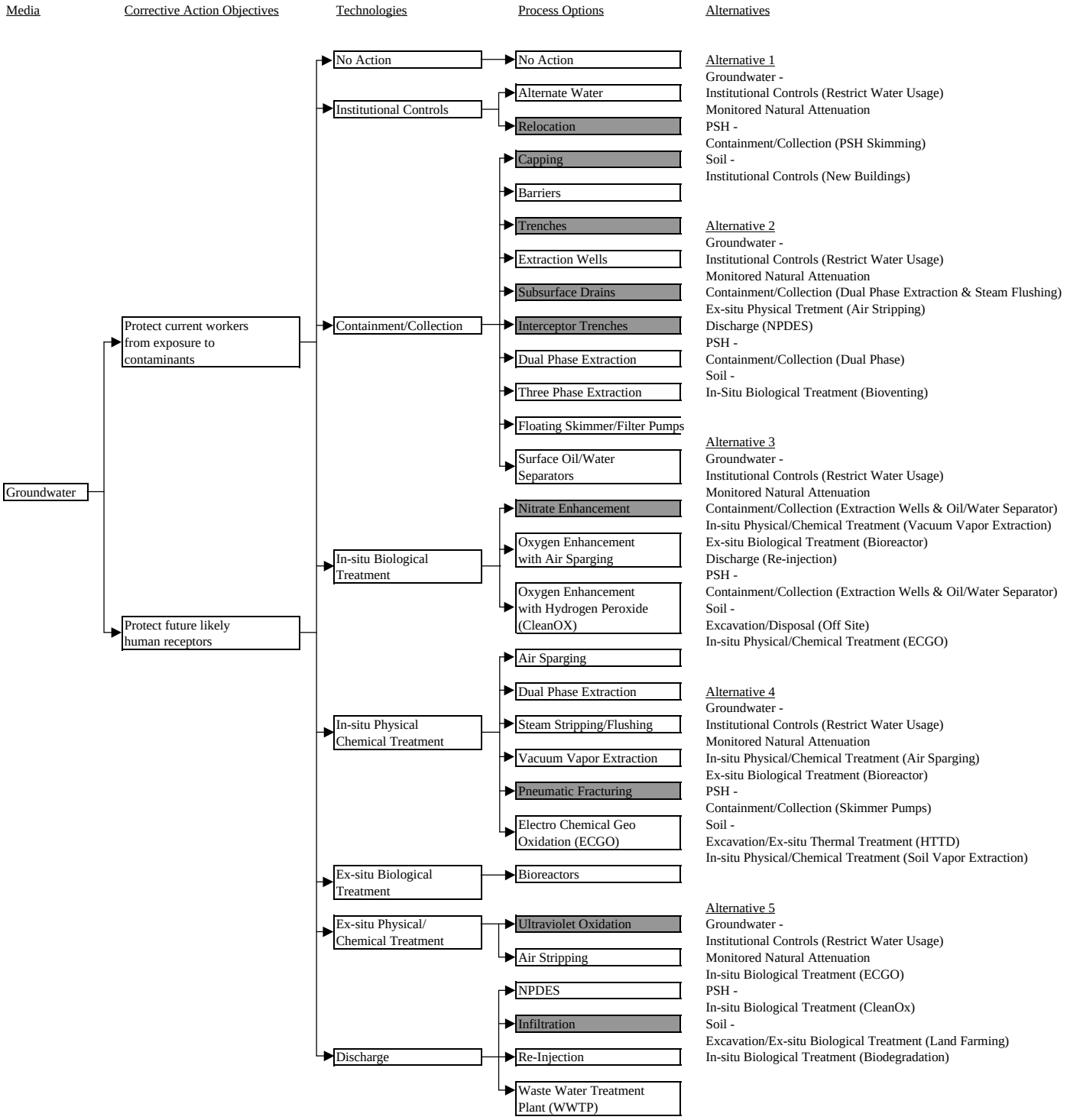
Note:

*Includes the various combinations of skimming, groundwater table depression, and reinjection of water upgradient to enhance head differentials

TABLE 8-1

Revised: January 3, 2003

ALTERNATIVE DEVELOPMENT PROCESS
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

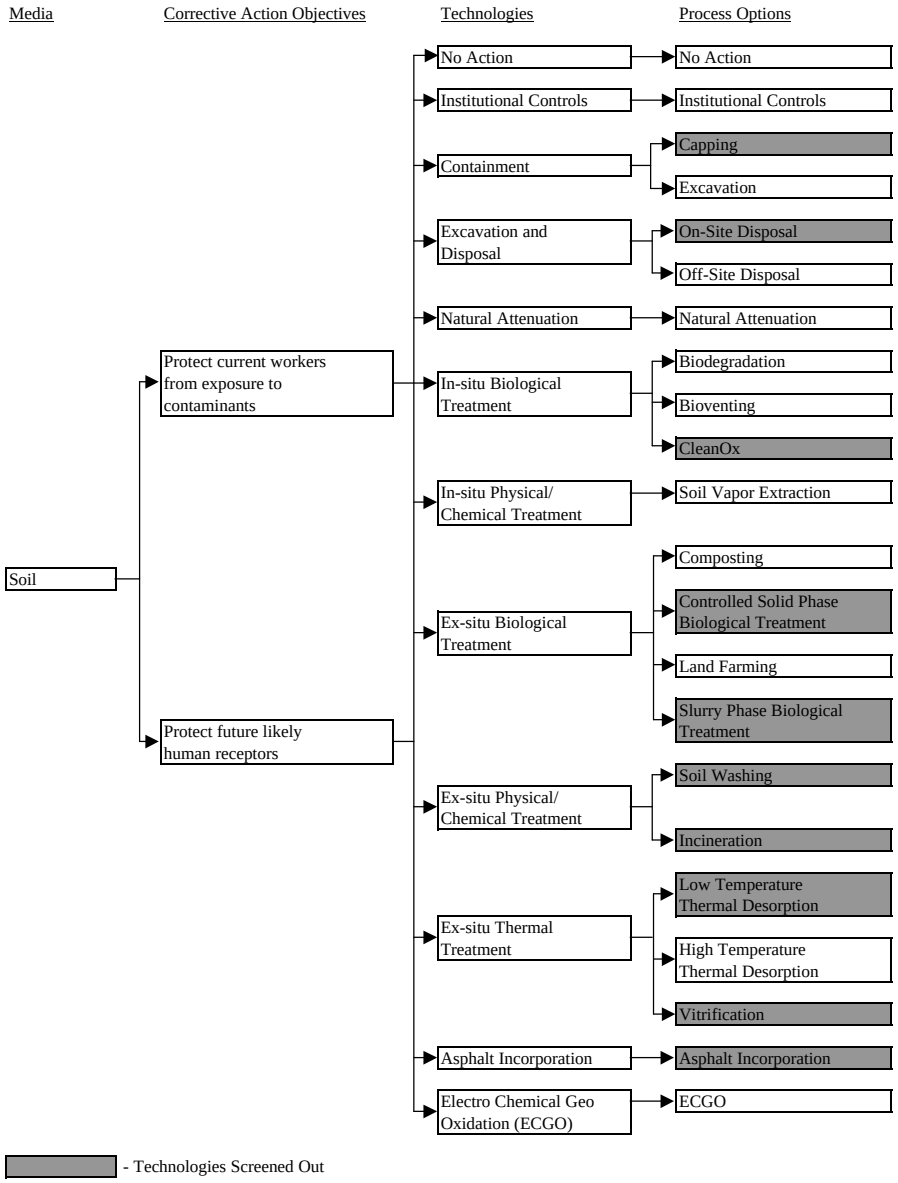


- Technologies Screened Out

TABLE 8-1

Revised: January 3, 2003

ALTERNATIVE DEVELOPMENT PROCESS
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO



Alternatives

Alternative 1
Groundwater -
Institutional Controls (Restrict Water Usage)
Monitored Natural Attenuation
PSH -
Containment/Collection (PSH Skimming)
Soil -
Institutional Controls (New Buildings)

Alternative 2
Groundwater -
Institutional Controls (Restrict Water Usage)
Monitored Natural Attenuation
Containment/Collection (Dual Phase Extraction & Steam Flushing)
Ex-situ Physical Tretment (Air Stripping)
Discharge (NPDES)
PSH -
Containment/Collection (Dual Phase)
Soil -
In-Situ Biological Treatment (Bioventing)

Alternative 3
Groundwater -
Institutional Controls (Restrict Water Usage)
Monitored Natural Attenuation
Containment/Collection (Extraction Wells & Oil/Water Separator)
In-situ Physical/Chemical Treatment (Vacuum Vapor Extraction)
Ex-situ Biological Treatment (Bioreactor)
Discharge (Re-injection)
PSH -
Containment/Collection (Extraction Wells & Oil/Water Separator)
Soil -
Excavation/Disposal (Off Site)
In-situ Physical/Chemical Treatment (ECGO)

Alternative 4
Groundwater -
Institutional Controls (Restrict Water Usage)
Monitored Natural Attenuation
In-situ Physical/Chemical Treatment (Air Sparging)
Ex-situ Biological Treatment (Bioreactor)
PSH -
Containment/Collection (Skimmer Pumps)
Soil -
Excavation/Ex-situ Thermal Treatment (HTTD)
In-situ Physical/Chemical Treatment (Soil Vapor Extraction)

Alternative 5
Groundwater -
Institutional Controls (Restrict Water Usage)
Monitored Natural Attenuation
In-situ Biological Treatment (ECGO)
PSH -
In-situ Biological Treatment (CleanOx)
Soil -
Excavation/Ex-situ Biological Treatment (Land Farming)
In-situ Biological Treatment (Biodegradation)

FIGURES

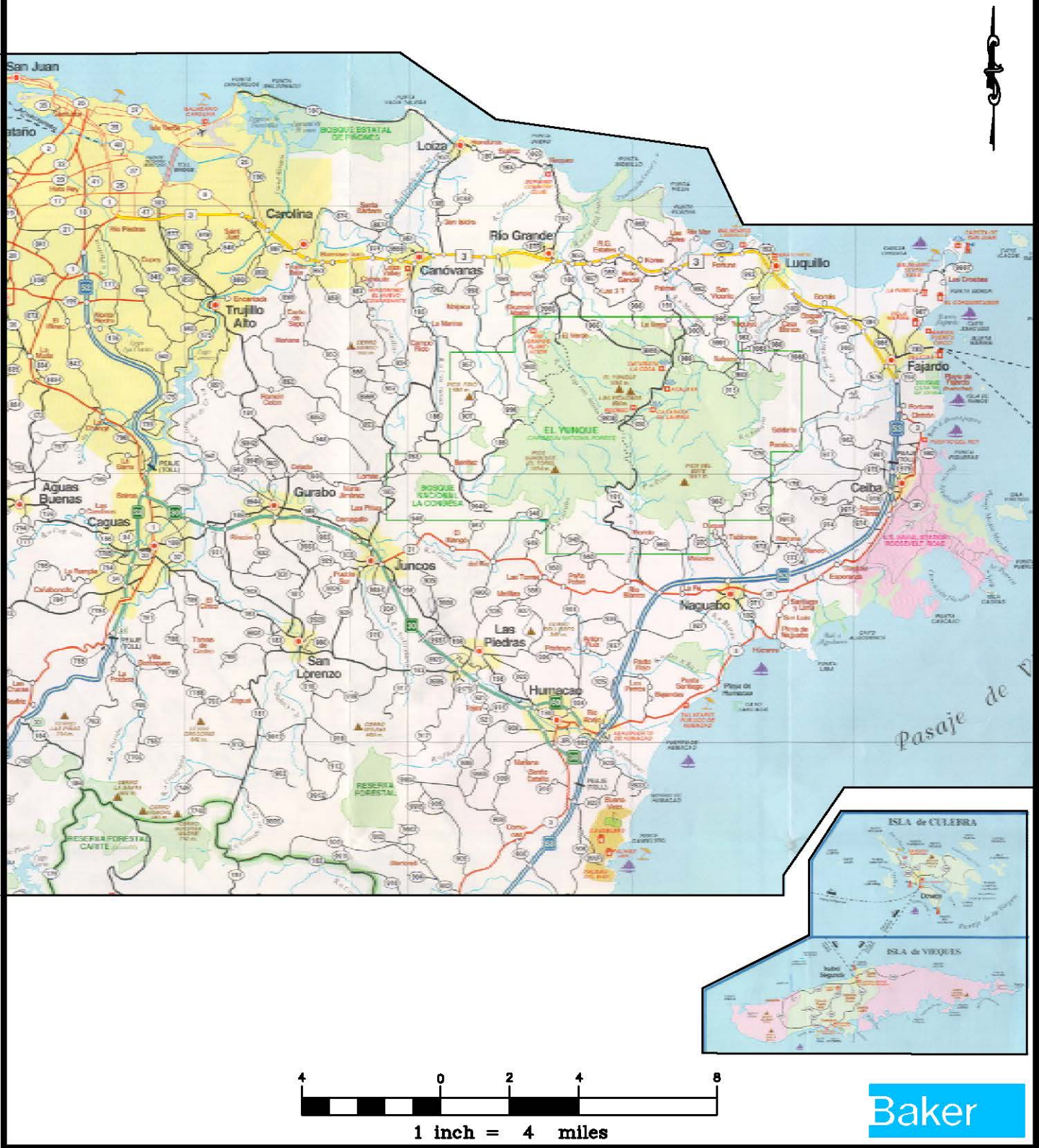
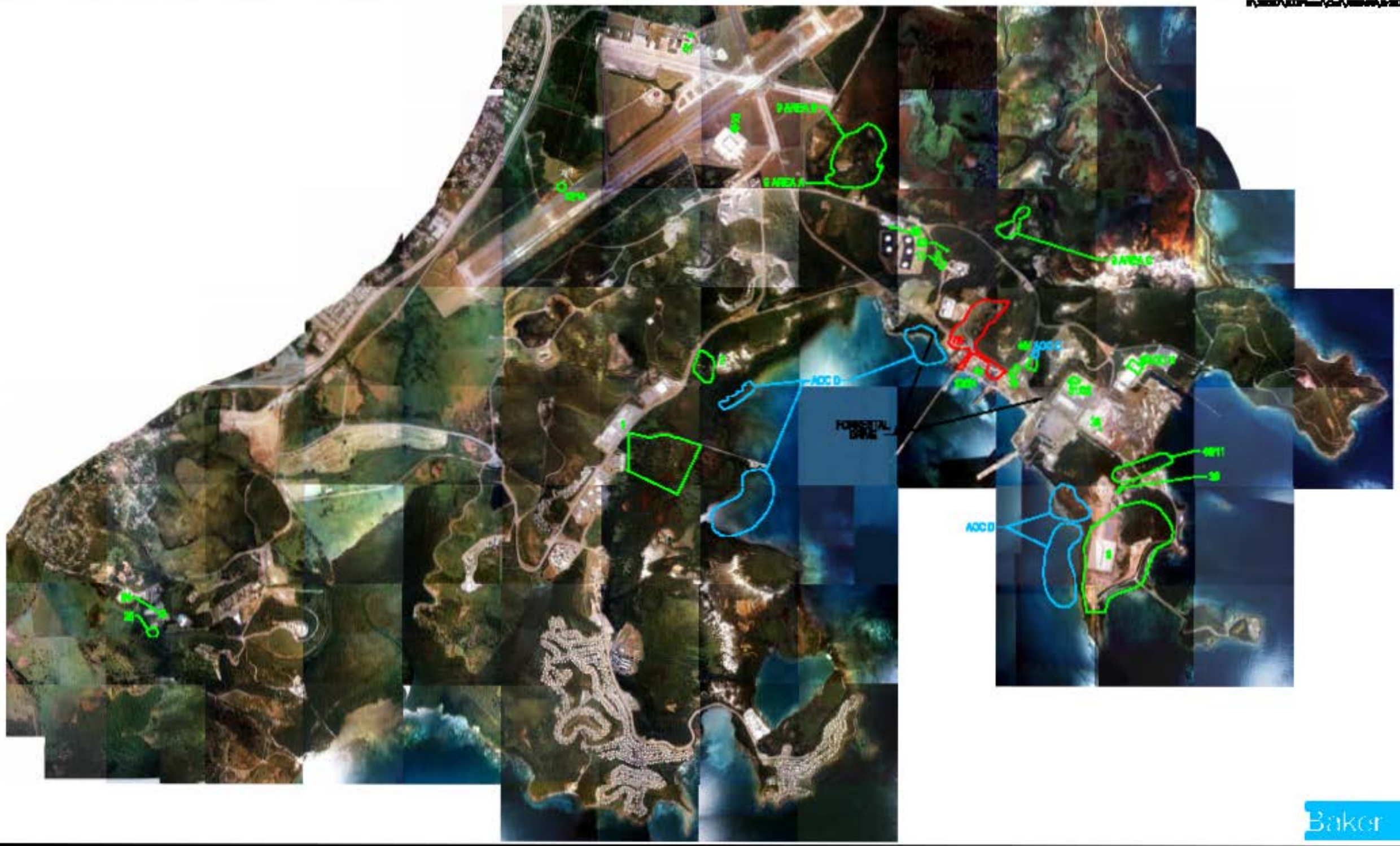


FIGURE 2-1
REGIONAL LOCATION MAP

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

SOURCE: METRODATA, INC., 1999.



LEGEND

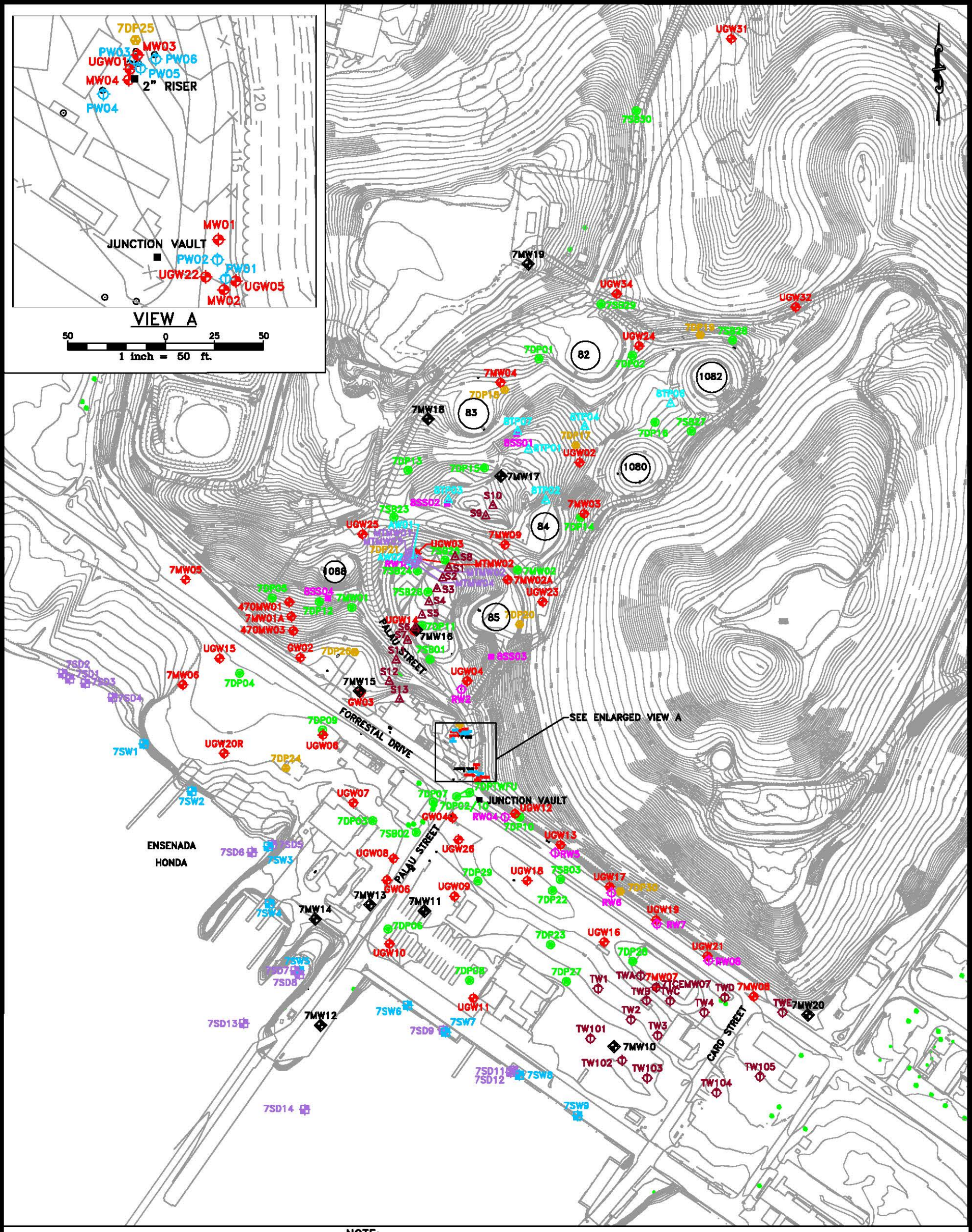
- SWMUs
- AOCs
- AREA OF WHICH THIS INVESTIGATION PERTAINS TO

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

1 Inch = 2500 ft.

FIGURE 2-2
TWFF LOCATION MAP

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



250 0 125 250
1 inch = 250 ft.

NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

K\26007\033Phase\Cad\RRoads\ Rr2033006

SOURCE: LANTDIV, FEB. 1992/1997

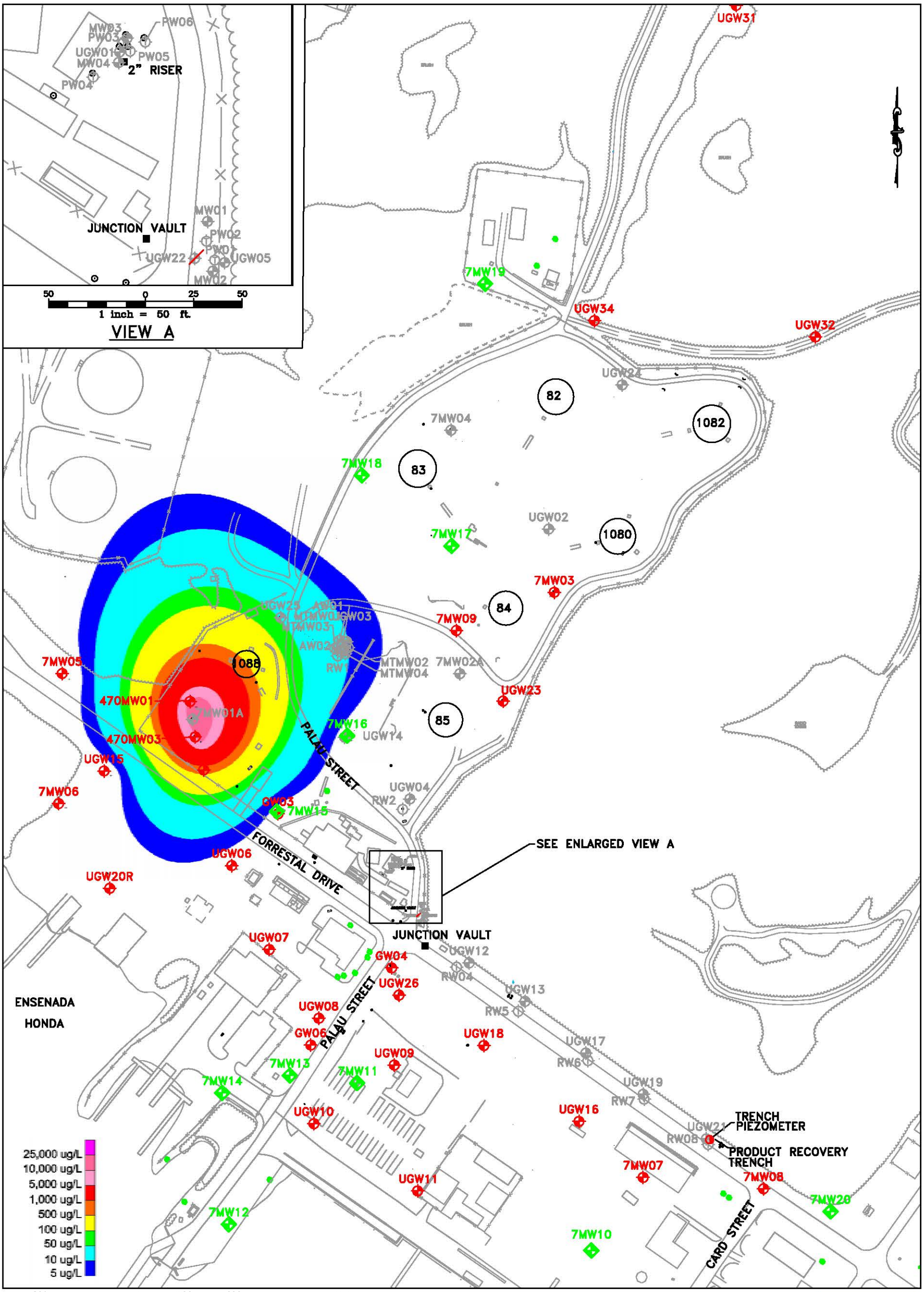
Baker

LEGEND

- NEW MONITOR WELL LOCATION (ADDITIONAL DATA COLLECTION INVESTIGATION, 2002)
- MONITOR WELL LOCATION
- SOIL BORING LOCATION
- SOIL BORING AND SOIL GAS SAMPLE LOCATION (CMSI, 1998)
- SURFACE SOIL LOCATION
- TEST PIT LOCATION (RFI, 1996)
- DFM FUEL LINE REPAIR (APRIL 1997)
- SEDIMENT SAMPLE LOCATION (ADDITIONAL DATA COLLECTION INVESTIGATION, 2002)
- SURFACE WATER SAMPLE LOCATION (ADDITIONAL DATA COLLECTION INVESTIGATION, 2002)
- TEMPORARY MONITOR WELL LOCATION (TCE INVESTIGATION, 1999)
- TERRAVAC PRODUCT RECOVERY WELL LOCATION
- ICHOR PRODUCT RECOVERY WELL LOCATION
- MANTECH MONITOR WELL
- MANTECH CLEANOx APPLICATION WELL

FIGURE 2-3
SITE PLAN
TOW WAY FUEL FARM

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



1 inch = 200 ft.

K:\28007\034PHASE\0000SUB\GRAPHICS\CAD\TWFF\2034828T

NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

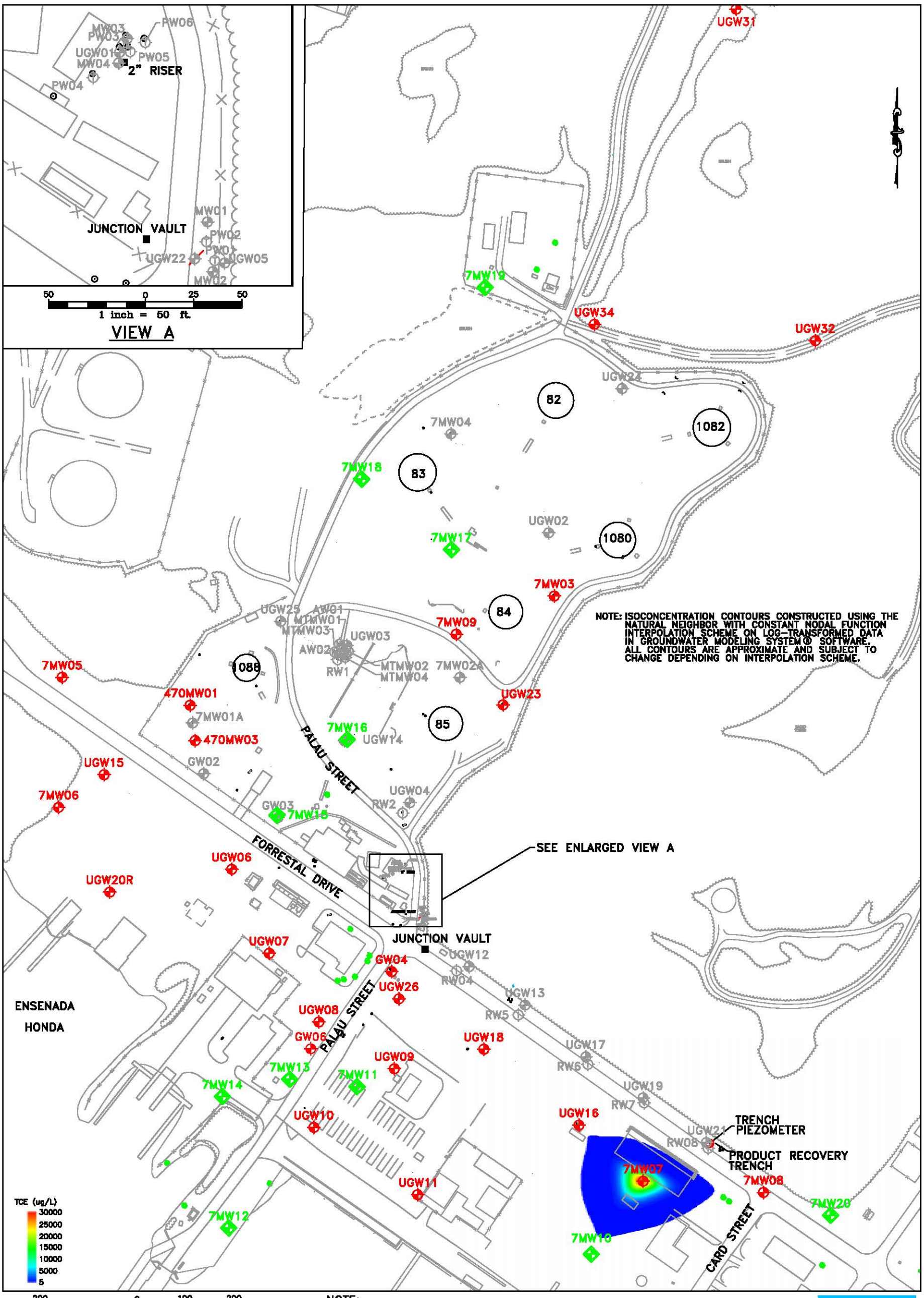
Baker

LEGEND

- MONITOR WELL LOCATION
- NEW MONITOR WELL LOCATION
- TERRAVAC PRODUCT RECOVERY WELL LOCATION
- ICHOR PRODUCT RECOVERY WELL LOCATION
- MANTECH MONITOR WELL
- MANTECH CLEANOx APPLICATION WELL

SOURCE: LANTDIV, FEB. 1992/1997

FIGURE 2-4
BENZENE IN GROUNDWATER
ISOPLETH MAP
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



NOTE: ISOCONCENTRATION CONTOURS CONSTRUCTED USING THE NATURAL NEIGHBOR WITH CONSTANT NODAL FUNCTION INTERPOLATION SCHEME ON LOG-TRANSFORMED DATA IN GROUNDWATER MODELING SYSTEM® SOFTWARE. ALL CONTOURS ARE APPROXIMATE AND SUBJECT TO CHANGE DEPENDING ON INTERPOLATION SCHEME.

NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

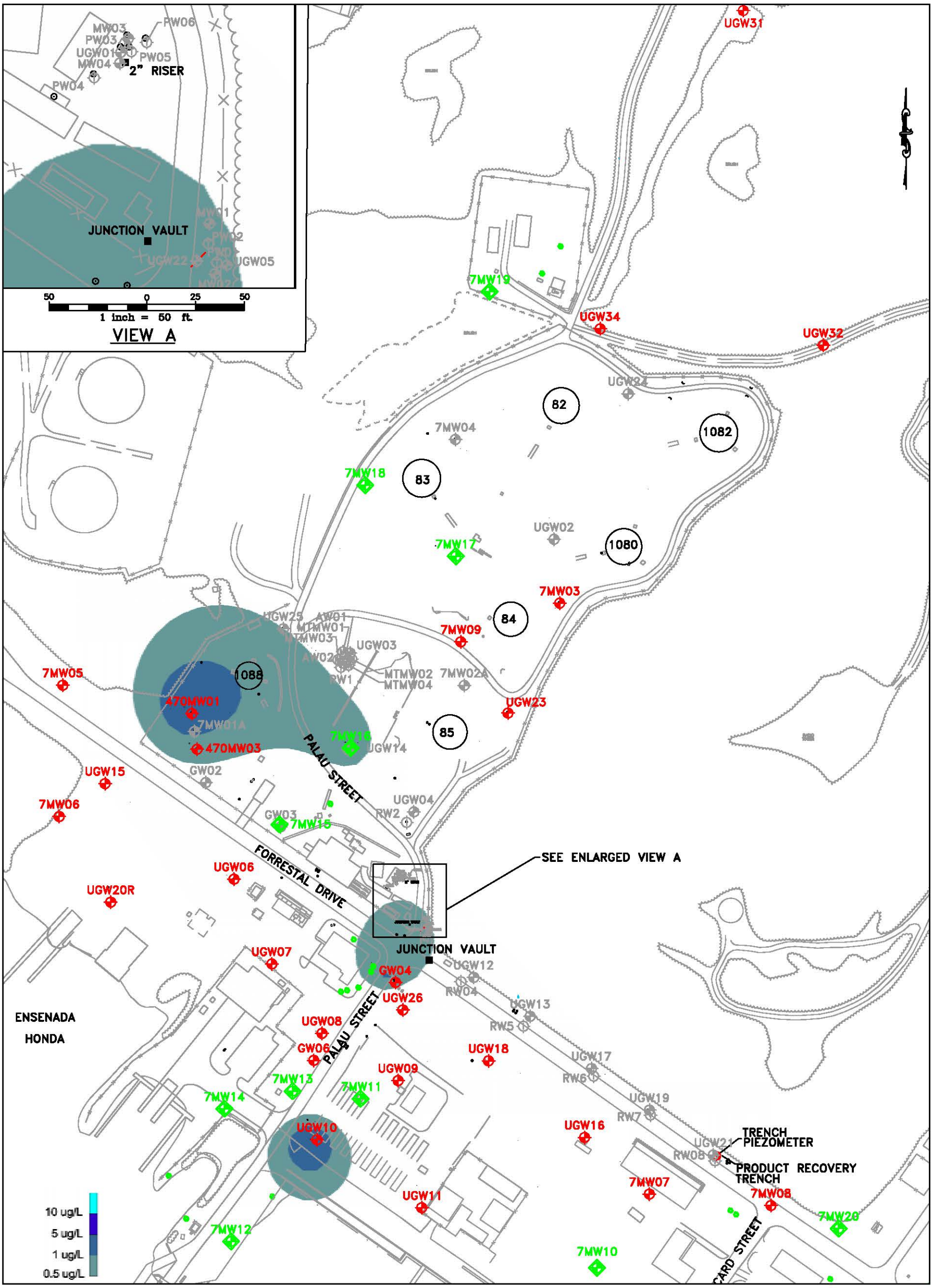
Baker

LEGEND

- MONITOR WELL LOCATION
- NEW MONITOR WELL LOCATION
- TERRAVAC PRODUCT RECOVERY WELL LOCATION
- ICHOR PRODUCT RECOVERY WELL LOCATION
- MANTECH MONITOR WELL
- MANTECH CLEANOx APPLICATION WELL

SOURCE: LANTDIV, FEB. 1992/1997

FIGURE 2-5
TCE IN GROUNDWATER
ISOPLETH MAP
CORRECTIVE MEASURES STUDY – TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



200 0 100 200
1 inch = 200 ft.

K:\28007\034PHASE\0000SUB\GRAPHICS\CAD\TWFF\2034830T

NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

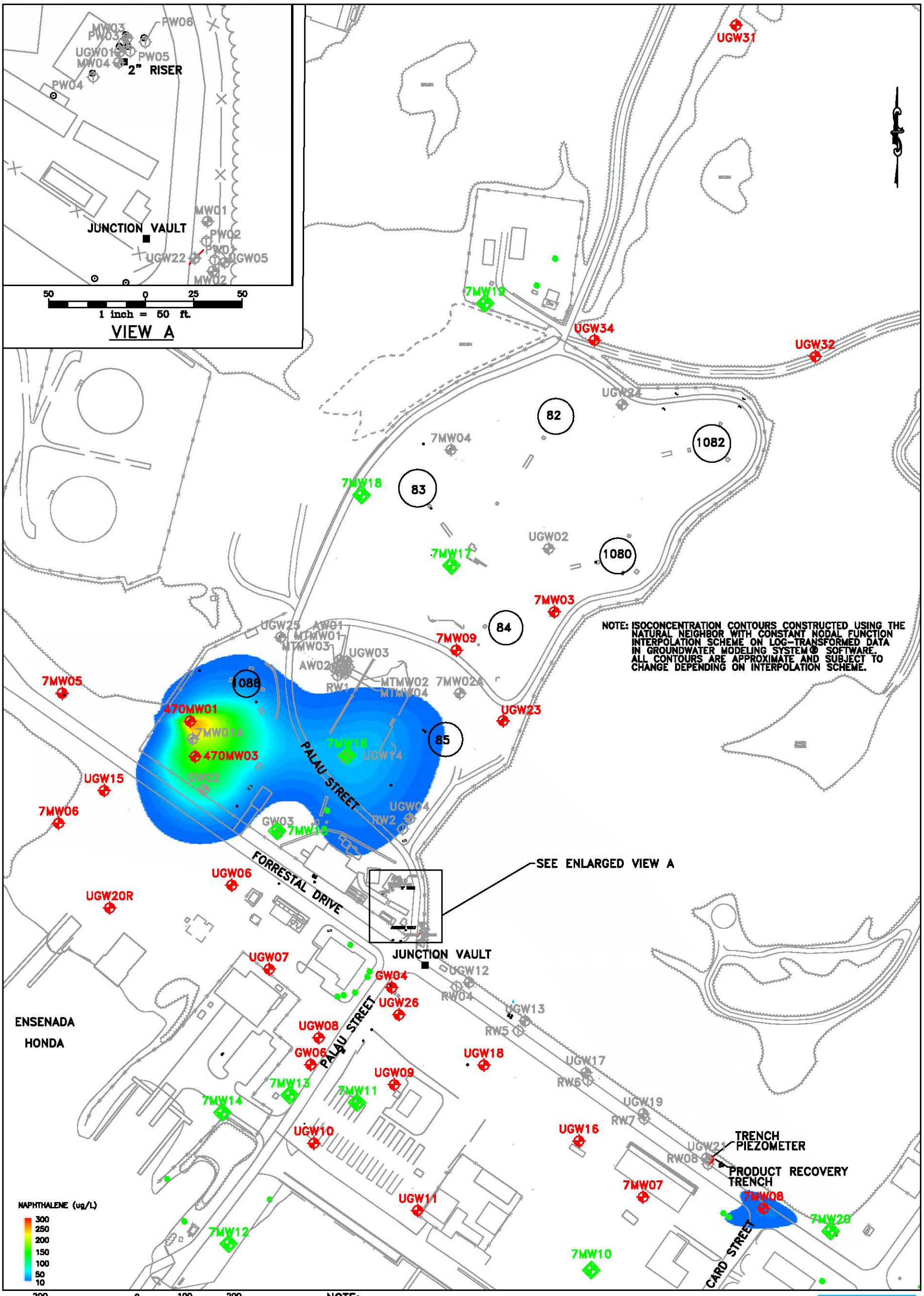
Baker

LEGEND

- MONITOR WELL LOCATION
- NEW MONITOR WELL LOCATION
- TERRAVAC PRODUCT RECOVERY WELL LOCATION
- ICHOR PRODUCT RECOVERY WELL LOCATION
- MANTECH MONITOR WELL
- MANTECH CLEANOx APPLICATION WELL

SOURCE: LANTDIV, FEB. 1992/1997

FIGURE 2-6
FLUORENE IN GROUNDWATER
ISOPLETH MAP
CORRECTIVE MEASURES STUDY – TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

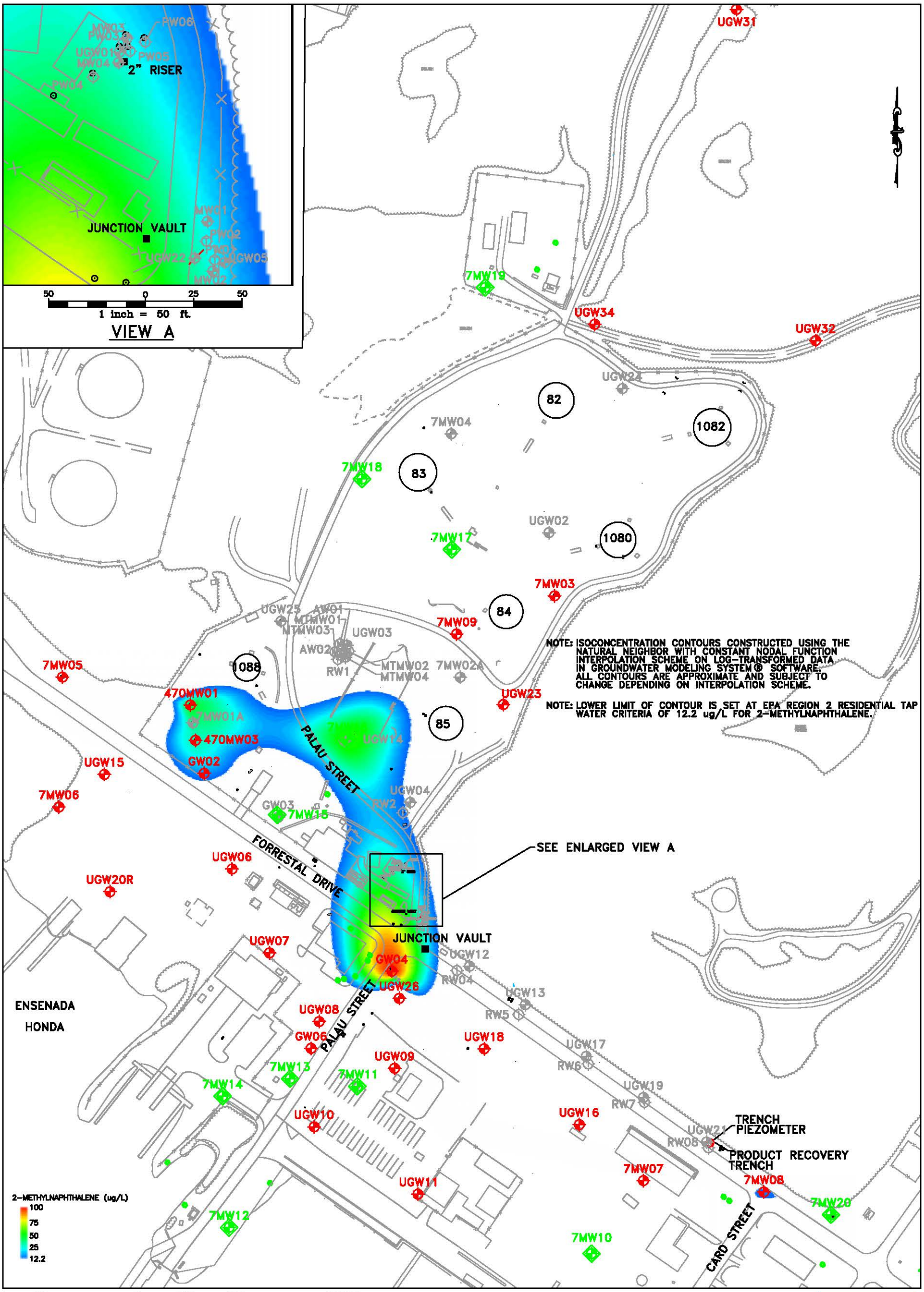
Baker

LEGEND

- MONITOR WELL LOCATION
- NEW MONITOR WELL LOCATION
- TERRAVAC PRODUCT RECOVERY WELL LOCATION
- ICHOR PRODUCT RECOVERY WELL LOCATION
- MANTECH MONITOR WELL
- MANTECH CLEANOx APPLICATION WELL

SOURCE: LANTDIV, FEB. 1992/1997

FIGURE 2-7
NAPHTHALENE IN GROUNDWATER
ISOPLETH MAP
CORRECTIVE MEASURES STUDY – TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

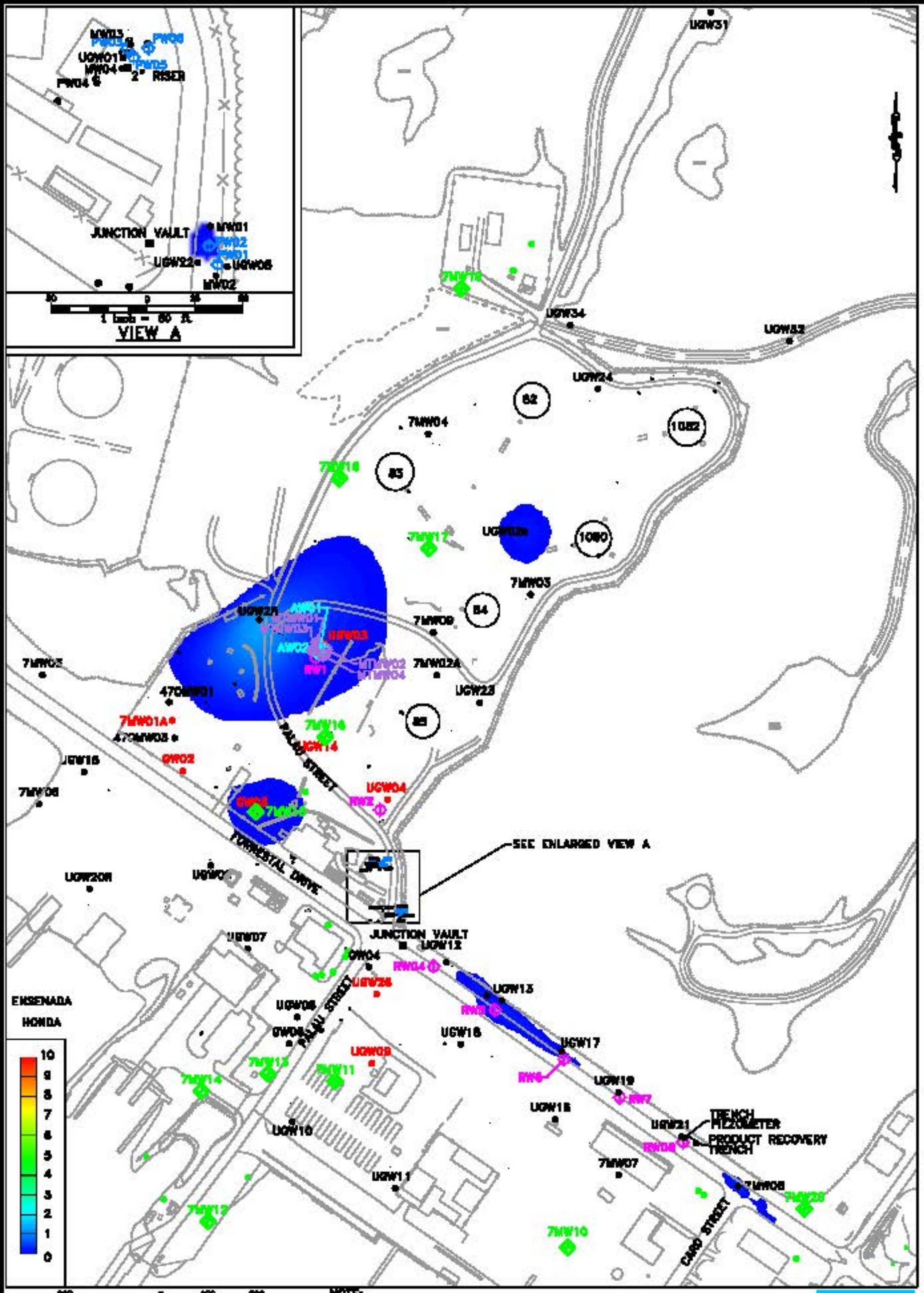
Baker

LEGEND

- MONITOR WELL LOCATION
- NEW MONITOR WELL LOCATION
- TERRAVAC PRODUCT RECOVERY WELL LOCATION
- ICHOR PRODUCT RECOVERY WELL LOCATION
- MANTECH MONITOR WELL
- MANTECH CLEANOx APPLICATION WELL

SOURCE: LANTDIV, FEB. 1992/1997

FIGURE 2-8
2-METHYLNAPHTHALENE IN GROUNDWATER
ISOPLETH MAP
CORRECTIVE MEASURES STUDY - TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



LEGEND

- NEW MONITOR WELL LOCATION
- MONITOR WELL LOCATION
- TERRAVAC PRODUCT RECOVERY WELL LOCATION
- ICHOR PRODUCT RECOVERY WELL LOCATION
- PRODUCT THICKNESS DATA NOT INCLUDED BECAUSE SCREEN IS CONSISTENTLY AND COMPLETELY BELOW THE WATER TABLE
- MANTECH MONITOR WELL
- MANTECH CLEANOx APPLICATION WELL

SOURCE: LANDIN, FEB. 1992/1997

FIGURE 2-9
FREE PRODUCT THICKNESS AND EXTENT MAP (FEBRUARY 28, 2002)
CORRECTIVE MEASURES STUDY – TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

Figure 3-1: Navy Ecological Risk Assessment Tiered Approach

RPM Input and Risk Management Consideration[3]

Step 8: Risk Management

Tier 1. Screening Risk Assessment (SRA): Identify pathways and compare exposure point concentrations to bench marks.

Step 1: Site visit; Pathway Identification/Problem Formulation; Toxicity Evaluation

Step 2: Exposure Estimate; Risk Calculation (SMDP) [1]

Proceed to Exit Criteria for SRA

Exit Criteria for the Screening Risk Assessment: Decision for exiting or continuing the ecological risk assessment.

1) Site passes screening risk assessment: A determination is made that the site poses acceptable risk and shall be closed out for ecological concerns.

2) Site fails screening risk assessment: The site must have both complete pathway and unacceptable risk. As a result the site will either have an interim cleanup or moves to the second tier.

Tier 2. Baseline Ecological Risk Assessment (BERA): Detailed assessment of exposure and hazard to "assessment endpoints" (ecological qualities to be protected). Develop site specific values that are protective of the environment.

Step 3a: Refinement of Conservative Exposure Assumptions[2] (SRA)---- **Proceed to Exit Criteria for Step 3a**

Step 3b: Problem Formulation - Toxicity Evaluation; Assessment Endpoints; Conceptual Model; Risk Hypothesis (SMDP)

Step 4: Study Design/DQO - Lines of Evidence; Measurement Endpoints; Work Plan and Sampling & Analysis Plan (SMDP)

Step 5: Verification of Field Sampling Design (SMDP)

Step 6: Site Investigation and Data Analysis [SMDP]

Step 7: Risk Characterization

Proceed to Exit Criteria for BERA

Exit Criteria Step 3a Refinement

1) If re-evaluation of the conservative exposure assumptions (SRA) support an acceptable risk determination then the site exits the ecological risk assessment process.

2) If re-evaluation of the conservative exposure assumptions (SRA) do not support an acceptable risk determination then the site continues in the Baseline Ecological Risk Assessment process. **Proceed to Step 3b**.

Exit Criteria Baseline Risk Assessment

1) If the site poses acceptable risk then no further evaluation and no remediation from an ecological perspective is warranted.

2) If the site poses unacceptable ecological risk and additional evaluation in the form of remedy development and evaluation is appropriate, proceed to third tier.

Tier 3. Evaluation of Remedial Alternative (RAGs C)

a. Develop site specific risk based cleanup values.

b. Qualitatively evaluate risk posed to the environment by implementation of each alternative (short term) impacts and estimate risk reduction provided by each (long-term) impacts; provide quantitative evaluation where appropriate. Weigh alternative using the remaining CERCLA 9 Evaluation Criteria. Plan for monitoring and site closeout.

Notes: 1) See EPA's 8 Steps ERA Process for requirements for each Scientific Management Decision Point (SMDP).

2) Refinement includes but is not limited to background, bioavailability, detection frequency. Etc.

3) Risk Management is incorporated throughout the tiered approach.

NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

Baker

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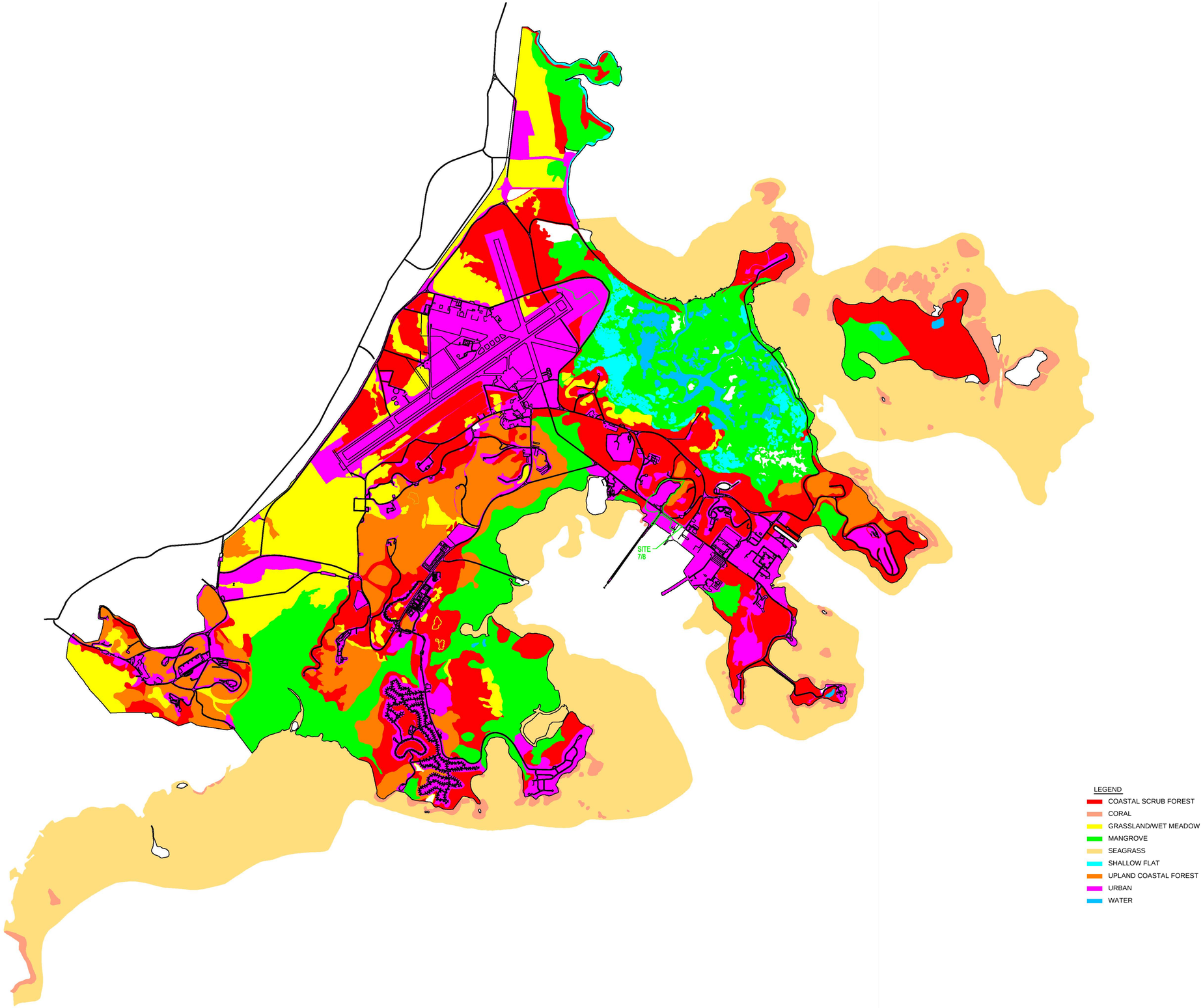
LEGEND

- MONITOR WELL LOCATION
- TERRAVAC PRODUCT RECOVERY WELL LOCATION
- ICHOR PRODUCT RECOVERY WELL LOCATION
- NEW MONITOR WELL LOCATION
- FREE PRODUCT PLUME
- DISSOLVED TCE PLUME
- UNSUPPORTED FREE PRODUCT PLUME

SOURCE: LANTDIV, FEB. 1992/1997

FIGURE 3-2
ZONE LOCATION MAP
TOW WAY FUEL FARM

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



SOURCE: GEO-MARINE, INC.

REVISIONS						
	DRAWN GLB/WJH REVIEWED MEK S.O.# 26007-033 CADD# Rr2033004	NORTH		NAVAL STATION ROOSEVELT ROADS PUERTO RICO BAKER ENVIRONMENTAL, Inc. Coraopolis, Pennsylvania	Baker	"TERRESTRIAL AND AQUATIC HABITAT OCCURRING AT NAVAL STATION ROOSEVELT ROADS" SCALE 1" = 600' DATE JUNE 6, 2002	FIGURE 3-3

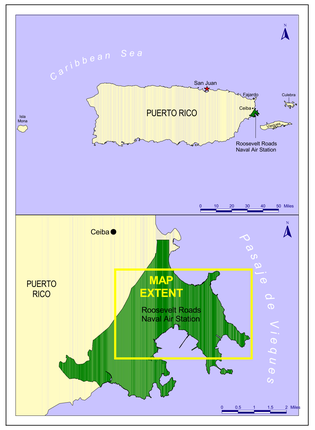


Figure 3-4
Naval Station Roosevelt Roads Wetlands Delineation

North and East Sections

This certifies that this plat identifies potential waters and wetlands regulated persuant to Section 404 of the Clean Water Act. Wetlands were delineated in December, 1999 from 1993 color infrared and 1998 true color aerial photography. Twenty percent of the wetlands were field checked to verify the accuracy of the delineations. Field verification were based upon the 1987 Corps of Engineers Wetland Delineation Manual.

Source: Geo-Marine, Inc., September 6, 2000

FIGURE 3-5
THE COWARDIN WETLAND CLASSIFICATION SYSTEM
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO

SYSTEM: M - MARINE

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

SYSTEM: E - ESTUARINE

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

SYSTEM: R - RIVERINE

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

SYSTEM: L - LACUSTRINE

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

SYSTEM: P - PALUSTRINE

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

MODIFIERS

WATER REGIME

	Non-Tidal		Tidal
A Temp. Flooded	H Permanently Flooded	K Artificially Flooded	*S Temporary-Tidal
B Saturated	J Intermittently Flooded	L Subtidal	*R Seasonal-Tidal
C Seasonally Flooded	K Artificially Flooded	M Irregularly Flooded	*T Semipermanent- Tidal
D Seasonally Flooded/ Well Drained	W Intermittently Flooded/ Temporary	N Regularly Flooded	*V Permanent-Tidal
E Seasonally Flooded/ Saturated	Y Saturated/Semipermanent/ Seasonal	P Irregularly Flooded	U Unknown
F Semipermanently Flooded	Z Intermittently Exposed Permanent		
G Intermittently Exposed	U Unknown		

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

WATER CHEMISTRY

Coastal Halinity	Inland Salinity	pH (fresh water)
1 Hyperhaline	7 Hypersaline	a Acid
2 Euhaline	8 Eusaline	t circumneutral
3 Mixohaline	9 Mixosaline	i Alkaline
4 Polyhaline	0 Fresh	
5 Mesohaline		
6 Oligohaline		
0 Fresh		

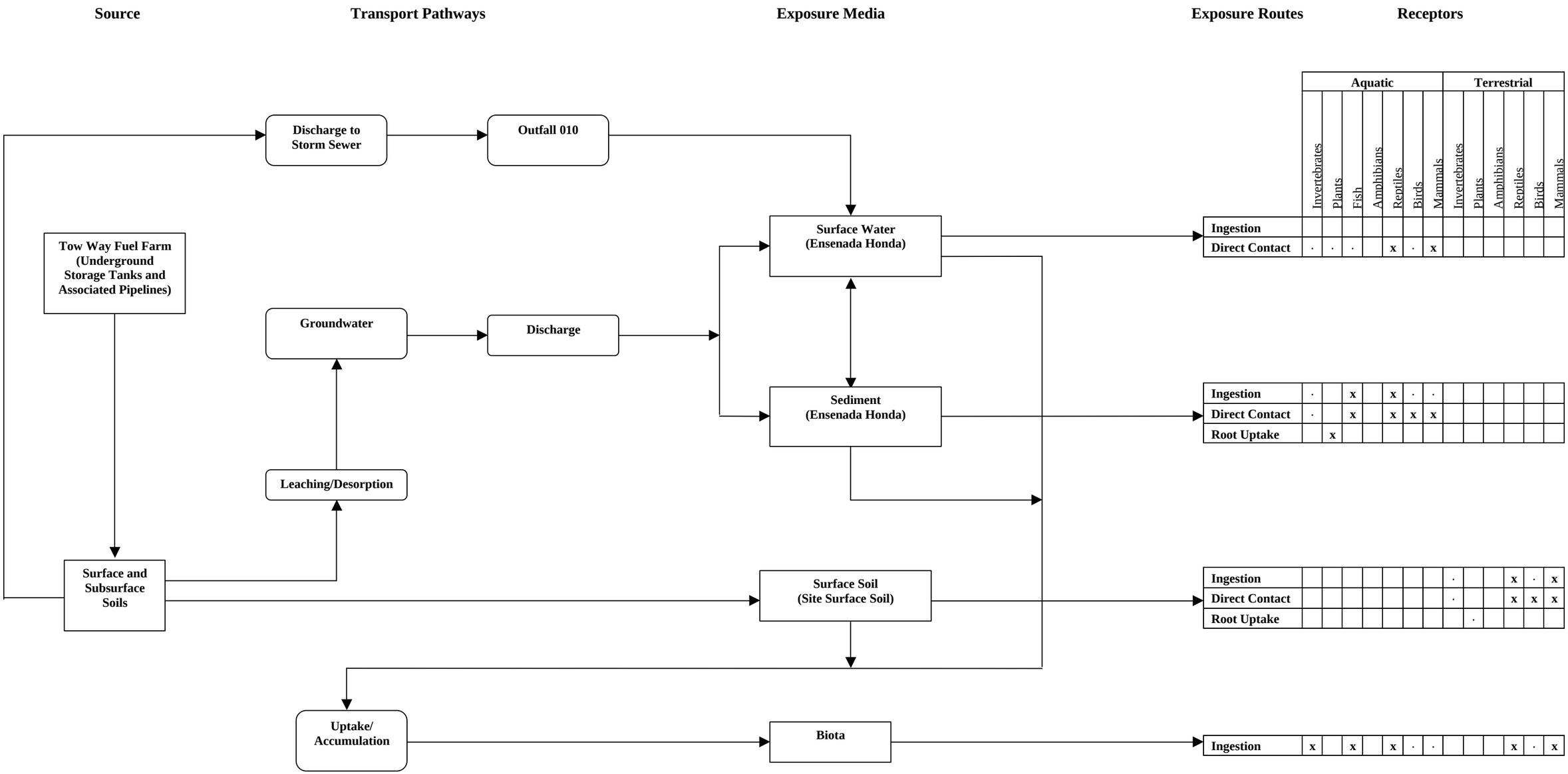
SOIL

g Organic
n Mineral

SPECIAL

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

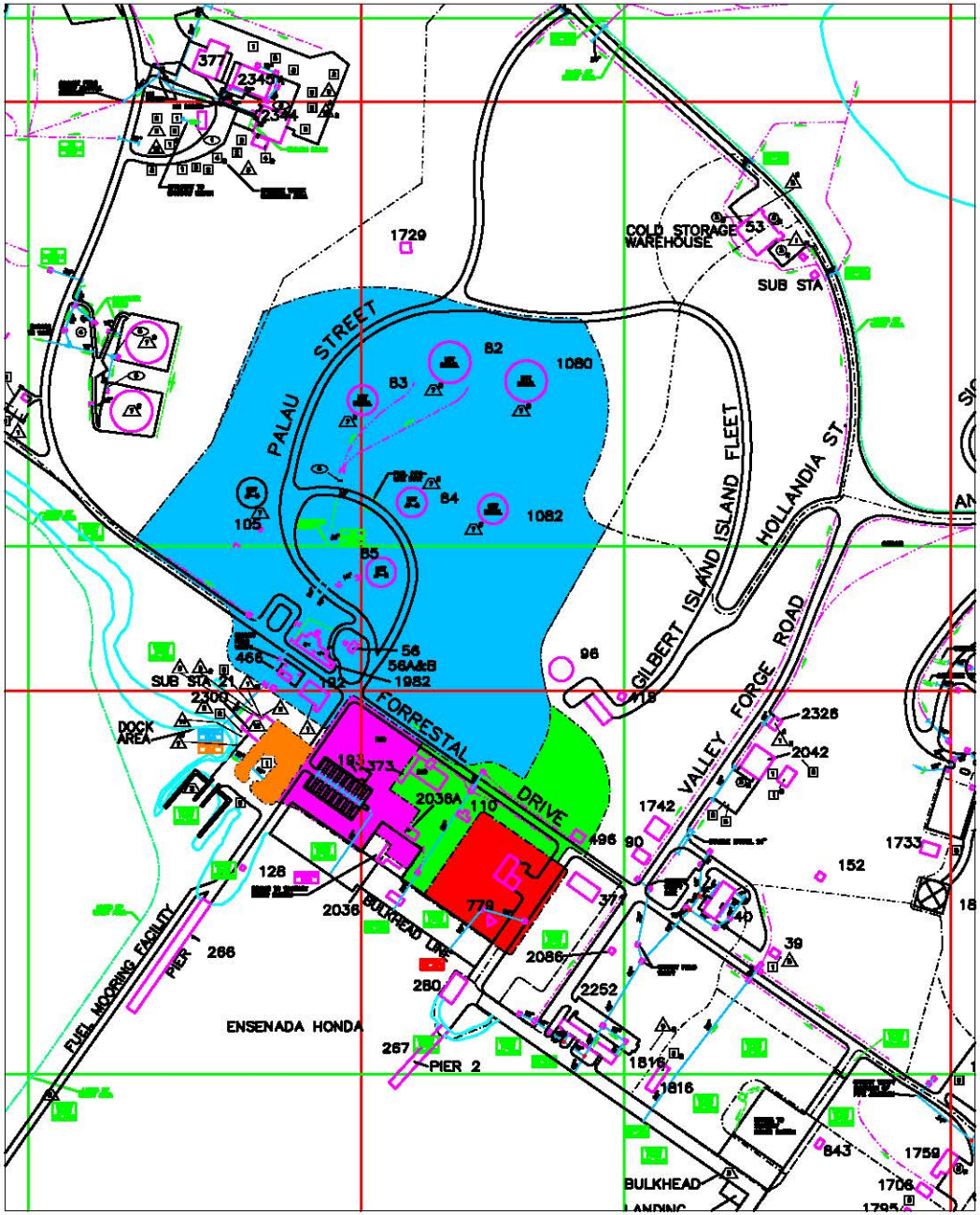
SOURCE: UNITED STATES, FISH AND WILDLIFE SERVICE. CLASSIFICATION OF WETLANDS AND DEEPWATER HABITATS OF THE UNITED STATES, 1985



Potentially complete and significant pathway

• - Receptor/pathway was evaluated quantitatively
x - Receptor/pathway was not evaluated quantitatively.

FIGURE 3-6
PRELIMINARY CONCEPTUAL MODEL
DRAFT FINAL TASK I CORRECTIVE MEASURES STUDY
SWMU 7/8 - TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS, CEIBA, PUERTO RICO



NOTES:

1. $\triangle^{c}$ THE SUPERSCRIPT "C" ON THE OUTSIDE OF A SYMBOL INDICATES SECONDARY CONTAINMENT.
2. $\triangle_{R}$ THE SUBSCRIPT "R" ON THE OUTSIDE OF A SYMBOL INDICATES THE AREA IS COVERED BY A ROOF.

HM/HW/POL STORAGE

- 1 FLAMMABLES IN METAL CABINETS/ STORAGE BUILDINGS
- 2 FLAMMABLES IN DRUMS
- 3 PETROLEUM OILS AND LUBRICANTS (POL'S) DRUM/TANK STORAGE
- 4 ABOVEGROUND JP-4, 5 TANKS
- 5 ABOVEGROUND DIESEL TANKS
- 6 ABOVEGROUND UNLEADED GAS TANKS
- 7 ABOVEGROUND WASTE OIL/JP-5 TANKS
- 8 ETHYLENE GLYCOL
- 9 COMPRESSED GAS CYLINDERS/TANKS
- 10 SOLVENTS/CLEANING COMPOUNDS
- 11 CORROSIVES
- 12 BATTERIES
- 13 PAINT AND PAINT RELATED MATERIALS/WASTE
- 14 WASTE IN DRUMS
- 15 SATELLITE HAZARDOUS WASTE ACCUMULATION
- 16 PCB CONTAINMENT/STORAGE
- 17 RADIOACTIVE MATERIAL
- 18 CHEMICAL AST

REGULATED INDUSTRIAL CATEGORIES

- 1 AIRPORTS/FLIGHT LINES
- 2 MARINE CARGO HANDLING
- 3 SEWAGE TREATMENT PLANTS>1 MGD
- 4 ACTIVE LANDFILLS
- 5 SOLID WASTE TRANSFER
- 6 HAZARDOUS WASTE STORAGE AREA
- 7 PETROLEUM BULK STORAGE
- 8 U.S. POSTAL SERVICE WITH VEHICLE MAINTENANCE FACILITIES
- 9 MARINA
- 10 SCRAP AND WASTE MATERIALS
- 11 PESTICIDE FORMULATION
- 12 SHIP REPAIR
- 13 IR PROGRAM SITE
- 14 VEHICLE WASHDOWN

MATERIAL STORAGE AREAS

- 1 VEHICLE/EQUIPMENT STORAGE
- 2 MISCELLANEOUS METALS
- 3 PLASTIC/RUBBER STORAGE
- 4 TIRE STORAGE
- 5 GARBAGE DUMPSTERS
- 6 EMPTY DRUMS
- 7 AGGREGATE STORAGE
- 8 WOOD/LUMBER STORAGE
- 9 MISCELLANEOUS CONSTRUCTION MATERIAL STORAGE
- 10 PORTABLE TOILET
- 11 AFFF

MATERIALS LOADING AND ACCESS AREAS

- 1 FUELING STATIONS
- 2 BULK FUEL TRANSFER
- 3 WAREHOUSE LOADING/ UNLOADING AREAS
- 4 CHEMICAL TRANSFER

LEAKS AND SPILLS

- 1 PETROLEUM FUELS
- 2 WASTE OIL

EXISTING BEST MANAGEMENT PRACTICES (BMP'S)

- 1 OIL/WATER SEPARATOR
- 2 OIL SPILL RECOVERY BOAT
- 3 ABSORBENT MATERIALS
- 4 BOOMS
- 5 SKIMMER DAM
- 6 SPILL CONTROL GATE/VALVE
- 7 VEGETATIVE FILTERS

CHEMICAL APPLICATION AREAS

- 1 PESTICIDES
- 2 HERBICIDES
- 3 FERTILIZERS

LEGEND

- PIPE
- DRAINAGE BOUNDARY
- STUDY AREA
- DITCH
- UNDER DRAIN
- CONCRETE DITCH
- DROP INLET
- MANHOLE
- REGULATED OUTFALL
- NON-REGULATED OUTFALL
- SHEET FLOW DISCHARGE

REVISIONS

DRAWN	RRR	
REVIEWED	MEK/JCE	
S.O.#	92077-008	
CADD#	R:\053003	

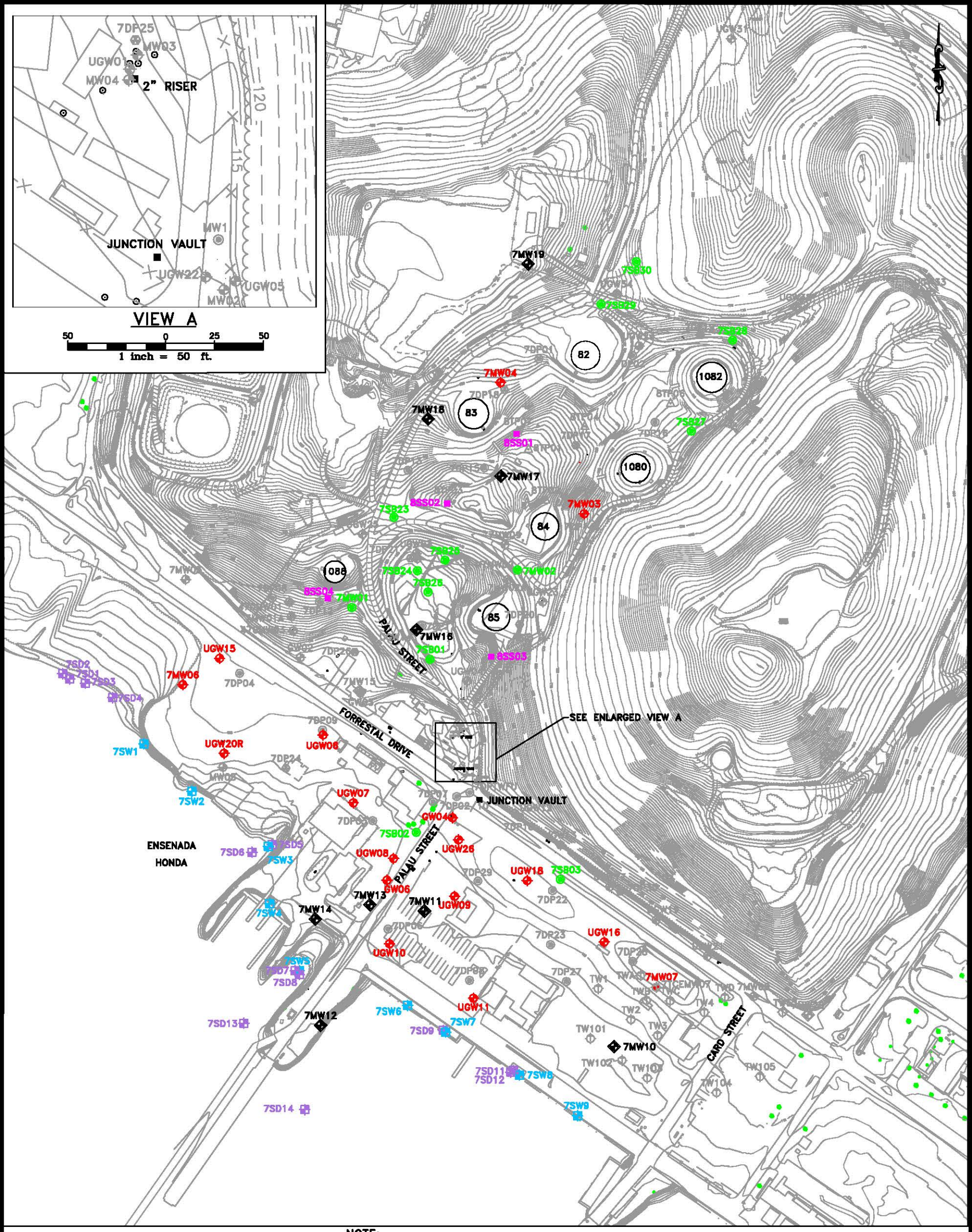
ATLANTIC DIVISION
DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND

Michael Baker, Inc.
Coraopolis, Pennsylvania

STORMWATER DRAINAGE MAP

SCALE	1" = 15'
DATE	8/15/02

FIGURE
3-7



NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

K\26007\033Phase\Cad\RRoads\ Rr2033007

SOURCE: LANTDIV, FEB. 1992/1997

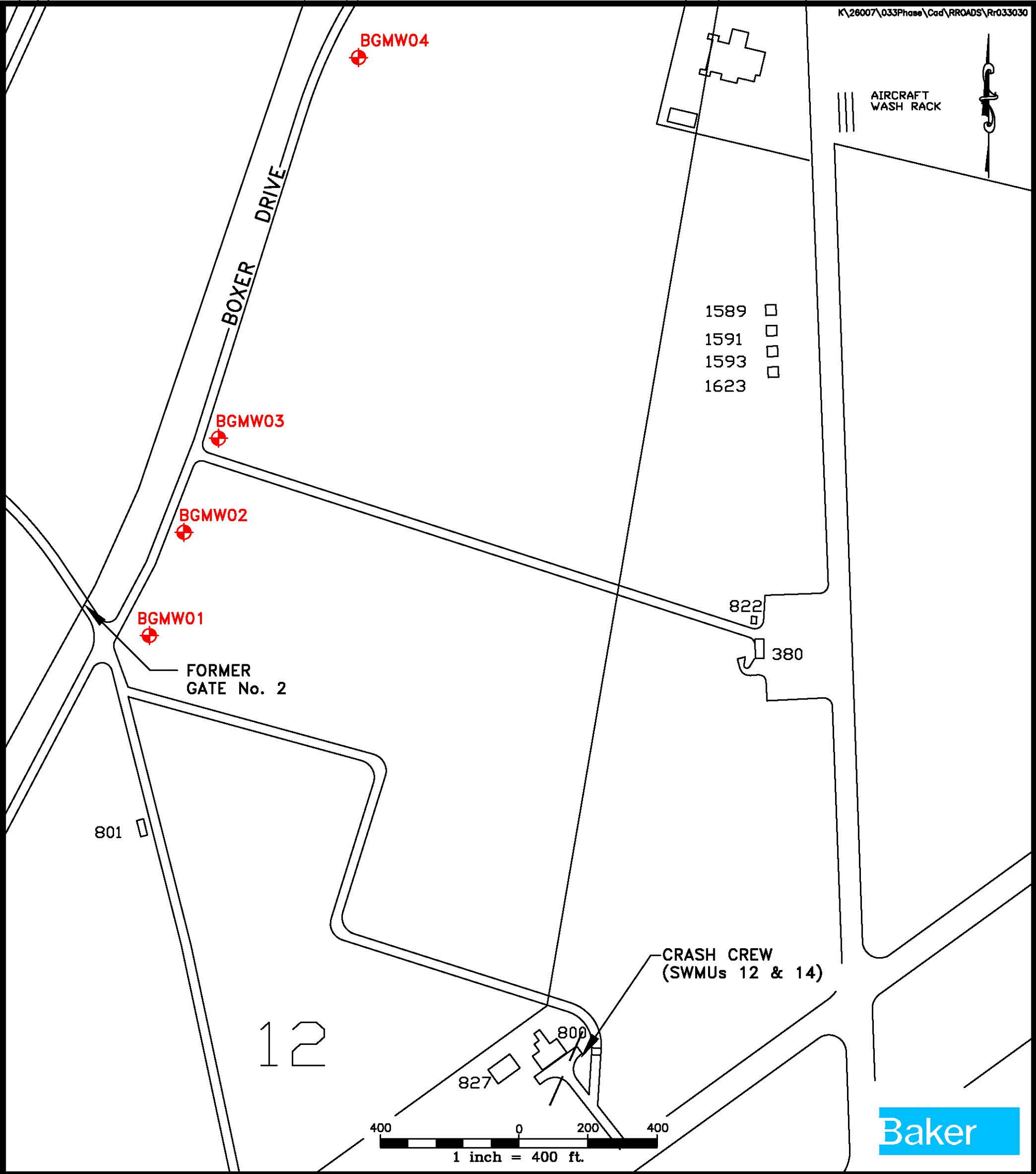
Baker

LEGEND

- NEW MONITOR WELL LOCATION
- MONITOR WELL LOCATION
- SOIL BORING LOCATION
- SOIL BORING AND SOIL GAS SAMPLE LOCATION
- SURFACE SOIL LOCATION
- TEST PIT LOCATION
- SEDIMENT SAMPLE LOCATION
- SURFACE WATER SAMPLE LOCATION
- TEMPORARY MONITOR WELL LOCATION

FIGURE 3-8
LOCATIONS OF SAMPLES USED IN ECOLOGICAL RISK ASSESSMENT
TOW WAY FUEL FARM

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO

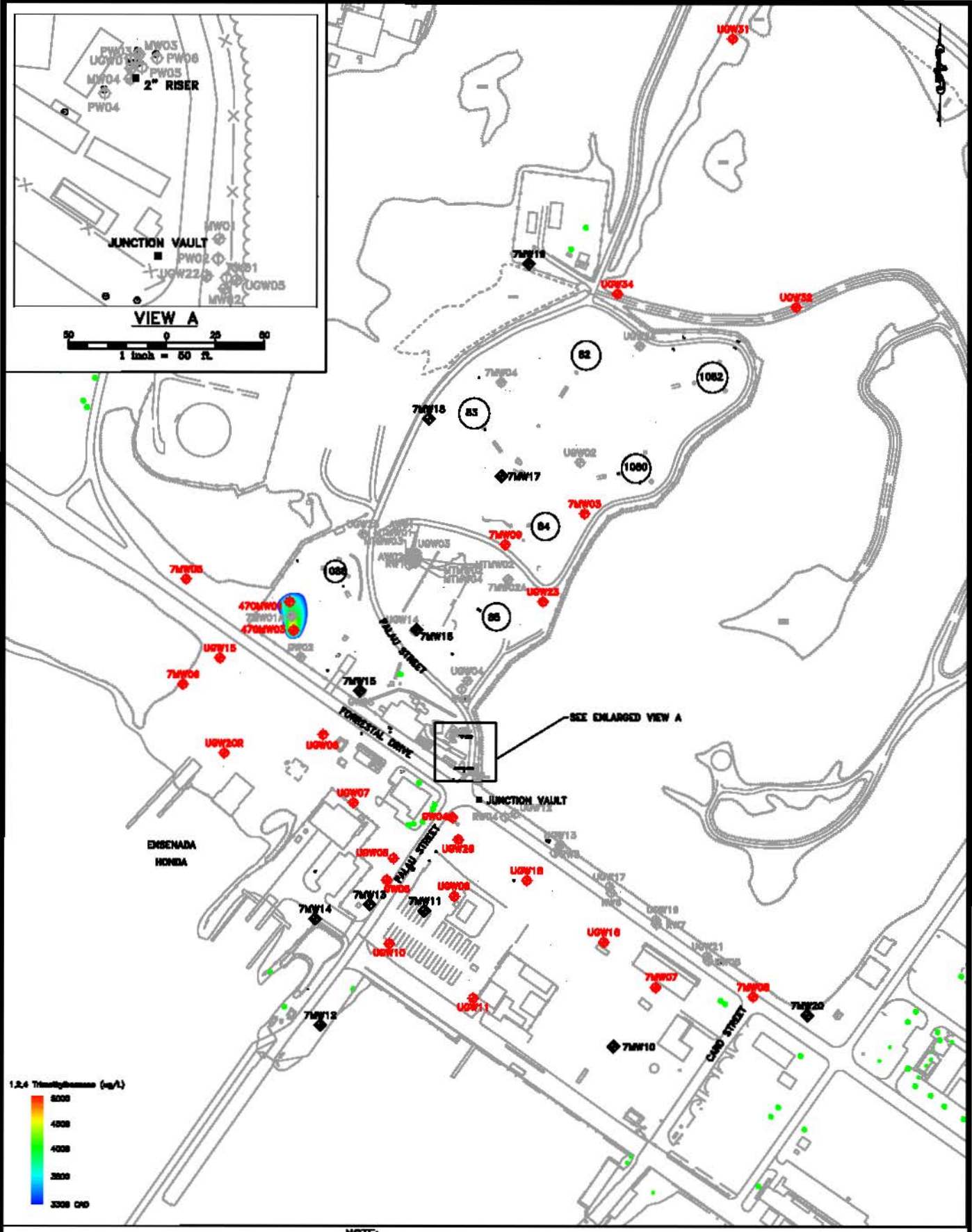


LEGEND

BGMW01 – BACKGROUND MONITOR WELL, BACKGROUND SOIL, AND BACKGROUND GROUNDWATER SAMPLE LOCATIONS

FIGURE 3–9
BASE BACKGROUND SURFACE SOIL AND GROUNDWATER SAMPLE LOCATIONS

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

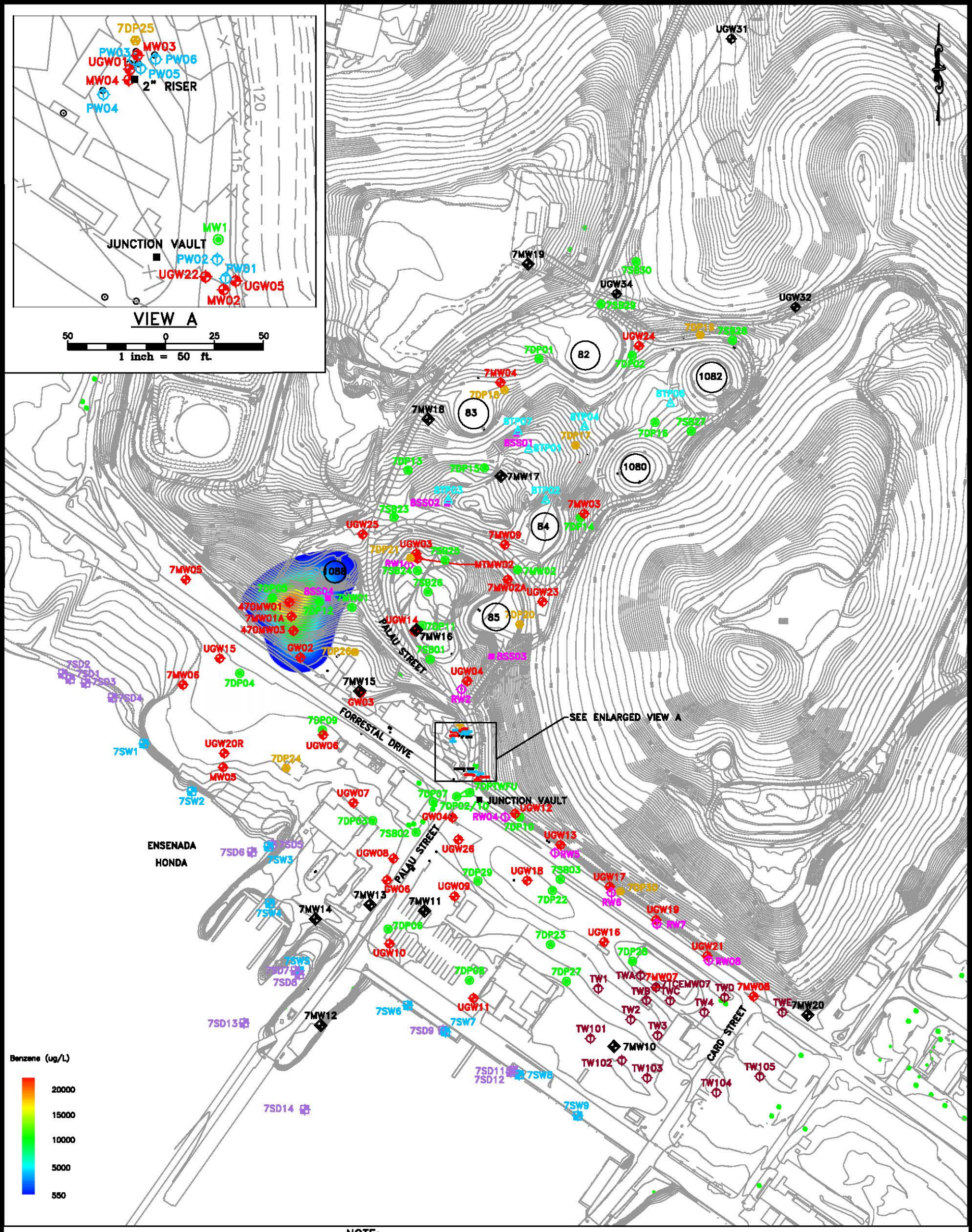
SOURCE: LANTDIV, FEB. 1992/1997

Baker

LEGEND

- NEW MONITOR WELL LOCATION
- MONITOR WELL LOCATION
- ICHOR PRODUCT RECOVERY WELL LOCATION
- TERRAVAC PRODUCT RECOVERY WELL LOCATION
- MANTECH MONITOR WELL
- MANTECH CLEANOx APPLICATION WELL

FIGURE 5-1
1,2,4-TRIMETHYLBENZENE DISSOLVED GROUNDWATER PLUME
CORRECTIVE MEASURES STUDY – TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



1 inch = 250 ft.

NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

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SOURCE: LANTDIV, FEB. 1992/1997

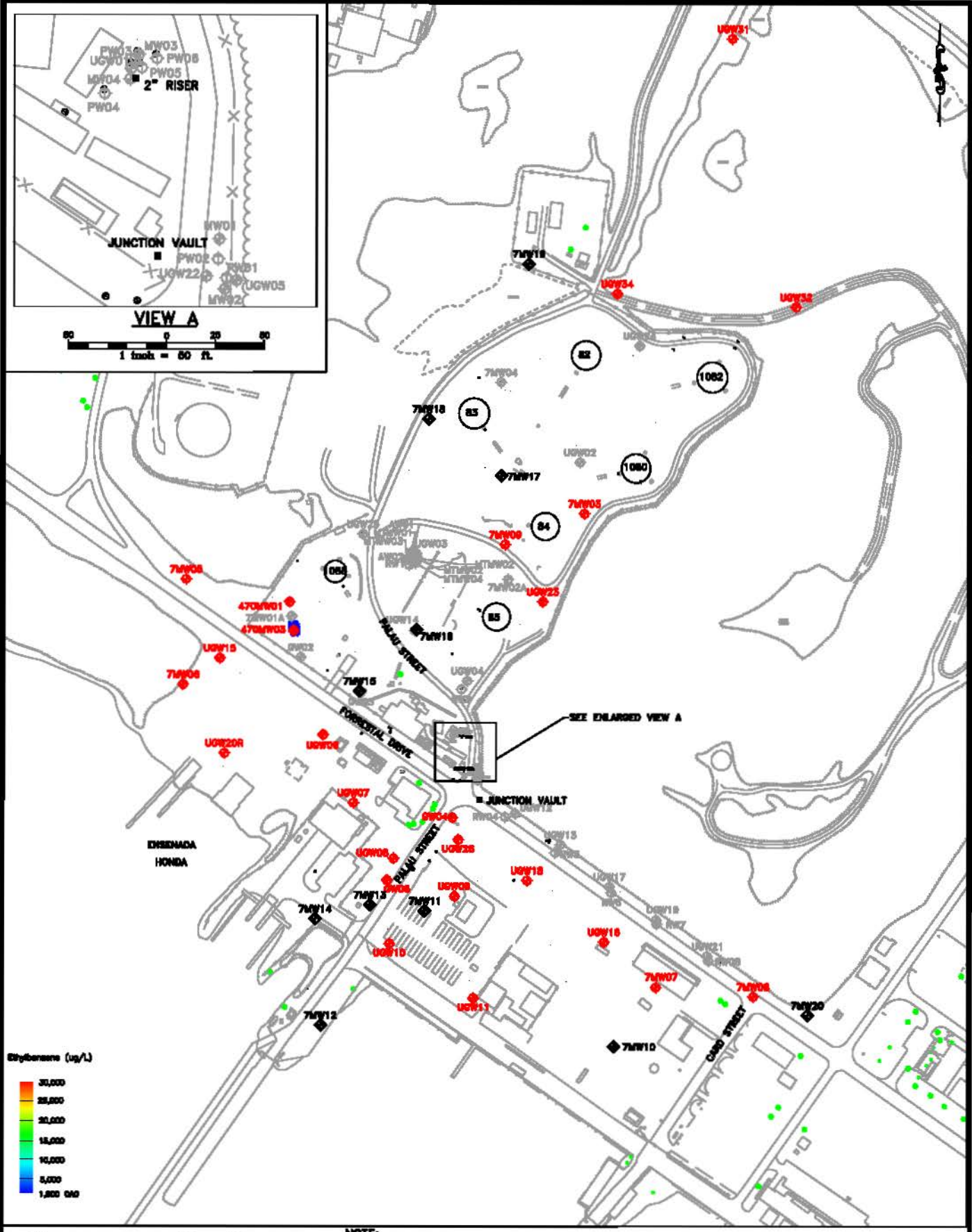
Baker

LEGEND

- NEW MONITOR WELL LOCATION
- MONITOR WELL LOCATION
- SOIL BORING LOCATION
- SOIL BORING AND SOIL GAS SAMPLE LOCATION
- SURFACE SOIL LOCATION
- TEST PIT LOCATION
- SEDIMENT SAMPLE LOCATION
- SURFACE WATER SAMPLE LOCATION
- TEMPORARY MONITOR WELL LOCATION
- TERRAVAC PRODUCT RECOVERY WELL LOCATION
- ICHOR PRODUCT RECOVERY WELL LOCATION
- 550 ug/L CAO CONTOUR

FIGURE 5-2
BENZENE DISSOLVED
GROUNDWATER PLUME
CORRECTIVE MEASURES STUDY – TASK I REPORT
TOW WAY FUEL FARM

NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

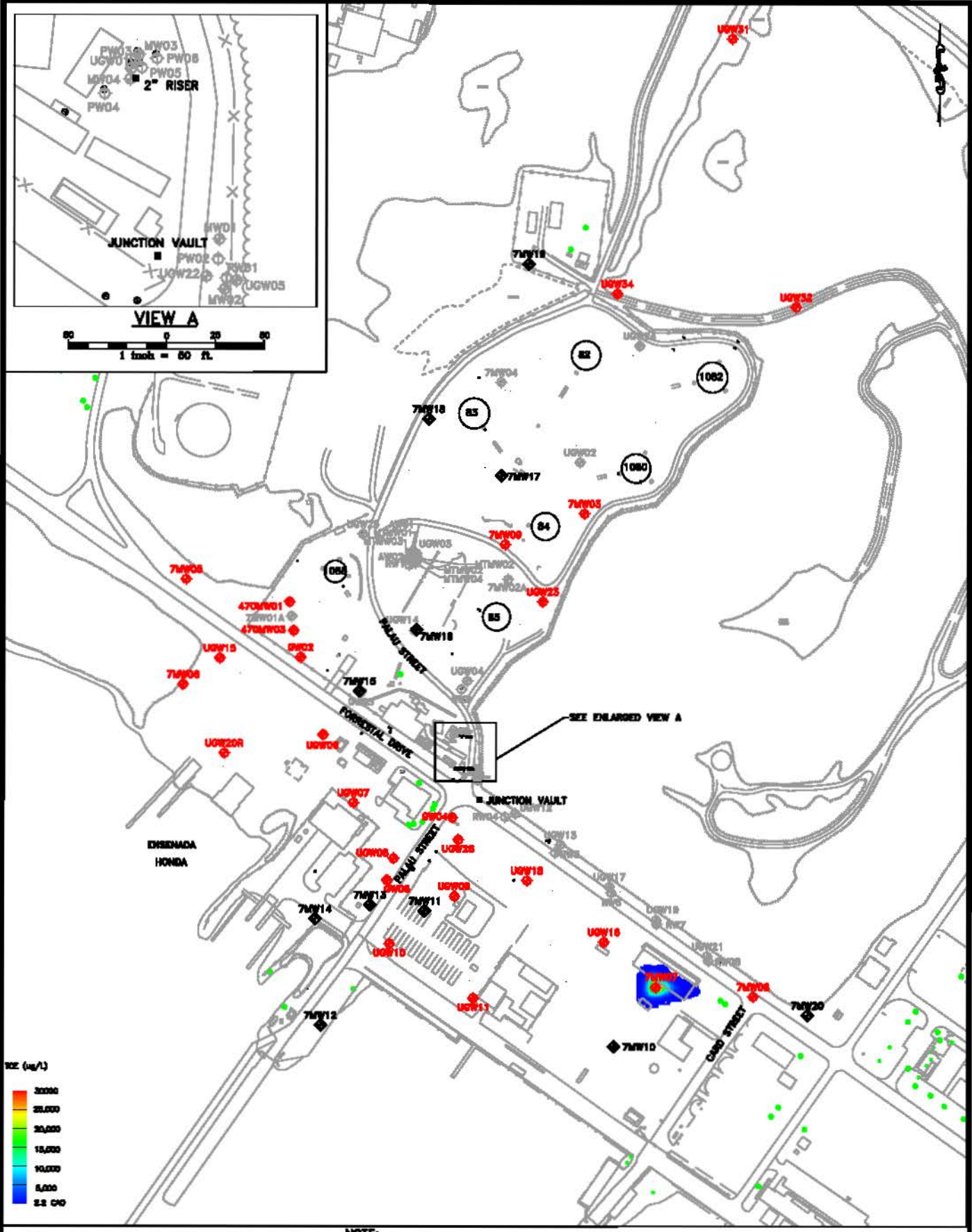
SOURCE: LANTDIV, FEB. 1992/1997

Baker

LEGEND

- NEW MONITOR WELL LOCATION
- MONITOR WELL LOCATION
- TERRAVAC PRODUCT RECOVERY WELL LOCATION
- ICHOR PRODUCT RECOVERY WELL LOCATION
- MANTECH MONITOR WELL
- MANTECH CLEANOx APPLICATION WELL

FIGURE 5-3
ETHYLBENZENE DISSOLVED GROUNDWATER PLUME
CORRECTIVE MEASURES STUDY – TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

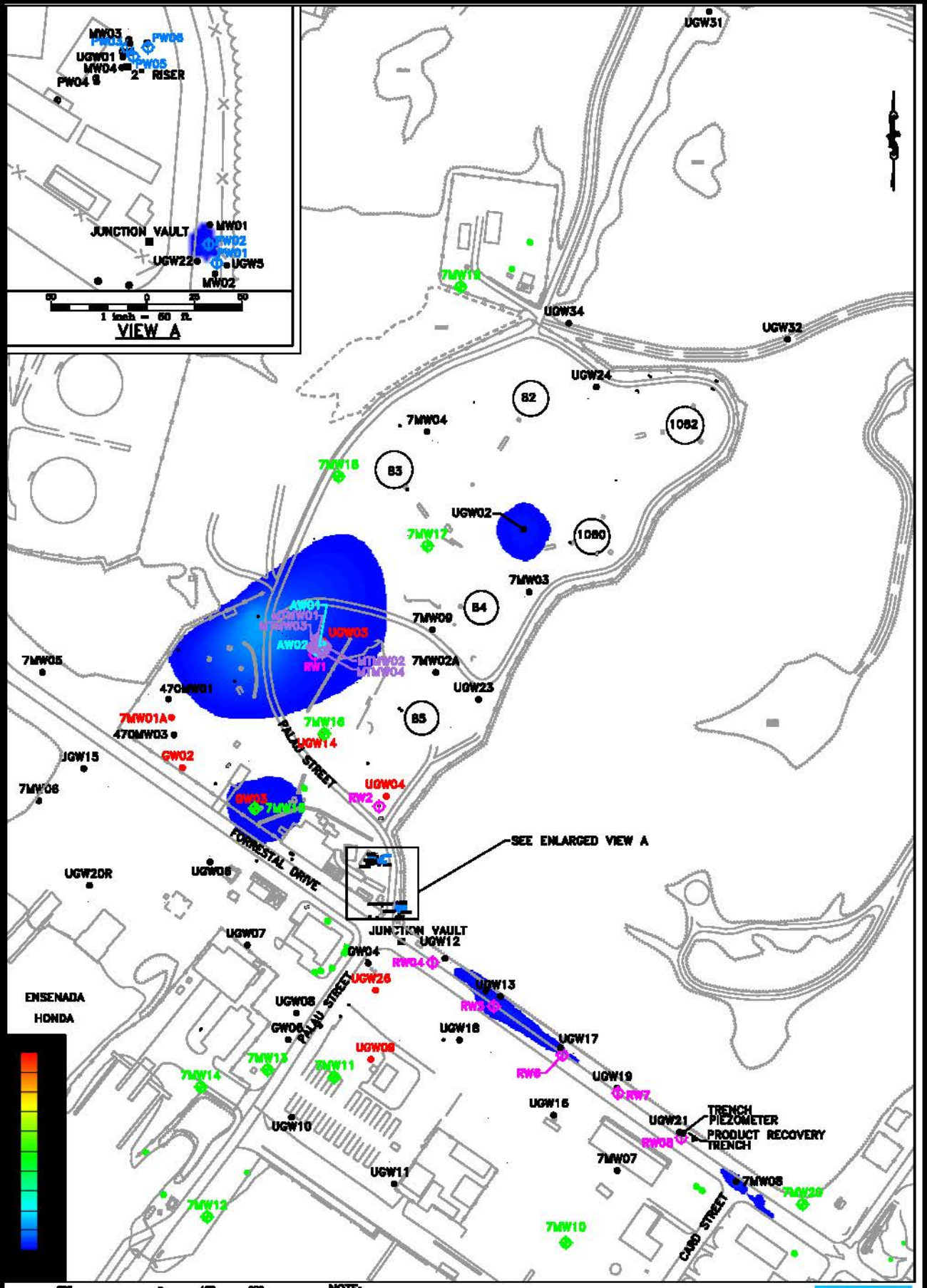
SOURCE: LANTDIV, FEB. 1962/1967

Baker

LEGEND

- NEW MONITOR WELL LOCATION
- MONITOR WELL LOCATION
- TERRAVAC PRODUCT RECOVERY WELL LOCATION
- ICHOR PRODUCT RECOVERY WELL
- MANTECH MONITOR WELL
- MANTECH CLEANOx APPLICATION WELL

FIGURE 5-4
TRICHLOROETHENE DISSOLVED GROUNDWATER PLUME
CORRECTIVE MEASURES STUDY – TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

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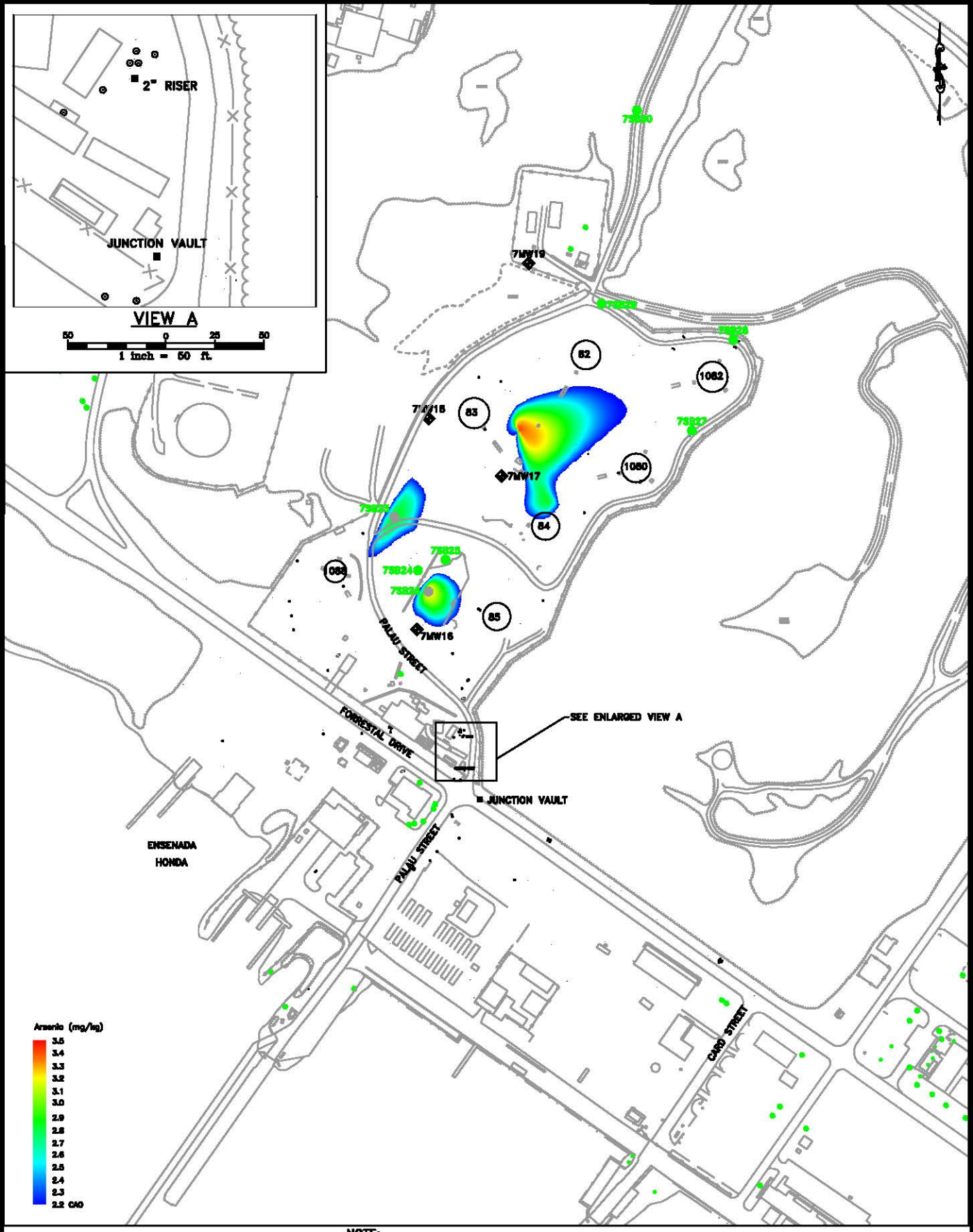
LEGEND

- MONITOR WELL LOCATION
- TERRAVAC PRODUCT RECOVERY WELL LOCATION
- ICHOR PRODUCT RECOVERY WELL LOCATION
- PRODUCT THICKNESS DATA NOT INCLUDED BECAUSE SCREEN IS CONSISTENTLY AND COMPLETELY BELOW THE WATER TABLE
- NEW MONITOR WELL LOCATION
- MANTECH MONITOR WELL
- MANTECH CLEANOx APPLICATION WELL

SOURCE: LANTDIV, FEB. 1992/1997

FIGURE 5-5
PHASE SEPARATED HYDROCARBON PLUME
(FEBRUARY 28, 2002)
CORRECTIVE MEASURES STUDY – TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

Baker

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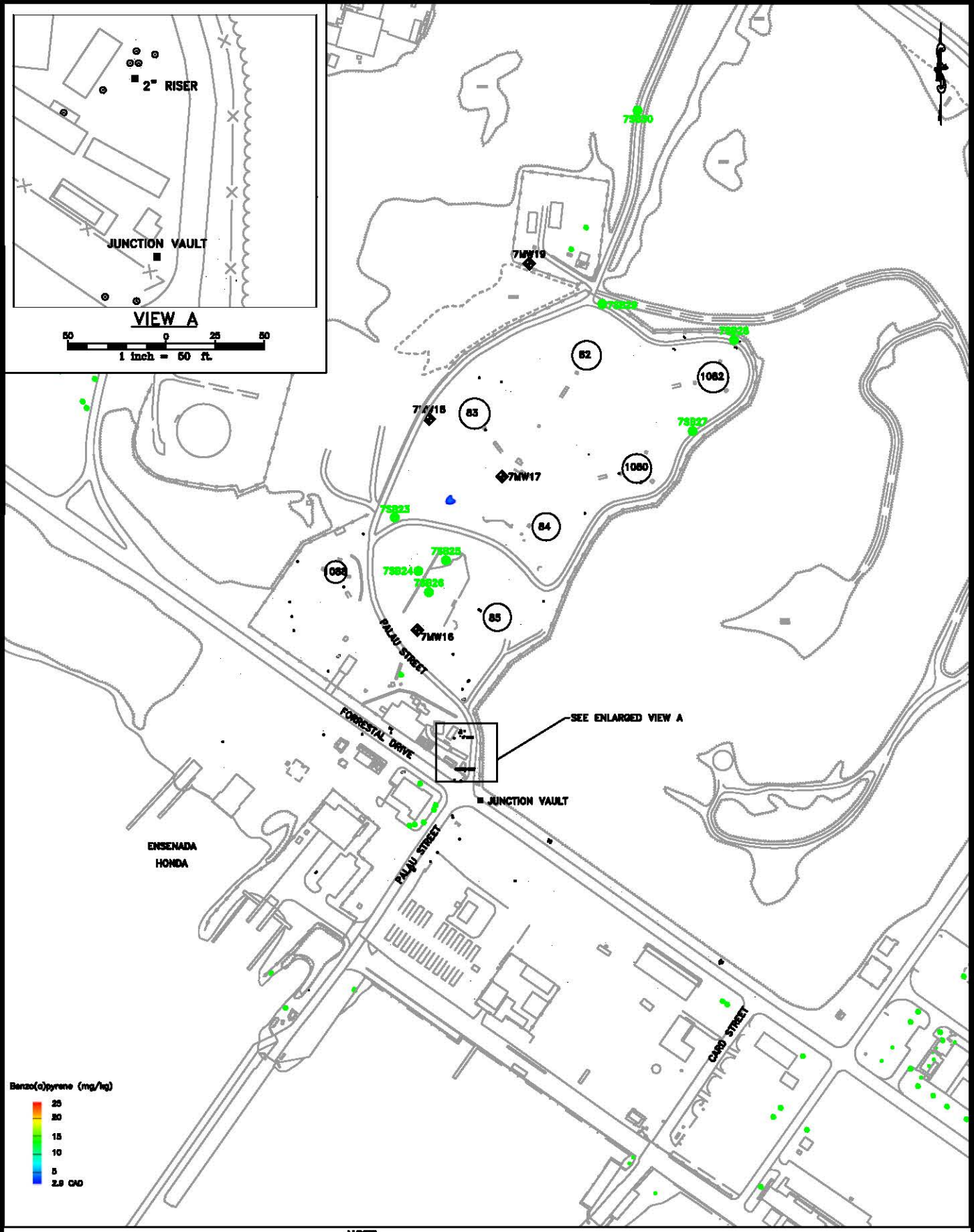
SOURCE: LANTDIV, FEB. 1962/1997

LEGEND

- ◆ – NEW MONITOR WELL LOCATION
- ● – SOIL BORING LOCATION

FIGURE 5-6
SURFACE SOIL WITH
ARSENIC ABOVE CAO
CORRECTIVE MEASURES STUDY – TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

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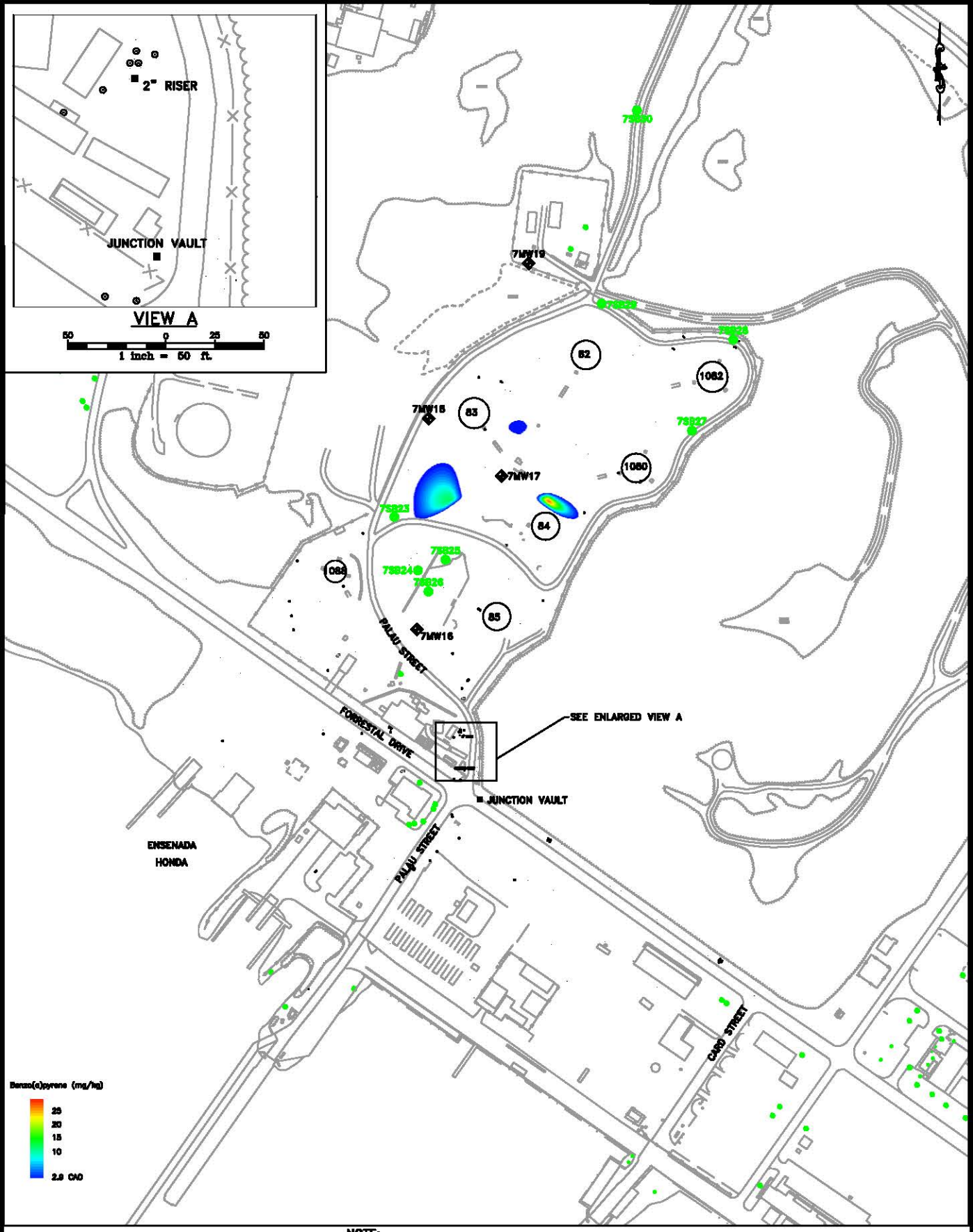
SOURCE: LANTDIV, FEB. 1962/1997

Baker

LEGEND

- ◆ – NEW MONITOR WELL LOCATION
- ● – SOIL BORING LOCATION

FIGURE 5-7
SURFACE SOIL WITH
BENZO(a)ANTHRACENE ABOVE CAO
CORRECTIVE MEASURES STUDY – TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

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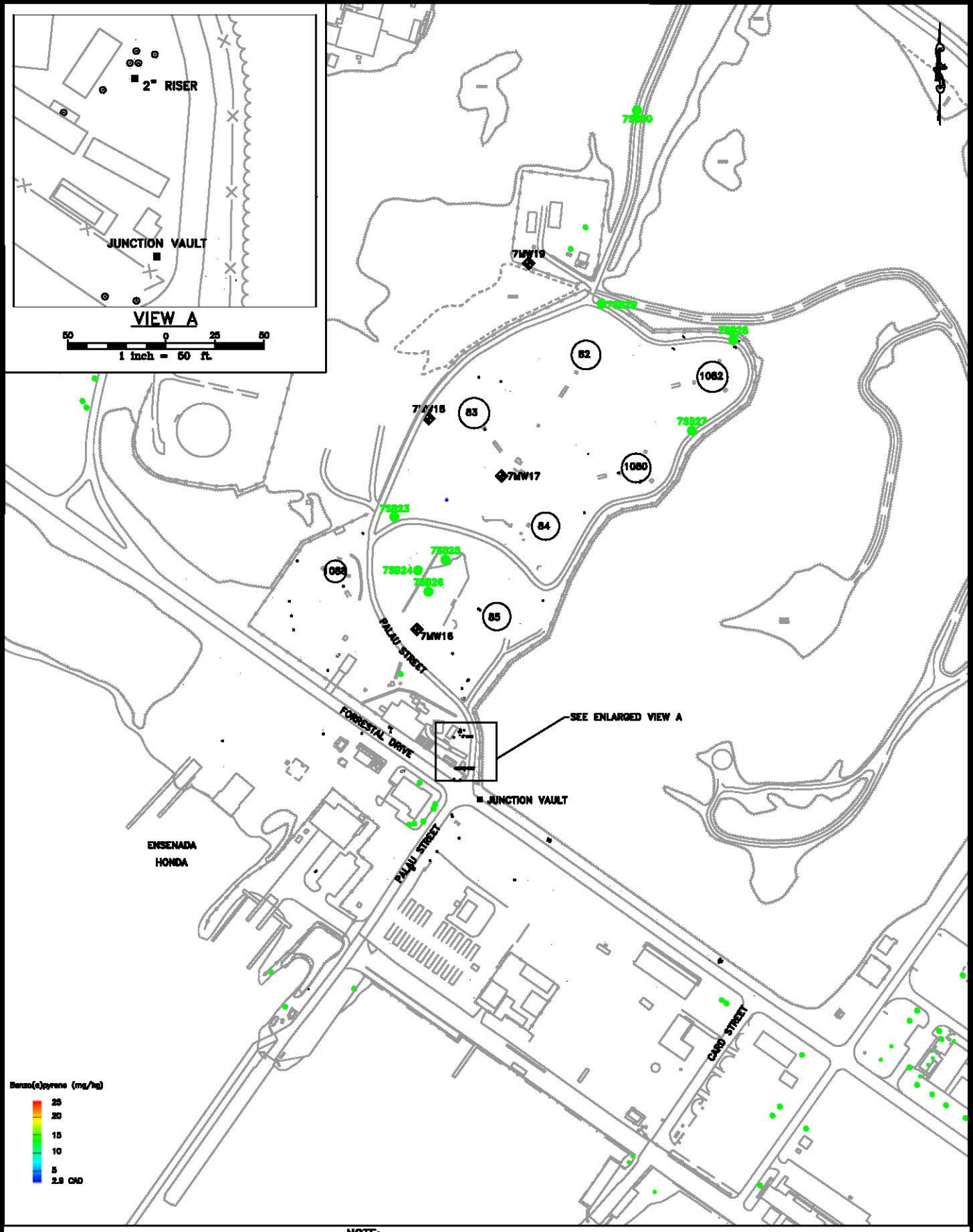
SOURCE: LANTDIV, FEB. 1962/1997

Baker

LEGEND

- ◆ – NEW MONITOR WELL LOCATION
- ● – SOIL BORING LOCATION

FIGURE 5-8
SURFACE SOIL WITH
BENZO(a)PYRENE ABOVE CAO
CORRECTIVE MEASURES STUDY – TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

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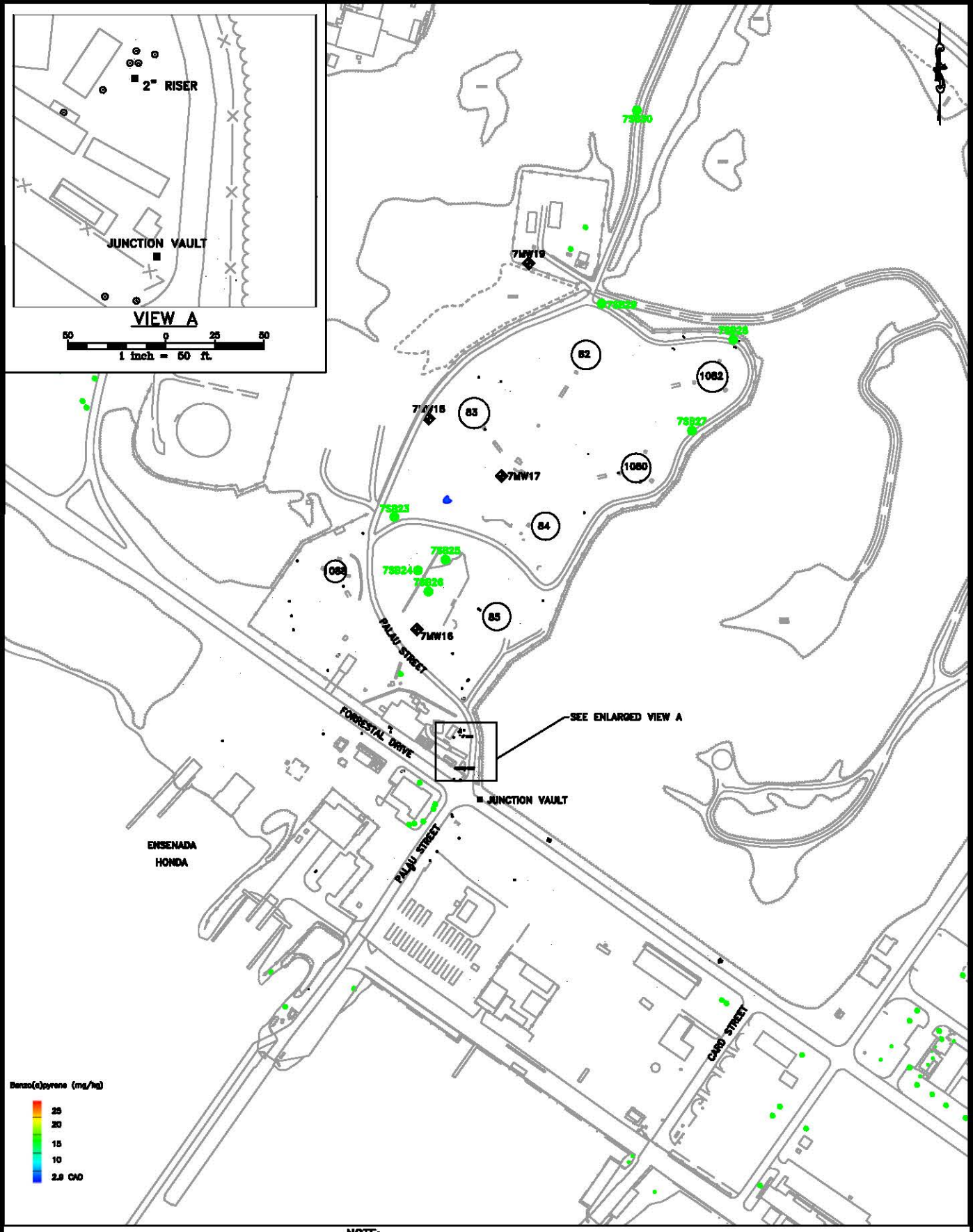
SOURCE: LANTDIV, FEB. 1962/1997

Baker

LEGEND

- ◆ – NEW MONITOR WELL LOCATION
- ● – SOIL BORING LOCATION

FIGURE 5-9
SURFACE SOIL WITH
BENZO(a)FLUORANTHENE ABOVE CAO
CORRECTIVE MEASURES STUDY – TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



NOTE:
DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

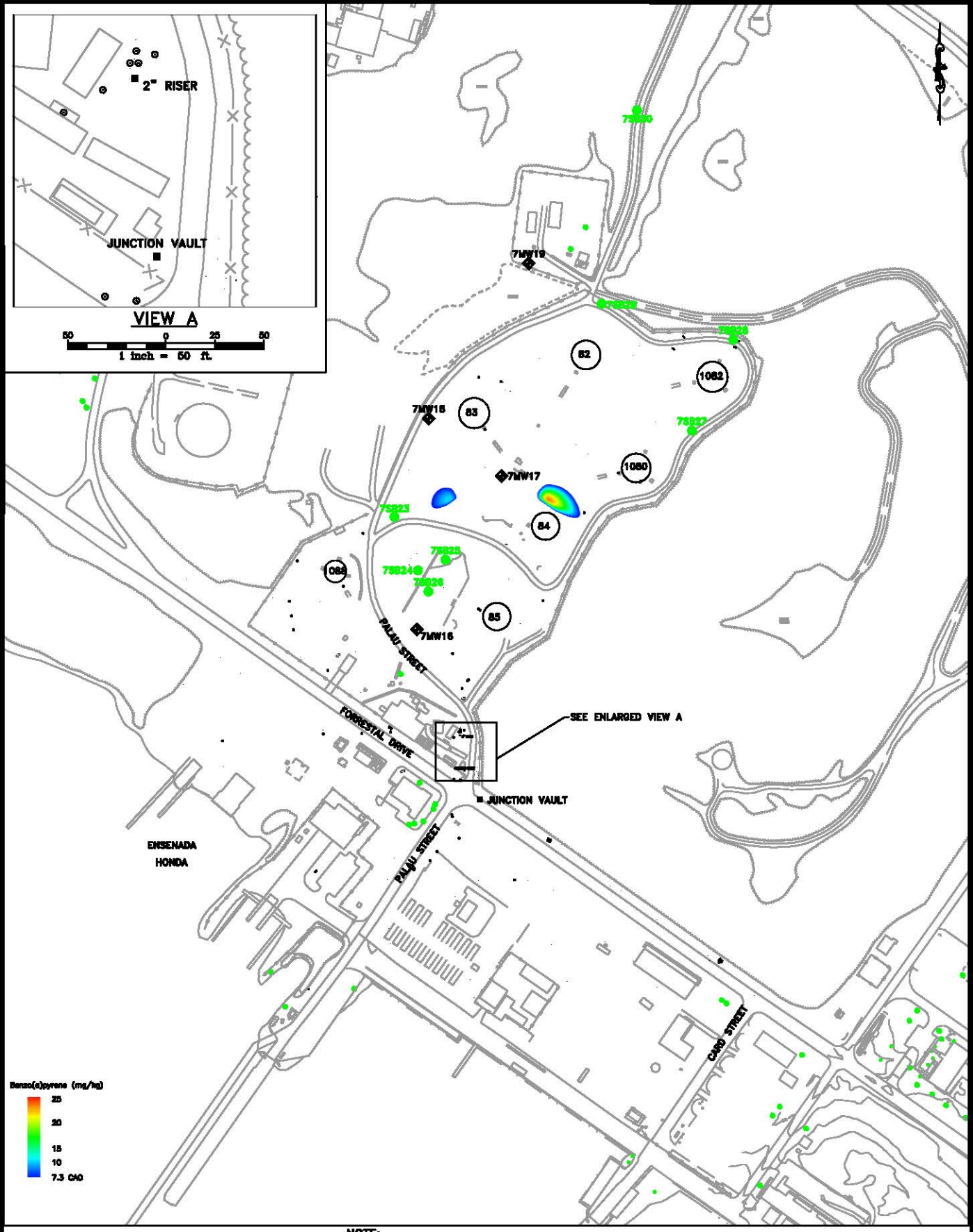
SOURCE: LANTDIV, FEB. 1962/1997

Baker

LEGEND

- ◆ – NEW MONITOR WELL LOCATION
- ● – SOIL BORING LOCATION

FIGURE 5-10
SURFACE SOIL WITH
INDENO(1,2,3-cd)PYRENE ABOVE CAO
CORRECTIVE MEASURES STUDY – TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO



LEGEND

- ◆ – NEW MONITOR WELL LOCATION
- ● – SOIL BORING LOCATION

FIGURE 5–11
TOTAL (SURFACE AND SUBSURFACE) SOIL WITH BENZO(a)PYRENE ABOVE CAO
CORRECTIVE MEASURES STUDY – TASK I REPORT
TOW WAY FUEL FARM
NAVAL STATION ROOSEVELT ROADS
PUERTO RICO