N40003.AR.001079
PUERTO RICO NA
5090.3a

Final

Corrective Measures Study Final Report for SWMUs 54 and 55 Naval Activity Puerto Rico RCRA/HSWA Permit No. PR2170027203 Ceiba, Puerto Rico

Prepared For

Department of the Navy
Naval Facilities Engineering Command Atlantic Division

Norfolk, Virginia

Under the LANTDIV CLEAN Program

Contract No. N62470-95-D-6007
CTO-0268

August 29, 2005

Prepared by

CH2M HILL

Baker
Environmental, Inc.

CDM
Federal Programs Corp.

FINAL

CORRECTIVE MEASURES STUDY FINAL REPORT FOR SWMUs 54 AND 55

NAVAL ACTIVITY PUERTO RICO
RCRA/HSWA PERMIT NO. PR2170027203
CEIBA, PUERTO RICO

CONTRACT TASK ORDER 0268

AUGUST 29, 2005

Prepared For:

DEPARTMENT OF THE NAVY
NAVAL FACILITIES
ENGINEERING COMMAND
ATLANTIC DIVISION
Norfolk, Virginia

Under the:

LANTDIV CLEAN Program
Contract N62470-95-D-6007

Prepared by:

CH2M Hill
Herndon, Virginia

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

TABLE OF CONTENTS

Page

LIST OF ACRONYMS AND ABBREVIATIONS vi

EXECUTIVE SUMMARY ES-1

1.0 INTRODUCTION 1-1
1.1 Context of the CMS Report 1-1
1.2 Objectives of the CMS Report—Tasks I, II, III, and IV 1-1
1.3 Organization of the CMS Report 1-2

2.0 TASK I—CAO DEVELOPMENT AND DETERMINATION OF CORRECTIVE MEASURE ALTERNATIVES 2-1
2.1 Site Description and History 2-1
2.1.1 SWMU 54 2-1
2.1.2 SWMU 55 2-3
2.2 Summary of Previous Investigations 2-6
2.2.1 SWMU 54 2-6
2.2.2 SWMU 55 2-7
2.3 Extent of Contamination by Media 2-9
2.3.1 SWMU 54 2-9
2.3.2 SWMU 55 2-11
2.4 Risk Assessments 2-11
2.4.1 Human Health Risk Assessments—SWMU 54 & SWMU 55 2-12
2.4.2 Screening Level Ecological Risk Assessment—SWMU 54 2-20
2.4.3 Screening Level Ecological Risk Assessment—SWMU 55 2-29
2.5 Establishment of Corrective Action Objectives 2-30a
2.5.1 Extent of Contamination Above CAOs—SWMU 54 ..... 2-30b
2.5.2 Extent of Contamination Above CAOs—SWMU 55 ..... 2-30b
2.6 Preliminary Corrective Measures Alternatives 2-31
2.6.1 Process Option Descriptions 2-32
2.6.2 Preliminary Screening of Alternatives 2-38
2.6.3 Identification of Corrective Measures Alternatives 2-39

3.0 TASK II—EVALUATION OF THE CORRECTIVE MEASURES ALTERNATIVES 3-1
3.1 SWMU 54 & 55 - Alternative 1 3-1
3.1.1 Technical 3-1
3.1.2 Environmental 3-2
3.1.3 Human Health 3-2
3.1.4 Institutional 3-2
3.1.5 Cost Estimate 3-2
3.2 SWMU 54 & 55 - Alternative 2 3-2
3.2.1 Technical 3-4
3.2.2 Environmental 3-6
3.2.3 Human Health 3-6
3.2.4 Institutional 3-7
3.2.5 Cost Estimate 3-7
3.3 SWMU 54 & 55 - Alternative 3 3-7
3.3.1 Technical 3-8
3.3.2 Environmental 3-10
3.3.3 Human Health 3-10

TABLE OF CONTENTS
(Continued)

3.3.4 Institutional 3-11
3.3.5 Cost Estimate 3-11
3.4 SWMU 54 & 55 - Alternative 4 3-11
3.4.1 Technical 3-12
3.4.2 Environmental 3-13
3.4.3 Human Health 3-14
3.4.4 Institutional 3-14
3.4.5 Cost Estimate 3-14
3.5 SWMU 55 Alternative 5 3-15
3.5.1 Technical 3-15
3.5.2 Environmental 3-16
3.5.3 Human Health 3-16
3.5.4 Institutional 3-17
3.5.5 Cost Estimate 3-17
3.6 SWMU 55 Alternative 6 3-17
3.6.1 Technical 3-18
3.6.2 Environmental 3-20
3.6.3 Human Health 3-20
3.6.4 Institutional 3-20
3.6.5 Cost Estimate 3-20

4.0 SWMU 54 TASK III—JUSTIFICATION AND RECOMMENDATION OF THE CORRECTIVE MEASURE(S) 4-1
4.1 Comparison of Alternatives 4-1
4.1.1 Comparison of Alternatives on Technical Merits 4-1
4.1.2 Comparison of Alternatives for Human Health Benefits 4-2
4.1.3 Comparison of Alternatives for Environmental Benefits 4-2
4.1.4 Comparison of Alternatives by Cost 4-2
4.2 Recommendation of the Preferred Corrective Measure 4-2
4.3 Schedule 4-3

5.0 SWMU 55 TASK III—JUSTIFICATION AND RECOMMENDATION OF THE CORRECTIVE MEASURE(S) 5-1
5.1 Comparison of Alternatives 5-1
5.1.1 Comparison of Alternatives on Technical Merits 5-2
5.1.2 Comparison of Alternatives for Human Health Benefits 5-2
5.1.3 Comparison of Alternatives for Environmental Benefits 5-2
5.1.4 Comparison of Alternatives by Cost 5-2
5.2 Recommendation of the Preferred Corrective Measure 5-3
5.3 Schedule 5-3

6.0 REFERENCES 6-1

LIST OF TABLES

2-1 Summary of Organic Detections in Surface Soil – SWMU 54
2-2 Summary of Organic Detections in Subsurface Soil – SWMU 54
2-3 Summary of Organic Detections in Groundwater – SWMU 54
2-4 Summary of Organic Detections in Groundwater – SWMU 55

TABLE OF CONTENTS
(Continued)

LIST OF TABLES
(Continued)

2-5 Surface Soil Data and COPC Selection Summary – SWMU 54
2-6 Subsurface Soil Data and COPC Selection Summary – SWMU 54
2-7 Groundwater Data and COPC Selection Summary – SWMU 54
2-8 Groundwater Data and COPC Selection Summary – SWMU 55
2-9 Summary of Quantitative CAO Calculations – Exposure via Ingestion of Chemicals in Soil – SWMU 54
2-10 Summary of Quantitative Soil CAO Calculations – Exposure via Inhalation of Chemicals in Particulates – SWMU 54
2-11 Summary of Quantitative Soil CAO Calculations – Exposure via Inhalation of Volatiles Emitted From Soil – SWMU 54
2-12 Summary of Soil-to-Air Volatilization Factor (VF) Calculation – SWMU 54
2-13 Chemical-Specific Volatilization Factor Data – SWMU 54
2-14 Summary of Quantitative CAO Calculations – Exposure via Dermal Absorption of Chemicals in Soil – SWMU 54
2-15 Summary of Quantitative CAO Calculations – Exposure via Ingestion of Chemicals in Groundwater – SWMU 54
2-16 Summary of Quantitative CAO Calculations – Exposure via Inhalation of Volatiles in Groundwater – SWMU 54
2-17 Summary of Quantitative CAO Calculations – Dermal Absorption of Chemicals in Groundwater – SWMU 54
2-18 Determination of Dermal Absorption Factor (DAF) for use in Calculating Dermal Absorption of Organic Chemicals from Water – SWMU 54
2-19 Dermal Absorption Factor Parameter Values for Groundwater COPCs – SWMUs 54 and 55
2-20 Toxicological Data Summary – SWMUs 54 and 55
2-21 Quantitative Soil CAOs – SWMU 54
2-22 Quantitative Groundwater CAOs – SWMU 54
2-23 Quantitative Groundwater CAOs – SWMU 55
2-24 List of Birds Reported from Naval Activity Puerto Rico – SWMU 54
2-25 Surface Water Screening Values – SWMU 55
2-26 Comparison of Groundwater Detections to Surface Water Screening Values - SWMU 55
2-27 Final COCs and CAOs – SWMUs 54 and 55
2-28 Preliminary Corrective Measures Technologies and Descriptions for Groundwater – SWMUs 54 and 55
2-29 Preliminary Selections of Corrective Measures Technologies – SWMUs 54 and 55

4-1 Corrective Measure Alternative Summary Table – SWMU 54
4-2 Comparison of Alternatives – SWMU 54

5-1 Corrective Measure Alternative Summary Table – SWMU 55
5-2 Comparison of Alternatives – SWMU 55

TABLE OF CONTENTS
(Continued)

LIST OF FIGURES

2-1 SWMU/AOC Location Map
2-2 Site Location Map – SWMU 54
2-3 Modified Groundwater Contour Map, March 3, 2002 – SWMU 54
2-4 Site Location Map – SWMU 55
2-5 Sample and Geologic Cross-Section Location Map – SWMU 55
2-6 Geologic Cross-Sections A-A' and B-B' – SWMU 55
2-7 Groundwater Elevations, September 25, 2003 – SWMU 55
2-8 Sample Locations, All Investigations – SWMU 54
2-9 TCE in Groundwater, February 2002 – SWMU 54
2-10 Benzene in Groundwater, February 2002 – SWMU 54
2-11 Ethylbenzene in Groundwater, February 2002 – SWMU 54
2-12 TCE Concentrations (µg/L), September 2003 – SWMU 55
2-13 Vertical Cross-Sections, TCE Concentrations, September 2003 – SWMU 55
2-14 Navy Ecological Risk Assessment Tiered Approach
2-15 Terrestrial and Aquatic Habitat at NAPR
2-16 Wetland Units at NAPR
2-17 The Cowardin Wetland Classification System
2-18 Preliminary Conceptual Model – SWMU 54
2-19 TCE in Groundwater Above CAO – SWMU 54
2-20 Benzene in Groundwater above CAO – SWMU 54

3-1 Injection Locations, Alternatives 3 and 4 – SWMU 54
3-2 Injection Locations, Alternatives 3 and 4 – SWMU 55
3-3 Injection Locations, Alternative 5 – SWMU 55
3-4 Well Locations, Alternative 6 – SWMU 55

4-1 CMS Project Schedule – SWMU 54

5-1 CMS Project Schedule – SWMU 55

LIST OF APPENDICES

A Analytical Results - SWMU 54 and SWMU 55
B Johnson and Ettinger Model
C Human Health Risk Assessment Calculations
D TCE and Benzene Fact Sheets
E Alternative 2 Calculations
F Cost Estimate Backup
G Alternative 6 Calculations

LIST OF ACRONYMS AND ABBREVIATIONS

AF	Adherence Factors
AFCEE	Air Force Center for Environmental Excellence
AOC	Area of Concern
AQUIRE	Aquatic Toxicity Information Retrieval
AST	aboveground storage tank
BaF	benzo(a)pyrene
Baker	Baker Environmental, Inc.
BB&L	Blasland, Bouck, and Lee
bgs	below ground surface
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
CAO	Corrective Action Objective
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm/sec	centimeters per second
CMS	Corrective Measures Study
CMSI	Corrective Measures Study Investigation
CNO	Chief of Naval Operations
COPCs	Chemicals of Potential Concern
C_{sat}	Soil Saturated Concentration
CVOC	Chlorinated Volatile Organic Compounds
DAF	Dermal Absorption Factor
DCE	cis-1,2-dichloroethene
DNAPL	Dense Non-Aqueous Phase Liquids
DO	Dissolved Oxygen
DoN	Department of the Navy
DRMO	Defense Reutilization and Marketing Office
DRO	Diesel Range Organics
ERA	Ecological Risk Assessment
ft/day	feet per day
feet/foot	feet per foot
ft/year	feet per year
GRO	Gasoline Range Organics
gpm	gallons per minute
HEAST	Health Effects Assessment Summary Table
HQ	Hazard Quotient
HRC	Hydrogen Release Compound
HSWA	Hazardous and Solid Waste Amendments
IR	Installation Restoration
IRIS	Integrated Risk Information System
J	Estimated Concentration
MED	Mid-Continent Ecology Division
µg/L	micrograms per liter
mg/L	milligrams per liter
MNA	Monitored natural attenuation
MTBE	methyl-tert-butyl-ether
NA	Natural Attenuation
NAPLs	Non-Aqueous Phase Liquids

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

NAPR	Naval Activity Puerto Rico
NAVFAC	Naval Facilities Engineering Command
NEX	Navy Exchange
NPDES	National Pollutant Discharge Elimination System
NSRR	Naval Station Roosevelt Roads
QA/QC	Quality Assurance/Quality Control
O & M	Operation and Maintenance
OP	Organophosphorus
ORC	Oxygen Release Compound
ORP	oxidation/reduction potential
OSWER	Office of Solid Waste and Emergency Response
PAH	Polynuclear Aromatic Hydrocarbons
PAHc	Carcinogenic Polynuclear Aromatic Hydrocarbons
PCBS	Polychlorinated Biphenyls
PEF	Particulate Emission factor
PSI	pounds per square inch
RBCs	Risk Based Concentrations
RCRA	Resource Conservation and Recovery Act
RFC	Reference Concentration
RFD	Reference Dose
RFI	RCRA Facility Investigation
SA	surface area
SERA	Screening-Level Ecological Risk Assessment
SF	slope factor
STSc	Superfund Technical Support Center
SWMU	Solid Waste Management Unit
SVOCs	Semivolatile Organic Compounds
T	total exposure time
TCA	Trichloroethane
TCE	Trichloroethene
TEA	Terminal Electron Acceptor
TPH	Total Petroleum Hydrocarbons
TWFF	Tow Way Fuel Farm
USEPA	United States Environmental Protection Agency
UIC	Underground Injection Control
USACE	United States Army Corps of Engineers
USGS	United States Geological Society
USFWS	United States Fisk and Wildlife Service
UST	Underground Storage Tank
UV	Ultraviolet
VF	Volatization Factor
VOC	Volatile Organic Compound
VC	Vinyl Chloride

EXECUTIVE SUMMARY

INTRODUCTION

This Corrective Measures Study (CMS) Report is prepared for Solid Waste Management Units (SWMU) 54 and 55 located at Naval Activity Puerto Rico (NAPR), Ceiba, Puerto Rico under the Corrective Action provisions of the Resource Conservation and Recovery Act (RCRA) permit (RCRA/HSWA Permit No PR 2170027203). The report has been prepared by Baker Environmental, Inc. (Baker) under contract to the Naval Facilities Engineering Command (NAVFAC) Atlantic, Contract Number N62470-95-D-6007.

It should be noted that until this report, all information relating to SWMU 55 has been published under the Tow Way Fuel Farm (TWFF) reports and SWMU 7 or SWMU 7/8 reports, specifically the area known as the "Trichloroethene (TCE) Plume." Subsequent to the publication of the draft version of the *Final TCE Plume Delineation and Source Investigation Report* (Baker, 2004), SWMU 55 was created as a separate SWMU from SWMU 7 or the TWFF.

The objective of the CMS for SWMUs 54 and 55 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 corrections actions at each SWMU. Task I includes a description of current conditions at the sites, establishes clean-up goals at the two sites, and includes an initial screening of the possible corrective actions for the two SWMUs. The evaluation of the corrective measure alternative or alternatives is conducted in Task II. The Task III justifies and recommends a corrective measure alternative using technical, human health, and environmental criteria. Task IV is simply the reporting task. The SWMUs were evaluated separately in each Task of the CMS.

TASK I

SWMU 54--Former NEX Repair/Maintenance Shop (Building 1914)

SWMU 54 is the Former NEX Repair/Maintenance Shop (Building 1914) built in 1979. It is currently unoccupied and lies on approximately 1 acre of land in the Bundy Area of Naval Activity Puerto Rico (NAPR). The building structure and pavement covers approximately 40 percent of the total SWMU 54 acreage. The stratigraphy observed during the RFI consisted of two distinct units, consisting of a surficial fill and clay. Groundwater flow beneath SWMU 54 appears to be divided with a ridge from northwest to the southeast, and is observed approximately 5 feet below the ground surface. The maximum groundwater velocity calculated at the site is 1 foot/year.

During the previous investigations, surface soil, subsurface soil, and groundwater media were found to be contaminated. However, throughout all the investigative reports, the groundwater was the only media forwarded for further investigation. During the Task I process, both a human health risk assessment and a screening level ecological risk assessment (ERA) were performed on the available data. The screening-level ERA for SWMU 54 indicated that, while source areas exist at SWMU 54, there are no complete and/or significant exposure pathways. As such, no further action is recommended at SWMU 54 for ecological resources. The corrective action objective (CAO) formulations for human health resulted in the presence of two compounds, benzene and trichloroethene, above corrective action objectives in the groundwater only. These two compounds are not co-located at the SWMU. Figures 2-19 and 2-20 depict the extent of contamination above the benzene CAO of 550 ug/L and the TCE CAO of 22 ug/L in SWMU 54 groundwater. The vertical extent of the contamination is assumed to be from 5 feet below the

ground surface to 25 feet below the ground surface. A depth of 25 feet below the ground surface was chosen conservatively since the previous investigations stopped at 20 feet below the ground surface. Justification for this depth is provided by well 54DW01, which is screened from 20 to 25 feet below the ground surface, and has no contamination above the CAOs. The aerial extent of the TCE plume is approximately 60 feet by 140 feet or 8,400 square feet (assuming a rectangular area). The aerial extent of the benzene plume is approximately 40 feet by 55 feet or 2,200 square feet (assuming a rectangular area).

SWMU 55—TCE Area at the Tow Way Fuel Farm

SWMU 55 is located in the eastern portion of NAPR as shown on Figure 2-1. The TCE area at the Tow Way Fuel Farm (TWFF) is located south of Forrestal Drive near the pad of former Building 46, now designated as Building 2314, southeast of the main area of the TWFF as presented on Figure 2-4. Previous investigations performed in the TWFF area, as well as the areas south of Forrestal Drive revealed that TCE was present in the groundwater in monitor well 7MW07 at elevated concentrations. The geology at SWMU 55 consists mainly of fill material, decomposed bedrock, and lithofied bedrock. Near the Ensenada Honda marine deposits are found on top of the bedrock formations. These marine deposits consist of interbedded coarse-grained and fine-grained sediments. The groundwater table slopes toward Ensenada Honda, and is located approximately 10 feet below the ground surface. An estimated range of groundwater velocity at SWMU 55 would be 52 feet/year to 113 feet/year.

Previous investigations have determined that the groundwater at SWMU 55 is contaminated with TCE. The establishment of CAOs for SWMU 55 was conducted during the TWFF Task I (Baker, 2003c). However, during the TCE Plume Delineation and Source Investigation Report (Baker, 2004), several additional compounds were found to be present in the TCE area at concentrations above those seen during the Task I process for the TWFF. As a result, these compounds were re-evaluated for human health and ecological risk. TCE in groundwater was found to be the only compound in excess of the human health based CAO of 22 ug/L at SWMU 55. The extent of contamination above this CAO can be seen on Figure 2-12. The approximate vertical extent of contamination will be assumed to be from 10 feet below the ground surface to 35 feet below the ground surface, and the aerial extent is approximately 150 feet by 180 feet, assuming a rectangular area.

Formulation of Alternatives

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 SWMUs 54 and 55.

- No Action
- Institutional Controls
- Containment/Collection
- In-situ Biological Treatment, including Monitored Natural Attenuation
- In-situ Physical/Chemical Treatment
- Ex-situ Biological Treatment and Discharge
- Ex-situ Physical/Chemical Treatment and Discharge
- Monitored Natural Attenuation

The above processes were screened and the following alternatives were formulated for evaluation under Task II:

SWMU 54

- Alternative 1
  No Action

- Alternative 2
  Institutional Controls and Monitored Natural Attenuation

- Alternative 3
  Institutional Controls, Enhanced Bioremediation (optional Bioaugmentation) and Monitored Natural Attenuation

- Alternative 4
  Institutional Controls, Oxidation, and Monitored Natural Attenuation

SWMU 55

- Alternative 1
  No Action

- Alternative 2
  Institutional Controls and Monitored Natural Attenuation

- Alternative 3
  Institutional Controls, Enhanced Bioremediation (optional Bioaugmentation), and Monitored Natural Attenuation

- Alternative 4
  Institutional Controls, Oxidation, and Monitored Natural Attenuation

- Alternative 5
  Institutional Controls, Reduction, and Monitored Natural Attenuation

- Alternative 6
  Institutional Controls, Groundwater Extraction with Liquid Phase Carbon Adsorption, Re-injection, and Long Term Monitoring

Each alternative except Alternative 1 addresses groundwater constituents at the SWMUs. Institutional controls and monitored natural attenuation are consistent throughout each alternative with the exception of Alternative 1—no action, and Alternative 6, where long-term monitoring is proposed rather than MNA.

Alternative 1 is the no action alternative. The no action alternative is not required to be evaluated by the RCRA Part B Permit; however, it was forwarded due to the relatively small probability of groundwater exposure at these SWMUs. It is not expected that the contaminated groundwater will migrate beyond the respective SWMU boundaries at NAPR.

Alternative 2 consists solely of institutional controls and monitored natural attenuation. This alternative would provide an assessment of naturally occurring degradation processes and occurrence of off-site migration at the respective SWMUs as the plumes are monitored with time. In addition, institutional controls in the form of a deed restriction on groundwater extractions would protect human health.

Alternative 3 utilizes institutional controls, enhanced bioremediation with optional bioaugmentation, and monitored natural attenuation to reduce contaminant concentrations at the SWMUs. It is not expected that active bioremediation will reduce concentrations below MCLs. As a result, monitored natural attenuation would likely still be required. Enhanced bioremediation options include the addition of an electron donor to the TCE-contaminated groundwater to promote reductive dechlorination, and the addition of a source of oxygen to promote biodegradation of the benzene-contaminated groundwater.

Alternative 4 includes the use of institutional controls, oxidation of contaminants through the use of an oxidizing agent such as permanganate or Fenton's reagent, and subsequent monitored natural attenuation for any remaining contamination.

Alternative 5 consists of institutional controls, and active remediation of the TCE plume at SMWU 55 using a reductive technology such as zero-valent iron, followed by monitored natural attenuation.

Alternative 6 utilizes institutional controls, groundwater extraction, treatment, and re-injection for five years with subsequent long term monitoring at SWMU 55.

TASK II

In Task II the various alternatives were evaluated with regard to the criteria set up in Appendix B of Module III of the RCRA Part B Permit. The technical, environmental, human health, and institutional concerns associated with each alternative were discussed. Because alternatives 1 through 4 are the same for both SWMUs, these were evaluated once, with SWMU differences due to site constraints and site conditions discussed within the text. Alternatives 5 and 6 were forwarded for SWMU 55 only.

In the technical evaluation, the performance, reliability, implementability, and safety of each alternative were evaluated. The performance is measured by the effectiveness and useful life of the alternative. The effectiveness is the ability of the alternative to perform the intended functions, such as contain, divert, remove, destroy, or treat the COCs. The combination of various technologies in the alternatives will be evaluated as a whole. Should a particular technology or process within the alternative be responsible for reducing the performance of the alternative, this was evident during these evaluations. The reliability is measured by the operation and maintenance requirements of the alternative and the risk and effect of failure of the alternative. Implementability criteria reflect the constructability of the alternative, the time it takes to implement the alternative, and the time of expected beneficial results. Any threat to the safety of the nearby communities and environments as a result of the alternative, including worker safety during implementation, was also evaluated.

In the environmental assessment of the alternative, the short and long term beneficial and adverse effects of the alternative on environmentally sensitive areas were assessed.

The protection of human health criteria examined the extent to which each alternative mitigates short and long term potential exposure to contamination. Residual levels expected from each alternative were compared to the CAOs.

Each alternative was assessed as to the requirements needed to meet relevant Federal, State, and local standards, regulations, ordinances and community relations.

A cost estimate of each alternative, including capital costs and operation and maintenance costs, was also provided.

TASK III—SWMU 54

At SWMU 54, Alternative 2, which includes MNA and institutional controls, was ranked above all other alternatives in most of the categories, including cost. However, because of the desire to reduce the time frame for implementation, it is likely that the next ranking alternative will be also be considered as viable. There are two areas of concern at SWMU 54, and it is possible to separate the two areas and recommend one alternative for the benzene plume and another alternative for the TCE plume.

At the benzene plume, a pilot test is recommended to evaluate the feasibility of alternative 3, enhanced bioremediation with ORC®. If this were successful, then a full-scale remediation of the benzene plume using Alternative 3 would be implemented.

It is clear that the TCE plume at SWMU 54 is relatively low in concentration. In addition, it has been fairly well delineated and the groundwater flow velocity is very low at this SWMU. It is recommended that MNA be combined with this alternative as a corrective measure for the TCE plume. The cost for this combination of alternatives is $1,386,858 as given in Appendix F. This cost is not shown on Table 4-2, since it is a combination of two alternatives. However, as expected, it is more than the cost for alternative 2 but less than the cost for alternative 3.

TASK III—SWMU 55

At SWMU 55, Alternative 2, which includes MNA and institutional controls, was ranked above all other alternatives in most of the categories, including cost. However, because of the desire to reduce the time frame for implementation, it is likely that the next ranking alternative will be considered as viable. The next-ranking alternatives overall, exclusive of cost, were Alternatives 4 and 5, the injection of oxidants and zero valent iron. However, the cost of Alternative 5 may be prohibitive to consider full-scale implementation. A pilot test of this technology would likely cost around $300,000. A pilot test of Alternative 4 would likely cost around $100,000.

The fourth overall ranking, exclusive of cost, was Alternative 3. The difference in this alternative included a slightly higher risk due to formation of vinyl chloride. Cost estimates also rank Alternative 3 below Alternative 4.

It is recommended that a pilot test of injection of sodium permanganate be performed to evaluate this oxidation technology at SWMU 55. Issues to address in the pilot test are related to constructability, that is the ability of the injections to reach the site contaminants, and any rebounding that may occur. The results of the pilot test should be used in the design phase of the corrective measure, allowing a successful application of this technology as the final corrective measure at this site.

1.0 INTRODUCTION

This Corrective Measures Study (CMS) Report is prepared for Solid Waste Management Units (SWMU) 54 and 55 located at Naval Activity Puerto Rico (NAPR), Ceiba, Puerto Rico under the Corrective Action provisions of the Resource Conservation and Recovery Act (RCRA) permit (RCRA/HSWA Permit No PR 2170027203). The report has been prepared by Baker Environmental, Inc. (Baker) under contract to the Naval Facilities Engineering Command (NAVFAC) Atlantic, 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 the former Naval Station Roosevelt Roads (NSRR), now NAPR. This permit contains requirements for RCRA Facility Investigation (RFI) activities at 24 SWMUs and three area 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 NAPR, included provisions for corrective action under the Hazardous and Solid Waste Amendments (HSWA) provisions of RCRA.

1.1 Context of the CMS Report

This report was developed to meet the requirements of Tasks I, II, III, and IV under Module III, Appendix B (Scope of Work for a CMS) as contained in the NAPR RCRA Part B Permit. The CMS Report identifies the corrective measure technologies to address the contamination present at both sites from 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. Previous reports at both SWMUs have been finalized and recommendations have been addressed so as to eliminate the production of a separate Task I report. Based on discussions with the USEPA, this CMS report will be produced as outlined in the CMS Work Plan for SWMUs 53 and 54 (Baker, 2003a).

At this time, management of the former NSRR has been turned over to NAPR. This entity is controlling the property in the same manner as during its use as an active naval facility. Land use is remaining industrial and corrective action requirements are still addressed under the Final RCRA Part B Permit. Transfer of property or parcels of property from NAPR to other entities (currently unknown) will require transfer of the USEPA Part B Permit to that entity for that parcel of property as well, and the USEPA will be involved in that transfer. At the current time, the land use at NAPR is industrial, and will be maintained as industrial as long as NAPR manages the property.

It should be noted that until this report, all information relating to SWMU 55 has been published under the Tow Way Fuel Farm (TWFF) reports and SWMU 7 or SWMU 7/8 reports, specifically the area known as the "Trichloroethene (TCE) Plume." Subsequent to the publication of the draft version of the *Final TCE Plume Delineation and Source Investigation Report* (Baker, 2004), SWMU 55 was created as a separate SWMU from SWMU 7 or the TWFF.

1.2 Objectives of the CMS Report—Tasks I, II, III, and IV

SWMU 54 and SWMU 55 are located in different areas of NAPR. This CMS Report will evaluate each SWMU separately. However, because of similarities in the site contamination, discussion of potential corrective measures at the SWMUs will be done together so as to make

efficient use of Navy funds. Any potential alternatives applicable only to a single SWMU, that is, either SWMU 54 or SWMU 55, will also be evaluated.

The objective of the CMS for SWMUs 54 and 55 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 corrections actions at each SWMU. Task I includes a description of current conditions at the sites, establishes clean-up goals at the two sites, and includes an initial screening of the possible corrective actions for the two SWMUs. The evaluation of the corrective measure alternative or alternatives is conducted in Task II. The Task III justifies and recommends a corrective measure alternative using technical, human health, and environmental criteria. Task IV is simply the reporting task.

1.3 Organization of the CMS Report

This report is divided into six sections based on the above-mentioned CMS Tasks. Section 1 contains the introductions, the context of the CMS, and objectives of the CMS Report. Section 2 contains items associated with Task I for both SWMU 54 and SWMU 55. Section 3 provides an evaluation of the alternatives at both SWMU 54 and 55, essentially Task II. Sections 4 and 5 contain Task III items for SWMU 54 and SWMU 55, respectively. Section 5 provides a listing of the references used in this report.

2.0 TASK I – CAO DEVELOPMENT AND DETERMINATION OF CORRECTIVE MEASURE ALTERNATIVES

The first task of this CMS report is to describe the current conditions and extent of contamination and promulgate the corrective action objective (CAO) for each contaminated media at SWMU 54 and SWMU 55, respectively. These will be established independently of each other in the subsections that follow. Once the CAOs are established, the extent of contamination above the CAOs will be described at each SWMU.

2.1 Site Description and History

The two subsections that follow contain a description and history, as well as site geology and hydrogeology for Solid Waste Management Unit (SWMU) 54 – Building 1914 (Former Navy Exchange [NEX] Repair/Maintenance Shop) and SWMU 55 (Trichloroethene [TCE] Plume near Tow Way Fuel Farm).

2.1.1 SWMU 54

The Former NEX Repair/Maintenance Shop (Building 1914) built in 1979, is currently unoccupied and lies on approximately 1 acre of land in the Bundy Area of Naval Activity Puerto Rico (NAPR) (Figure 2-1). The building structure and pavement covers approximately 40 percent of the total SWMU 54 acreage. This SWMU contains a slight slope to the west and a small hill to the east approximately 100 feet in elevation. A small hill lies in the southern part of this SWMU, which is approximately 50 feet in elevation. The building structure itself consists of a small concrete block building with a center office area and open bays on either side. The building was used to perform maintenance on vehicles including oil changes, lubrications, etc. No wastes are known to have been disposed of at the unit and there are no known releases related to the unit. SWMU 54 is located north-northeast across Bairoko Street from SWMU 26 and west across Bairoko Street from Building 1686 (Former Base Laundromat), as presented on Figure 2-2. Site 510 is an underground storage tank (UST) site consisting of a 4,000 gallon UST associated with Building 510, located south of Building 1914, as presented on Figure 2-2. The UST was constructed of steel and used to store fuel for fueling operations conducted in the area. The date of installation and the type of fuel stored is unknown, but was assumed to be gasoline. In December 1992, the tank was removed from Site 510 (Blasland, Bouck, and Lee [BB&L], 1995).

The information gathered from the visual site inspection performed by CH2M Hill and environmental staff at NAPR revealed that there were several areas of oil stained soil around NEX Building 1914 (CH2M Hill, 2000). For that reason, it was recommended that a sampling program be performed to characterize the areas around several structures in the SWMU 54 area. The results from the Site Characterization for Site 510 developed by BB&L (BB&L, 1995) were taken into consideration in development of the work plan utilized during the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) investigation, due to the close proximity of its existing monitor wells to SWMU 54. CH2M Hill also observed two open excavation locations south of the building containing algae stained water. With this information, along with the activities (oil changes, lubrications, etc.) known to have taken place at this SWMU, a site characterization was performed to determine whether a release of hazardous waste including hazardous constituents has occurred, is likely to have occurred, or is likely to occur.

2.1.1.1 Site Geology

The stratigraphy observed during the RFI consisted of two distinct units, consisting of a surficial fill and clay. Only three borings were advanced in SWMU 54 as part of the RFI. However,

observations correlate well with those of the more-extensive site characterization of Site 510 (BB&L, 1995) and the Sampling and Analysis Investigation (Baker, 2001a). The paragraphs that follow describe site stratigraphy based on the RFI, supplemented with information from the BB&L study (BB&L, 1995) and the 2000 Sampling and Analysis investigation.

The surficial fill was observed to consist of predominantly silt or fine sand, with lesser amounts of fine to coarse gravel and cinders as documented in test boring and well construction records presented within the EPA approved Final RFI Report (Baker, 2003d). The fill was observed to be approximately two-feet thick in all three borings (surface to two-feet below ground surface [bgs]) advanced during the RFI, and the soil borings advanced during the 2000 Sampling and Analysis investigation. BB&L observed the fill to be clay and gravel fill approximately two- to four-feet thick.

A predominantly clay unit was generally observed from 2-feet bgs to boring terminus (20-feet bgs). This clay unit was observed to contain thin silt lenses in all three borings advanced during the RFI. Some thin clay-filled fractures were additionally observed in all borings. BB&L also observed this clay unit throughout the site to a depth of approximately 45-feet (at well 510DW2). This clay is likely a saprolite. A saprolite is a soft, thoroughly decomposed rock, which is predominantly composed of clay-rich minerals. Saprolite is formed in place by chemical weathering of igneous rocks (typically in tropical climates).

2.1.1.2 Site Hydrogeology

Groundwater was encountered during the SWMU 54 RFI. Groundwater was measured in the permanent and temporary wells at three different times. Based on depth to groundwater, as presented in the EPA approved Final RFI Report (Baker, 2003d), potentiometric surface maps were generated (Figure 2-3) for the March 3, 2002 round of water levels. As mentioned in the RFI Report, Figure 2-3 was generated without using information from locations 54PZ02, 54TW07, 54TW12, and 510MW1, due to mounding identified in these areas caused by perched groundwater on clay lenses.

Utilizing Figure 2-3, groundwater flow beneath SWMU 54 appears to be divided with a ridge from northwest to the southeast. These groundwater flow directions have been determined from evaluating groundwater data from 29 measurement points across the site. Long-term evaluations of groundwater flow directions and gradients have not been performed at this site, resulting in a great deal of uncertainty in this information. Gradients calculated from the potentiometric contours on Figure 2-3 range from 0.001 to 0.003 feet/foot.

Evidence from the RFI investigation, as well as the BB&L Site Characterization suggests that groundwater beneath SWMU 54 occurs in a low-yield (low hydraulic conductivity) aquifer with narrow relatively higher yield zones. Clay was observed to predominate in the subsurface at SWMU 54 as described in the previous subsection. Boring logs from the BB&L report suggest that the clays appeared only moist, substantial flow zones were not observed. Additionally, BB&L reported hydraulic conductivity to range from 0.027 feet per day (ft/day) (9.5×10^{-6} centimeters per second [cm/sec]) to 0.272 feet/day (9.6×10^{-5} cm/sec). These values were calculated based on the Bouwer and Rice method using slug tests results. In some of the temporary wells, field personnel observed narrow flow zones (approximately 0.5 feet thick) embedded in moist clay. These zones likely correspond to fractures in the clay and would exhibit a higher hydraulic conductivity than the surrounding matrix.

Based on the above quantifications of hydrogeologic parameters, the groundwater velocity can be estimated using Darcy's Law (velocity = hydraulic conductivity-k * hydraulic gradient-i /

porosity-n, or v = ki/n). Using a range of 0.0272 ft/day to 0.272 ft/day for hydraulic conductivity, 0.001 to 0.003 ft/foot for hydraulic gradient, and a porosity of 0.3 (assumed), the resulting groundwater flow velocity range is 0.03 ft/year to 1 ft/year. Even the largest of these values indicates a very slow groundwater velocity at this site.

2.1.2 SWMU 55

SWMU 55 is located in the eastern portion of NAPR as shown on Figure 2-1. The TCE area at the Tow Way Fuel Farm (TWFF) is located south of Forrestal Drive near the pad of former Building 46, now designated as Building 2314, southeast of the main area of the TWFF as presented on Figure 2-4. Previous investigations performed in the TWFF area, as well as the areas south of Forrestal Drive revealed that TCE was present in the groundwater in monitor well 7MW07 at elevated concentrations. After these concentrations were detected in the groundwater, a history of the buildings in proximity to 7MW07 was compiled based on interviews with station personnel, and an investigation was performed (Baker, 2000). A substantial structure (Building 46), located on the building pad immediately northeast of 7MW07 (between Forrestal Drive and the well), was destroyed during Hurricane Hugo in September 1989. This building was reportedly used for the storage and maintenance of small watercraft used in various harbor operations. While the repair activities had apparently been somewhat limited, the fact that maintenance was performed indicates the potential for cleaning and degreasing operations. This activity could potentially have led to a release of solvents. Also, it is unclear to what extent the buildings were used for storage and what was stored. The potential of a release of stored material in the past must be considered. Building 46 was rebuilt in 1991 as Building 2314; a commercial storage building used by Surface Operations and Morale, Welfare, and Recreation Departments. Building 2314 was originally a Quonset-style building with a cloth roof. This building was used for cold storage, and partially destroyed during Hurricane Georges in September 1998. Currently, Building 2314 exists as an uncovered concrete foundation with several unused walk-in freezers and buoys placed on top of the foundation.

2.1.2.1 Site Geology

Several reports have documented the TWFF geology at this location, including most recently, the *Final TCE Plume Delineation and Source Investigation Report* (Baker, 2004). This section will focus on the geology as it is currently understood in the immediate location of the TCE plume.

During the 1999 TCE investigation (Baker, 2000), a conceptual model of the geology was developed through installation of wells and advancement of borings and illustrated in cross sections. This conceptual model identified unconsolidated and consolidated formations. The unconsolidated formations were categorized as fill and marine deposits. The consolidated formation was identified as Gabbro bedrock. This Gabbro was identified as either soft (decomposed) or hard (weathered or unweathered lithofied bedrock).

Based on information collected during the most recent investigation (*Final TCE Plume Delineation and Source Investigation Report*, Baker 2004), the conceptual model was updated. The physical conceptual model generally did not change, but the terms describing the geology has. The terms “hard” and “soft” have been replaced with “decomposed” and “lithofied”, respectively. The terms “hard” and “soft” were defined by split spoon blow counts. The new definitions of decomposed and lithofied are broader. The term decomposed considers not only blow counts, but also includes a visual description and qualitative drilling pressures. Decomposed bedrock is defined by the following:

- Gabbro rock fragments in a fine-grained matrix or as a sapprolite. (Sapprolite is decomposed bedrock that has maintained its original crystal structure.)

- Split spoon sampling generally occurring with blow counts of less than 50 blows per 6-inch interval, and penetrations greater than 0.5-foot.

- Augers can generally be used to advance the boring.

Lithofied bedrock is defined by the following:

- Gabbro rock fragments without a fine-grained matrix, or only a trace of fine-grained matrix.

- Split spoon sampling generally occurring with blow counts of more than 50 blows per 6-inch interval, with penetrations less than 0.5-foot.

- The down-hole hammer is generally required to advance the boring.

As presented in the Final TCE Plume Delineation and Source Investigation Report (Baker, 2004), the geology at this site is illustrated by two new cross sections with orientations as shown on Figure 2-5. The geology is generally similar with previous investigations.

Cross Section A-A' is somewhat perpendicular to Forrestal Drive. Similar to previous investigations three different formations are shown in this cross section; fill material, marine deposits, and bedrock (Cross Section A-A' on Figure 2-6). Fill material is present across the entire section and consists predominantly of rock fragments, with lesser amounts of sand, silt, and clay. In the area of 7MW23 and TW-3, the fill material consists mostly of cobbles. The fill material is thinnest near Ensenada Honda (approximately 1-foot thick), and thickens in the vicinity of the harbor police maintenance building (approximately 4-feet thick). Lithofied and decomposed bedrock are present along this section. Decomposed bedrock is present in the vicinity of well 7MW23 and boring 7TCESB08. This decomposed bedrock was generally observed as sand, silt, or clay, and rock fragments in varying amounts. The lithofied bedrock is gray and black in color and unweathered, to brown in color and weathered. Lithofied bedrock is present below the decomposed zones, indicating a pattern of progressively less weathering with depth. It is evident that the top of the bedrock dips to the southwest, toward the Ensenada Honda. This is likely an erosional feature, presumably caused by the Caribbean Sea, and replaced by marine deposits. These marine deposits consist of interbedded coarse-grained and fine-grained sediments. The upper coarse-grained marine bed consists of fine to coarse sand and shell/coral fragments. The fine-grained marine beds consist of silt or clay with a trace amount of shell fragments. The lower coarse-grained marine bed consists of fine to coarse sand with some clay and a lesser amount of shell and coral fragments.

Cross-section B-B' is somewhat parallel to Forrestal Drive. Again, this cross-section is similar to previous cross sections, showing the progression of fill, decomposed bedrock, and lithofied bedrock (see Figure 2-6). The thickness of the filled material is variable, from 1-foot (e.g., temporary well 7TCETW208) to 6-feet (e.g., boring 7TCESB03). This fill generally consists of fine sand and rock fragments, with a lesser amount of silt and clay. The existence of decomposed bedrock in this section is sporadic. A relatively deep channel of decomposed bedrock is evident between temporary well 7TCETW207 and boring 7TCESB01. This decomposed bedrock is characterized as highly fractured, easily crumbled Gabbro, and with silt-size particle zones. At well 7MW07, it is characterized as rock fragments in a silt matrix. A narrower and shallower decomposed bedrock zone is evident in the vicinity of boring 7TCESB03 and temporary well

TW-C, and is similar in character as the other zone. Lithofied bedrock predominates along the southeastern end of this section, in the vicinity of well 7TCETW208. The lithofied bedrock is mainly gray or greenish-gray in color and unweathered, to brown in color and weathered.

On cross-section B-B', the contact between the decomposed and lithofied bedrock in the vicinity of boring 7TCESB05 and well 7MW07 was interpreted based on borings 7TCESB01 and 7TCESB02, rather than well 7MW07. This contact appears to be considerably shallower in borings 7TCESB01 and 7TCESB02 compared with well 7MW07. There were some subjective characterization differences (e.g., descriptions) and objective characterization differences (e.g., blow counts) between the borings and the well. The lithology descriptions from borings 7TCESB01 and 7TCESB02 were used to interpret the geology on cross-section B-B'. At this time it is not clear what has caused the difference; however, as mentioned in the Final TCE Plume Delineation and Source Investigation Report (Baker, 2004), one possibility might be that the presence of decomposed bedrock at well 7MW07 to 28-feet bgs is due to a narrow fracture and attendant weathered zone at the well.

2.1.2.2 Site Hydrogeology

Figure 2-7 depicts the top of the groundwater-bearing zone as it was encountered in the monitoring wells, both temporary and permanent, during the current TCE Investigation. The groundwater table slopes toward Ensenada Honda as shown. At this time, Cape Environmental is recording groundwater elevations in this area on a monthly basis as part of the RCRA Quarterly Monitoring. The hydraulic gradient at the site, as measured on Figure 2-7, is approximately 0.006 feet/foot.

There is not a well-defined contact between the residual soil and bedrock at the TWFF, including the SWMU 55 area; rather, there is a gradational change of decreased weathering and fracturing with increasing depth. There is no distinct physical or hydraulic boundary between the residual soil and the bedrock, therefore, they are considered as one hydrogeologic unit.

Hydraulic conductivity was measured at two monitor wells (7MW10 and UGW16) during the previous investigations at this SWMU. The hydraulic conductivity in the lower portion of TWFF (i.e., including one portion now considered SWMU 55 area) is generally higher than the conductivity in the upper portion of the TWFF. The hydraulic conductivity in a portion of the lower TWFF area (i.e., SWMU 55), was approximately 4.77 feet/day in the vicinity of 7MW10 during January 2002. This information was obtained from the results of a slug test. It should be noted that 7MW10 was not located in fractured bedrock (Baker, 2003b). The description on the boring log reads "medium to coarse sand and fine gravel." This description differs considerably from the "light brown and gray rock, angular" describing the boring at 7MW07, where the contaminant plume is located. During the RCRA Facility Investigation (RFI) (Baker, 1997), slug tests were performed at wells located in the lower TWFF. The result of a slug test done at well UGW16, located just northwest of SWMU 55 was 10.31 feet/day, similar to that found at 7MW10.

Using the above estimated hydrogeologic parameters, an approximate groundwater flow velocity can be determined from Darcy's Law as described in Section 2.1.1.2. Using the range of hydraulic conductivity provided above, and an assumed porosity of 0.2, an estimated range of groundwater flow at SWMU 55 would be 52 feet/year to 113 feet/year.

2.2 Summary of Previous Investigations

This section summarizes the findings of previous environmental investigations conducted at SWMUs 54 and 55.

2.2.1 SWMU 54

Three investigations have occurred at this site including a Site Characterization for Site 510, a Sampling and Analysis Investigation, as well as a RCRA Facility Investigation. A description of each investigation performed at SWMU 54 is provided below.

2.2.1.1 Site Characterization for Site 510

Blasland, Bouck, and Lee conducted a site characterization to evaluate the potential impact of the UST on the soils and groundwater in the area of Site 510, located on the western end of the Naval Activity, just south of SWMU 54 (BB&L, 1995). The site formerly contained a 4,000-gallon UST; its contents are unknown, but were assumed to be gasoline. The objective of the investigation was to define the areas of soil and groundwater contamination. Petroleum hydrocarbons were detected in soil samples at concentrations exceeding target levels and dissolved petroleum hydrocarbons were detected at concentrations exceeding target levels in groundwater samples obtained from two of the seven monitoring wells installed. No free product was detected in the monitor wells during this investigation.

Results of the qualitative risk assessment indicated that the human health risks associated with Site 510 were extremely low. Based on the results of the site characterization, the contaminated soil was to remain in place due to the low health hazards associated with the soil. Similarly, groundwater contamination was not to be remediated due to the low hydraulic conductivity of the soils in the area and the low health hazards associated with the groundwater (BB&L, 1995).

2.2.1.2 Sampling and Analysis Investigation

The objective of the Sampling and Analysis Investigation at SWMU 54 (Baker, 2001a) was to present the data collected in the field, compare analytical results to various screening criteria, and determine if additional investigations were warranted for these sites through the performance of a RFI.

A sampling program was conducted at SWMU 54 that included the collection of surface soil, subsurface soil, groundwater, and standing water samples (Baker, 2001a). The surface and subsurface soil samples, as well as the groundwater and standing water samples, were analyzed for the full Appendix IX list, as well as total petroleum hydrocarbons (TPH) diesel range organics (DRO) and gasoline range organics (GRO). Results from the analytical data associated with soil at SWMU 54 showed minor detections of various constituents in the surface and subsurface soil samples, the majority below risk-based concentrations (RBCs) (Baker, 2001a). The results from the groundwater portion of the investigation indicated that there has been a release of TCE in the vicinity of SWMU 54. The other groundwater contaminants observed during this investigation were believed to be related to the former UST associated with Site 510. However, results comparing the data collected during this report and 1995 data indicate natural attenuation of the groundwater was occurring, decreasing the concentration of petroleum related contaminants. Low levels of polyaromatic hydrocarbons (PAHs) (at estimated concentrations less than the analytical method detection limit) were detected in soil, groundwater, and in standing water from SWMU 54. This data is considered more likely to represent anthropogenic background than site-related contamination (Baker, 2001a).

The sampling and analysis investigation recommended that the standing water be removed and properly disposed of from the open excavation at SWMU 54 followed by backfilling the excavation. It was also recommended that a RFI be conducted at this SWMU to further investigate the presence of TCE in groundwater. The results presented in the Site 510 Site Characterization (BB&L, 1995) and the Sampling and Analysis Report indicate that natural biodegradation is effectively remediating the contaminants associated with Site 510. Therefore, further investigations related to those particular contaminants were not warranted (Baker, 2001a).

2.2.1.3 RCRA Facility Investigation

The RFI evaluated the nature and extent of contamination at SWMU 54 located at NAPR. The objective of the RFI was to summarize the results of the data and determine the nature and extent of contamination.

The field portion of the RFI was conducted in February 2002. Field activities included the sampling of surface soil, subsurface soil, and groundwater. All samples collected were analyzed for volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs), based on the EPA comment letter dated July 5, 2001. Based on results of the field investigation, it was determined that no further action was required to mitigate surface soil or subsurface soil. One VOC, 1,2-dibromo-3-chloropropane, was detected above screening criteria in the subsurface soil. This is indicative of a benzene, toluene, ethylbenzene, and xylene (BTEX) plume located in the vicinity of sample 54TW15A. A plume of TCE contamination in groundwater was identified and delineated as a result of the field investigation. In addition, a plume of benzene and ethylbenzene was delineated in the vicinity of Bairoko Street around 54TW15.

The extents of the TCE, benzene, and ethylbenzene groundwater contamination were delineated during this investigation. Because of the relatively high levels of benzene and ethylbenzene, it was recommended that a Corrective Measures Study (CMS) be developed to determine remedial alternatives for the compounds in the groundwater at this site.

2.2.2 SWMU 55

Four investigations have occurred at this site including a CMS investigation for the TWFF, a TCE Investigation, Additional Data Collection Investigation, and a TCE Plume Delineation and Source Investigation. A description of each investigation performed at SWMU 55 is provided below. An RFI (Baker, 1997) was also conducted at the TWFF, but the investigation area did not include the current location of SWMU 55.

2.2.2.1 CMS Investigation

The Corrective Measures Study Investigation (CMSI) was conducted to gather additional data with respect to the fuel related contamination at the TWFF to assist in the development of the CMS for SWMU 7/8.

During the CMS Investigation conducted in April 1998, dissolved TCE was detected in and around 7MW07 at a concentration of 2,000J micrograms per liter (µg/L). The contamination of TCE in the field quality control/quality assurance (QA/QC) duplicate sample was 2,100 µg/L. Monitor well 7MW07 is screened from 5 feet to 25 feet below the ground surface (bgs).

2.2.2.2 TCE Investigation

The TCE Investigation Report (Baker, 2000) documented the TCE concentration at 7MW07 again at 2,000 µg/L with an on-site laboratory. In addition, a temporary well placed next to 7MW07 (7-TCE-MW07), and screened from 30 feet to 35 feet bgs, was sampled with a TCE concentration of 1,000 µg/L by a stateside laboratory. Another temporary well located approximately 50 feet southeast of 7MW07 (TW-C), and screened from 17 feet – 22 feet bgs (shallow) and again from 21 feet to 26 feet bgs (deep), had TCE concentrations of 25 µg/L and 1,500 µg/L in the shallow and deep zones. The remaining TCE concentrations found in this investigation ranged from non-detect to 140 µg/L, with the higher concentrations found in the deeper wells.

2.2.2.3 Additional Data Collection Investigation

During the Additional Data Collection Investigation performed in January 2002 (Baker, 2003b), TCE was again measured in monitor well 7MW07 with the result being a concentration of 28,000J µg/L. The concentration of TCE in the field QA/QC duplicate was found to be 23,000J µg/L. (Note that both concentrations were quantified as estimated by the laboratory based on sample dilutions.) These concentrations were approximately 2.5 percent of the solubility of TCE (TCE solubility is ~1,100,000 µg/L). The presence of dense non-aqueous phase liquids (DNAPL) is suspected at concentrations in groundwater over 1 percent of the solubility of a compound (USEPA, 1992a). Because the TCE concentration in 7MW07 was over 1 percent of its solubility, DNAPL was potentially thought to be present in the vicinity of this well. Four other monitor wells also had very small estimated concentrations of TCE during the Additional Data Collection Investigation. These include monitor wells 7MW08, UGW11, and 7MW20 in the area of the lower TWFF. All concentrations were estimated at less than 1 µg/L. A newly installed well, 7MW10, located downgradient of 7MW07, was sampled during this investigation with the result being non-detection of TCE. It should be noted, however, that the screen of this well was installed from 4 feet to 14 feet bgs, most likely too shallow to intercept the TCE plume should it have traveled to this point. A temporary well installed during the previous TCE Investigation near this location (TW-102), and screened from 17 feet to 22 feet bgs, yielded a small TCE detection of 5.4 µg/L during the TCE Investigation (Baker, 2000).

2.2.2.4 TCE Plume Delineation and Source Investigation

The TCE Plume Delineation and Source Investigation was performed in September 2003 in order to determine if a TCE source is present, whether or not this source exists as a DNAPL, and to determine if the dissolved-phase groundwater plume has changed since June 1999. It should be noted that this source would be a result of a historical release, not the result of current activities resulting in contamination at this site. The assumption of this investigation was that Building 2314 (formerly Building 46) was the source of the dissolved-phase groundwater contamination based on a relatively high level of TCE that was detected in well 7MW07, located near Building 2314; TCE was not detected in wells upgradient of Building 2314 and well 7MW07, and, TCE could be associated with the past use of Building 46 (a small craft boathouse).

The objectives and specific elements of the field effort included a soil sampling program in the TCE investigation area to determine if a TCE source was present in a residual or mobile phase form of DNAPL near monitor well 7MW07 and/or Building 2314. A groundwater monitor well installation program was conducted to provide monitoring points downgradient of the dissolved TCE plume, including a sentinel groundwater monitor well at an appropriate depth in the aquifer. Groundwater samples from new and select existing groundwater monitor wells were collected to establish the extent of the dissolved TCE plume at that point in time. Soil and groundwater water

samples were collected and analyzed during this field investigation for select VOCs to further determine the nature and extent of contamination at this location at SWMU 7 (Baker, 2004). Field analysis included dye shake test, pH, specific conductance, temperature, turbidity, oxidation/reduction potential (ORP), and dissolved oxygen (DO).

This TCE Plume Delineation and Source Investigation provided valuable information for use in this report. It was determined that no continuing source of TCE is apparent in the soil or groundwater at this site. The original source and/or location of the TCE contamination in this area of the TWFF remains unknown, despite the gathering of historical information and the efforts of environmental sampling during two focused investigations. The TCE plume was delineated and a sentinel well was placed downgradient of the plume in order to determine, through subsequent sampling events, if contamination is approaching the Ensenada Honda. It was recommended that a CMS proceed for the TCE plume at this site, including screening level risk assessments for cis-1,2-dichloroethene, 1,2-dichloroethane, 1,1,1-trichloroethane, trans-1,2-dichloroethene, and tetrachloroethene in the groundwater at this site. These compounds were detected during this investigation at levels above those found in previous investigations. At this time also, SWMU 55 was established in order to evaluate the TCE plume as a separate SWMU from the TWFF.

2.3 Extent of Contamination by Media

The following subsections provide a description and summary of the extent of contamination, both historical and current, per media collected at SWMUs 54 and 55. Appendix A provides a full list of VOC, SVOC, and TPH results for the surface soil, subsurface soil, and groundwater collected at SWMU 54, as well as a full list of VOCs for SWMU 55 groundwater.

Following the summary of existing contamination, a discussion on the extent of contamination above the quantitative CAOs as forwarded in Section 2.5 and as established by the respective risk assessments in Section 2.4, will be presented for both SWMU 54 and 55.

2.3.1 SWMU 54

Surface soil, subsurface soil, and groundwater collected during the three previous investigations performed at this SWMU will be discussed in this section. The subsections that follow provide an extent of contamination for each of these media. Based on a review of the previous data collected at this site and rationale provided in the EPA approved Final RFI Work Plan (Baker, 2001b), a determination was made for this report to focus only on the VOC, SVOC, and TPH constituents. Therefore, Tables 2-1 through 2-3 provide a summary of the VOC, SVOC, and TPH detections per surface soil, subsurface soil, and groundwater, respectively, at this site. Figure 2-8 depicts all sample locations discussed herein.

2.3.1.1 Surface Soil

A total of 21 surface soil samples were collected during the Sampling and Analysis Investigation and the RFI at SWMU 54.

As presented in Table 2-1, six VOCs (methylene chloride, toluene, chlorobenzene, ethylbenzene, styrene, and acetone) were positively detected in the surface soil collected during these two investigations. The number of positive detections, range of positive detections, as well as the location of the maximum detection for these samples are provided at the end of Table 2-1.

A total of six SVOCs were positively detected in the surface soil at this site including phenanthrene, fluoranthene, benzo(a)anthracene, bis(2-ethylhexyl)phthalate, benzo(k)fluoranthene, and benzo(a)pyrene. A majority of the highest detections of these constituents were found in sample 54SS07, as presented in Table 2-1. This surface soil was collected southwest of Building 1914 as presented on Figure 2-8.

Of the 21 surface soil samples collected during the previous investigations, only 18 of these samples were analyzed for TPH DRO and GRO. The diesel range organics were detected in 14 of the 18 samples collected, with a range from 5.7J milligrams per liter (mg/L) in sample 54SS02, to 490 mg/L in sample 54SS12 (see Table 2-1). Sample 54SS12 was collected immediately west of the aboveground storage tank (AST) containment pad as presented on Figure 2-8. The gasoline range organics were detected in only one sample (54SS06), with a concentration of 0.11J mg/L. Sample 54SS06 was collected west of the southwestern corner of Building 1914.

2.3.1.2 Subsurface Soil

A total of nine subsurface soil samples were collected during the previous investigations at SWMU 54. The results are shown in Table 2-2.

Fourteen VOCs were positively detected in the subsurface soil collected during these two investigations. These VOCs included 1,1,2,2-tetrachloroethane, 1,1-dichloroethene, 1,2-dibromo-3-chloropropane, 2-butanone, 2-hexanone, acetone, carbon tetrachloride, chlorobenzene, ethylbenzene, styrene, toluene, trichloroethene, trichlorofluoromethane, and xylenes. As presented in Table 2-2, all of the positive detections with the exception of toluene and acetone, were detected in sample 54TW15A-04. This sample was collected across Bairoko Street, southwest of monitor wells 510DW1 and DW2. The highest detection of toluene was detected in sample 54SB02-02 (54TW02), located immediately west of the southwestern corner of the building, as presented on Figure 2-8.

Only two SVOCs (2,4-dimethylphenol and di-n-butylphthalate) were positively detected in the subsurface soil at this site. The constituent, 2,4-dimethylphenol, was detected in sample 54TW15A-04, while di-n-butylphthalate was detected in sample 54SB01-08 (54TW01), located adjacent to an oil/water separator east of Building 1914 (see Figure 2-8).

There was no TPH detected in any of the subsurface soil samples collected during the Sampling and Analysis Investigation. The samples collected during the RFI were not analyzed for this analysis as explained in Table 2-2.

2.3.1.3 Groundwater

Table 2-3 presents a total of 40 groundwater samples collected at SWMU 54 during two investigations. However, as observed on this table, there are two sets of data for monitor wells 510DW1, 510DW2, 510MW1, 510MW2, 510MW3, 510MW4, and 510MW5. Each of these monitor wells was sampled during both investigations at this SWMU. Therefore, both sets of data are presented to show a history of the groundwater at this location.

A total of 14 VOCs were positively detected in the groundwater as presented in Table 2-3. The VOC detected included 1,1,1-trichloroethane, 1,1-dichloroethene, 1,2-dichloroethane, 2-butanone, acetone, benzene, chlorobenzene, chloroform, ethylbenzene, isobutanol, methylene chloride, toluene, trichloroethene, and xylene. Many of the locations of the maximum detections listed in Table 2-3 were found in the southwestern portion of this site, as presented on Figure 2-8. A majority of these maximum detections were observed during the 2002 RFI. Figure 2-9 through

2-11 provide the extent of contamination for some of the constituents containing higher detections including TCE, benzene, and ethylbenzene.

The following 13 SVOCs were detected in the groundwater at SWMU 54 during the prior investigations: 2,4-dimethylphenol, 2-methylnaphthalene, 4-bromophenyl-phenylether, benzo(a)anthracene, bis(2-ethylhexyl)phthalate, butylbenzylphthalate, chrysene, di-n-butylphthalate, diethylphthalate, fluoranthene, fluorene, naphthalene, and phenanthrene, as presented in Table 2-3. More than half of the maximum detections were observed during the 2002 RFI.

Only the ten samples listed in Table 2-3 were analyzed for TPH DRO and GRO. These samples were collected during the 2000 Sampling and Analysis Investigation. The diesel range organics were observed at a range of 0.2 mg/L (510MW2) to 6.7 mg/L (54TW01). The gasoline range organics were observed at a range of 0.036J mg/L in sample 510MW1 to 0.84 mg/L in sample 510DW1.

2.3.2 SWMU 55

Groundwater from the previous four investigations at this SWMU will be the only media that will be discussed in this section. Based on discussions and conclusions associated with the CMS process for the TWFF and a review of the previous analytical data collected at SWMU 55, it was decided that this report would focus only on the VOC constituents in groundwater. Therefore, Table 2-4 provides a comprehensive summary of VOC detections in groundwater for the samples collected at this SWMU. Appendix A contains all groundwater analytical results obtained to date in the area now considered SWMU 55. All locations sampled are shown in Figure 2-5.

2.3.2.1 Groundwater

Table 2-4 presents a total of 58 groundwater samples collected at this SWMU during the previous investigations. However, as observed on this table, there are multiple sets of data for monitor wells 7MW07, 7MW08, 7MW10, 7MW20, and UGW11. These monitor wells were sampled multiple times during the previous investigations performed. Therefore, all data sets are presented to show a history of the groundwater at this SWMU.

A total of 26 VOCs were positively detected in the groundwater as presented in Table 2-4. The highest detection of any VOCs in the table was 28,000J µg/L of TCE found in sample 7MW07 during the 2002 Additional Data Collection Investigation. However, this same location reported a TCE result of 1,800 µg/L during the 2003 TCE Plume Delineation and Source Investigation. Figures 2-12 and 2-13 provide the extent of contamination for TCE in groundwater, as well as vertical cross-sections of TCE concentrations within the SWMU 55 area.

2.4 Risk Assessments

Human health risk analyses and ecological risk discussions are contained in this subsection.

The *Final CMS Task I Report, Tow Way Fuel Farm, Naval Station Roosevelt Roads, Ceiba, Puerto Rico* (Baker, 2003c) was finalized on April 22, 2003. Since the TCE area had been included within the confines of the TWFF until the creation of SWMU 55, the corrective action objectives (CAOs) established for the TWFF will be used for SWMU 55, with the exception of assessment of additional compounds detected during the last TCE investigation in excess of previous concentrations, as noted in Section 2.2.2.4. Section 2.4.1 provides a human health risk analyses for SWMU 54, as well as a brief summary of the human health risk assessment done for

the Task I CMS Report for the TWFF (Baker, 2003c). The additional compounds detected at SWMU 55 are also included in Section 2.4.1. Section 2.4.2 contains a brief discussion on the ecological impact of the additional compounds at SWMU 55, as well as a comprehensive discussion on the ecological risk at SWMU 54.

2.4.1 Human Health Risk Assessments—SWMU 54 & SWMU 55

Generally, human health risk assessment is a quantitative process whereby potential carcinogenic risks and noncarcinogenic hazards are calculated from exposure point concentrations (developed by averaging site data for contaminants of potential concern (COPC) for each media sampled) combined with toxicity criteria for the COPCs and assumed exposure pathways and values for exposure variables for a given land use (e.g., inadvertant ingestion of soil at a work place with an ingestion rate of 50 mg/day of soil). EPA has developed simple algorithms for each exposure pathway and toxicity criteria based on the health effects seen at various doses of chemicals in toxicological studies. The CMS process continues, from a human health risk assessment perspective, when potential exposure to a site is considered to pose unacceptable levels of risk and hazard and medium- and chemical-specific CAOs are calculated for comparison to the site data to determine if and where potential cleanup may occur.

Based on discussions with EPA Region 2 the initial step of quantitative risk assessment has been omitted for SWMUs 54 and 55, since it was presumed that the levels of contamination warranted evaluation of corrective measures, and the next step of developing CAOs was performed for this report. This section of the document established the site-specific objectives and clean up goals used to identify corrective measures and follows the methodology established in the Task I CMS submission for the TWFF site at NAPR and approved by USEPA (Baker, 2003c).

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

CAOs can be 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 SWMUs 54 and 55, developed in Section 2.5, are based on land use and potential receptor assumptions (Section 2.4.1.1), summary of the human health risk assessment and selection of contaminants of potential concern (Section 2.4.1.2), exposure assessment and methodology (Section 2.4.1.3), and toxicity evaluation (Section 2.4.1.4). The CAOs were developed in accordance with the USEPA guidance (USEPA, 1989, 1991a, and others) and other human health risk assessments performed for NAPR.

2.4.1.1 Land Use and Potentially Exposed Receptors

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

SWMU 54 is in an industrial area of NAPR where fuel was stored and maintenance and repair activities were conducted to support Base proceedings. Future property use at the site is expected to remain industrial for the duration of naval operations of NAPR and likely even afterwards. As a result, potential human exposure is limited to industrial or commercial property use, now and in the foreseeable future. SWMU 55 is also expected to remain industrial as discussed Baker, 2003c.

The assumption of EPA's default industrial/commercial exposure scenario accounts for long term exposure (workers are assumed to be at each site eight hours per work day for twenty-five years) and is used to reflect future land use. Construction workers are also assumed to be potential future receptors. Although future onsite residential land use was conservatively used for screening criteria, it is not considered reasonably anticipated.

2.4.1.2 Selection of Contaminants of Potential Concern

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 used 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 2004 (USEPA, 2004a) 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 from multiple contaminants.)

Tables 2-5 through 2-8 summarize the data for the three media identified at SWMU 54 (surface soil, subsurface soil, and groundwater), groundwater at SWMU 55 and the COPC selection process.

COPC selection is based on the detected concentrations of analytes, not their detection limits. This criterion introduces some uncertainty as some analytes in soil have maximum detection limits in excess of the RBCs. The only analyte for which this is the case is benzo(a)anthracene in surface soil data (see Tables 2-1 and 2-5). One 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. The detection limits of most of the subsurface soil samples exceed the RBCs, however, both benzo(a)anthracene and benzo(a)pyrene were detected at estimated concentrations (indicated by a J-flag) in some samples less than the listed detection limit indicating that the practical detection limit may be less than the listed detection limit.

Although it cannot be ascertained if benzo(a)anthracene is in fact present or not in some of the samples at levels that exceed the RBC, the actual effect on the CMS of this uncertainty is minimized by the fact that other PAHs in soil are present in the same samples and are identified as COPCs that will be addressed in the risk assessment contained in this CMS.

2.4.1.3 Exposure Assessment and Methodology for Development of CAOs

Qualitative CAOs--There is no direct current exposure to contaminated groundwater at NAPR nor is future exposure likely. (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 NAPR's present and projected needs.

Under nonresidential land use it is reasonable to assume that no groundwater well(s) 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 NAPR 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. 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 (it should be noted that there has been no free product observed at either SWMU 54 or SWMU 55).

Under the continued military or industrial/commercial land use scenario, contact with contaminants will occur from both surface and subsurface soil at the SWMU 54. 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).

Quantitative CAOs--Quantitative CAOs are acceptable residual contaminant concentrations. The following components of the human health risk assessment 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 2.4.1.4).

- 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:

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

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

HQ = Intake/RfD

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 or industrial/commercial land use scenario at the SWMU 54, the industrial worker and construction worker are used to characterize potential future exposure to contaminated soil and groundwater. Groundwater exposure from SWMU 55 will be characterized using both the industrial worker and construction worker receptors. Industrial worker exposure is limited to surface soil at SWMU 54 (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). This version of the Johnson and Ettinger model is summarized and the results of the modeling efforts for SWMUs 54 and 55 are presented in Appendix B. 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 SWMUs 54 and 55 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 2-9 to 2-19 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 (PAHc) 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 other risk assessments performed for NAPR.

- 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 2003c). Supporting calculations are provided in Appendix C.

  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 SWMUs 54 and 55 are considered volatile by these criteria and are quantitatively evaluated with the exception of 2-methylnaphthalene and benzo(a)anthracene.

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 2-12 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 C).

  Table 2-12 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 SWMU 54 and it exceeded the VF-based CAO for 1,2-dibromo-3-chloropropane but not for benzo(a)pyrene. Therefore, the VF model is applicable only for 1,2-dibromo-3-chloropropaneand is not used for benzo(a)pyrene.

- 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).

2.4.1.4 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, 1989).

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 B), 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, 1989).

- 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, 1989). 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 B), 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, 2004b). 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 2-20 presents the toxicological criteria used to calculate CAOs for SWMU 54 and 55 COPCs.

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 2-14 and 2-17, 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, 1989; 1992b).

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. EPA guidance on the dermal exposure pathway (USEPA, 2001a) recommends adjusting health effects criteria only if gastrointestinal absorption is less than 50 percent. This guidance summarizes the available

gastrointestinal absorption data in its Exhibit 4-1 and those values are used here. A gastrointestinal absorption of 100 percent is assumed as recommended for COPCs not included in the Exhibit 4-1 from this source (USEPA, 2001a) or compounds with greater than 50 percent absorption. Tables in Appendix C, for the dermal absorption pathways present the gastrointestinal absorption data used to develop CAOs.

Approach to Evaluating Carcinogenic PAHs

Two approaches exist for evaluating carcinogenic PAHs; 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. 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 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.

2.4.1.5 Quantitative CAOs

Quantitative CAOs are calculated based on the exposure methodology, contaminants, and health effects criteria presented in Sections 2.4.1.3 and 2.4.1.4. Table 2-21 presents the quantitative soil CAOs for the industrial/commercial and construction exposure scenarios to be used for comparison with site data. These values represent the concentrations at which a target risk level

of 1×10^{-6} (or $1x10^{-5}$ 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 2.4.1-3. Tables 2-22 and 2-23 present a similar quantitative CAO summary for groundwater at SWMUs 54 and 55.

Tables C-1 through C-14 in Appendix C 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 C-5, C-10, and C-14 in Appendix C summarize the 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.

2.4.2 Screening Level Ecological Risk Assessment—SWMU 54

This section presents a screening-level ecological risk assessment (SERA) for SWMU 54 – Building 1914 (Former NEX Repair/Maintenance Shop) located at NAPR, 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 2-14) consists of eight steps organized into three tiers and represents a clarification and interpretation of the eight-step ERA process outlined in the USEPA ERA guidance for the Superfund program (USEPA, 1997c). 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 Steps 1 and 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 pose 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. 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 conservative exposure assumptions does not support an acceptable risk determination, the site continues through the baseline ERA process, starting with Step 3b (baseline ERA problem formulation).

At the conclusion of the SERA, three possible decision points:

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

2. **Further evaluation is warranted**. This decision is appropriate if the screening-level ERA indicates that there is the potential for unacceptable risks for some pathways, receptors, and chemicals. In this instance, the ERA would progress to Step 3 of the 8-step process.

3. **Further data are required.** This decision is appropriate if the screening-level ERA indicates that there are insufficient data on which to base a risk estimate. This decision may also be appropriate if the potential for unacceptable risks is identified following the screening-level and additional data to refine these estimates (e.g., additional analytical data, measures of bioavailability, etc.) are needed for Step 3.

2.4.2.1 Environmental Setting

The sections that follow provide a brief description of the site. The habitats occurring within and contiguous to SWMU 54 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 NAPR.

2.4.2.1.1 Site History

NAPR occupies over 8,600 acres on the East Coast of Puerto Rico, along Vieques Passage (see Figure 2-1), with Vieques Island lying approximately ten miles to the east. NAPR was commissioned in 1943 as a Naval Operations Base and re-designated a Naval Station in 1957. The current primary mission of NAPR is limited (NAPR is currently under an operational closure).

SWMU 54 – Building 1914 (Former NEX Repair/Maintenance Shop), built in 1979, is currently unoccupied and lies on approximately 1 acre of land in the Bundy Area of NAPR (Figure 2-2). The building structure and pavement covers approximately 40 percent of the total SWMU 54 acreage. Urban grass areas surround the gravel parking area and building to the east and a maintained grass area borders Bairoko Street, crossing through the SWMU. This SWMU contains a slight slope to the west and a small hill to the east approximately 100 feet in elevation. A small hill lies in the southern part of this SWMU, which is approximately 50 feet in elevation. The building structure itself consists of a small concrete block building with a center office area and open bays on either side. A gravel parking area surrounds the vehicle maintenance building. The building was used to perform maintenance on vehicles including oil changes, lubrications, etc. No wastes are known to have been disposed of at the unit and there are no known releases related to the unit. SWMU 54 is located north-northeast across Bairoko Street from SWMU 26 and west across Bairoko Street from Building 1686 (Former Base Laundromat), as presented on Figure 2-2. Site 510 is an underground storage tank (UST) site which consisted of a 4,000 gallon UST associated with Building 510, located south of Building 1914, as presented on Figure 2-2. The UST was constructed of steel and used to store fuel for fueling operations conducted in the area. The date of installation and the type of fuel stored is unknown, but was assumed to be gasoline. In December 1992, the tank was removed from Site 510 (Blasland, Bouck, and Lee [BB&L], 1995).

Blasland, Bouck, and Lee conducted the site characterization to evaluate the potential impact of the UST on the soils and groundwater in the area of Site 510, located on the western end of the Naval Activity, just south of SWMU 54 (BB&L, 1995). The objective of the investigation was to define the areas of soil and groundwater contamination. Based on the results of the site characterization, the contaminated soil was to remain in place due to the low health hazards associated with the soil. Similarly, groundwater contamination was not to be remediated due to

the low hydraulic conductivity of the soils in the area and the low health hazards associated with the groundwater (BB&L, 1995).

The information gathered from a visual site inspection performed by CH2M Hill and environmental staff at NAPR revealed that there were several areas of oil stained soil around NEX Building 1914 (CH2M Hill, 2000). For that reason, it was recommended that a sampling program be performed to characterize the areas around several structures in the SWMU 54 area. The results from the Site Characterization for Site 510 developed by BB&L (BB&L, 1995) were taken into consideration in development of the work plan utilized during the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) investigation due to the close proximity of its existing monitor wells to SWMU 54. CH2M Hill also observed two open excavation locations south of the building containing algae-stained water. With this information, along with the activities (oil changes, lubrications, etc.) known to have taken place at this SWMU, a Sampling and Analysis Investigation was performed to determine whether a release of hazardous waste including hazardous constituents has occurred, is likely to have occurred, or is likely to occur.

The Sampling and Analysis Investigation conducted at SWMU 54 (Baker, 2001a) presented the data collected in the field, compare analytical results to various screening criteria, and determine if additional investigations were warranted for these sites through the performance of a RFI. Results from the analytical data associated with soil at SWMU 54 showed minor detections of various constituents in the surface and subsurface soil samples, the majority below risk based concentrations (RBCs) (Baker, 2001a). The results from the groundwater portion of the investigation indicated that there has been a release of trichloroethene (TCE) in the vicinity of SWMU 54. The other groundwater contaminants observed during this investigation were believed to be related to the former UST associated with Site 510. However, results comparing the data collected during this report and 1995 data indicate natural attenuation of the groundwater was occurring, decreasing the concentration of petroleum related contaminants. Low levels of polyaromatic hydrocarbons (PAHs) (at estimated concentrations less than the analytical method detection limit) were detected in soil, groundwater, and in standing water from SWMU 54. This data is considered more likely to represent anthropogenic background than site-related contamination (Baker, 2001a).

The sampling and analysis investigation recommended that the standing water be removed and properly disposed of from the open excavation at SWMU 54 followed by backfilling the excavation. It was also recommended that a RFI be conducted at this SWMU to further investigate the presence of TCE in groundwater. The results presented in the Site 510 Site Characterization (BB&L, 1995) and the Sampling and Analysis Report indicate that natural biodegradation is effectively remediating the contaminants associated with Site 510. Therefore, further investigations related to those particular contaminants were not warranted (Baker, 2001a).

The RFI evaluated the nature and extent of contamination at SWMU 54 located at NAPR. The objective of the RFI was to summarize the results of the data and determine the nature and extent of contamination. Based on results of the field investigation, it was determined that no further action was required to mitigate surface soil or subsurface soil. One VOC, 1,2-Dibromo-3-chloropropane, was detected above screening criteria in the subsurface soil. This is indicative of a benzene, toluene, ethylbenzene, and xylene (BTEX) plume located in the vicinity of sample 54TW15A. A plume of TCE contamination in groundwater was identified and delineated as a result of the field investigation. In addition, a plume of benzene and ethylbenzene was delineated in the vicinity of Bairoko Street around 54TW15. The extent of the TCE, benzene, and ethylbenzene groundwater contamination were delineated during this investigation. Based on the concentration of benzene and ethylbenzene detected, it was recommended that a Corrective

Measures Study (CMS) be developed to determine remedial alternatives for the compounds in the groundwater at this site.

2.4.2.1.2 *Habitats*

A description of the terrestrial and aquatic habitats occurring within and contiguous to SWMU 54 is provided in the sections that follow. The description of habitats relies primarily on literature-based information for Puerto Rico and NAPR.

Terrestrial Habitats

The upland habitat bounded by NAPR is classified as subtropical dry forest (Ewel and Witmore, 1973). Similar to other forested areas of Puerto Rico, this region was previously clear-cut in the early part of the century, primarily for pastureland (Geo-Marine, Inc., 1998). After acquisition by the Navy, a secondary growth of thick scrub, dominated by lead tree (*Leucaena spp.*), Christmas tree (*Randia 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 majority of the area bounded by SWMU 54 is devoid of vegetation; however, secondary growth encroaches upon the SWMU's eastern and southern boundary. The species composition of this community, classified as an upland coastal forest community (see Figure 2-15), is not known.

Cobana negra (*Stahlia monosperma*), a federally threatened tree species, is known to occur between the boundary of black mangrove communities and coastal upland forest communities. This species is also known to occur in coastal forests of southeastern Puerto Rico (Little and Wadsworth, 1964). However, this species has not been found to occur on NAPR by previous surveys (Geo-Marine, Inc., 1998) and, therefore, is not likely to occur within the secondary growth upland coastal forest community contiguous to SWMU 54.

Aquatic Habitats

The marine environment surrounding NAPR includes mudflats, mangroves (black mangrove [*Avicenia germinans*], red mangrove [*Rhizophora mangle*] communities), seagrass beds (turtle grass [*Thalassia testudium*], and manatee grass [*Syringodium filliforme*]). 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, and the West Indian manatee is a federally endangered species. Both species have been reported from the marine environment surrounding NAPR.

A map showing the spatial relationship of SWMU 54 to aquatic habitat at NAPR is provided as Figure 2-16. Included on this figure are wetland units identified by the Cowardian Wetland Classification System (Cowardian et al., 1979 [see Figure 2-17]). The wetlands depicted on Figure 2-16 were delineated by Geo-Marine, Inc. in December 1999 based on 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 (United States Army Corps of Engineers [USACE], 1987). As evidenced by the figure, there are no freshwater or marine wetland units or open water marine habitats within or contiguous to the boundaries of SWMU 54. The nearest downgradient aquatic habitat, a wetland unit classified by the Cowardian Wetland

Classification System as estuarine, intertidal, forested, needle-leaved evergreen (E2FO3), is approximately one mile from the SWMU.

2.4.2.1.3 *Biota*

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

Mammals

A total of 22 terrestrial mammal species are known historically from Puerto Rico; however, all mammals except bats (13 species) have been extirpated (United States Geological Society [USGS], 1999). None of the bats found on Puerto Rico are exclusive to the island. The West Indian manatee, a federally endangered species, is known to occur in the marine environment surrounding NAPR. As discussed in Section 2.4.2.1.2, SWMU 54 is not contiguous to open water marine habitat.

Several terrestrial mammals have been introduced into 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 United States Fish and Wildlife Service [USFWS], 1996a).

Birds

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

Numerous native and migratory bird species have been reported at NAPR (Geo-Marine, Inc., 1998). A list of bird species reported at NAPR or having the potential to occur is provided in Table 2-24. 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 NAPR include the Puerto Rican lizard cuckoo (*Saurothera vieilloti*), Puerto Rican flycatcher (*Myiarchus antillarum*), Puerto Rican woodpecker (*Malanerpes portoricensis*), Puerto Rican emerald (*Chlorostilbon maugaeus*), and yellow-shouldered blackbird (*Agelaius xanthomus*).

The yellow-shouldered blackbird is a federally endangered species. One of the principal reasons for the status of this species is attributed to parasitism by the non-indigenous shiny cowbird, which lays its eggs in blackbird nests and sometimes punctures the host's eggs (United States Fish and Wildlife Society [USFWS], 1983). Other factors contributing to the status of this species include nest predation by the introduced black rat, Norway rat, and mongoose, as well as

habitat modification and destruction (USFWS 1996a). The entire land area of NAPR was declared critical habitat for the yellow-shouldered blackbird in 1976; however, a 1980 agreement with the USFWS exempted certain areas from this categorization (Geo-Marine, Inc., 1998). A study conducted by the Naval Facilities Engineering Command (NFEC) (NFEC, 1996) reported that the mangrove forests surrounding NAPR should be considered the most important nesting habitats for the yellow-shouldered blackbird. SWMU 54 is outside the critical habitat designation for the yellow-shouldered blackbird and is not contiguous to any potential feeding habitat (shrubland) or nesting. It is noted that only seven sightings in all have been reported at NAPR from 1986 to 1996. The last reported nesting pair of yellow-shouldered blackbirds at NAPR was in 1986 (USFWS, 1996).

Other federally listed bird species that have been reported at NAPR 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). Given their habitat preferences for feeding (open water or shoreline habitat), the brown pelican, roseate tern, and piping plover have little potential to occur at SWMU 54.

Reptiles and Amphibians

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. On the coastal lowlands, almost all coqui species are arboreal. The only amphibians listed under provisions of the Endangered Species Act of 1973 are the Puerto Rican ridge-headed toad (*Peltophryene lemur*) and the golden coqui (*Eleutherodactylus jasperi*). Both species are listed as threatened. Distribution of the golden coqui is restricted to areas of dense bromeliad growth. All specimens to date have been collected from a small semicircular area of a 6-mile radius south of Cayeye (approximately 30 miles southwest of NAPR), generally at elevations above 700 meters (USFWS, 1984). The Puerto Rican ridge-headed toad occurs at low elevations (below 200 meters) where there is exposed limestone or porous, well drained soil offering an abundance of fissures and cavities (USFWS, 1987). A single large population is known to exist from the southwest coast in Guanica Commonwealth Forest, and a small population is believed to survive on the north coast near Quebradillas, Arecibo, Barceloneta, Viga Baja, and Bayamon (USFWS, 1987). It has also been collected on the southeastern coastal plain near Coamo (USFWS, 1987). Given the habitat preferences and locations of known occurrences, these two species are not expected to occur at NAPR.

Puerto Rico's native reptilian species include 31 lizards, 8 snakes, 1 freshwater turtle, and 5 sea turtles (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. These three sea turtles, as well as the leatherback sea turtle (*Caretta caretta*) and the Puerto Rican boa (*Epicrates inornatus*) represent the reptilian species listed under the provisions of the Endangered Species Act of 1973 (USGS, 1999). Given the upland location of SWMU 54, there is little potential for site-related impacts to the sea turtle species. The Puerto Rican boa uses a variety of habitats but is most commonly found in karst forest habitats. Given the absence of any significant habitat at SWMU 54 (including karst forest habitat), there is a low probability of occurrence for this species at SWMU 54.

Fish and Aquatic Invertebrates

A diverse fish and invertebrate community can be found in the marine environment surrounding NAPR. This can be attributed to the varied habitats that include marine and estuarine open water habitat, mud flats, sea grass beds, and mangrove forests. The fish community surrounding NAPR is represented by stingrays, herrings, groupers, needlefish, mullets, barracudas, jacks, snappers, grunts, snooks, lizardfishes, parrotfishes, gobies, filefishes, wrasses, damselfishes, and butterflyfish (Geo-Marine, Inc., 1998). The benthic invertebrate community includes sponges, corals, anemones, sea cucumbers, sea stars, urchins, and crabs. As discussed in Section 2.4.2.1.2, there are no marine or freshwater habitats located within or contiguous to SWMU 54.

2.4.2.2 Sources of Available Analytical Data

Three investigations have occurred at SWMU 54, a Site Characterization for Site 510, a Sampling and Analysis Investigation, and a RFI. The specific sampling and analysis programs of each investigation are described in the sections below.

2.4.2.2.1 Site Characterization of Site 510

Blasland, Bouck, and Lee conducted a site characterization to evaluate the potential impact of the UST on the soils and groundwater in the area of Site 510, located on the western end of the Naval Activity, just south of SWMU 54 (BB&L, 1995). The objective of the investigation was to define the areas of soil and groundwater contamination. Fifteen soil borings were advanced to determine the extent of soil contamination in the area of the UST near Building 510 (510-SB1 through 510SB15 (BB&L, 1995). At least two subsurface soil samples from each boring were selected for laboratory analysis based on elevated field OVA results. A total of 23 subsurface soil samples were analyzed for at least one of the following parameters: total petroleum hydrocarbons (TPH)-diesel range organics (DRO), TPH-gasoline range organics (GRO), TPH, and total BTEX constituents (BB&L, 1995). Seven monitoring wells were installed during this investigation (510-MW1 through 510-MW5, 510-DW1 and 510-DW2, see Figure 2-8). The seven groundwater samples collected were analyzed for at least one of the following parameters: BTEX, total BTEX, methyl-tert-butyl ether (MTBE), PAHs, total naphthalenes, lead, and TPH (BB&L, 1995).

2.4.2.2.2 Sampling and Analysis Investigation

The objective of the Sampling and Analysis Investigation at SWMU 54 (Baker, 2001a) was to present the data collected in the field, compare analytical results to various screening criteria, and determine if additional investigations were warranted for these sites through the performance of a RFI. The initiation of the Sampling and Analysis Investigation was based upon the visual site inspection conducted by CH2M Hill in 2000 in which several areas of oil stained soils were discovered in the vicinity of Building 1914.

A sampling program was conducted at SWMU 54 that included the collection of surface soil, subsurface soil, groundwater, and standing water samples (Baker, 2001a). A total of 18 surface soil samples (including 2 duplicate sample), 4 subsurface soil samples, 10 groundwater samples (including 1 duplicate sample), and 3 standing water samples were collected during this investigation and analyzed for the full Appendix IX list including: VOCs, SVOCs, pesticides/polychlorinated biphenyls (PCBs), organophosphorus (OP)-pesticides, dioxins/furans, chlorinated herbicides, and metals. The samples were also analyzed for TPH-DRO and TPH-GRO (Baker, 2001). Appendix A provides the VOC, SVOC, and TPH results for the Sampling and Analysis Investigation. The monitoring wells installed during the 1995 Site Characterization

Investigation were sampled for groundwater, as well as two temporary wells (54TW01 and 54TW02) that were installed during the Sampling and Analysis Investigation. The standing water samples were collected based upon the visual inspection of SWMU 54 in which two excavation pits located to the south of Building 1914 within SWMU 54 contained algae stained water. It was recommended from this investigation that a RFI be conducted at this SWMU to further investigate the presence of TCE in groundwater.

2.4.2.2.3 RCRA Facility Investigation

The RFI evaluated the nature and extent of contamination at SWMU 54 located at NAPR. The objective of the RFI was to summarize the results of the data and determine the nature and extent of contamination. Field activities conducted in February/March 2002 included the collection of 3 surface soil, 5 subsurface soil (including 1 duplicate sample), and 30 groundwater samples (including 3 duplicate samples) (see Figure 2-8). All samples collected were analyzed for VOCs and SVOCs, based on the EPA comment letter dated July 5, 2001 (see Appendix A). The monitoring wells installed during the 1995 Site Characterization Investigation were also sampled during this investigation.

2.4.2.3 Screening-Level Problem Formulation

Problem formulation establishes the goals, scope, and focus of the ERA. The products of the screening-level problem formulation are (1) the preliminary conceptual model and, if complete exposure pathways are present (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.

2.4.2.3.1 Preliminary Conceptual Model

The preliminary conceptual model for SWMU 54 is presented on Figure 2-18. Exposure, and thus potential for risk, can only occur if each of the following conditions is 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 affected media.
- An exposure route must exist whereby the contaminant can be taken up by ecological receptors.

The information gathered from the visual site inspection performed by CH2M Hill and environmental staff at NAPR revealed that there were several areas of oil stained soil in the vicinity of NEX Building 1914 (CH2M Hill, 2000). Analytical data collected during the

Sampling and Analysis Investigation and/or RFI field investigation indicated that VOCs, SVOCs, and inorganics that were surface soils, subsurface soils and/or groundwater in the area contiguous to Building 1914, could be related to site activities occurring at the maintenance shop (see Appendix A).

Another source area for SMWU 54 includes the UST located near Building 510. Groundwater analytical data taken during the 2002 RFI indicated a plume of benzene and ethylbenzene located in the vicinity of sample 54TW15A (see Figure 2-10 and 2-11, respectively); however, BTEX constituents were not detected in surface soil samples (see Appendix A).

TCE contamination was discovered in groundwater at SWMU 54 at two locations during the 2002 RFI, near the UST in the vicinity of sample 54TW15A and also in the vicinity of sample location 510MW5 (see Figure 2-9). While TCE is present in the groundwater, it was determined that no further action is required to mitigate surface or subsurface soil.

2.4.2.3.2 Transport Pathways

A transport pathway describes the mechanisms whereby chemicals may be transported from a source of contamination to ecologically relevant media (i.e., an exposure point). As depicted on Figure 2-18, potential mechanisms for contaminant transport from the potential source areas at SWMU 54 are believed to include the following:

- Overland transport of chemicals with surface soil via surface runoff to downgradient surface soil.

- Leaching of chemicals from surface and subsurface soil by infiltrating precipitations and subsequent transport to surface water and sediment with groundwater.

As evidenced by Figure 2-8, there are no storm water conveyances (e.g., storm sewers) present at Building 1914 or its immediate area that can serve as a pathway for the transport of chemicals with surface soil (via surface runoff) to downgradient surface water and sediment. There is a maintained grass ditch located within SWMU 54 near Bairoko Street. However, this ditch drains to the north and west from the site area, away from any significant aquatic habitat located nearest to SWMU 54 (see Figure 2-8). Furthermore, sheet flow conveyances to off-site surface soil are hindered by the nearly level terrain at SWMU 54 and the nature of the on-site habitat (gravel parking area and maintained lawns). The spatial extent of each groundwater plume detected at SWMU 54 is approximately one mile from does the nearest downgradient aquatic habitat. Groundwater itself does not represent an exposure point for ecological receptors. Finally, SWMU 54 does not offer any significant habitat based on the gravel parking lots, buildings, and maintained lawns within the immediate area. For the reasons discussed above, the potential transport pathways present at SWMU 54 are considered incomplete and/or insignificant.

2.4.2.4 Screening Level Ecological Assessment Decision Point and Recommendations

The screening-level ERA for SWMU 54 indicated that, while source areas exist at SWMU 54, there are no complete and/or significant exposure pathways. As such, no further action is recommended at SWMU 54 for ecological resources.

2.4.3 Screening Level Ecological Risk Assessment—SWMU 55

A screening-level ecological risk assessment (ERA) and Step 3a of the baseline ERA for the Tow Way Fuel Farm was presented in the *Final CMS Task 1 Report* (Baker, 2003c). The ERA was conducted in accordance with the Chief of Naval Operations (CNO) document entitled *Navy Policy for Conducting Ecological Risk Assessments* (CNO, 1999). As part of the ERA, groundwater data for samples collected in March 2002 from monitoring wells located south of Forrestal Drive were compared to surface water screening values. TCE was detected in a single groundwater monitoring well (7MW07) at a concentration greater than the surface water screening value of 200 µg/L (28,000 µg/L). Based on this exceedence, as well as the proximity of the monitoring well to the Ensenada Honda, an ecological CAO of 200 µg/L was established for TCE in groundwater. It is noted that TCE was not detected in the groundwater sample collected from a monitoring well located within the estimated travel path of the TCE plume (7MW010), nor was it detected in downgradient surface water and sediment collected from the Ensenada Honda (Baker, 2003c). Therefore, it was concluded that this VOC is not migrating with groundwater to the Ensenada Honda at ecologically important concentrations.

The Final CMS Task I Report for the Tow Way Fuel Farm recommended that an investigation be performed to delineate the extent of TCE and identify the source of TCE at 7MW07. The recommended investigation, conducted in September 2003 in accordance with the *Final TCE Plume Delineation and Source Investigation Work Plan* (Baker, 2003e), included the installation of four permanent monitoring wells (7MW21 through 7MW24) and ten temporary monitoring wells (7TCETW201 through 7TCETW210) contiguous to and downgradient from 7MW07. Groundwater samples were collected from these fourteen wells and five existing monitoring wells (7MW07, 7MW08, 7MW10, 7MW20, and UGW11) during the September 2003 field investigation. The locations of these wells are depicted on Figure 2-5. Groundwater samples were analyzed for a modified TCL VOC list (trichloroethene, cis-1,2-dichloroethene, trans-1,2-dichloroethene, 1,1,1-trichloroethane, tetrachloroethane, 1,2-dichloroethane, 1,1-dichloroethane, chloroform, vinyl chloride, 1,1,2-trichlorethane, 1,1,1-trichloroethane, tetrachloroethene, 1,2-dichloroethane, 1,1-dichloroethane, chloroform, methylene chloride, pentachloroethane, and chloromethane). Rational for the parameter list was presented in the *Final TCE Plume Delineation and Source Investigation Work Plan* (Baker, 2003e).

To determine if groundwater CAOs are necessary for any additional VOC, groundwater data for samples collected during the September 2003 field investigation were compared to the surface water screening values presented in Table 2-25. Nine VOCs (1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,1-dichloroethene, 1,2-dichloroethane, chloromethane, cis-1,2-dichloroethene, trans-1,2-dichloroethene, and trichloroethene) were detected in the September 2003 groundwater samples at presented in Table 2-26. As evidenced by this table, 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,1-dichloroethene, 1,2-dichloroethane, chloromethane, tetrachloroethene, cis-1,2-dichloroethene, and trans-1,2-dichloroethene were detected at concentrations less than surface water screening values. Furthermore, maximum detected concentrations did not occur in wells located nearest the Ensenada Honda (i.e., wells 7MW21 and UGW11 [see Figure 2-5]), indicating that these eight VOCs are not migrating to the Ensenada Honda at ecologically important concentrations. Based on the comparison presented in Table 2-26 and the location of maximum detections, the establishment of groundwater ecological CAOs for 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,1-dichloroethene, 1,2-dichloroethane, chloromethane, tetrachloroethene, cis-1,2-dichloroethene, and trans-1,2-dichloroethene is not deemed necessary.

TCE was detected in two monitoring wells at concentrations greater than the surface water screening value and CAO of 200 µg/L (1,800 µg/L in 7MW07 and 1,600 µg/L in 7MW24). Identical to the January 2002 sampling event, the maximum TCE concentration was detected in

well 7MW07; however, this maximum concentration is less than the concentration detected at well 7MW07 in 2002 (28,000 µg/L). This VOC was not detected above the surface water screening level in wells located downgradient from well 7MW24 (i.e., wells 7MW10, 7MW21, 7MW22, 7MW23, UGW11, 7CETW201, 7TCETW202, 7TCETW203, 7TCETW204, 7TCETW05, 7TCETW09, and 7TCETW10 [see Figure 2-5]), indicating that TCE is not migrating to the Ensenada Honda at ecologically important concentrations.

Given the uncertainty of the site conceptual model for the fractured bedrock subsurface, two mass balance calculations were performed to investigate potential ecological impacts to the Ensenada Honda. The mass balance calculations are described below:

1) In this calculation, the mass flux of TCE through a vertical cross-section of aquifer at SWMU 55 was assumed to reach the base of the Ensenada Honda at some location with the same mass flux as is seen at the site. Very conservative assumptions were made for estimating both the concentration and the cross-sectional area values. In Figure 2-13 a cross-section of the aquifer perpendicular to groundwater flow is seen (B-B'). Superimposed on this cross-section are contours depicting the TCE concentrations. These concentrations were the maximum observed at the site. A rectangular area represented by 280 feet in the horizontal direction and 20 feet in the vertical direction was used to calculate mass flux through this cross-section. This is approximately 88 percent larger than the area of the outside contour on this figure. A concentration in the cross-section of 2,000 ug/L was used to represent the concentration crossing this entire area of the cross-section, even though this concentration is higher than was seen during the last investigation (maximum was 1,800 ug/L), and certainly would not be found over this entire area. Using a groundwater flow velocity of 113 ft/day (the maximum given in the site hydrogeology section 2.1.2.2), a mass flux through this cross-section can be calculated to be 98.2 g/day as shown below [mass flux (M/T) = concentration (M/L^3) * cross-sectional area (L^2) * groundwater flow velocity (L/T)].

$$\text{Mass Flux} = 2000\ \text{ug/L} * 5600\ \text{ft}^2 * 113\ \text{ft/year} * 28.317\ \text{L/ft}^3 * 1 \times 10^{-6}\ \text{g/ug} * 1\text{yr}/365\ \text{days}$$

$$\underline{\text{Mass Flux} = 98.2\ \text{g/day}}$$

If the same cross-sectional area is assumed at a hypothetical discharge point at the base of the Ensenada Honda, with a water column above it of 1 foot, the associated volume receiving this mass is 5,600 ft^3. (It should be noted that this assumes that there is NO degradation, retardation, dilution, or dispersion along the flow path, and that the mass flux into the Honda remains exactly the same as in the source area of the plume. All of these are unlikely, resulting in an extremely conservative calculation.)

The concentration (mass/volume) in this water would be 619 ug/L after one day of discharge and no dilution or flushing (98.2 g/day / 5600 ft^3 * 0.035315 ft^3/L * $1x10^6$ ug/g = 619 ug/L). If a dilution factor of 10 were assumed (Buchman, 1999) the concentration of TCE in this small volume would not exceed 61.9 ug/L, or be less than the surface water screening value for TCE (200 ug/L from Table 2-26) during any given day. Again, note the many extremely conservative assumptions used in these calculations.

2) The second calculation assumes that the water in the Ensenada Honda is completely mixed but stays in the confines of the Honda, that is, there is no water entering the Honda or leaving it. It also assumes again that there is no degradation or volatilization, i.e., no mass is lost due to any mechanism within the Ensenada Honda itself. The question is

posed: how long would it take the concentration in the Ensenada Honda to reach the surface water screening value given a constant mass flux of 98.2 g/day. A cursory measurement of Figure 2-1shows that the aerial extent of the Honda is approximately 7,500 feet by 10,000 feet. If an average depth of 10 feet is assumed throughout the Honda (maximum depth is assumed to be 44 feet at the entrance passage as shown in Public Works Drawing No. 5289, but experience by site personnel indicates that the rest of the Ensenada Honda is fairly shallow), the calculated volume is 7.5×10^8 ft^3. If concentration is defined as some mass in a volume, and the mass flux multiplied by some time yields the mass, then the concentration is defined as:

C(screening level) = mass flux * time / volume

The equation can be rearranged to find the time to reach that concentration or:

Time = C * volume / mass flux

Plugging in the numbers yields:

Time = 200 ug/L * 7.5×10^8 ft^3 * 28.317 L/ft^3 / 98.2 g/day / 1×10^6 ug/g

Time = 43,254 days or 118.5 years

This is the time it would take to degrade the entire Ensenada Honda to a concentration of 200 ug/L of TCE. It would also take approximately 4,250 kg of TCE source material to accomplish this.

Given these two calculations, it appears that the ecological risk to the Honda due to TCE discharge of a hypothetical plume reaching this surface water body is extremely small.

In summary, the September 2003 analytical data do not indicate that groundwater CAOs are necessary for 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,1-dichloroethene, 1,2-dichloroethane, chloromethane, cis-1,2-dichloroethene, tetrachloroethene, and trans-1,2-dichloroethene. As evidenced by Table 2-26, maximum detected concentrations did not exceed surface water screening values, nor did they occur in groundwater samples collected from wells nearest the Ensenada Honda. Although TCE was detected in two wells at concentrations greater than the surface water screening value and ecological CAO, the available analytical data from March 2002 and September 2003 do not indicate that this VOC is migrating with groundwater to the Ensenada Honda at ecologically important concentrations.

2.5 Establishment of Corrective Action Objectives

Based on the human health and ecological risk screening level assessments provided in Section 2.4, quantitative CAOs are promulgated for SWMUs 54 and 55. These CAOs typically would represent the minimum risk-based concentration established for the groundwater in either the human health risk assessment or the ecological risk screening process. However, because ecological risk analyses indicated no ecological impact at SWMU 54, and no migration toward Ensenada Honda of the additional compounds evaluated at SWMU 55, the human health CAOs will be promulgated. Table 2-27 provides a comprehensive summary of all COCs and their respective CAOs in all media for both SWMU 54 and SWMU 55.

2.5.1 Extent of Contamination Above CAOs—SWMU 54

All COCs at SWMU 54 were compared to the CAOs promulgated as shown in Table 2-27, with the result being that only two compounds, trichloroethene and benzene exceed CAOs in the groundwater. Figures 2-19 and 2-20 depict the extent of contamination above the benzene CAO of 550 ug/L and the TCE CAO of 22 ug/L in SWMU 54 groundwater. The vertical extent of the contamination is assumed to be from 5 feet below the ground surface to 25 feet below the ground surface. A depth of 25 feet below the ground surface was chosen conservatively since the previous investigations stopped at 20 feet below the ground surface. In addition, little contamination is found below this depth as shown by the analytical data from wells 54DW1 (screened from 20-25 feet bgs) and 54DW2 (screened from 30-35 feet bgs) as shown in Table 2-3. The aerial extent of the TCE plume is approximately 60 feet by 140 feet or 8,400 square feet (assuming a rectangular area). The aerial extent of the benzene plume is approximately 40 feet by 55 feet or 2,200 square feet (assuming a rectangular area). These extents will be considered in Tasks II, III, and IV of the CMS process.

2.5.2 Extent of Contamination Above CAOs—SWMU 55

The CAOs of the COCs forwarded from the human health risk assessment for groundwater at SWMU 55 were compared to groundwater concentrations at SWMU 55. The result was that only the compound of TCE exceeds the CAO of 22 ug/L established at SWMU 55. The extent of TCE contamination exceeding this concentration was shown in Figure 2-12. The approximate vertical extent of contamination will be assumed to be from 10 feet below the ground surface to 35 feet below the ground surface. This depth was chosen conservatively since the previous

investigations have not gone below 30 feet below the ground surface with the exception of TW-4d, located outside the TCE plume to the east, and exhibiting no contamination at 35 feet below the ground surface (Baker, 2000). The aerial extent of the TCE plume above the CAO is approximately 150 feet by 180 feet or 27,000 square feet. This extent will be considered in Tasks II, III, and IV of the CMS process in the following sections.

2.6 Preliminary Corrective Measures Alternatives

As a result of the current Task I process, groundwater at SWMU 54 and SWMU 55 was found to be the only contaminated media. An evaluation of the extent of contamination above the CAOs resulted in the compounds of benzene and TCE at SWMU 54 and TCE at SWMU 55 being above the CAOs established for each SWMU. Corrective measures alternatives will be presented that would provide suitable protection of human health and the environment of these compounds in the groundwater.

This section will provide a preliminary evaluation of the corrective measures alternatives as specified in Task I of Module III—Appendix B of the RCRA Part B Permit. In the following section a brief description of the different process options available will be provided.

Following the descriptions of the process options, a formulation of alternatives and evaluation of these alternatives will be discussed for SWMU 54 and SWMU 55. Because groundwater is the only affected media requiring corrective measures, it is expected that the alternatives will be simple, consisting at most of only one, or possibly two, process options.

This section of the CMS Report provides a preliminary listing of the corrective measure technologies potentially applicable for use at SWMUs 54 and 55 as specified in the Final CMS Work Plan (Baker 2003a).

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 SWMUs 54 and 55.

- No Action
- Institutional Controls
- Containment/Collection
- In-situ Biological Treatment, including Monitored Natural Attenuation
- In-situ Physical/Chemical Treatment
- Ex-situ Biological Treatment and Discharge
- Ex-situ Physical/Chemical Treatment and Discharge
- Monitored Natural Attenuation

Table 2-28 provides a listing of more detailed technologies that are generally addressed under the broad categories bulleted above, along with a brief description of them.

2.6.1 Process Option Descriptions

2.6.1.1 In-Situ Treatment of Groundwater

In-situ treatment, whether passive or active, may be preferred due to the elimination (in most cases) of an external treatment system and the associated operation and maintenance requirements and costs.

In-situ treatment can be biological or physical/chemical. Biological processes include 1) natural biodegradation evaluated through monitored natural attenuation (MNA); 2) enhanced bioremediation through the addition of electron donors and/or bacterial cultures (referred to as bioaugmentation); and 3) phytoremediation. Enhanced bioremediation can be configured in a couple different ways, namely by treating the entire plume or the plume "hot spot" as it is currently understood, or by relying on plume movement through a permeable biological zone of treatment.

Physical/chemical processes include 1) MNA processes of dilution, dispersion, and volatilization; 2) volatilization by air sparging or in-well aeration; 3) oxidation through the use of oxidizer such as hydrogen peroxide, permanganate, persulfate, or ozone; 4) reduction through the use of reducing agents such as zero-valent iron; or 5) thermal treatment through the use of electric heat applied to contaminated soils beneath the water table. These are described below. With the exception of zero-valent iron and in some cases, enhanced bioremediation, most of these technologies involve direct contact of the reagent/process with the contaminated media. Zero-valent iron permeable reactive barriers have frequently been used downgradient of a plume to intercept the contaminants and remediate them prior to plume movement off-site. Recently, enhanced biological zones have been found to be successful in remediating plumes as they move through these zones.

The success of an in-situ technology is directly dependent on the ability to target the remediation in the correct location(s). In very low permeability zones, these technologies may be limited. Artificial methods of enhancing permeability, such as through hydraulic fracturing or pneumatic fracturing can be implemented prior to or in conjunction with the use of these technologies to ensure that the correct target location is remediated. Naturally, this option will add to the cost, and the cost-benefits will need to be evaluated. Another method of distributing the various compounds to the target zones is through the use of groundwater circulation wells.

Monitored Natural Attenuation

In the monitored natural attenuation (MNA) alternative, no physical remedial actions will be performed to reduce the toxicity, mobility, or volume of contaminants present in groundwater. Instead, groundwater samples will be collected and analyzed on a regular basis from a network of monitoring wells to evaluate the migration of the groundwater plume over time. Sentinel wells also will be monitored to determine if the plume has moved beyond the boundaries of the current conceptual model.

The two primary components of natural attenuation in groundwater are:

1. **Nondestructive Processes** such as mechanical dispersion, diffusion, sorption, dilution, and volatilization.

2. **Destructive Processes** such as biodegradation and abiotic degradation mechanisms, such as hydrolysis and dehydrohalogenation.

Microorganisms that degrade petroleum compounds, especially BTEX are ubiquitous in the soil and groundwater environments. Most of these organisms need some form of oxygen, whether in its dissolved state or in the form of a "terminal electron acceptor (TEA)", to "breathe" in order to convert the BTEX, their food, to carbon dioxide, water, energy, other metabolic by-products, and more microorganisms. Naturally, the more energy that is produced during any one of these reactions, the more favorable that reaction is over one that produces less energy.

Because of the energy considerations, there is an order in which the different microorganisms utilize different terminal electron acceptors in the groundwater. Obviously, dissolved oxygen is the most preferential electron acceptor because it is the easiest to breathe and it produces the most energy. Once the dissolved oxygen is depleted, nitrate, manganese oxides, iron oxides, and sulfate are used as TEA's. Finally, methane-producing bacteria (methanogens) utilize the acetate that forms when petroleum compounds ferment in a completely anaerobic environment.

In an aqueous environment in which biodegradation of BTEX or other anthropogenic or natural organic carbon has occurred, there are several geochemical parameters that can be measured in order to indicate how reduced or in which state of reduction the aquifer is. These are dissolved oxygen, nitrate, manganese, ferrous iron, sulfate, and methane. In addition, the oxidation-reduction potential and alkalinity can be measured. It should be noted that the values of these parameters in a contaminant plume are considered in relation to their values outside of a contaminant plume.

The biodegradation of chlorinated volatile organic compounds (CVOCs) is typically termed "reductive dechlorination" because the CVOC has its chloride ions sequentially replaced with hydrogen ions through a mechanism termed "halorespiration". This process is optimized in a reduced aqueous environment and results in the formation of daughter products from the more highly chlorinated parent compounds (i.e., tetrachlorethene and TCE). For the case of chlorinated ethylenes, tetrachloroethene reduces to TCE, then predominantly to cis-1,2-dichloroethene (DCE), vinyl chloride (VC), and finally to ethylene and ethane. Occasionally, the 1,1-DCE and trans-1,2-DCE isomers are also produced as intermediate degradation products. During each of these reactions, a chloride ion on the parent compound is replaced by a hydrogen ion. All of these reactions are biological. In the case of the chlorinated ethanes, trichloroethane (TCA) can be biologically reduced to DCA, or it can be abiotically reduced to 1,1-DCE or acetate. These and other mechanisms are described in several documents, including Weidemeier and others (1998).

The energy released from dechlorinating PCE and TCE is greater than that released from the reductive dechlorination of cis-1,2-DCE to VC and VC to ethylene. Hence, the former two reactions are more likely to occur than the later two. This is one reason why at some sites, an abundance of cis-1,2-DCE is seen, but little or no VC and ethylene are detected. In addition, the absence of other microbial species capable of further dechlorinating cis-1,2-DCE to VC and VC to ethylene may also slow down the breakdown of the daughter products within an aquifer. A third reason is that iron-reducing microbes may inhibit further dechlorination until the bioavailable iron is reduced in the aquifer (Evans and Koenigsburg, 2001).

EPA's Office of Solid Waste and Emergency Response (OSWER) Directive 9200.4-17 (1999) identifies three lines of evidence that can be used to evaluate the natural attenuation (NA) of chlorinated aliphatic hydrocarbons. These lines of evidence are:

1) Historical groundwater and/or soil chemistry data that demonstrate a clear and meaningful trend of decreasing solvent mass and/or concentration over time at appropriate monitoring or sampling points.

2) Hydrogeologic and geochemical data that can be used to demonstrate indirectly the types of NA processes active at the site, and the rate at which such processes will reduce solvent concentrations to required levels.

3) Data from field or microcosm studies (conducted with impacted site media), which directly demonstrate the occurrence of a particular NA process at the site and its ability to degrade the solvents of concern.

A report by the National Research Council (NRC, 2000) also proposed a three-part strategy for MNA decision making. These three points differ slightly from the OWSER directive and are listed below:

a) develop a site conceptual model that identifies what destruction or immobilization processes are responsible for protecting human health and the environment;

b) obtain site-specific information that documents the cause-and-effect relationship between solvent loss and the destruction and immobilization process; and

c) implement a long-term data acquisition and evaluation program that documents that these processes are sustained and are consistent with achieving remediation design objectives.

In effect, the former three lines of evidence from the OSWER directive are condensed into the first two parts of the NRC strategy, with the third part of the strategy dealing with documenting sustainability of NA at a site through the use of an evaluation program. The "footprint" concept (that is, showing the different areas of the site that have amenable conditions for reductive dechlorination) is a key element of the NRC strategy. Also, an increased "level of effort" is part of the NRC strategy when uncertainty due to reaction mechanisms and site heterogeneity is high.

Enhanced Bioremediation and Bioaugmentation

In-situ enhanced bioremediation is a developing technology that has been shown to be an effective treatment for BTEX compounds and CVOCs, in particular the chlorinated ethylenes. For enhanced bioremediation of BTEX compounds, oxygen-releasing materials are added to the aquifer in order to promote aerobic degradation of BTEX compounds in an efficient manner. For CVOC degradation, enhanced bioremediation involves the microbial degradation of an organic carbon source to generate hydrogen (an electron donor) to degrade the CVOCs. Molasses, sodium lactate, methanol, emulsified oil, and Hydrogen Release Compound (HRC®) manufactured by Regenesis® are common organic carbon sources used to enhance the reductive dechlorination process. All of these compounds slowly dissolve groundwater to produce hydrogen, which is used by halo-respiring bacteria to degrade CVOCs to non-toxic by-products. Electron donors change the conditions of the aquifer to enhance natural biodegradation of the chlorinated solvents. During the degradation process, the existing aerobic or mildly anoxic aquifer is altered to an anaerobic environment, which is essential for the dechlorination of the chlorinated solvents.

Bioaugmentation is a modification to the bioremediation process for CVOCs whereby specific microorganisms are added to the groundwater containing chlorinated solvents, along with an organic carbon source, in order to ensure the correct microbial consortium is present for reductive

dechlorination to occur. (It should be noted that bioaugmentation is rarely necessary for BTEX compounds.) Bioaugmentation is most often performed when daughter products of reductive dechlorination are present, but in limited quantities, or the reductive dechlorination process is stalled at a certain point, leaving the site with a build-up of daughter products, such as the DCE compounds, or vinyl chloride. The isolation and development of these cultures has been ongoing in the past few years. It is known to date that only one microbe, *dehalococcoides ethenogenes*, can degrade chlorinated ethylenes, beginning with PCE, all the way to ethylene. KB-1™ is one microbial culture, developed by Dupont, which has been used for bioaugmentation at chlorinated solvent sites. Recently, a microbial culture called "BAV1" has been shown to degrade VC to ethylene (Kahn, 2003). Other laboratories often have their own proprietary dechlorinating cultures for use in these studies.

Limitations typically involve difficulties with accurate placement of the compounds and the ability of the aquifer to accept electron donor materials, such as would occur in a tight formation.

Phytoremediation

Phytoremediation is a process that uses plants to remove, transfer, stabilize, and destroy contaminants in groundwater (see www.frtr.gov/matrix2/section4/4-33.html for a complete description). The mechanisms of phytoremediation include enhanced rhizosphere biodegradation, phyto-extraction (also called phyto-accumulation), hydraulic control, phyto-degradation, phyto-volatilization, and phyto-stabilization.

The most commonly used flora in phytoremediation projects are poplar trees, primarily because the trees are fast growing and can survive in a broad range of climates. In addition, poplar trees can draw large amounts of water (relative to other plant species) as it passes through soil or directly from an aquifer. This may draw greater amounts of dissolved pollutants from contaminated media and reduce the amount of water that may pass through soil or an aquifer, thereby reducing the amount of contaminant flushed though or out of the soil or aquifer.

Currently, trees are under investigation to determine their ability to remove organic contaminants from ground water, translocate and transpiration, and possibly metabolize them either to CO_2 or plant tissue.

There are a number of limitations to phytoremediation (see www.frtr.gov/matrix2/section4/4-33.html):

- It is limited to shallow soils, streams, and ground water.
- High concentrations of hazardous materials can be toxic to plants.
- It involves the same mass transfer limitations as other biotreatments.
- Climatic or seasonal conditions may interfere or inhibit plant growth, slow remediation efforts, or increase the length of the treatment period.
- It can transfer contamination across media, e.g., from soil to air.
- It is not effective for strongly sorbed (e.g., PCBs) and weakly sorbed contaminants.
- Phytoremediation will likely require a large surface area of land for remediation and a large time frame for implementation.

- The toxicity and bioavailability of biodegradation products is not always known. Products may be mobilized into ground water or bioaccumulated in animals. More research is needed to determine the fate of various compounds in the plant metabolic cycle to ensure that plant droppings and products manufactured by plants do not contribute toxic or harmful chemicals into the food chain or increase risk exposure to the general public.

Air Sparging/In-Well Aeration

Air sparging involves the injection of air into the aquifer matrix in order to promote the volatilization of the contaminants, thereby forcing them to migrate upward through the groundwater and into the unsaturated soil zone where they are removed through soil-vapor extraction. In-well aeration is a slight modification to this system where air is injected into the groundwater within an outer well casing and the volatilized contaminants are contained within this casing and forced to migrate upward to a treatment area. No release of the contaminants to the unsaturated zone is possible with in-well aeration. The oxygen added to the groundwater can also be used to enhance any bioremedial activity that may be occurring.

Limitations of air sparging include uneven distribution of the air once it enters the aquifer due to soil heterogeneity. It is also not applicable to fractured bedrock formations and does not work well in tight formations.

Oxidation

Chemical oxidation is a developing technology that has been shown to be an effective remedial treatment for dissolved, sorbed, and non-aqueous phase liquid chlorinated solvents (ethylenes and ethanes), as well as other organic compounds. Oxidants that are commonly used include potassium permanganate, sodium permanganate, hydrogen peroxide, Fenton's reagent, and ozone. Recently, sodium persulfate also has been found to be an effective oxidant. A direct electron transfer is involved with the permanganate compounds, while hydrogen peroxide, Fenton's reagent, and ozone use a free radical process (Siegrist, 2001). Persulfate is also a free radical process. Both methods rapidly degrade organic compounds by cleaving and oxidizing the substances non-selectively, a process that results in forming successively smaller-chained compounds. A wide range of organic compounds can be treated using these oxidants including: chlorinated ethylenes, chlorinated ethanes, vinyl chloride, toluene, xylene, pentachlorophenol, and PAHs. Some oxidants are not effective at treating acetone, benzene, ethylbenzene, methylene chloride, carbon tetrachloride, chloroform and heavier weight petroleum hydrocarbons (Clayton, 2000).

Reduction

Reducing technologies are similar to oxidative technologies with the exception that the site contaminants are reduced instead of oxidized. Typical reductants currently used are zero-valent iron for CVOCs, sodium sulfide and sodium dithionite for metals (Nyer, et al., 2001). The reaction mechanism for zero-valent iron is two-fold, including electron transfer to the iron by the groundwater, producing hydrogen gas, ferrous iron, and hydroxide. The second reaction is between the iron and organic compound, again producing ferrous iron, chloride, and the non-chlorinated compounds (Nyer, et al., 2001).

Thermal Treatment

In groundwater thermal treatment, steam is forced into an aquifer through injection wells in order to vaporize VOCs and SVOCs. Vaporized components rise to the unsaturated zone and are removed by soil vapor extraction and treated. Hot water or steam-based techniques are pilot-scale technologies. The process can be used to remove large portions of oily waste accumulations and to retard downward and lateral migration of organic contaminants. Target contaminants for this technology are SVOCs, fuels, and DNAPLs. Dissolved VOCs can usually be treated more cost-effectively with other process options.

2.6.1.2 Collection and Ex-Situ Treatment of Groundwater

Pumping and subsequent treatment and discharge of the extracted groundwater is a process option considered for this CMS. Ex-situ treatment can be biological or physical/chemical, involving bioreactors, air stripping, liquid phase carbon adsorption, or ultraviolet oxidation. All require the construction of a treatment plant or area, some operation and maintenance activity over an extended period of time, and discharge options. The different treatment options are described below.

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.

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.

Liquid Phase Carbon Adsorption

Groundwater is pumped through activated carbon canisters that provide adsorption capabilities for VOCs. Periodic replacement of the carbon is required when adsorption sites are used up. The carbon can be regenerated and reused. If concentrations are low, the duration of the carbon is longer than if the concentrations are high. Target contaminant groups for liquid phase carbon adsorption are VOCs, SVOCs, hydrocarbons, pesticides, and explosives.

Ultraviolet 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.

Discharge or Reinjection

When groundwater is extracted and treated via any of the above processes, the treated water is discharged to a nearby surface water body. Regulations require that a National Pollutant Discharge Elimination System (NPDES) permit be applied for and granted prior to this action. Limitations include extremely low organic/inorganic allowable discharge levels that may require additional treatment prior to discharge and regulatory requirements for disposal. Alternatively, when groundwater is extracted and treated via any of the above processes, the treated groundwater is re-injected into the aquifer at a location and rate approved through regulations via an Underground Injection Control (UIC) permit. Limitations include soil permeability and regulatory requirements.

2.6.1.3 Containment

Containment of contamination in the subsurface groundwater would typically involve construction of some sort of barrier in the groundwater in order to prevent the flow of groundwater in a particular direction. Slurry walls, sheet piling, or grout curtains are examples of this type of corrective measure. This remedial technique would not be effective in reducing contamination in the groundwater, only preventing movement of it in an undesirable direction or to an undesirable location. Other containment options include groundwater pumping to prevent off-site migration of contaminated groundwater.

2.6.2 Preliminary Screening of Alternatives

The above process options were considered for both SWMU 54 and 55 during this task of the CMS process. Screening of these technologies is done in this subsection with the result being a list of alternatives applicable for either SWMU 54 or SWMU 55 or both. Screening is done in order to eliminate those technologies that may be infeasible to implement, rely on processes unlikely to perform satisfactorily or reliably, or that do not achieve the corrective measure objective within a reasonable time period. The site and waste characteristics and technology limitations for the two SWMUs are discussed in the following subsections.

2.6.2.1 Site Characteristics

Section 2.1 provided a description of the geologic and hydrogeologic conditions at SWMU 54 and SWMU 55. This information is valuable when screening those technologies that require groundwater pumping. Contaminated SWMU 54 groundwater is located in a clay unit. SWMU 55 groundwater is located in mostly a weathered bedrock and unweathered bedrock geology. Slug test results were also given in Section 2.1.1.2 and 2.1.2.2, with SWMU 54 exhibiting a low hydraulic conductivity of 0.027 to 0.272 feet/day, and SWMU 55 having a hydraulic conductivity of 0.012 to 4.77 feet/day.

2.6.2.2 Waste Characteristics

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

At these two SWMUs there are only two compounds that exceed CAOs and must be addressed in this CMS. They are benzene (SWMU 54 only) and trichloroethene (SWMU 54 and SWMU 55). Both of these exceed CAOs in groundwater only. They were both found only in a dissolved,

aqueous phase, and are likely not present as non-aqueous phase liquids (NAPLs). However, because of uncertainty in this characterization, some consideration will be given to the potential of residual NAPL presence in the subsurface when evaluating different alternatives in Sections 3, 4, and 5. Chemical characteristics of these two compounds can be found on fact sheets provided in Appendix B.

2.6.2.3 Technology Limitations and Screening

Technology limitations with regard to development, performance record, construction, operation and maintenance problems, and ease of implementation were used to screen corrective measure technologies in this section. Also, the technologies were screened on whether or not they were applicable to the sites. Table 2-29 provides a comprehensive list of the process options and technologies presented in Section 2.6.1, along with a preliminary screening of those technologies and the reasons for exclusion.

A few technologies possess limitations due to the fine-grained nature of the soil at SWMU 54. These include any technology that requires groundwater movement to accomplish the remediation. Specifically, any groundwater pumping option or permeable reactive barrier, either biological or physical/chemical, were eliminated from SWMU 54 options. Also, air sparging was eliminated from SWMU 54 due to the tight-grained nature of the soil. It was also eliminated from SWMU 55 because bedrock conditions are likely not conducive to effective air sparging. In-well aeration was also eliminated from both of these SWMUs for these reasons. Phytoremediation was eliminated due to the long time frame associated with this technology and because the contamination is not located near enough to the ground surface. Thermal remediation of any sort was eliminated due to the fact that soil contamination is not present at these SWMUs. Thermal remediation is typically used as a remedial alternative when just soil, or both soil and groundwater, are contaminated. Also the high cost of thermal technologies is difficult to justify for the limited extent and concentration of the contamination at these sites. Containment of the contaminant plumes was also screened out because of the low concentrations and the lack of need for diversion, such as away from a water supply well.

2.6.3 Identification of Corrective Measures Alternatives

Several alternatives were formulated from the technologies and response actions that made it through the preliminary screening process. The development of these alternatives included sound engineering judgment to determine which of the identified technologies appear most suitable for the SWMU 54 or SWMU 55. Different alternatives are given for SWMU 54 and SWMU 55 as shown in the following sections. The selected alternatives represent a workable number of options that each appears to adequately address all site problems and CAOs. These will be screened further in the following sections, Tasks II and III, for their suitability to the different SWMUs.

2.6.3.1 SWMU 54

- Alternative 1
  No Action

- Alternative 2
  Institutional Controls and Monitored Natural Attenuation

- Alternative 3
  Institutional Controls, Enhanced Bioremediation (optional Bioaugmentation) and Monitored Natural Attenuation

- Alternative 4
  Institutional Controls, Oxidation, and Monitored Natural Attenuation

2.6.3.2 SWMU 55

- Alternative 1
  No Action

- Alternative 2
  Institutional Controls and Monitored Natural Attenuation

- Alternative 3
  Institutional Controls, Enhanced Bioremediation (optional Bioaugmentation), and Monitored Natural Attenuation

- Alternative 4
  Institutional Controls, Oxidation, and Monitored Natural Attenuation

- Alternative 5
  Institutional Controls, Reduction, and Monitored Natural Attenuation

- Alternative 6
  Institutional Controls, Groundwater Extraction with Liquid Phase Carbon Adsorption, Re-injection, and Long Term Monitoring

Each alternative except Alternative 1 addresses groundwater constituents at the SWMUs. Institutional controls and monitored natural attenuation are consistent throughout each alternative with the exception of Alternative 1—no action, and Alternative 6, where long-term monitoring is proposed rather than MNA.

Alternative 1 is the no action alternative. The no action alternative is not required to be evaluated by the RCRA Part B Permit; however, it was forwarded due to the relatively small probability of groundwater exposure at these SWMUs. It is not expected that the contaminated groundwater will migrate beyond the respective SWMU boundaries at NAPR.

Alternative 2 consists solely of institutional controls and monitored natural attenuation. This alternative would provide an assessment of naturally occurring degradation processes and occurrence of off-site migration at the respective SWMUs as the plumes are monitored with time. In addition, institutional controls in the form of a deed restriction on groundwater extractions would protect human health.

Alternative 3 utilizes institutional controls, enhanced bioremediation with optional bioaugmentation, and monitored natural attenuation to reduce contaminant concentrations at the SWMUs. It is not expected that active bioremediation will reduce concentrations below MCLs. As a result, monitored natural attenuation would likely still be required. Enhanced bioremediation options include the addition of an electron donor to the TCE-contaminated groundwater to promote reductive dechlorination, and the addition of a source of oxygen to promote biodegradation of the benzene-contaminated groundwater.

Alternative 4 includes the use of institutional controls, oxidation of contaminants through the use of an oxidizing agent such as permanganate or Fenton's reagent. It is not expected that oxidation

will reduce concentrations below MCLs. As a result, monitored natural attenuation would likely still be required.

Alternative 5 consists of institutional controls, and active remediation of the TCE plume at SMWU 55 using a reductive technology such as zero-valent iron. It is not expected that an active reduction technology will reduce concentrations below MCLs. As a result, monitored natural attenuation would likely still be required.

Alternative 6 utilizes institutional controls, groundwater extraction, treatment, and re-injection for five years at SWMU 55. It is not expected that extraction and treatment will reduce concentrations below MCLs. As a result, a long-term monitoring program would likely still be required.

3.0 TASK II—EVALUATION OF THE CORRECTIVE MEASURES ALTERNATIVES

In this section the various alternatives are evaluated with regard to the criteria set up in Appendix B of Module III of the RCRA Part B Permit. The technical, environmental, human health, and institutional concerns associated with each alternative will be discussed. Because alternatives 1 through 4 are the same for both SWMUs, these will be evaluated once, with SWMU differences due to site constraints and site conditions discussed within the text. Alternatives 5 and 6 were forwarded for SWMU 55 only.

The use of institutional controls for corrective measures at NAPR is subject to some scrutiny due to the transfer of the former NSRR to NAPR. The Navy and EPA are currently negotiating a RCRA 7003 Order on Consent that is expected to include, among other things, requirements that institutional and/or engineering controls be maintained for any SWMUs and AOCs at the NAPR facility where clean-up levels based on unrestricted (i.e., residential) land-usage are not achieved. The RCRA 7003 Order on Consent is also expected to include requirements addressing responsibility for maintaining such institutional and/or engineering controls for a SWMU or AOC in the event of the sale or transfer of that portion of the NAPR facility to an entity other than the U.S. Navy. The Navy has indicated to EPA that it expects any entity acquiring a portion of the NAPR facility where clean-up levels based on unrestricted (i.e., residential) land-usage have not been achieved, will be required to enter into an "enforceable agreement" (such as an Administrative Order) with EPA. If the acquired parcel is subject to institutional and/or engineering controls, it would be the Navy's expectation that continued maintenance of those institutional and/or engineering controls would be required under any "enforceable agreement" (such as an Administrative Order) between the acquiring entity and EPA.

In the technical evaluation, the performance, reliability, implementability, and safety of each alternative will be evaluated. The performance is measured by the effectiveness and useful life of the alternative. The effectiveness is the ability of the alternative to perform the intended functions, such as contain, divert, remove, destroy, or treat the COCs. The combination of various technologies in the alternatives will be evaluated as a whole. Should a particular technology or process within the alternative be responsible for reducing the performance of the alternative, this will be evident during these evaluations. The reliability is measured by the operation and maintenance requirements of the alternative and the risk and effect of failure of the alternative. Implementability criteria reflect the constructability of the alternative, the time it takes to implement the alternative, and the time of expected beneficial results. Any threat to the safety of the nearby communities and environments as a result of the alternative, including worker safety during implementation, is also evaluated.

In the environmental assessment of the alternative, the short and long term beneficial and adverse effects of the alternative on environmentally sensitive areas are assessed.

The protection of human health criteria examines the extent to which each alternative mitigates short and long term potential exposure to contamination. Residual levels expected from each alternative shall be compared to the CAOs.

Each alternative will be assessed as to the requirements needed to meet relevant Federal, State, and local standards, regulations, ordinances and community relations.

A cost estimate of each alternative, including capital costs and operation and maintenance costs, is also provided.

3.1 SWMU 54 & 55—Alternative 1

This alternative consists solely of no action. Under the no action general response, no physical remedial actions will be performed to reduce the toxicity, mobility, or volume of contaminants identified in groundwater. Aquifer use restrictions will not be implemented under a no action alternative to prevent potential exposure to contaminated groundwater at the site. No groundwater monitoring will be conducted to warn receptors of contaminant migration under this alternative. The no action alternative is not required to be evaluated by the Part B Permit, but is presented here for completeness and potential applicability to these SWMUs.

3.1.1 Technical

3.1.1.1 Performance and Reliability

There are no performance and reliability issues associated with this alternative. Although this alternative does not involve physical remediation, over time the contaminant concentrations

throughout the plume will be reduced through natural attenuation processes. Contaminant concentrations may decrease over time due to other processes such as dispersion and dilution, although this would occur over a very long period of time.

3.1.1.2 Implementability

This alternative is easily implemented.

3.1.1.3 Safety

Under the no action alternative, no means are provided to monitor or confirm the natural remediation process or to track contaminant migration. In addition, this alternative does not preclude the installation of new water supply wells or building construction within the plume areas; therefore, this alternative is not effective in protecting potential future receptors.

3.1.2 Environmental

The ability of this alternative to benefit the environment is limited, but as stated above, contaminant concentrations may decrease over time due to natural processes such as dispersion, dilution, volatilization, and biodegradation. There would be no short or long term adverse effects of the alternative on environmentally sensitive areas. In addition, there is no exposure pathway for ecological risk at SWMU 54. At SWMU 55, exposure through groundwater migration to Ensenada Honda is unlikely.

3.1.3 Human Health

This alternative is not protective of human health, as concentrations will remain constant for an undetermined amount of time. Construction and industrial workers would potentially be exposed to concentrations exceeding CAOs, through the mechanism of volatilization of contaminated groundwater or potential direct contact.

3.1.4 Institutional

This alternative does not satisfy water quality standards.

3.1.5 Cost Estimate

There is no cost for this alternative.

3.2 SWMU 54 & 55—Alternative 2

Alternative 2 consists of institutional controls and monitored natural attenuation. Institutional controls for groundwater include the restriction of groundwater extraction at the site through the use of a perpetual deed restriction, thereby avoiding exposure to groundwater to any receptor at the site both now and in the future. They can also include the requirement of the provision of an alternative water source. An alternative water source is already in place at NAPR through the use of a potable water supply originating from El Yunque. Additional institutional controls can consist of access limitations such as fencing and signage.

Monitored natural attenuation includes the documentation of processes occurring in the groundwater that reduce contaminant concentrations. It also documents any plume migration that

may be occurring. Specific requirements of this process option for the site contaminants were enumerated in Section 2.6.1.

For the purposes of this CMS, it will be assumed that fourteen wells will be included in the MNA program for SWMU 54, and eight wells for SWMU 55. The differences in the two SWMUs' contaminant characteristics and the applicability of this alternative to each SWMU are discussed below.

SWMU 54

Specific institutional controls for SWMU 54 would potentially include a deed restriction on future building construction in areas of the known plumes. Because Building 1910 is not located over a contaminated area, no restriction on the occupancy of this building would be expected to be necessary. However, it is currently unoccupied. Construction of a water supply well would be restricted as well.

At SWMU 54, natural attenuation processes have not been documented with the exception of obtaining dissolved oxygen and oxidation-reduction potential measurements in the field during the RFI investigation. A monitored natural attenuation evaluation would need to be done at this SWMU prior to implementation of this alternative. During the RFI, the dissolved oxygen concentrations were low across the site. In particular, the DO at wells 510MW5 and 54TW15 were below 1.0 mg/L (Baker, 2003a), indicating an anaerobic environment. Correspondingly low oxidation-reduction potential measurements (in the negative range) were also observed at these locations. The two different processes occurring, oxidation of the benzene, and reductive dechlorination of the TCE, would be expected to be ongoing in the anaerobic environments.

During reductive dechlorination, dichloroethene isomers are produced from TCE. These include cis 1,2-DCE (primary), trans 1,2-DCE and 1,1-DCE. The TCE daughter product of cis 1,2-dichloroethene was not quantified during the RFI, nor was the total 1,2-DCE concentration, due to their absence in the Appendix IX list of VOCs. Trans 1,2-DCE was quantified with the result being no detections, either during the SAR or the RFI. During both these investigations, however, 1,1-DCE was found to be present at an estimated concentration of less than 1 ug/L at well 510MW5, potentially indicating that a small biological conversion of TCE to this daughter compound is occurring. Logic would indicate that, because this minor degradation product is present, the primary DCE isomer (cis 1,2-DCE) would also be present. The second-generation daughter product of TCE degradation, vinyl chloride, has not been detected at this site.

Time trends indicate that benzene concentrations have decreased in well 510DW1, from 4,800 ug/L in 1995 to 91 ug/L in 2000 and 2002. The benzene concentration of 3,000 µg/L in well 54TW15 during 2002 is in a previously uncharacterized area and is not believed to be a result of migration of the plume from 510DW1 to the location near 54TW15 due to the low hydraulic conductivity at this site. From 1995 to 2002 the groundwater would have been expected to move a maximum of 7 feet, based on the maximum groundwater flow velocity calculated in Section 2.1.1.2. Therefore, the decrease in concentration of benzene at 510DW1 is likely to be from naturally occurring processes.

Time trends for TCE at well 510MW5 also indicate a decrease from 230 µg/L in 2000 to 190 µg/L in 2002. Again, it is unlikely that this decrease is due to plume movement due to the slow groundwater velocity, but can possibly be attributed to naturally occurring processes.

SWMU 55

Institutional controls at SWMU 55 would include restriction of building construction over the area of the TCE plume and restricting groundwater withdrawal for potable water use.

Limited natural attenuation information is available from past investigations at SWMU 55. During the last TCE Plume Delineation and Source Investigation (Baker, 2004), TCE concentrations were found to be similar to those in 1999 during the CMSI. Some attenuation mechanisms are occurring, including reduction of TCE to its primary degradation product, cis 1,2-DCE. Vinyl chloride has not been detected at SWMU 55. Reducing conditions do not appear to be present across the entire SWMU, but DO readings less than 1.0 mg/L were seen within the TCE plume at wells 7MW23 and 7MW24. Degradation mechanisms other than reductive dechlorination may be occurring to reduce the TCE in the plume. A monitored natural attenuation evaluation will be conducted prior to implementation of this alternative in order to refine the site conceptual model for natural attenuation.

Time trend information indicates that TCE has been reduced in concentration slightly since its discovery in 1999, from 2,000 µg/L (1999) to 1,800 µg/L (2003).

3.2.1 Technical

3.2.1.1 Performance and Reliability

Institutional controls in the form of restricted access and land use restrictions would remove any future risk pathway by restricting future development of building on the site that may be occupied on a regular basis by humans. They are appropriate and required to address groundwater at the site. They also offer a high level of effectiveness that requires no physical maintenance, other than inspection of fencing or signage on a regular basis. Institutional controls have an indefinite useful and service life.

Monitored natural attenuation, while not requiring an active remedial technology, can provide useful information on the performance of the natural system's ability to contain and remove contamination. The processes that need to occur in the subsurface can be documented through the use of MNA specific sampling and analysis. If natural attenuation processes are found to be occurring, this alternative can provide reliable contaminant reduction. If they are not found to be occurring, but adequate downgradient monitoring is ongoing as a part of this process option, this technology can also assumed to be reliable for risk reduction, if the institutional controls are enforced.

In an MNA alternative, both performance and reliability are dependent on adequate spatial monitoring of the extent of contamination above the CAOs. For SWMU 54, it will be assumed that 14 wells will be used to monitor both the TCE plume (8 wells) and the benzene plume (6 wells). Of these wells, one will be an upgradient background well. It will be assumed that 11 of these wells will be newly installed and 3 of them will be existing wells.

At SWMU 55, many wells are already installed at the site. Because of this, only three new wells will be installed. For the monitoring program, it will be assumed that 8 wells will be monitored during the MNA program.

Frequency of monitoring is also a factor in the performance and reliability of this alternative. Quarterly monitoring for 2 years is recommended to determine if any seasonality in the concentrations or MNA conditions is present. Semi-annual monitoring for the next ten years, and annual sampling for an additional eighteen years will be used to ascertain the decrease in concentrations at both SWMUs. If sampled wells (other than the background well) have non-

detect concentrations for consecutive sampling events during the semi-annual monitoring, or even the quarterly monitoring, they can be reliably dropped from the sampling program.

3.2.1.2 Implementability

Institutional controls are easily implemented and the time frame for implementation is relatively short. The time of expected beneficial results is immediate for reducing risk to potential receptors.

MNA implementation requires a comprehensive assessment of the currently observed natural processes that are reducing contaminant concentrations. This assessment would likely include Geoprobe® or temporary well sampling to determine the state of reduction the aquifers are in and subsequent installation of one or more monitoring wells within the plumes, if necessary. In addition, upgradient monitoring wells, and sentinel wells should be installed to measure background conditions of the aquifer (upgradient wells) and plume movement beyond the SWMU boundaries (sentinel wells). Once this assessment is done, implementation of this process option simply requires a long-term monitoring plan and subsequent reporting of the MNA processes and plume status occurring at the SWMUs.

The expected time of implementation of MNA is short. The expected time of beneficial results is dependent on the natural system's ability to degrade the contamination in the groundwater. As an aid in assessing the impact of MNA in the aquifer, two screening models were used to predict the ability of natural attenuation processes to reduce concentrations to below the CAOs or predict plume movement beyond SWMU boundaries given natural conditions. The model BIOCHLOR (Aziz, et al., 2001) was used to predict the extent of a TCE plume with a constant concentration source if 30 years of groundwater flow was modeled at both SWMU 54 and SWMU 55. The model BIOSCREEN (USEPA, 1996c) was used to predict benzene degradation at SWMU 54 after a time period of 30 years. Both of these models assume a constant source of the parent compounds, and because of this constraint, the time to complete decay of the contaminants in the groundwater is unable to be obtained using these models. They can, however, predict the extent of the plumes with and without biodegradation occurring in the groundwater. All model descriptions, assumptions, input parameters, and results can be found in Appendix E.

SWMU 54

The results of the BIOCHLOR model for SWMU 54 shows that the TCE plume extent at non-detect levels will not exceed a distance of 50 feet downgradient in a 30-year time frame if the TCE concentration in the plume stays at its current level and the naturally occurring processes of adsorption and biodegradation take place. If no degradation takes place, the extent of the TCE plume above the CAO of 22 µg/L is approximately 50 feet, still within the SWMU 54 boundary.

The BIOSCREEN model results indicate that the benzene plume at SWMU 54 also will not exceed a length of 80 feet using a first order decay model and 30 years of plume movement. The extent of the benzene plume above 550 ug/L (CAO) does not exceed 40 feet in this time frame. Using an instantaneous reaction decay model, the plume does not extend beyond 20 feet of the current configuration in 30 years. Again, model constraints required that a constant concentration of 3,000 µg/L be assumed for the duration of the modeled time frame.

SWMU 55

SWMU 55 BIOCHLOR modeling indicates that TCE plume movement would go beyond the boundary of the SWMU into the Ensenada Honda downgradient of the source area at 7MW07 in

approximately 5 years at detectable concentrations. A similar time frame was predicted with the groundwater flow model (Baker, 2003c). However, current knowledge of the plume indicates that the plume has not reached the Ensenada Honda, and that concentrations decrease to non-detect after 240 feet. In addition, the plume configuration did not change significantly from 1999 (Baker, 2000) to 2003 (Baker, 2004). Other abiotic mechanisms may be at work in the aquifer to keep the concentrations low. These include dilution or some other abiotic degradation of the chlorinated hydrocarbons, such as has been found in aquifer materials containing iron (Ferrey, et al., 2004). Given that two full-scale plume characterization field events have already occurred at this site, it may be that it is not possible to accurately predict with certainty what is causing the plume concentrations to be non-detect past 240 feet.

Because of the difficulty of monitoring a plume in a fractured bedrock aquifer, the monitoring network emplaced for the MNA implementation will be closely evaluated during the initial two years of monitoring. Should any concentrations detected in the monitoring well network be found to be atypical and not consistent with the site conceptual model, additional wells may be installed to refine the site conceptual model and reduce the uncertainty of the existing monitoring network. Periodic evaluation of the site conceptual model will be done during the entire term of MNA as well, with the effect of reducing the uncertainty in monitoring of the fractured rock environment.

For the purposes of this CMS, it will be assumed that a MNA plan will be followed for 30 years.

3.2.1.3 Safety

Safety concerns for the nearby community and for the workers during implementation are minimal. The implementation of the MNA corrective measure implies a great deal of safety simply due to the fact that no active systems will be installed or operational during the implementation period.

3.2.2 Environmental

The ability of this alternative to benefit the environment at SWMU 54 is evident by the reduction in groundwater concentrations of the COCs due to naturally occurring processes. There would be no short or long term adverse effects of the alternative on environmentally sensitive areas.

At SWMU 55, the monitoring of the groundwater at locations near Ensenada Honda would indicate if protection of the marine environment would be adequate with this alternative. Current information at this SWMU indicates that the plume is stable, but this would be confirmed with continued monitoring. Should concentrations begin to rise, active remediation efforts can be initiated by incorporating a contingency plan into the MNA Long-Term Monitoring program.

3.2.3 Human Health

For SWMU 54 this alternative is protective of human health by removing the potential exposure pathways, through land use control restrictions, to humans. The volatilization into indoor air pathway and construction worker exposure pathway will be removed by restricting building construction of new buildings in the contaminated groundwater areas through the use of a deed restriction. Because the groundwater movement is believed to be very slow at this site, this restriction will be effective to protect human health for at least 100 years (based on a groundwater flow velocity of 0.3 feet per year, provided no hydrogeologic changes occur at SWMU 54).

SWMU 55 institutional controls would be adequate to protect human health at this location under this alternative.

3.2.4 Institutional

The requirements necessary to meet institutional needs would require only a limited effort because this alternative represents only a limited extension of the current conditions. A MNA long term monitoring plan for each SWMU along with any contingency actions in place would have to be approved by federal, state, and location environmental agencies. This alternative satisfies federal, state, and local requirements.

3.2.5 Cost Estimate

The cost estimate provided here assumes the following for each SWMU: legal preparation of institutional controls, additional site characterization as necessary, installation of new wells, MNA monitoring plan with contingencies, and MNA monitoring for 30 years. Appendix F contains the cost estimate information and assumptions.

The cost estimate for Alternative 2 at SWMU 54 is $931,818. The cost estimate for Alternative 2 at SWMU 55 is $731,675. The primary difference in these two cost estimates is related to additional well installation costs at SWMU 54, and number of monitoring wells sampled at the different SWMUs.

3.3 SWMU 54 & 55 - Alternative 3

Alternative 3 for both SWMU 54 and SWMU 55 consists of institutional controls, enhanced bioremediation with the option of bioaugmentation, and MNA. In essence, the process option of enhanced bioremediation is added to Alternative 2 to form this alternative. Enhanced bioremediation of TCE plumes typically consists of the addition of electron donor to the aquifer to promote an anaerobic aqueous environment suitable for halorespiration of chlorinated compounds to occur. Several electron donors were listed in Section 2.6.1. Enhanced bioremediation of benzene plumes consists of the addition of some form of oxygen to the aquifer to promote aerobic biodegradation of the benzene compound.

At SWMU 54, both of these microbial processes, anaerobic and aerobic, would need to be promoted in the two different areas of the SWMU requiring remediation. It is not expected that employing competing processes at one SWMU would be difficult as these two areas are approximately 200 feet apart, with little groundwater movement occurring at this site. At SWMU 55, only the anaerobic biodegradation process would be employed because only TCE is present at concentrations exceeding the CAOs.

Because SWMU 54 TCE concentrations are relatively low, it is not expected that bioaugmentation would be necessary for the reduction of TCE to below the CAO. If the conversion of TCE only resulted in DCE (as is possible with no bioaugmentation), it is unlikely that the concentration of the DCE compounds would exceed any risk to human health and the environment as the CAO for cis 1,2-DCE would likely be 60,000 µg/L (see Table 2-23). If the highest concentration of TCE at SWMU 54 (190 µg/L) was completely converted to DCE, the resulting concentration would only be 140 µg/L DCE, well below the CAO for this compound. Even with build-up of additional DCE due to conversion of sorbed TCE to DCE, it is unlikely that the DCE concentration would approach the CAO.

At SWMU 55, TCE concentrations are higher than at SWMU 54. Even though, as above, if all the TCE in the aquifer were converted to DCE, it would be unlikely to exceed the CAO for DCE, bioaugmentation of the aquifer to complete the dechlorination process is presented as an option for SWMU 55.

Specific processes evaluated in this alternative include the addition of a carbon source (lactate based) or electron donor for anaerobic biostimulation in groundwater. For the purposes of this CMS, it will be assumed that the carbon source will need to be imported from the mainland. Local sources of electron donors such as molasses provided by a sugar cane treatment plant can also be considered during the design phase. This process will be evaluated at both the SWMU 54 and SWMU 55 TCE plumes.

The other process evaluated at SWMU 54 includes the addition of some form of oxygen into the subsurface at the location of the benzene contamination. For the purposes of this CMS, it will be assumed that Oxygen Release Compound (ORC®) will be used to provide oxygen to the groundwater. ORC® is a patented formulation of magnesium dioxide that slowly releases oxygen upon hydration from six to nine months. The "time-release" feature of ORC® is accomplished with the use of a food grade phosphate that is intercalated within the magnesium dioxide. The phosphate both inhibits water from immediately permeating the magnesium dioxide and also allows the crystalline structure to remain open for complete dissolution with time. The by-products of the ORC® reaction with water are oxygen gas and magnesium hydroxide. With this technology, the oxygen that is released is used for direct aerobic biodegradation of petroleum hydrocarbon plumes.

ORC® is available as a white powder. It is mixed with water to form a slurry which is injected under pressure into an aquifer. Once it is mixed, it is injected into the aquifer at grid points located in the area of the vinyl chloride plume using direct push technology. Configuration of the injection can also be in the form of a permeable "oxygen barrier" for controlling plume migration downgradient of the source area.

ORC®'s effectiveness does not rely on direct contact with target contaminants. Rather, the diffusion and dispersion processes in the groundwater deliver oxygen to the targeted areas. In tight soils, diffusion plays a significant role. It is a greater challenge to allow dispersion to carry the oxygen, but this challenge can be overcome by varying the spacing of the grid points and the amount of ORC® injected. ORC® is expected to last from six to nine months in a subsurface aqueous environment. In the event of a large oxygen demand in the subsurface due to an oxygen starved environment, two injections of ORC® may be necessary.

At SWMU 54 the amendments will be injected into the subsurface via direct push technology applied in a grid pattern throughout the plumes. The number of injection locations and volume of injected liquid will be determined in the design phase, but for the conceptual design in this CMS it will be assumed that 14 injection locations will be used in the benzene plume and 42 injection locations will be used in the TCE plume (see Figure 3-1). It is assumed that two injection events spaced three months apart will be sufficient to reduce the contamination to below the CAO for the TCE plume. It is assumed that one injection of ORC® will be sufficient at the benzene plume, unless bench testing (see below) determines otherwise.

At SWMU 55, the electron donor will be placed into the aquifer using injection into temporary wells placed in a grid pattern within the TCE plume. For the purposes of this CMS, a conceptual design includes 30 injection locations (see Figure 3-2). It will be assumed that four injections spaced three months apart will be used, with the second injection, if necessary, containing the microbial culture for bioaugmentation. At both SWMUs, monitoring of the concentrations of the COCs in the groundwater between injections will be done using new or existing wells and/or injection wells.

3.3.1 Technical

3.3.1.1 Performance

Enhanced bioremediation is an effective way to reduce concentrations of compounds in the groundwater. Several case studies and full-scale implementations of this technology can be found in the literature (c.f. Nyer, et al., 2001). The performance of this technology can be expected to reduce concentrations of COCs in the groundwater to levels below those currently observed. How much reduction of concentration is realized depends on several factors, including the ability

to target the correct zone of contamination, and the original source strength of the COCs in the target areas. Given the concentrations found at these SWMUs and the confidence in the accuracy of those source concentrations, it is expected that enhanced bioremediation will perform adequately at the three areas of concern within these SWMUs.

3.3.1.2 Reliability

Most enhanced bioremediation systems can reliably reduce concentrations in groundwater. Often, microcosm testing with several different electron donors is done to determine the appropriate electron donor for use at the site(s). This additional testing is beneficial to the reliability of the system because the electron donor that provides maximum reduction of the COCs can be used with more confidence than just picking an electron donor off the shelf so to speak. In addition, if bioaugmentation is necessary at the site(s), this will become apparent during the microcosm testing, and appropriate microorganisms can be specified for this alternative. For the ORC® application, bench testing, or at a minimum, total oxidant demand testing, can determine if a large oxygen sink is present prior to injection, and the pilot study design can be adjusted accordingly.

Even with a microcosm test, there is still uncertainty in the ability of biological activity to reduce concentrations at any given site. It is usually recommended that a pilot study be performed prior to full-scale implementation of this alternative. The pilot study should be performed after results of a microcosm test indicate the appropriate electron donor for use at the site(s).

Rebound of dissolved organic compound concentrations following injection can occur with enhanced bioremediation technologies. Rebound occurs when target compound concentrations are initially reduced following treatment, but increase again over time. If the amendment is used up before the biological system stabilizes, rebound is likely to occur.

Because there are no operation and maintenance (O & M) requirements for this alternative, it is inherently more reliable than an option that requires continuous O & M. The process is flexible in that different areas of the groundwater plume(s) can be targeted with different doses of the amendments, depending on contaminant concentrations. This option also increases the reliability of this alternative. The effect of failure of the active portion of this alternative would be to revert back to current conditions with the added protection of institutional controls.

In the MNA portion of this alternative, both performance and reliability are dependent on adequate spatial monitoring of the extent of contamination above the CAOs. For SWMU 54, it will be assumed that 14 wells will be used to monitor both the TCE plume (8 wells) and the benzene plume (6 wells). Of these wells, one will be an upgradient background well. It will be assumed that 11 of these wells will be newly installed and 3 of them will be existing wells.

At SWMU 55, many wells are already installed at the site. Because injection wells will be used in this alternative, no new monitoring wells will be installed, as it will be supposed that a few injection wells can also be sampled. For the monitoring program, it will be assumed that 8 wells will be monitored during the MNA program.

3.3.1.3 Implementability

Implementation issues will be directly related to the ability to inject the amendments into the groundwater given the site constraints of low permeability at SWMU 54 and bedrock formations at SWMU 55. The time frame of implementation is expected to be up to three years. This includes time for additional site characterization, microcosm testing, pilot study testing, design,

and repeated injections (if necessary) of the different amendments. The time frame for expected beneficial results is dependent on the ability of the microbes in the groundwater to react to the more optimum conditions. Given an increase in biological decay rates, a time frame of five years is reasonable for site cleanup. MNA will follow the active portion of the remediation to ensure site concentrations remain below CAOs.

Implementation of the bioaugmentation portion of the alternative, proposed only at SWMU 55, will require some care in order to ensure that the microbial culture remains viable after injection. The primary concern is that the aquifer be in a reduced state prior to introduction of the culture. If it is not in a reduced state, the culture may die. For this reason, the culture should not be introduced during the first injection of the electron donor. Generally, one or two doses of electron donor are required prior to introduction of the microbial culture.

As stated above, implementation at SWMU 54 will be assumed to occur with direct push technology. At SWMU 55, direct push technology is not possible, and therefore, injection wells will have to be installed, adding significantly to the cost.

3.3.1.4 Safety

Safety concerns for the nearby community and for the workers during implementation are minimal. There will be no ongoing above ground operations with equipment, resulting in a high level of safety for this alternative.

3.3.2 Environmental

The ability of this alternative to benefit the environment at SWMU 54 is evident by the reduction in groundwater concentrations of the COCs due to naturally occurring processes. At SWMU 55, the monitoring of the groundwater at locations near Ensenada Honda would indicate if protection of the marine environment would be adequate with this alternative. However, the potential for formation of vinyl chloride in the groundwater may provide a negative impact on the environment due to the potential exposure pathway at Ensenada Honda. This pathway is not applicable to SWMU 54. It is likely that some short-term environmental changes will be present in the geochemistry at the SWMUs due to increased microbial activity.

3.3.3 Human Health

For SWMU 54 this alternative is protective of human health by removing the potential exposure pathways, through land use control restrictions, to humans. The volatilization into indoor air pathway and construction worker exposure pathway will be removed by restricting building construction of new buildings in the contaminated groundwater areas through the use of a deed restriction. Enhanced biological removal of the COCs will provide additional protection of human health, although the formation of vinyl chloride may make this alternative less attractive. For the purposes of this CMS, it is expected that there will be a reduction in concentration of an order of magnitude, resulting in concentrations in the same order of magnitude as the CAOs, at SWMU 54.

SWMU 55 institutional controls would be adequate to protect human health at this location under this alternative. However, the implementation of enhanced bioremediation will provide additional protection of human health. At SWMU 55, a one order of magnitude reduction would not be enough to reduce the concentration to CAO's. Even with the bioaugmentation option added to the alternative, it may or may not be possible to reduce the TCE concentration by two

orders of magnitude to get it in the same order of magnitude as the CAO. Formation of vinyl chloride with this option will need to be assessed for any risk should it occur.

3.3.4 Institutional

An injection permit may be necessary for the injections described above. It is likely that the requirements would be moderate for the application and approval of these permits. Other institutional requirements necessary for implementation of this alternative are minimal. Alternative 3 satisfies all Federal, state, and local requirements.

3.3.5 Cost Estimate

The cost estimate provided here assumes the following for each SWMU: legal preparation of institutional controls, one microcosm test, one pilot study, one year of injections, and follow on MNA for 14 years (resulting in a total treatment time of 15 years). The amendment proposed for costing purposes for the TCE plumes at both SWMUs is a concentrated 60 percent lactate. Dilution of this to 6 percent will be done prior to injection. The amendment proposed for the benzene plume is ORC®. As noted above, local sources of electron donor, such as molasses from a sugar cane processing plant, will also be considered and evaluated during the microcosm test. If a local electron donor is used, some cost savings can be realized. Bioaugmentation will be included in the cost estimate for SWMU 55 only, as described above. Appendix F contains cost backup information.

The costs for the two different plumes at SWMU 54 are as follows. For the benzene plume with ORC® remediation, the cost is $646,158. For the TCE plume with lactate remediation, the cost is $793,050, giving a total cost for SWMU 54 of $1,439,208.

The cost for the lactate remediation at SWMU 55 is estimated to be $1,747,770. The additional costs at SWMU 55 are related to injection well installation (as opposed to direct push injection at SWMU 54), bioaugmentation, and additional injection events.

3.4 SWMU 54 & 55—Alternative 4

Alternative 4 for both SWMUs 54 and 55 includes Alternative 2 with the addition of the oxidation process option for the contaminant plumes. Oxidation processes differ depending on the oxidant used. Oxidants that are commonly used include potassium permanganate, sodium permanganate, hydrogen peroxide, Fenton's reagent and ozone. Recently, sodium persulfate has also been found to be an effective oxidant. A direct electron transfer is involved with the permanganate compounds, while hydrogen peroxide, Fenton's reagent and ozone use a free radical process (Siegrist, 2001). Both methods rapidly degrade the contaminants by cleaving and oxidizing organic compounds non-selectively, a process that results in forming successively smaller-chained hydrocarbon compounds.

For this alternative, the same oxidant will be used for both plumes at SWMU 54. It will be assumed that some type of Fenton's reagent process will be used at this SWMU because Fenton's has the ability to oxidize both benzene and TCE. At SWMU 55, permanganate will be evaluated for oxidation of the TCE plume. Permanganate specifically targets the double bond of the TCE and continues to oxidize TCE in the aquifer as long as the permanganate persists.

For SWMU 54 it is expected that the method of implementation will be in a grid pattern across the plume areas and will be determined during the design phase. For the conceptual design in this CMS it will be assumed that 14 injection locations will be used in the benzene plume and 42

injection locations will be used in the TCE plume (see Figure 3-1). The strength of the oxidant solution will also be determined during the design phase. However, it is expected that the TCE plume will not require as high of a dose of oxidant as the benzene plume. There are two reasons for this. First the TCE concentrations are about an order of magnitude lower than the benzene concentrations. Second, the benzene plume also contains ethylbenzene, isobutanol, toluene, xylene, and a few SVOCs, all of which will also be oxidized by this process. In addition, any naturally occurring organic carbon will be oxidized by the Fenton's process and will need to be factored into oxidant demand calculations.

At SWMU 55, it is expected that the method of implementation will also be in a grid pattern throughout the TCE plume and 30 injection locations will be assumed for the conceptual design, as shown in Figure 3-2. The oxidant calculations will factor into them the ability to overcome both the chlorinated compounds present at the site and any naturally occurring carbon.

3.4.1 Technical

3.4.1.1 Performance

Oxidation is an effective way to reduce concentrations of compounds in the groundwater. Several case studies and full-scale implementations of this technology can be found in the literature (c.f. Battelle, 2002). The performance of this technology can be expected to reduce concentrations of COCs in the groundwater to levels below those currently observed. How much reduction of concentration is realized depends on several factors, including the ability to target the correct zone of contamination, and the original source strength of the COCs in the target areas. Given the concentrations found at these SWMUs and the confidence in the accuracy of those source concentrations, it is expected that oxidation will perform adequately at the three areas of concern within these SWMUs. Additional benefits of oxidation include its ability to treat residual NAPL at the site, should it be present.

Rebound of dissolved contaminant levels following injection is a common occurrence with in situ oxidation technologies. This treatment is often implemented in phases to address the zones of greatest rebound after the initial application of substrate. This approach may result in a more efficient use of the technology and treatment of contaminants.

Naturally occurring metals in the matrix should be considered when evaluating this technology because certain inorganics (including arsenic, chromium, uranium, vanadium, selenium, and molybdenum) can be oxidized and mobilized under the oxidizing conditions that the oxidant creates. These conditions may attenuate over time and the inorganics would return to a reduced state (Siegrist, 2001). However, at NAPR, any change in inorganic concentrations may be of concern.

3.4.1.2 Reliability

Most applications of oxidation technologies reliably reduce concentrations in groundwater. Often, laboratory bench scale testing with several different oxidants is done to determine the appropriate oxidant for use at the site(s). This additional testing is beneficial to the reliability of the system because the oxidant that provides maximum reduction of the COCs can be used with more confidence because site groundwater and site soil is used in the bench scale test. In addition, if naturally occurring organic matter inhibits the effectiveness of oxidation, this will be apparent during the bench testing.

Even with the bench scale test, there is still uncertainty in the ability of the oxidant to target the contaminants at the site. It is usually recommended that a pilot study be performed prior to full-

scale implementation of this alternative. The pilot study should be performed after results of a bench scale test indicate the appropriate oxidant for use at the site(s).

Rebound of dissolved organic compound concentrations following injection is a common occurrence with oxidation technologies. Rebound occurs when target compound concentrations are initially reduced following treatment, but increase again over time. If the reagent does not reach into all pore spaces to react with the target compounds, rebound is likely to occur.

Because there are no operation and maintenance (O & M) requirements for this alternative, it is inherently more reliable than an option that requires continuous O & M. The process is flexible in that different areas of the groundwater plume(s) can be targeted with different doses of the amendments, depending on contaminant concentrations. This option also increases the reliability of this alternative. The effect of failure of the active portion of this alternative would be to revert back to current conditions with the added protection of institutional controls.

In the MNA portion of this alternative, both performance and reliability are dependent on adequate spatial monitoring of the extent of contamination above the CAOs. For SWMU 54, it will be assumed that 14 wells (some injection wells will be sampled) will be used to monitor both the TCE plume (8 wells) and the benzene plume (6 wells). Of these wells, one will be an upgradient background well.

At SWMU 55, many wells are already installed at the site. Because injection wells will be used in this alternative, no new monitoring wells will be installed, as it will be supposed that a few injection wells can also be sampled. For the monitoring program, it will be assumed that 8 wells will be monitored during the MNA program.

3.4.1.3 Implementability

Implementation issues will be directly related to the ability to inject the oxidants into the groundwater given the site constraints of low permeability at SWMU 54 and bedrock formations at SWMU 55. The time frame of initial implementation is expected to be up to three years. This includes time for additional site characterization, bench scale testing, pilot study testing, design, and repeated injections (if necessary) of the different oxidants. The time frame for expected beneficial results is immediate. A time frame of three years is reasonable for site cleanup, depending on rebounding of contaminants in the aquifer that may require additional oxidation doses. MNA will follow the active portion of the remediation to ensure site concentrations remain at or below CAOs.

3.4.1.4 Safety

Safety concerns for the nearby community and for the workers during implementation are minimal to moderate. Fenton's reagent applications have, in the past, been known to be uncontrolled, resulting issues with safety of workers in the immediate area during application. Modifications have been made to the processes and at the current time, safe implementation of this technology is standard. Minimal safety issues have been noted with permanganate applications. In addition, there will be no ongoing above ground operations with equipment, resulting in a high level of safety for this alternative.

3.4.2 Environmental

The ability of this alternative to benefit the environment at SWMU 54 is evident by the reduction in groundwater concentrations of the COCs due to active processes, in this case, oxidation. At

SWMU 55, the monitoring of the groundwater at locations near Ensenada Honda would indicate if protection of the marine environment would be adequate with this alternative. In particular, mobilization of permanganate to the Ensenada Honda would have to be carefully monitored under this alternative. Any residual environmental effects of this alternative are unlikely in the long term. It is likely that some short-term environmental changes will be present in the geochemistry at the SWMUs due to potential metal mobilization in the groundwater as a result of the oxidation process. As stated above, these are unlikely to persist. However, metals in the groundwater are an ongoing ecological concern at NAPR, and this possibility may make this alternative less attractive.

3.4.3 Human Health

For SWMU 54 this alternative is protective of human health by removing the potential exposure pathways, through land use control restrictions, to humans. The volatilization into indoor air pathway and construction worker exposure pathway will be removed by restricting building construction of new buildings in the contaminated groundwater areas through the use of a deed restriction. Removal of the COCs by oxidation will provide additional protection of human health. For the purposes of this CMS, it is expected that there will be a reduction in concentration of an order of magnitude, resulting in concentrations in the same order of magnitude as the CAOs, at SWMU 54.

SWMU 55 institutional controls would be adequate to protect human health at this location under this alternative. However, the implementation of oxidation will provide additional protection of human health. At SWMU 55, a one order of magnitude reduction would not be enough to reduce the concentration to CAO's, resulting in a less favorable result with this alternative.

3.4.4 Institutional

An injection permit may be necessary for the injections described above. It is likely that the requirements would be moderate for the application and approval of these permits. Other institutional requirements necessary for implementation of this alternative are minimal. Alternative 4 satisfies all Federal, state, and local requirements.

3.4.5 Cost Estimate

The cost estimate provided here assumes the following for each SWMU: legal preparation of institutional controls, one bench scale test, one pilot study (two at SWMU 54), one year of implementation, and follow on MNA for 14 years (resulting in a total treatment time of 15 years). As noted above, the amendment proposed for costing purposes for SWMU 54 is Fenton's reagent, and the amendment proposed for SWMU 55 is sodium permanganate. Appendix F contains the cost backup information.

At SWMU 54, the costs for the two different plumes are as follows: for the benzene plume, the total cost is $704,163, and for the TCE plume it is $947,673, resulting in a total cost at SWMU 54 of $1,651,836.

At SWMU 55 the total treatment cost for the TCE plume is $824,594.

The primary difference in these two SWMUs is related to the inclusion of two mobilizations assumed for the two different plumes at SWMU 54, which may or may not be necessary. Other factors include the larger number of monitoring wells at SWMU 54, and the higher costs associated with the reagents at SWMU 54.

3.5 SWMU 55 Alternative 5

Alternative 5 consists of institutional controls, a reduction process option, and monitored natural attenuation. This alternative is only proposed for SWMU 55, because this technology would not apply to the benzene plume at SWMU 54.

The reduction process option proposed for this alternative is direct injection of zero-valent iron into the TCE plume at SWMU 55. The TCE in the groundwater plume reacts with the zero-valent iron to form innocuous by-products as described above. This injection can be accomplished by a pneumatic fracturing technique. Direct injection is forwarded as the implementation technology as opposed to trench construction because of the likelihood that trench construction will not be feasible in the bedrock formation. Also, trench construction implies a passive remediation technique due to its reliance on groundwater flow through the permeable reactive barrier. Direct injection of the zero-valent iron is a more active remedial technique, reducing the time frame required for results. A typical radius of injection for pneumatic fracturing of fractured bedrock is approximately 15 feet. See Figure 3-3 for a conceptual rendering of injection locations for implementation of this alternative.

3.5.1 Technical

3.5.1.1 Performance

The use of zero-valent iron for reduction of halogenated chlorinated compounds is well documented in the literature (Yin and Allen, 1999). At SWMU 55, it is expected that this technology will perform well with regard to reducing the concentration of the TCE at this site. A 98 percent reduction in TCE concentration is expected with this technology. However, Chen, et al. (2002) provided documentation of an application of the injection of colloidal zero-valent iron in a fractured bedrock in New Jersey. The results indicated that TCE concentrations similar to those found at SWMU 55 were reduced by approximately 90 percent in the areas of injection. In addition to the rapid reduction of the TCE, an additional benefit of zero-valent iron is its ability to promote reducing conditions in the groundwater, enabling biodegradation to occur as well as abiotic reduction of the chlorinated compounds. If reduction of the TCE by 90 percent was obtained, it is unlikely that the TCE concentrations will be reduced to below the CAOs for this site. A 98 percent reduction in concentrations will reduce the TCE level to 36 ug/L, in the same order of magnitude as the CAO. MNA will follow the active portion of the remediation in order to ensure protection of human health and the environment.

The useful life of the zero-valent iron is dependent of the size of the iron particles. For this application, the particle size is very small in order to allow injection of the iron powder. A typical bench scale test is usually run for 30 days to determine the degradation of the COC with time with the use of iron powder. The iron is long lasting in the aquifer, although the period of reactivity in the field is likely limited to one year.

3.5.1.2 Reliability

Most applications of zero valent iron in chlorinated groundwater plumes reliably reduce contaminant concentrations. Because there are no operation and maintenance (O & M) requirements for this alternative, it is inherently more reliable than an option that requires continuous O & M. The process is flexible in that different areas of the groundwater plume(s) can be targeted with different doses of the of the zero valent iron, depending on contaminant concentrations. This option also increases the reliability of this alternative. The effect of failure

of the active portion of this alternative would be to revert back to current conditions with the added protection of institutional controls.

Because zero valent iron has been proven to treat TCE in groundwater, no bench scale testing will be necessary for this alternative. It is recommended, however, that a pilot scale test be done to determine the reliability of the pneumatic injection process.

3.5.1.3 Implementability

Implementation issues will be directly related to the ability to place the iron powder into the formation given the geology at SWMU 55. The time frame of initial implementation is expected to be up to two years. This includes time for additional site characterization if necessary, pilot study testing, design, and one injection of the iron powder. The time frame for expected beneficial results is immediate. MNA will follow the active portion of the remediation to ensure site concentrations remain protective.

The pneumatic fracturing technology requires the construction of continuously screened monitoring wells. These wells are used with the pneumatic fracturing tool, essentially a gas injection system equipped with packers in order to isolate the injection of the carrier gas and corresponding amendment (in this case, zero valent iron). The pressures of injection are only enough to overcome the in-situ pressures of the geologic formation, usually less than 100 pounds per square inch (psi). The flow rates of the carrier gas are quite high, however, often exceeding 1000 standard cubic feet per minute. The packer assembly is moved up and down in the well in order to distribute the iron powder in several locations with depth.

Minimal ground movement has been observed with this implementation technology, and what has been observed is usually associated with injections in shallower injection intervals. The deeper injections do not produce any ground heave due to the higher overburden pressures. Monitoring of ground heave can be conducted and can also be evaluated during a pilot test. No buildings are present in the area of the TCE plume at SWMU 55 so any issues associated with ground heave are expected to be minimal.

3.5.1.4 Safety

Safety concerns for the nearby community and for the workers during implementation are minimal. There will be no ongoing above ground operations with equipment, resulting in a high level of safety for this alternative.

3.5.2 Environmental

The ability of this alternative to benefit the environment is evident by the reduction in groundwater concentrations of the COCs due to active processes, in this case, reduction. At SWMU 55, the monitoring of the groundwater at locations near Ensenada Honda would indicate if protection of the marine environment would be adequate with this alternative. Any residual environmental effects of this alternative are unlikely in the long term. It is likely that some short-term environmental changes will be present in the geochemistry due to reaction of the iron with the groundwater. These changes are unlikely to persist as the iron loses its reactivity.

3.5.3 Human Health

SWMU 55 institutional controls would be adequate to protect human health at this location under this alternative. However, the implementation of reductive technology will provide additional

protection of human health. As stated above, a 90-98 percent reduction in concentration is expected with this alternative. With this performance, it is likely that the TCE concentrations will be in the same order of magnitude as the CAO, making this alternative potentially more favorable.

3.5.4 Institutional

An injection permit may be necessary for the injection described above. However, because iron is a relatively prevalent element and it may be classified as food grade, the injection permits may not be necessary. It is likely that the requirements would be moderate for the application and approval of these permits, if required. Other institutional requirements necessary for implementation of this alternative are minimal. Alternative 5 satisfies all Federal, state, and local requirements.

3.5.5 Cost Estimate

The cost estimate provided here assumes the following: legal preparation of institutional controls, one pilot study, additional site characterization as necessary, implementation, and follow on MNA for 14 years (resulting in a total treatment time of 15 years). The zero valent iron amendment proposed for this alternative is proprietary Ferox® powder, marketed by ARS Technologies. ARS Technologies also provides pneumatic fracturing of geologic formations for injection applications. Appendix F contains the cost backup information.

The cost estimated for this alternative at SWMU 55 is $2,016,609.

3.6 SWMU 55 Alternative 6

Alternative 6, proposed for SWMU 55 only, includes institutional controls, conventional extraction, subsequent treatment via liquid phase carbon adsorption, and discharge of the extracted groundwater for five years. As groundwater extraction and treatment will not address the entire plume and is not expected to decrease VOCs to regulatory levels in the short term, it is assumed that a long-term monitoring program will be required following the conclusion of the extraction program.

As stated, the conventional pump and treatment alternative is not expected to provide complete reduction of contaminant concentrations to CAOs in the area of interest. Rather, it is expected that this alternative will provide containment of the contaminant plume, prevent any migration outside of the currently understood plume boundaries, and remove a portion of the contaminant mass currently in the groundwater.

This alternative does not destroy COCs. Rather it removes them from the extracted groundwater and contains them in an activated carbon system. The activated carbon can be regenerated or disposed of. The treated groundwater will be assumed to be able to be re-injected upgradient of the plume at SWMU 55. Regulations require that a UIC permit be applied for and granted prior to this action. Limitations may include the ability of the formation to accept the treated groundwater, and inadequate hydraulic control of the injected water, potentially mobilizing contamination along the north side of Forrestal Road associated with the TWFF.

For the purposes of this CMS, the conceptual design of the groundwater extraction system will include two pumping wells, two injection wells, and one treatment shed. The pumping wells will be co-located with wells 7MW07 and 7MW24, the two areas where the highest concentrations of TCE were found, and will be screened in the treatment area from 10 to 35 feet bgs. The injection

wells will be located north of Building 2314, but south of Forrestal Road. Please refer to Figure 3-4 for a conceptual rendering of this design. The treatment shed will house the activated carbon canisters and sampling ports for influent and effluent sampling.

3.6.1 Technical

3.6.1.1 Performance

In this option the groundwater would be treated by a combination of institutional controls and extraction wells. Several assumptions will be made in this section to determine the adequacy of the performance of this alternative. They include number of pumping wells, pumping rates, efficiency, radii of influence, and mass removal assumptions. Any calculations presented in this section are provided in Appendix G.

Each of the two extraction wells will be fitted with a pump to collect groundwater from the SWMU 55 aquifer. For the purposes of this CMS, an assumed extraction rate of 20 gallons per minute (gpm) (10 gpm per well) will be used to evaluate the performance of the system. This rate is reasonable given the hydraulic characteristics of the aquifer at SWMU 55. It is not expected that this portion of NAPR will experience the low yield problems that other portions of NAPR exhibit, due to the results of the hydraulic conductivity slug tests that have been performed in this area. (The boring logs for well 7MW07 and 7MW24 are reproduced in Appendix G for review purposes). A pump test is highly recommended prior to implementation of this alternative in order to determine if this flow rate is feasible. If it is feasible, then the volume of groundwater extracted by the system in five years, assuming 80 percent efficiency, will be approximately 42 million gallons or 8.4 million gallons per year.

Another assumption that can be made is the radius of influence of the pumping wells. If the two wells are located near 7MW07 and 7MW24, as stated above, then the assumed radius of influence is approximately 30 feet since a distance of approximately 60 feet separates these two locations. The volume of groundwater contained within these two radii of influence is calculated to be approximately 320,000 gallons, assuming a 25-foot section of aquifer depth and a porosity of 30 percent. With the given flow rate, approximately 132 pore volumes of this portion of the aquifer will be removed in the five year period. Since DNAPL is not suspected to be present at the site (Baker, 2004), this quantity of water should be more than sufficient to contain and/or remove the sorbed and dissolved phase TCE at the site.

Treatment of extracted groundwater through the use of an ex-situ liquid phase carbon adsorption system would remove the COC from the groundwater stream. Assuming an average influent concentration of 100 μg/L for the entire 5-year period of operation, 16.5 grams of TCE would be removed. For comparison purposes, if an average of 500 μg/L of TCE is contained within the plume configuration as it is now (150 feet by 180 feet by 25 feet depth and 30 percent porosity), the entire plume would contain only 3 grams of TCE in the dissolved phase. Additional TCE is likely contained in a sorbed phase, but in any case, this alternative would be able to theoretically remove most of the TCE from the aquifer and contain it in a liquid phase carbon adsorption system. Naturally, influent sampling of the aqueous phase concentrations can be done on a regular basis to ensure that mass is being removed. If the influent concentration of TCE in the extracted groundwater drops below the CAO of 22 μg/L, the system can be shut down. Cycling of the system, that is, repeated shutdown and startup, could improve the performance of the system by allowing rebound to occur in the aquifer through the mechanism of desorption.

Following treatment of the groundwater, the water will be reinjected to the aquifer upgradient of the TCE plume area upon receipt of a UIC permit.

This alternative is expected to be effective at removing a portion of the TCE from the aquifer, and the useful life of the extraction, treatment, and injection portion of the alternative is expected to last the duration of its expected implementation time of five years.

3.6.1.2 Reliability

The reliability of the system is dependent on the reliability of the individual parts of the system. Regular operation and maintenance activities increase the reliability of this alternative, and labor and materials are readily available. The effect of failure of the active portion of this alternative would be to revert back to the current condition, with the added protection of institutional controls. Flexibility in this alternative, should conditions change, would require installation of additional extraction wells in the new area of concern and associated piping to the treatment shed. This would not require a huge effort, indicating that this alternative is flexible. Another aspect of the flexibility is the ability to shut down the system if influent concentrations are not above the CAO, and subsequently restart the system if concentrations should rise above the CAO again.

3.6.1.3 Implementability

This alternative is moderately easy to implement. Installation of new extraction and injection wells should not pose any problems. Conventional water treatment equipment will be used for onsite treatment of the groundwater. Long-term operation and maintenance will be required, but extraction and treatment systems are not complicated. Long term groundwater monitoring and reporting is easily implemented.

As stated above, a pumping and injection pilot test is recommended prior to design of the systems in this alternative in order to assess the groundwater extraction and contaminant removal rates at this site. The information obtained from this test will address any implementation issues, and any modeling assumptions, associated with groundwater removal and injection, including pump size selection, well construction requirements, and activated carbon needs.

Implementation of the UIC permit will require some effort. While it is expected that this permit will eventually be obtained, the effort involved in pursuing this option may make this alternative less attractive.

It is expected that the time frame of implementation will be approximately two years, including time for a pump test, design of the system, and installation of the pump and treat system. Under this alternative, a time limit for groundwater extraction and treatment of five years is imposed, during which time semi-annual groundwater monitoring will occur. Subsequent to that portion of the treatment, it will be assumed that an additional 20 years of semi-annual monitoring will be necessary to ensure that this alternative meets the CAO for TCE at this site. This assumption may or may not be valid, depending on groundwater concentrations following the cessation of the pump and treat process.

3.6.1.4 Safety

Safety concerns for the nearby community and for the workers during implementation are moderate. Because there will be some ongoing above ground operations with equipment, precautionary measures will need to be addressed in the design of this alternative. In addition, because groundwater is extracted, there is the potential of exposure to the groundwater containing TCE above the CAOs by operation and maintenance workers.

3.6.2 Environmental

The ability of this alternative to benefit the environment is not as apparent as other alternatives due to the fact that no contaminant mass is being destroyed, only transferred to other media. At SWMU 55, the monitoring of the groundwater at locations near Ensenada Honda will indicate if protection of the marine environment would be adequate with this alternative. Injection of the treated water may affect nearby contamination at TWFF, due to the potential lack of adequate hydraulic control.

3.6.3 Human Health

At SWMU 55, institutional controls alone would be adequate to protect human health at this location under this alternative. Protection of human health is less likely as the active portion of this alternative is implemented because of the extraction of the groundwater to locations where human exposure is possible. This alternative has the potential to reduce concentrations in the groundwater to the same order of magnitude as the CAO.

3.6.4 Institutional

Alternative 6 satisfies all Federal, state, and local requirements. The procedure necessary to obtain a UIC permit that satisfies all federal, state, and local requirements will likely involve a moderate effort and be the primary limitation in implementing this alternative.

3.6.5 Cost Estimate

The cost estimate provided here assumes the following: legal preparation of institutional controls, pump tests, additional site characterization as necessary, implementation, including monitoring, and follow on monitoring for 20 years (resulting in a total treatment time of 25 years). Appendix F contains the cost backup information for this alternative.

The cost for this alternative is estimated to be $1,136,180.

4.0 SWMU 54 TASK III—JUSTIFICATION AND RECOMMENDATION OF THE CORRECTIVE MEASURE(S)

The alternatives described and evaluated for SWMU 54 in Section 3.0 are reprinted here for ease of review. Four alternatives were forwarded for evaluation. They are:

- Alternative 1
  No Action

- Alternative 2
  Institutional Controls and Monitored Natural Attenuation

- Alternative 3
  Institutional Controls, Enhanced Bioremediation using lactate and ORC®, and Monitored Natural Attenuation

- Alternative 4
  Institutional Controls, Oxidation with Fenton's Reagent, and Monitored Natural Attenuation

4.1 Comparison of Alternatives

This section provides a discussion of the alternatives as they compare to each other in terms of meeting the goals of the corrective measure at SWMU 54. This will be a qualitative discussion, ranking the four SWMU 54 alternatives with regard to technical aspects, human health benefits, and environmental benefits. The ranking process is not a quantitative ranking but is a qualitative ranking. The ranking merely shows the relative benefit of an alternative in relation to the other alternatives. Throughout the comparative process, a recommended alternative will be presented and justified. The basis of this qualitative ranking will be the criteria evaluation of each alternative as presented to satisfy the Part B Permit in Section 3.0. Following the qualitative ranking, a quantitative ranking of costs associated with each alternative will be provided.

Before a comparative analysis could occur, summary tables were developed from information supplied in Section 3.0. Table 4-1 presents a qualitative analysis of the alternatives for the remediation of the two groundwater plumes, both benzene and TCE, at SWMU 54. The summary tables were color coded to more easily discern qualitative differences. The color coding goes from green, which identifies the alternative as most favorable, to red, which identifies the alternative as least favorable. Blue, yellow, and orange are used to qualitatively identify alternatives as more favorable, favorable, and less favorable, respectively. A qualitative rating was given to each alternative as it meets each evaluation criterion. Addition information that supports the rating is also presented within the table.

Table 4-2 presents a summary of the rankings that are discussed below. Also included in this table is the quantitative cost ranking.

4.1.1 Comparison of Alternatives on Technical Merits

The alternatives were ranked on their respective technical merit, that is, the subcriteria of performance, reliability, implementability, and safety. The rankings were obtained by considering all subcriteria of the technical evaluation equal. Alternative 2 was given the highest ranking on technical merit. The only drawback to this alternative was the time frame for obtaining results satisfying the CAOs, and the demonstrated and/or expected reliability of the alternative.

While MNA is an established technology for both COCs at SWMU 54, the processes involved are not guaranteed to be ongoing or sustainable at the site.

Alternatives 1 and 3 were tied for a second place rank, and Alternative 4 was ranked last. It should be noted that because Alternative 1 did not have many technical subcriteria to evaluate, this alternative was not completely evaluated under the technical merits and should not be compared directly with the other alternatives.

4.1.2 Comparison of Alternatives for Human Health Benefits

The human health benefit comparison revealed that both Alternatives 2 and 3 were equal in terms of protection of human health. Alternative 4 was ranked slightly less due to the active remediation portion of the alternative, namely application of the oxidant, Fenton's Reagent, may result in an uncontrolled reaction, and release to the ground surface during implementation. The likelihood of this occurring is small, but was included in the criteria. Alternative 1 was ranked last due to the unknown nature of the groundwater contamination and inadequate protection of human health without institutional controls.

4.1.3 Comparison of Alternatives for Environmental Benefits

Because there is no exposure pathway to the environment, Alternative 2, 3, and 4 were ranked equally for environmental benefits because groundwater concentrations will be known, and hopefully decreased under each of these alternatives. Alternative 1 was ranked slightly less due to the fact that groundwater concentrations will not be known, and therefore, environmental benefits under Alternative 1 are questionable.

4.1.4 Comparison of Alternatives by Cost

Table 4-2 contains the comparison of the alternatives by cost. As shown, the alternatives 1 and 2 were ranked in the order of first and second. Alternative 3 was next, followed by Alternative 4, although the difference between the two is only around $125,000.

4.2 Recommendation of the Preferred Corrective Measure

At SWMU 54, Alternative 2, which includes MNA and institutional controls, was ranked above all other alternatives in most of the categories, including cost. However, because of the desire to reduce the time frame for implementation, it is likely that the next ranking alternative will be also be considered as viable. Because there are two areas of concern at SWMU 54, it is possible to separate the two areas and recommend one alternative for the benzene plume and another alternative for the TCE plume.

At the benzene plume, a pilot test is recommended to evaluate the feasibility of alternative 3, enhanced bioremediation with ORC®. If this were successful, then a full-scale remediation of the benzene plume using Alternative 3 would be implemented, including institutional controls for the entire site, which includes the TCE plume.

It is clear that the TCE plume at SWMU 54 is relatively low in concentration. In addition, it has been fairly well delineated and the groundwater flow velocity is very low at this SWMU. It is recommended that MNA be combined with this alternative as a corrective measure for the TCE plume. The cost for this combination of alternatives is $1,386,858 as given in Appendix F. This cost is not shown on Table 4-2, since it is a combination of two alternatives. However, as expected, it is more than the cost for Alternative 2 but less than the cost for Alternative 3. The

monitoring network for the entire SWMU would include 20 wells and be assumed to continue for 25 years.

A pilot test utilizing ORC® in the area of the benzene plume would likely take approximately 1 year to complete (see Section 4.3) due to the slow release nature of ORC®. If the pilot test in Alternative 3 for the benzene plume does not produce favorable results, the remaining alternatives will be re-evaluated for potential implementation within the Engineering Evaluation Report of the pilot study. This re-evaluation would be done based on the remaining benzene contamination at the site. If necessary, a second pilot test using the next ranked technology will be initiated. On the other hand, the remaining concentrations may be reduced enough to consider MNA as a primary treatment technology, following evaluation of results from a comprehensive MNA evaluation in the area of the benzene plume.

4.3 Schedule

A schedule for implementation of the active portion of the proposed alternative at SWMU 54 is provided in Figure 4-1.

5.0 SWMU 55 TASK III—JUSTIFICATION AND RECOMMENDATION OF THE CORRECTIVE MEASURE(S)

The alternatives described and evaluated for SWMU 55 in Section 3.0 are reprinted here for ease of review. Six alternatives were forwarded for evaluation. They are:

- Alternative 1
  No Action

- Alternative 2
  Institutional Controls and Monitored Natural Attenuation

- Alternative 3
  Institutional Controls, Enhanced Bioremediation (optional Bioaugmentation) with lactate, and Monitored Natural Attenuation

- Alternative 4
  Institutional Controls, Oxidation using permanganate, and Monitored Natural Attenuation

- Alternative 5
  Institutional Controls, Reduction with zero-valent iron, and Monitored Natural Attenuation

- Alternative 6
  Institutional Controls, Groundwater Extraction with Liquid Phase Carbon Adsorption treatment, reinjection, and Long Term Monitoring

5.1 Comparison of Alternatives

This section provides a discussion of the alternatives as they compare to each other in terms of meeting the goals of the corrective measure at SWMU 55. This will be a qualitative discussion, ranking the six SWMU 55 alternatives with regard to technical aspects, human health benefits, and environmental benefits. The ranking process is not a quantitative ranking but is a qualitative ranking. The ranking merely show the relative benefit of an alternative in relation to the other alternatives. Throughout the comparative process, a recommended alternative will be presented and justified. The basis of this qualitative ranking will be the criteria evaluation of each alternative as presented to satisfy the Part B Permit in Section 3.0. Following the qualitative ranking, a quantitative ranking of costs associated with each alternative will be provided.

Before a comparative analysis could occur, summary tables were developed from information supplied in Section 3.0. Table 5-1 presents a qualitative analysis of the alternatives for the remediation of the TCE groundwater plume at SWMU 55. The summary tables were color coded to more easily discern qualitative differences. The color-coding goes from green, which identifies the alternative as most favorable, to red, which identifies the alternative as least favorable. Blue, yellow, and orange are used to qualitatively identify alternatives as more favorable, favorable, and less favorable, respectively. A qualitative rating was given to each alternative as it meets each evaluation criterion. Addition information that supports the rating is also presented within the table.

Table 5-2 presents a summary of the rankings that are discussed below. Also included in this table is the quantitative cost ranking.

5.1.1 Comparison of Alternatives on Technical Merits

The alternatives were ranked on their respective technical merit, that is, the subcriteria of performance, reliability, implementability, and safety. The rankings were obtained by considering all subcriteria of the technical evaluation equal. Alternatives 1, 2, 3, and 4 were tied for the highest ranking on technical merit. The only drawbacks to these alternatives were the time frame for obtaining results satisfying the CAOs, and the demonstrated and/or expected reliability of the alternative. (It should be noted that many of the subcriteria for technical evaluation are not applicable for the no-action alternative.) While MNA is an established technology for TCE, the processes involved are not guaranteed to be ongoing or sustainable at SWMU 55.

Next, Alternative 5 was ranked fifth, primarily because of the specialized equipment necessary for the injections. Alternative 6 was ranked last, primarily due to the O and M requirements, resulting in less reliability and less safety, and the slightly longer time to see results.

5.1.2 Comparison of Alternatives for Human Health Benefits

The human health benefit comparison revealed that Alternatives 2, 4, and 5 were equal in terms of protection of human health. Alternatives 3 and 6 were ranked slightly less. Alternative 3 has the potential for formation of vinyl chloride, which is not beneficial to human health. Alternative 6 had additional risk associated with another exposure pathway for humans due to the extraction process. Alternative 1 was ranked last due to the unknown nature of the groundwater contamination and inadequate protection of human health without institutional controls.

5.1.3 Comparison of Alternatives for Environmental Benefits

Because there is a slight chance of exposure to environment due to migration of contaminants to Ensenada Honda, Alternatives 2, 5, and 6 were ranked equally for environmental benefits because groundwater concentrations will be known, and hopefully decreased under each of these alternatives. Alternatives 1, 3, and 4 were ranked slightly less. In Alternative 1, groundwater concentrations will not be known, and therefore, environmental benefits under Alternative 1 are questionable. Alternative 3 may cause the formation of vinyl chloride. While vinyl chloride may be produced under natural conditions such as exist currently and in Alternative 2, it has not been detected at SWMU 55 to date. If it is being produced naturally, it is unlikely to migrate due to the aerobic nature of the aquifer currently existing outside the plume boundaries, causing the vinyl chloride to oxidize naturally. Under Alterative 3, reducing conditions will be induced and sustained, and bioaugmentation implemented, in order to promote complete dechlorination, ensuring the production of vinyl chloride, and its potential migration to the Ensenada Honda. Since it is unknown whether or not there is an exposure pathway to the Ensenada Honda, this potential must be considered in the rankings for environmental benefits, even though, as shown in Section 2.4.3, it would be unlikely to affect the Honda at ecologically important concentrations. Alternative 4 was ranked equally with Alternatives 1 and 3, because metals mobilization may occur with Alternative 4, again with a potential exposure to the Honda.

5.1.4 Comparison of Alternatives by Cost

Table 5-2 contains the quantitative ranking of the alternatives for cost. As shown, Alternatives 1 and 2 are ranked first and second, closely followed by Alternative 4. Alternatives 6, 3, and 5 were ranked fourth, fifth, and sixth, respectively.

5.2 Recommendation of the Preferred Corrective Measure

At SWMU 55, Alternative 2, which includes MNA and institutional controls, was ranked above all other alternatives in most of the categories, including cost. However, because of the desire to reduce the time frame for implementation, it is likely that the next ranking alternative will be considered as viable. The next-ranking alternative overall, exclusive of cost, were Alternatives 4 and 5, the injection of oxidants and zero valent iron. However, the cost of Alternative 5 may be prohibitive to consider full-scale implementation. A pilot test of this technology would likely cost around $300,000. A pilot test of Alternative 4 would likely cost around $100,000. This alternative also would be the most effective on any residual phase NAPL that may be present in the aquifer.

The fourth overall ranking, exclusive of cost, was Alternative 3. The difference in this alternative included a slightly higher risk due to formation of vinyl chloride. Cost estimates also rank Alternative 3 below Alternative 4.

It is recommended that a pilot test of injection of sodium permanganate be performed to evaluate this oxidation technology at SWMU 55. Issues to address in the pilot test are related to constructability, that is the ability of the injections to reach the site contaminants, and any rebounding that may occur. The results of the pilot test should be used in the design phase of the corrective measure, allowing a successful application of this technology as the final corrective measure at this site.

A pilot study of Alternative 4 would likely take six months to complete (see Section 5.3). Should the results of the pilot study for Alternative 4 prove unfavorable, the remaining alternatives will be re-evaluated for potential implementation within the Engineering Evaluation Report of the pilot study. This re-evaluation would be done based on the remaining contamination at the site. If necessary, a second pilot test using the next ranked technology will be initiated. On the other hand, the remaining concentrations may be reduced enough to consider MNA as a primary treatment technology, following evaluation of results from a comprehensive MNA evaluation in the area of the TCE plume.

5.3 Schedule

A schedule for implementation of the active portion of the proposed alternative at SWMU 55 is provided in Figure 5-1.

6.0 REFERENCES

Aziz, C.E., C.J. Newell, J.R. Gonzales, P. Haas. 2001. *BIOCHLOR, Natural Attenuation Decision Support System, Version 2.0,* User' s Manual, March, 2001.

Blasland, Bouck, and Lee (BB&L, Inc.). 1995. *Site Characterization Site 510, Roosevelt Roads Naval Station, Ceiba, Puerto Rico.* July 1995.

Baker Environmental, Inc., (Baker). 1997. *RCRA Facility Investigation Report for Operable Unit 2 (SWMU 7/8), Naval Station Roosevelt Roads, Ceiba, Puerto Rico.* June 1997.

Baker. 2000. *Final TCE Investigation Report for SWMU 7/8 – Tow Way Fuel Farm, Naval Station Roosevelt Roads, Ceiba, Puerto Rico.* February 15, 2000. Coraopolis, Pennsylvania.

Baker. 2001a. *Final Sampling and Analysis Report SWMUs 53 and 54, Naval Station Roosevelt Roads, Ceiba, Puerto Rico.* August 2001.

Baker. 2001b. *Final RFI Work Plan SWMUs 53 and 54, Naval Station Roosevelt Roads, Ceiba, Puerto Rico.* December 2001.

Baker. 2003a. *Final CMS Work Plan for SWMUs 53 and 54, Naval Station Roosevelt Roads, Ceiba, Puerto Rico.* March 2003.

Baker. 2003b. *Final Additional Data Collection Investigation Report, Tow Way Fuel Farm, Naval Station Roosevelt Roads, Ceiba, Puerto Rico.* April 22, 2003, Coraopolis, Pennsylvania.

Baker. 2003c. *Final Corrective Measures Study Task 1 Report, Tow Way Fuel Farm, Naval Station Roosevelt Roads, Ceiba, Puerto Rico.* April 22, 2003. Coraopolis, Pennsylvania.

Baker. 2003d. *Final Corrective RCRA Facility Investigation Report for SWMUs 53 and 54, Naval Station Roosevelt Roads, Ceiba, Puerto Rico.* July 23, 2003. Coraopolis, Pennsylvania.

Baker. 2003e. *Final TCE Plume Delineation and Source Investigation Work Plan, Tow Way Fuel Farm, Naval Station Roosevelt Roads, Ceiba, Puerto Rico.* July 25, 2003. Coraopolis, Pennsylvania.

Baker. 2004. *Final TCE Plume Delineation and Source Investigation Report, SWMU 55, Naval Activity Puerto Rico, Ceiba, Puerto Rico.* August 11, 2004. Coraopolis, Pennsylvania.

Bradley, L. J. N., B H. Magee, and S. L. Allen, 1994. "Background Levels of Polycyclic Aromatic Hydrocarbons (PAH) and Selected Metals in New England Urban Soils," *Journal of Soil Contamination*, Vol. 3, No. 4, pp. 349-361.

Buchman, M.F. 1999. *NOAA Screening Quick Reference Tables. NOAA HAZMAT Report 99-1.* Coastal Protection and Restoration Division, National Oceanic and Atmospheric Administration, Seattle, WA. 12 pp.

CH2M Hill, 2000. *Phase I Environmental Assessment at Building 1914 NEX, Naval Station Roosevelt Roads, Ceiba, Puerto Rico.* February 2000.

Chen, S., S.J Markesic, S.H. Abrams, 2002. "Injection of Zero-Valent Iron Into a Bedrock Formation for the Reduction of TCE," *Remediation of Chlorinated and Recalcitrant Compounds—2002, Proceedings of the Third International Conference*.

Chief of Naval Operations (CNO). 1999. *Navy Policy for Conducting Ecological Risk Assessments*. Memorandum from Chief of Naval Operations to Commander, Naval Facilities Engineering Command. Ser. N453E/9U595355. April 5, 1999.

Clayton, W.S., B.K., Marvin, T. Pac, and E. Mott-Smith, 2000. A Multi-site Field Performance Evaluation of *In-Situ* Chemical Oxidation Using Permanganate, in: *Chemical Oxidation and Reactive Barriers: Remediation of Chlorinated and Recalcitrant Compounds*, G.B., Wickramanayake, A.R., Gavaskar, A.S.C., Chen (editors), Battelle Press, Columbus, Ohio, pages 101-108.

Evans, P.J., and S.S. Koenigsburg, 2001. "A Bioavailable Ferric Iron Assay and Relevance to Reductive Dechlorination," *Bioaugmentation, Biobarriers, and Biogeochemistry*, A. Leeson, et al., editors. Proceedings of Battelle Sixth International In Situ and On-Site Bioremediation Symposium, June 2001.

Ewel, J.J., and J.L. Whitmore. 1973. The Ecological Life Zones of Puerto Rico and the U.S. Virgin Islands. Institute of Tropical Forestry, Rio Piedras, PR. (U.S. Forest Service Research Paper ITF-18).

Ferrey, M.L., R.T. Wilkin, R.G. Ford, and J.T. Wilson, 2004. "Nonbiological Removal of cis-DCE and 1,1-DCE in Aquifer Sediment Containing Magnetite," *Environmental Science and Technology*, Vol. 38, No. 6, pp 1746-1752.

Fitzpatrick, N. A., and J. J. Fitzgerald, 1997. "An Evaluation of Vapor Intrusion into Buildings Through a Study of Field Data", *Soil Vapor Transport to Indoor Air Workshop*, February 6-7, 1997, Brea, California.

Geo-Marine, Inc. 1998. Integrated Natural Resource Management Plan for U.S. Naval Station Roosevelt Roads: Plan Years 1998-2007. Geo-Marine, Inc., Plano, TX.

Johnson, P. C., and R. A. Ettinger, 1991. "Heuristic Model for Predicting the Intrusion Rate of Contaminant Vapors Into Buildings," *Environmental Science and Technology*, Vol. 25, pp. 1445-1452.

Kahn, Chris, 2003, "Microbe Eats Industrial Chemical that Can Linger in Soil for Centuries, Associated Press," July 3, 2003.

Longuemare, R. N., 1997. *Responsibility for Additional Environmental Cleanup after Transfer of Real Property*, Office of Under Secretary of Defense, July 25, 1997.

Maddaloni, M., 2000. Personal communication, Kathy Rogovin, Booz Allen & Hamilton, with Mark Maddaloni, toxicologist, EPA Region II, October 2000.

Menzie, C. A., Potocki, B. B., and Santodonato, J., 1992. "Exposure to Carcinogenic PAHs in the Environment," *Environmental Science and Technology*, Vol. 26, No. 7, pp. 1278-1284.

Michigan Department of Environmental Quality, 1998. *Part 201 Generic Groundwater and Soil Volatilization to Indoor Air Inhalation Criteria: Technical Support Document*, Environmental Response Division, August 31, 1998.

National Research Council, 2000, *Natural Attenuation for Groundwater Remediation*, National Academy Press, Washington, DC.

Naval Facilities Engineering Command. (NFEC). 1996. Survey of Potential Habitat for Yellow-Shouldered Blackbird on U.S. Naval Station Roosevelt Road, Puerto Rico. Naval Facilities Engineering Command, Atlantic Division, Norfolk, VA.

Nyer, E.K., et.al., 2001. *In Situ Treatment Technology*, Lewis Publishers, Washington, DC, 536 pp.

Raffaele, H.A. 1989. A Guide to the Birds of Puerto Rico and the Virgin Islands. Princeton University Press, Princeton, N.J. 254 pp.

Risk Assessment Information System (RAIS), 2004. Internet site sponsored by the U.S. Department of Energy, Office of Environmental Management, http://risk.lsd.ornl.gov/index.shtml.

Siegrist, M.A., M.A. Urynowicz, O.R. West, M.L. Crimi, and K.S. Lowe, 2001, *Principles and Practices of In Situ Chemical Oxidation Using Permanganate*, Battelle Press: Columbus, Ohio, 348 pages

United States Environmental Protection Agency (USEPA), 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, OSWER Directive 9335.3-01, Office of Solid Waste and Emergency Response, Washington, D.C.

USEPA. 1989. *Risk Assessment Guidance for Superfund – Volume 1 Human Health Evaluation Manual (Part A) (Interim Final),* EPA/540/1-89/002, Office of Emergency and Remedial Response, Washington, D.C.

USEPA. 1991a. Risk *Assessment Guidance for Superfund – Volume I Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals (Interim)*, PB92-963333, Office of Emergency and Remedial Response, Washington, D.C.

USEPA. 1991b. Risk *Assessment Guidance for Superfund, Supplemental Guidance, Standard Exposure Factors (Interim Final)*, Office of Emergency and Remedial Response, Washington, D.C.

USEPA. 1992a. *Estimating Potential for Occurrence of DNAPL at Superfund Sites*. 9355.4-07FS. Office of Solid Waste and Emergency Response, Washington, D.C.

USEPA. 1992b. *Dermal Exposure Assessment: Principles and Applications (Interim Report)*, EPA/600/8-91/011B, Office of Research and Development, Washington, D.C.

USEPA. 1993. *Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons*, EPA/600/R-93/089, Office of Research and Development, Washington, D.C., July 1993.

USEPA. 1995. *Land Use in the CERCLA Remedy Selection Process*, Office of Solid Waste and Emergency Response Directive 9355.7-04, Washington, D.C., May 25, 1995.
USEPA. 1996a. *Soil Screening Guidance: Technical Background Document*, Publication 9355.4-17A, Office of Emergency and Remedial Response, Washington, D.C., May 1996.

USEPA. 1996b. *Soil Screening Guidance: User's Guide*, EPA/540/R-96//018, Office of Emergency and Remedial Response, Washington, D.C.

USEPA. 1996c. *BIOSCREEN, Natural Attenuation Decision Support System*, EPA/600/R-96/087, Version 1.4 August 1996.

USEPA. 1997a. *Exposure Factors Handbook, Volume I, General Factors*, EPA/600/P-95/002Ba, Office of Research and Development, Washington, D.C., August 1996.

USEPA. 1997b. *Health Effects Assessment Summary Tables (HEAST)*, Annual Update, FY 1997, National Center for Environmental Assessment, Office of Research and Development, Washington, D.C.

USEPA. 1997c. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (Interim Final). Office of Solid Waste and Emergency Response. EPA/540/R-97-006.

USEPA. 1998. Guidelines for Ecological Risk Assessment. Risk Assessment Forum, Washington, DC. EPA/630/R-95/002B.

USEPA, 1999, *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*, Directive Number 9200.4-17P, April 1999, USEPA Office of Solid Waste and Emergency Response (OSWER).

USEPA. 2000. *User's Guide for the Johnson and Ettinger (1991) Model for Subsurface Vapor Intrusion into Buildings (Revised)*, Office of Emergency and Remedial Response, Washington, D.C., December 2000.

USEPA. 2001a. *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Interim*, EPA/540/R/99/005, Office of Solid Waste and Emergency Response, Washington D.C., September 2001.

USEPA. 2001b. *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*, OSWER 9355.4-24, Office of Solid Waste and Emergency Response, Washington, D.C., March 2001.

USEPA. 2001c. Region 4 Ecological Risk Assessment Bulletins – Supplement to RAGS. Waste Management Division, Atlanta, GA. http://www.epa.gov/region4/waste/ots/ecolbul.htm.

USEPA. 2003. ECOTOX Database System, Aquatic Toxicity Information Retrieval (AQUIRE) Database. Mid-Continent Ecology Division (MED), Duluth, MN. http://www.epa.gov/ecotox/.

USEPA. 2004a. *Risk-Based Concentration Summary Table*, April 14, 2004. Region III, Philadelphia, Pennsylvania.

USEPA. 2004b. *Integrated Risk Information System (IRIS), online*, Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, Ohio.

U.S. Fish and Wildlife Service (USFWS). 1983. Yellow-Shouldered Blackbird Recovery Plan. USFWS, Southeast Region, Atlanta, GA.

USFWS. 1984. Recovery plan for the Golden Coqui (*Eleutherodactylus jasperi*). USFWS, Southeast Region, Atlanta, GA.

USFWS. 1987. Endangered and Threatened Wildlife and Plants: Determination of Threatened Status for the Puerto Rican Crested Toad. Federal Register, 52 (149): 28828-28831.

USFWS. 1996. Recovery Plan for the Yellow-Shouldered Blackbird (*Agelaius xanthomus*). USFWS, Southeast Region, Atlanta, GA.

United States Geological Society (USGS). 1999. Status and Trends of the Nation's Biological Resources. http://biology.usgs.gov/s+t/SNT/index.htm

Weidemier, T.H, M.A. Swanson, D.E. Moutoux, E.K. Gordon, J.T. Wilson, B.H. Wilson, D.H. Kampbell, P.E. Haas, R.N. Miller, J.E. Hansen, and F.H. Chapelle, 1998, *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater, for Air Force Center for Environmental Excellence (AFCEE)*, U.S. EPA Office of Research and Development, EPA/600/R-98/198, 78 pages.

Yin Y., Allen, H.E. July 1999. "In Situ Chemical Treatment," Technology Evaluation Report, TE-99-01, Ground-Water Remediation Technologies Analysis Center.

TABLES

TABLE 2-1

SUMMARY OF ORGANIC DETECTIONS IN SURFACE SOIL
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation							
Site ID	54SS01	54SS02	54SS03	54SS04	54SS04	54SS05	54SS06	54SS07
Sample ID	54SS01	54SS02	54SS03	54SS04	54SS04D	54SS05	54SS06	54SS07
Sample Date	12/13/00	12/13/00	12/13/00	12/14/00	12/14/00	12/14/00	12/13/00	12/13/00
Sample Depth (ft bgs)	0.0-0.1	0.0-0.1	0.0-0.1	0.0-0.1	0.0-0.1	0.0-0.1	0.0-0.1	0.0-0.1
Volatiles (ug/kg)								
Methylene chloride	5.5 U	5.4 U	6.8	4.2 J	4.1 J	3.2 J	5.6 U	5.5 U
Toluene	7.8	10	2.7 J	2.1 J	5.6 U	3 J	2.7 J	4.4 J
Chlorobenzene	5.5 U	5.4 U	6.6 U	5.6 U	5.6 U	5.4 U	5.6 U	18
Ethylbenzene	5.5 U	5.4 U	6.6 U	5.6 U	5.6 U	5.4 U	5.6 U	5.5 U
Styrene	5.5 U	2.1 J	6.6 U	5.6 U	5.6 U	5.4 U	5.6 U	5.5 U
Acetone	55 U	54 U	66 U	56 U	56 UJ	54 U	56 U	55 U
Semivolatiles (ug/kg)								
Phenanthrene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U	220 J
Fluoranthene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	420 J	630 J
Benzo(a)anthracene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U	350 J
bis(2-Ethylhexyl)phthalate	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U	3,600 U
Benzo(k)fluoranthene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U	560 J
Benzo(a)pyrene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U	580 J
TPH (mg/kg)								
Diesel Range Organics	7.5 U	5.7 J	320	33 J	95 J	47	35	28
Gasoline Range Organics	0.28 U	0.27 U	0.33 U	0.29 U	0.28 U	0.27 U	0.11 J	0.27 U

Notes:
ug/kg - micrograms per kilogram.
mg/kg - milligrams per kilogram.
J - Estimated value.
U - Not Detected.
UJ - Report quantitation limit is qualified as estimated.
NA - Not Analyzed.
ft bgs - feet below ground surface.

TABLE 2-1

SUMMARY OF ORGANIC DETECTIONS IN SURFACE SOIL
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation						
Site ID	54SS08	54SS09	54SS10	54SS11	54SS12	54SS13	54SS13
Sample ID	54SS08	54SS09	54SS10	54SS11	54SS12	54SS13	54SS13D
Sample Date	12/14/00	12/14/00	12/20/00	12/20/00	12/13/00	12/14/00	12/14/00
Sample Depth (ft bgs)	0.0-0.1	0.0-0.1	0.0-0.1	0.0-0.1	0.0-0.1	0.0-0.1	0.0-0.1
Volatiles (ug/kg)							
Methylene chloride	9.1	6.4	6 UJ	5.6 UJ	5.8 U	3.7 J	4 J
Toluene	15	13	6 U	5.6 U	6.7	5.6 U	6.1 U
Chlorobenzene	7.8 U	5.5 U	6 U	5.6 U	5.8 U	5.6 U	6.1 U
Ethylbenzene	7.8 U	5.5 U	6 U	3.8 J	5.8 U	5.6 U	6.1 U
Styrene	7.8 U	2.4 J	6 U	22	5.8 U	5.6 U	6.1 U
Acetone	78 U	55 U	48 J	9.6 J	58 U	4.2 J	61 U
Semivolatiles (ug/kg)							
Phenanthrene	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U	4,000 U
Fluoranthene	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U	4,000 U
Benzo(a)anthracene	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U	4,000 U
bis(2-Ethylhexyl)phthalate	5,200 U	3,600 U	400 U	370 U	3,800 U	530 J	4,000 U
Benzo(k)fluoranthene	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U	4,000 U
Benzo(a)pyrene	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U	4,000 U
TPH (mg/kg)							
Diesel Range Organics	36	14	4 U	3.7 U	490	17 J	23
Gasoline Range Organics	0.38 U	0.27 U	0.33 UJ	0.29 U	0.28 UJ	0.28 U	0.32 U

Notes:
ug/kg - micrograms per kilogram.
mg/kg - milligrams per kilogram.
J - Estimated value.
U - Not Detected.
UJ - Report quantitation limit is qualified as estimated.
NA - Not Analyzed.
ft bgs - feet below ground surface.

TABLE 2-1

SUMMARY OF ORGANIC DETECTIONS IN SURFACE SOIL
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation			RCRA Facility Investigation					
Site ID	54SS14	54SS15	54TW01	54TW15A	54TW19	54TW20	Number	Range	
Sample ID	54SS14	54SS15	54SB01-00	54TW15A-00	54TW19-00	54TW20-00	of	of	Location of
Sample Date	12/13/00	12/13/00	12/15/00	03/01/02	03/02/02	03/02/02	Positive	Positive	Maximum
Sample Depth (ft bgs)	0.0-0.1	0.0-0.1	0.0-0.1	0.0-1.0	0.0-1.0	0.0-1.0	Detecions	Detections	Detection
Volatiles (ug/kg)									
Methylene chloride	5.6 U	5.5 U	5.4 UJ	5.2 UJ	7.8 U	9.2 U	8/21	3.2J - 9.1	54SS08
Toluene	15	4.6 J	2.8 J	5.2 U	7.8 U	9.2 U	13/21	2.1J - 15	54SS08, 54SS14
Chlorobenzene	5.6 U	5.5 U	5.4 U	5.2 U	7.8 U	9.2 U	1/21	18	54SS07
Ethylbenzene	5.6 U	5.5 U	5.4 U	5.2 U	7.8 U	9.2 U	1/21	3.8J	54SS11
Styrene	2.5 J	5.5 U	5.4 U	5.2 U	7.8 U	9.2 U	4/21	2.1J - 22	54SS11
Acetone	56 U	55 U	54 U	52 U	78 U	92 U	3/21	4.2J - 48J	54SS10
Semivolatiles (ug/kg)									
Phenanthrene	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U	1/21	220J	54SS07
Fluoranthene	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U	2/21	420J - 630J	54SS07
Benzo(a)anthracene	3,700 U	3,600 U	3,500 U	350 UJ	560 U	570 U	1/21	350J	54SS07
bis(2-Ethylhexyl)phthalate	3,700 U	3,600 U	3,500 U	350 UJ	560 U	570 U	1/21	530J	54SS13
Benzo(k)fluoranthene	3,700 U	3,600 U	3,500 U	350 UJ	560 U	570 U	1/21	560J	54SS07
Benzo(a)pyrene	3,700 U	3,600 U	3,500 U	350 UJ	560 U	570 U	1/21	580J	54SS07
TPH (mg/kg)									
Diesel Range Organics	32	33	3.5 U	NA	NA	NA	14/18	5.7J - 490	54SS12
Gasoline Range Organics	0.28 UJ	0.27 U	0.27 U	NA	NA	NA	1/18	0.11J	54SS06

Notes:
ug/kg - micrograms per kilogram.
mg/kg - milligrams per kilogram.
J - Estimated value.
U - Not Detected.
UJ - Report quantitation limit is qualified as estimated.
NA - Not Analyzed.
ft bgs - feet below ground surface.

TABLE 2-2

SUMMARY OF ORGANIC DETECTIONS IN SUBSURFACE SOIL
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation				RCRA Facility Investigation	
Site ID	54TW01	54TW01	54TW02	54TW02	54TW15A	54TW15A
Sample ID	54SB01-05	54SB01-08	54SB02-02	54SB02-06	54TW15A-02	54TW15A-02D
Sample Date	12/15/00	12/15/00	12/15/00	12/15/00	03/01/02	03/01/02
Depth (ft bgs)	8.0-10.0	14.0-16.0	2.0-4.0	10.0-12.0	4.0-6.0	4.0-6.0
Volatiles (ug/kg)						
1,1,2,2-Tetrachloroethane	6.6 U	6.8 U	6.8 U	6.9 U	7.6 U	7.6 U
1,1-Dichloroethene	6.6 U	6.8 U	6.8 U	6.9 U	7.6 U	7.6 U
1,2-Dibromo-3-chloropropane	13 U	14 U	14 U	14 U	15 U	15 U
2-Butanone	33 U	34 U	6.2 J	35 U	38 U	38 U
2-Hexanone	33 U	34 U	34 U	35 U	38 U	38 U
Acetone	89 J	18 J	130 J	43 J	76 U	76 U
Carbon tetrachloride	6.6 U	6.8 U	6.8 U	6.9 U	7.6 U	7.6 U
Chlorobenzene	6.6 U	6.8 U	6.8 U	6.9 U	7.6 U	7.6 U
Ethylbenzene	6.6 U	6.8 U	6.8 U	6.9 U	7.6 U	7.6 U
Styrene	6.6 U	6.8 U	6.8 U	6.9 U	7.6 U	7.6 U
Toluene	6.6 U	2.8 J	3.6 J	2.6 J	7.6 U	7.6 U
Trichloroethene	6.6 U	6.8 U	6.8 U	6.9 U	7.6 U	7.6 U
Trichlorofluoromethane	6.6 U	6.8 U	6.8 U	6.9 U	7.6 U	7.6 U
Xylenes	13 U	14 U	14 U	14 U	7.6 U	7.6 U
Semivolatiles (ug/kg)						
2,4-Dimethylphenol	430 U	450 U	440 U	460 U	520 U	530 U
Di-n-butylphthalate	430 U	57 J	440 U	460 U	520 U	530 U
TPH (mg/kg) [(1)]						
Not Detected						

Notes:

J - Estimated value.

U - Not detected.

R - Result is rejected and unusable.

ft bgs - feet below ground surface.

ug/kg - micrograms per kilogram.

[(1)] - Only subsurface soil samples collected during the 2000 Sampling and Analysis Investigation were analyzed for TPH DRO and GRO.

TABLE 2-2

SUMMARY OF ORGANIC DETECTIONS IN SUBSURFACE SOIL
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation					
Site ID	54TW15A	54TW19	54TW20	Number	Range	
Sample ID	54TW15A-04	54TW19-05	54TW20-04	of	of	Location of
Sample Date	03/01/02	03/02/02	03/02/02	Positive	Positive	Maximum
Depth (ft bgs)	9.0-11.0	10.0-11.4	8.0-9.0	Detecions	Detections	Detection
Volatiles (ug/kg)						
1,1,2,2-Tetrachloroethane	210 J	8 U	280 U	1/9	210J	54TW15A-04
1,1-Dichloroethene	140 J	8 U	280 U	1/9	140J	54TW15A-04
1,2-Dibromo-3-chloropropane	610	16 U	560 U	1/9	610	54TW15A-04
2-Butanone	1,500	40 U	1,400 U	2/9	6.2J - 1,500	54TW15A-04
2-Hexanone	1,700	40 U	1,400 U	1/9	1,700	54TW15A-04
Acetone	2,900 J	80 U	1,400 J	6/9	18J - 2,900J	54TW15A-04
Carbon tetrachloride	110 J	8 U	280 U	1/9	110J	54TW15A-04
Chlorobenzene	110 J	8 U	280 U	1/9	110J	54TW15A-04
Ethylbenzene	190 J	8 U	280 U	1/9	190J	54TW15A-04
Styrene	100 J	8 U	280 U	1/9	100J	54TW15A-04
Toluene	260 U	8 U	280 U	3/9	2.6J - 3.6J	54SB02-02
Trichloroethene	130 J	8 U	280 U	1/9	130J	54TW15A-04
Trichlorofluoromethane	160 J	8 U	280 U	1/9	160J	54TW15A-04
Xylenes	640	8 U	560 U	1/9	640	54TW15A-04
Semivolatiles (ug/kg)						
2,4-Dimethylphenol	68 J	540 U	480 R	1/8	68J	54TW15A-04
Di-n-butylphthalate	430 U	540 U	480 U	1/9	57J	54SB01-08
TPH (mg/kg) [1]						
Not Detected						

Notes:

J - Estimated value.
U - Not detected.
R - Result is rejected and unusable.
ft bgs - feet below ground surface.
ug/kg - micrograms per kilogram.

[1] - Only subsurface soil samples collected during the 2000 Sampling and Analysis Investigation were analyzed for TPH DRO and GRO.

TABLE 2-3

SUMMARY OF ORGANIC DETECTIONS IN GROUNDWATER
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEAURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation										
Site ID	510DW1	510DW2	510MW1	510MW2	510MW2	510MW3	510MW4	510MW5	54TW01	54TW02	510D
Sample ID	510DW1	510DW2	510MW1	510MW2	510MW2D	510MW3	510MW4	510MW5	54TW01	54TW02	510D
Sample Date	12/19/00	12/19/00	12/15/00	12/19/00	12/19/00	12/19/00	12/18/00	12/21/00	12/20/00	12/19/00	02/2
Volatiles (ug/L)											
1,1,1-Trichloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5
1,1-Dichloroethene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	0.61 J	5 U	5 U	5
1,2-Dichloroethane	5 U	3 J	5 U	5 U	5 U	0.86 J	5 U	5 U	5 U	5 U	5
2-Butanone	26	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25
Acetone	40 J	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50
Benzene	91	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	92
Chlorobenzene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5
Chloroform	5 U	1.2 J	5 U	5 U	5 U	5.8	5 U	1.4 J	5 U	5 U	7.8
Ethylbenzene	32	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	64
Isobutanol	2,900 J	200 R	200 R	200 R	200 R	200 R	200 R	200 R	200 R	200 R	200
Methylene chloride	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5
Toluene	3.7 J	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5.4
Trichloroethene	5 U	1.1 J	5 U	5 U	5 U	5.9	5 U	230 D	5 U	5 U	5
Xylene	19	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	14
Semivolatiles (ug/L)											
2,4-Dimethylphenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10
2-Methylnaphthalene	0.4 J	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	0.51
4-Bromophenyl-phenylether	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	2.2 J	10
Benzo(a)anthracene	10 U	10 U	0.95 J	10 U	0.86 J	10 U	10 U	10 U	10 U	10 U	10
Bis(2-ethylhexyl)phthalate	3.9 J	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10
Butylbenzylphthalate	10 U	10 U	0.77 J	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10
Chrysene	10 U	10 U	1.5 J	10 U	1.2 J	10 U	10 U	10 U	10 U	10 U	10
Di-n-butylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10
Diethylphthalate	0.6 J	10 U	10 U	10 U	10 U	0.52 J	10 U	10 U	0.68 J	10 U	10
Fluoranthene	10 U	10 U	10 U	10 U	0.44 J	10 U	10 U	2.4 J	10 U	10 U	10
Fluorene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10
Naphthalene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10
Phenanthrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10
TPH (mg/L)											

TABLE 2-3

SUMMARY OF ORGANIC DETECTIONS IN GROUNDWATER
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEAURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation										
Site ID	510DW1	510DW2	510MW1	510MW2	510MW2	510MW3	510MW4	510MW5	54TW01	54TW02	510D
Sample ID	510DW1	510DW2	510MW1	510MW2	510MW2D	510MW3	510MW4	510MW5	54TW01	54TW02	510D
Sample Date	12/19/00	12/19/00	12/15/00	12/19/00	12/19/00	12/19/00	12/18/00	12/21/00	12/20/00	12/19/00	02/2
Diesel Range Organics	1.2	0.59	0.33	0.2	0.21	0.37	0.84	0.1 U	6.7	1.6	NA
Gasoline Range Organics	0.84	0.05 U	0.036 J	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.13	0.05 U	NA

Notes:
D - Result value is based on dilution analysis.
J - Estimated value.
U - Not detected.
R - Result is rejected and unusable.
UJ - Reported quantitation limit is qualified as estimated.
ug/L - micrograms per liter.
mg/L - milligrams per liter.
NA - Not Analyzed.

TABLE 2-3

SUMMARY OF ORGANIC DETECTIONS IN GROUNDWATER
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEAURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation							
Site ID	DW1	510DW1	510DW2	510MW1	510MW2	510MW3	510MW4	510MW5
Sample ID	DW1	510DW1D	510DW2	510MW1	510MW2	510MW3	510MW4	510MW5
Sample Date	7/02	02/27/02	02/27/02	02/26/02	02/27/02	02/13/02	02/26/02	02/13/02
Volatiles (ug/L)								
1,1,1-Trichloroethane	U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1-Dichloroethene	U	5 U	5 U	5 U	5 U	1.5 J	5 U	0.79 J
1,2-Dichloroethane	U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
2-Butanone	UJ	25 UJ	25 UJ	25 UJ	25 UJ	12 U	25 UJ	25 U
Acetone	U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Benzene		91	5 U	5 U	5 U	5 U	5 U	5 U
Chlorobenzene	U	5 U	5 U	5 U	5 U	2 J	5 U	5 U
Chloroform		7.1	5 U	5 U	5 U	5 U	5 U	5 U
Ethylbenzene		62	5 U	5 U	5 U	5 U	5 U	5 U
Isobutanol	R	200 R	200 R	200 R	200 R	200 R	200 R	200 R
Methylene chloride	U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Toluene		5.3	5 U	5 U	0.56 J	2.5 J	5 U	5 U
Trichloroethene	U	5 U	5 U	5 U	5 U	2.8 J	5 U	190
Xylene		14	10 U	10 U	10 U	10 U	10 U	10 U
Semivolatiles (ug/L)								
2,4-Dimethylphenol	U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Methylnaphthalene	J	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Bromophenyl-phenylether	U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(a)anthracene	U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bis(2-ethylhexyl)phthalate	U	10 U	10 U	0.88 J	10 U	10 U	10 U	10 U
Butylbenzylphthalate	U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chrysene	U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Di-n-butylphthalate	U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Diethylphthalate	U	10 U	10 U	10 U	1.3 J	10 U	0.86 J	10 U
Fluoranthene	U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Fluorene	U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Naphthalene	U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Phenanthrene	U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
TPH (mg/L)								

TABLE 2-3

SUMMARY OF ORGANIC DETECTIONS IN GROUNDWATER
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEAURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation							
Site ID	DW1	510DW1	510DW2	510MW1	510MW2	510MW3	510MW4	510MW5
Sample ID	DW1	510DW1D	510DW2	510MW1	510MW2	510MW3	510MW4	510MW5
Sample Date	7/02	02/27/02	02/27/02	02/26/02	02/27/02	02/13/02	02/26/02	02/13/02
Diesel Range Organics		NA	NA	NA	NA	NA	NA	NA
Gasoline Range Organics		NA	NA	NA	NA	NA	NA	NA

Notes:
D - Result value is based on dilution analysis.
J - Estimated value.
U - Not detected.
R - Result is rejected and unusable.
UJ - Reported quantitation limit is qualified as estimated.
ug/L - micrograms per liter.
mg/L - milligrams per liter.
NA - Not Analyzed.

TABLE 2-3

SUMMARY OF ORGANIC DETECTIONS IN GROUNDWATER
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEAURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation								
Site ID	54PZ01	54TW03	54TW04	54TW05	54TW06	54TW07	54TW08	54TW09	54TW09
Sample ID	54PZ01	54TW03	54TW04	54TW05	54TW06	54TW07	54TW08	54TW09	54TW09D
Sample Date	02/20/02	02/14/02	02/14/02	02/14/02	02/15/02	02/15/02	02/15/02	02/15/02	02/15/02
Volatiles (ug/L)									
1,1,1-Trichloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1-Dichloroethene	5 U	0.8 J	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,2-Dichloroethane	5 U	5 U	5 U	5 U	5 U	2.8 J	2.2 J	5 U	5 U
2-Butanone	25 U	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ
Acetone	50 U	50 U	50 U	50 U	50 R	50 R	50 R	50 R	50 R
Benzene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Chlorobenzene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Chloroform	5 U	5 U	2.1 J	2.9 J	5 U	5 U	8	4.5 J	4.3 J
Ethylbenzene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Isobutanol	200 R	200 R	200 R	200 R	200 R	200 R	200 R	200 R	200 R
Methylene chloride	5 U	0.54 J	0.54 J	5 U	5 U	5 U	5 U	5 U	5 U
Toluene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Trichloroethene	2.4 J	53	84	170 D	34	5 U	8	20	19
Xylene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Semivolatiles (ug/L)									
2,4-Dimethylphenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Methylnaphthalene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Bromophenyl-phenylether	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(a)anthracene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bis(2-ethylhexyl)phthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Butylbenzylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chrysene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Di-n-butylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Diethylphthalate	10 U	10 U	10 U	10 U	10 U	2.7 J	10 U	10 U	10 U
Fluoranthene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Fluorene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Naphthalene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Phenanthrene	10 U	10 U	0.46 J	10 U	10 U	10 U	10 U	10 U	10 U
TPH (mg/L)									

TABLE 2-3

SUMMARY OF ORGANIC DETECTIONS IN GROUNDWATER
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEAURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation								
Site ID	54PZ01	54TW03	54TW04	54TW05	54TW06	54TW07	54TW08	54TW09	54TW09
Sample ID	54PZ01	54TW03	54TW04	54TW05	54TW06	54TW07	54TW08	54TW09	54TW09D
Sample Date	02/20/02	02/14/02	02/14/02	02/14/02	02/15/02	02/15/02	02/15/02	02/15/02	02/15/02
Diesel Range Organics	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gasoline Range Organics	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
D - Result value is based on dilution analysis.
J - Estimated value.
U - Not detected.
R - Result is rejected and unusable.
UJ - Reported quantitation limit is qualified as estimated.
ug/L - micrograms per liter.
mg/L - milligrams per liter.
NA - Not Analyzed.

TABLE 2-3

SUMMARY OF ORGANIC DETECTIONS IN GROUNDWATER
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEAURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation								
Site ID	54TW10	54TW11	54TW11	54TW12	54TW13	54TW14	54TW15	54TW16	54TW17
Sample ID	54TW10	54TW11	54TW11D	54TW12	54TW13	54TW14	54TW15	54TW16	54TW17
Sample Date	02/15/02	02/18/02	02/18/02	02/19/02	02/19/02	02/19/02	02/19/02	02/19/02	02/21/02
Volatiles (ug/L)									
1,1,1-Trichloroethane	5 U	5 U	5 U	5 UJ	5 UJ	5 UJ	120 UJ	5 UJ	5 U
1,1-Dichloroethene	5 U	5 U	5 U	5 U	5 U	5 U	120 U	5 U	5 U
1,2-Dichloroethane	1.2 J	5 U	5 U	5 UJ	5 UJ	5 UJ	120 UJ	5 UJ	5 U
2-Butanone	25 UJ	25 U	25 U	25 UJ	25 UJ	25 UJ	620 UJ	25 UJ	25 UJ
Acetone	50 R	50 R	50 R	50 UJ	50 UJ	50 UJ	1,200 UJ	50 UJ	50 U
Benzene	5 U	5 U	5 U	5 U	5 U	5 U	3,000	5 U	5 U
Chlorobenzene	5 U	5 U	5 U	5 U	5 U	5 U	120 U	5 U	5 U
Chloroform	6.4	5 U	5 U	5 U	5 U	1.8 J	120 U	5 U	5 U
Ethylbenzene	5 U	5 U	5 U	5 U	5 U	5 U	2,400	5 U	5 U
Isobutanol	200 R	200 R	200 R	200 R	200 R	200 R	2,600 J	200 R	200 U
Methylene chloride	5 U	5 U	5 U	5 U	5 U	5 U	120 U	5 U	5 U
Toluene	5 U	5 U	5 U	5 U	5 U	5 U	400	5 U	5 U
Trichloroethene	11	140	150	5 U	1.1 J	25	120 U	0.34 J	1.3 J
Xylene	10 U	10 U	10 U	10 U	10 U	10 U	8,000	10 U	10 U
Semivolatiles (ug/L)									
2,4-Dimethylphenol	10 U	10 U	10 U	10 U	10 U	10 U	8.5 J	10 U	10 U
2-Methylnaphthalene	10 U	10 U	10 U	10 U	10 U	10 U	65	10 U	10 U
4-Bromophenyl-phenylether	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(a)anthracene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bis(2-ethylhexyl)phthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Butylbenzylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chrysene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Di-n-butylphthalate	10 U	10 U	10 U	0.26 J	10 U	10 U	10 U	0.37 J	10 U
Diethylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Fluoranthene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Fluorene	10 U	10 U	10 U	10 U	10 U	10 U	1.6 J	10 U	10 U
Naphthalene	10 U	10 U	10 U	10 U	10 U	10 U	190	10 U	10 U
Phenanthrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
TPH (mg/L)									

TABLE 2-3

SUMMARY OF ORGANIC DETECTIONS IN GROUNDWATER
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEAURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation								
Site ID	54TW10	54TW11	54TW11	54TW12	54TW13	54TW14	54TW15	54TW16	54TW17
Sample ID	54TW10	54TW11	54TW11D	54TW12	54TW13	54TW14	54TW15	54TW16	54TW17
Sample Date	02/15/02	02/18/02	02/18/02	02/19/02	02/19/02	02/19/02	02/19/02	02/19/02	02/21/02
Diesel Range Organics	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gasoline Range Organics	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
D - Result value is based on dilution analysis.
J - Estimated value.
U - Not detected.
R - Result is rejected and unusable.
UJ - Reported quantitation limit is qualified as estimated.
ug/L - micrograms per liter.
mg/L - milligrams per liter.
NA - Not Analyzed.

TABLE 2-3

SUMMARY OF ORGANIC DETECTIONS IN GROUNDWATER
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEAURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation						
Site ID	54TW18	54TW19	54TW20	54TW21	Number	Range	
Sample ID	54TW18	54TW19	54TW20	54TW21	of	of	Location
Sample Date	02/21/02	03/03/02	03/03/02	03/05/02	Positive	Positive	Maximum
					Detecions	Detections	Detect
Volatiles (ug/L)							
1,1,1-Trichloroethane	5 U	0.64 J	5 U	5 U	1/40	0.64J	54TW19 (3/3/02)
1,1-Dichloroethene	5 U	5 U	5 U	5 U	4/40	0.61J - 1.5J	510MW3 (2/13/02)
1,2-Dichloroethane	5 U	5 U	5 U	5 U	5/40	0.86J - 2.8J	54TW07 (2/15/02)
2-Butanone	25 UJ	25 U	25 U	25 UJ	1/40	26	510DW1(12/19/00)
Acetone	50 U	50 UJ	50 UJ	50 UJ	1/28	40J	510DW1(12/19/00)
Benzene	5 U	5 U	2 J	5 U	5/40	2J - 3,000	54TW15 (2/19/02)
Chlorobenzene	5 U	5 U	5 U	5 U	1/40	2J	510MW3 (2/13/02)
Chloroform	5 U	5 U	5 U	5 U	12/40	1.2J - 8	54TW08 (2/15/02)
Ethylbenzene	5 U	5 U	68	5 U	5/40	32 - 2,400	54TW15 (2/19/02)
Isobutanol	200 U	200 R	200 R	200 R	2/4	2,600J - 2,900J	510DW1(12/19/00)
Methylene chloride	5 U	5 U	5 U	5 U	2/40	0.54J	54TW03 (2/14/02),54TW04 (2/14/02)
Toluene	5 U	5 U	0.76 J	5 U	7/40	0.56J - 400	54TW15 (2/19/02)
Trichloroethene	5 U	3.2 J	5 U	5 U	21/40	0.34J - 230D	510MW5 (12/21/00)
Xylene	10 U	10 U	5.5 J	10 U	5/40	5.5J - 8,000	54TW15 (2/19/02)
Semivolatiles (ug/L)							
2,4-Dimethylphenol	10 U	10 U	10 U	10 U	1/40	8.5J	54TW15 (2/19/02)
2-Methylnaphthalene	10 U	10 U	1.2 J	10 U	4/40	0.4J - 65	54TW15 (2/19/02)
4-Bromophenyl-phenylether	10 U	10 U	10 U	10 U	1/40	2.2J	54TW02 (12/19/00)
Benzo(a)anthracene	10 U	10 U	10 U	10 U	2/40	0.86J - 0.95J	510MW1 (12/15/00)
Bis(2-ethylhexyl)phthalate	10 U	10 U	1 J	10 U	3/40	0.88J - 1J	54TW20 (3/3/02)
Butylbenzylphthalate	10 U	10 U	10 U	10 U	1/40	0.77J	510MW1 (12/15/00)
Chrysene	10 U	10 U	10 U	10 U	2/40	1.2J - 1.5J	510MW1 (12/15/00)
Di-n-butylphthalate	10 U	10 U	10 U	10 U	2/40	0.26J - 0.37J	54TW16 (2/19/02)
Diethylphthalate	10 U	10 U	10 U	0.96 J	7/40	0.52J - 2.7J	54TW07 (2/15/02)
Fluoranthene	10 U	10 U	10 U	10 U	2/40	0.44J - 2.4J	510MW5 (12/21/00)
Fluorene	10 U	10 U	0.64 J	10 U	2/40	0.64J - 1.6J	54TW15 (2/19/02)
Naphthalene	10 U	10 U	10 U	10 U	1/40	190	54TW15 (2/19/02)
Phenanthrene	10 U	10 U	10 U	10 U	1/40	0.46J	54TW04 (2/14/02)
TPH (mg/L)							

TABLE 2-3

SUMMARY OF ORGANIC DETECTIONS IN GROUNDWATER
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEAURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation						
Site ID	54TW18	54TW19	54TW20	54TW21	Number	Range	
Sample ID	54TW18	54TW19	54TW20	54TW21	of	of	Location
Sample Date	02/21/02	03/03/02	03/03/02	03/05/02	Positive	Positive	Maximum
					Detecions	Detections	Detect
Diesel Range Organics	NA	NA	NA	NA	9/10	0.2 - 6.7	54TW01 (12/20/00)
Gasoline Range Organics	NA	NA	NA	NA	3/10	0.036J - 0.84	510DW1(12/19/00)

Notes:
D - Result value is based on dilution analysis.
J - Estimated value.
U - Not detected.
R - Result is rejected and unusable.
UJ - Reported quantitation limit is qualified as estimated.
ug/L - micrograms per liter.
mg/L - milligrams per liter.
NA - Not Analyzed.

TABLE 2-4

SUMMARY OF ORGANIC DETECTIONS IN GROUNDWATER
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	CMS Investigation								
Site ID	7MW07	7MW07	7MW08	7MW08	UGW11	UGW13	UGW16	UGW17	UGW18
Sample ID	7MW07	7MW07D	7MW08	7MW08D	UGW11	UGW13	UGW16	UGW17	UGW18
Sample Date	04/19/98	04/19/98	04/18/98	04/18/98	04/17/98	04/21/98	04/16/98	04/21/98	04/16/98
Volatile Organic Compounds (ug/L)									
1,1,1-Trichloroethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ	0.5 U
1,1,2-Trichloroethane	0.5	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ	0.5 U
1,1-Dichloroethene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	2	50 UJ	0.5 U
1,2,3-Trichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	530	0.5 U	50 UJ	0.5 U
1,2,4-Trimethylbenzene	0.5 U	0.5 U	0.5 U	0.5 U	9 J	12 UJ	0.5 U	150 J	0.5 U
1,2-Dibromo-3-chloropropane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ	0.5 U
1,2-Dichloroethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ	0.5 U
1,3,5-Trimethylbenzene	0.5 U	0.5 U	0.5 U	0.5 U	3 J	250 J	0.5 U	50 UJ	0.5 U
Acrolein	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzene	0.5 U	0.5 U	0.5 U	0.5 U	0.8 J	12 UJ	0.5 U	50 UJ	0.5 U
Chloroform	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ	2
Chloromethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ	0.5 U
cis-1,2-Dichloroethene	6	6	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ	0.5 U
Ethylbenzene	0.5 U	0.5 U	0.5 U	0.5 U	2 J	86 J	0.5 U	50 UJ	0.5 U
Isopropylbenzene	0.5 U	0.5 U	0.5 U	0.5 U	12 J	69 J	0.5 U	50 UJ	0.5 U
Methylene chloride	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ	0.5 U
n-Butylbenzene	0.5 U	0.5 U	0.5 U	0.5 U	14 J	360 J	0.5 U	92 J	0.5 U
n-Propylbenzene	0.5 U	0.5 U	0.5 U	0.5 U	20 J	150 J	0.5 U	50 UJ	0.5 U
Pentachloroethane	NA	NA	NA	NA	NA	NA	NA	NA	NA
p-Isopropyltoluene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	170 J	0.5 U	50 UJ	0.5 U
sec-Butylbenzene	0.5 U	0.5 U	0.5 U	0.5 U	13 J	160 J	0.5 U	62 J	0.5 U
Tetrachloroethene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ	0.5 U
Toluene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ	0.5 U
trans-1,2-Dichloroethene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ	0.5 U
Trichloroethene	2,000 J	2,100	3	2	0.5 UJ	12 UJ	0.5 U	50 UJ	0.5 U
Xylene (m&p)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	86 J	0.5 U	50 UJ	0.5 U

TABLE 2-4

SUMMARY OF ORGANIC DETECTIONS IN GROUNDWATER
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	CMS Investigation								
Site ID	7MW07	7MW07	7MW08	7MW08	UGW11	UGW13	UGW16	UGW17	UGW18
Sample ID	7MW07	7MW07D	7MW08	7MW08D	UGW11	UGW13	UGW16	UGW17	UGW18
Sample Date	04/19/98	04/19/98	04/18/98	04/18/98	04/17/98	04/21/98	04/16/98	04/21/98	04/16/98

Notes:
J - Estimated value.
U - Not detected.
R - Result is rejected and unusable.
UJ - Reported quantitation limit is qualified as estimated.
ug/L - micrograms per liter.
NA - Not Analyzed.
Not included in Appendix IX compounds

TABLE 2-4

SUMMARY OF ORGANIC DETECTIONS IN GROUNDWATER
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	CMS Investigation		TCE Investigation						
Site ID	UGW19	UGW21	TW102	TW104	TW105	TW1	TW1	TW2	TW3
Sample ID	UGW19	UGW21	7TCE102	7TCE104	7TCE105	7TCE1s	7TCE1d	7TCE2d	7TCE3d
Sample Date	04/17/98	04/17/98	07/01/99	07/01/99	07/01/99	06/26/99	06/29/99	06/29/99	06/29/99
Volatile Organic Compounds (ug/L)									
1,1,1-Trichloroethane	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1,2-Trichloroethane	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1-Dichloroethene	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U	5 U	3 J
1,2,3-Trichlorobenzene	5 UJ	250 U	NA	NA	NA	NA	NA	NA	NA
1,2,4-Trimethylbenzene	310 J	260	NA	NA	NA	NA	NA	NA	NA
1,2-Dibromo-3-chloropropane	5 UJ	250 U	NA	NA	NA	NA	NA	NA	NA
1,2-Dichloroethane	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,3,5-Trimethylbenzene	72 J	250 U	NA	NA	NA	NA	NA	NA	NA
Acrolein	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzene	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Chloroform	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Chloromethane	5 UJ	250 U	10 U	10 U	10 U	13	10 U	10 U	9 J
cis-1,2-Dichloroethene	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Ethylbenzene	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Isopropylbenzene	15 J	250 U	NA	NA	NA	NA	NA	NA	NA
Methylene chloride	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
n-Butylbenzene	5 UJ	250 U	NA	NA	NA	NA	NA	NA	NA
n-Propylbenzene	18 J	250 U	NA	NA	NA	NA	NA	NA	NA
Pentachloroethane	NA	NA	NA	NA	NA	NA	NA	NA	NA
p-Isopropyltoluene	27 UJ	250 U	NA	NA	NA	NA	NA	NA	NA
sec-Butylbenzene	21 J	250 U	NA	NA	NA	NA	NA	NA	NA
Tetrachloroethene	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Toluene	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
trans-1,2-Dichloroethene	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Trichloroethene	5 UJ	250 U	5.4	5 U	5 U	5 U	5 U	5 U	44
Xylene (m&p)	11 J	250 U	NA	NA	NA	NA	NA	NA	NA

TABLE 2-4

SUMMARY OF ORGANIC DETECTIONS IN GROUNDWATER
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	CMS Investigation		TCE Investigation						
Site ID	UGW19	UGW21	TW102	TW104	TW105	TW1	TW1	TW2	TW3
Sample ID	UGW19	UGW21	7TCE102	7TCE104	7TCE105	7TCE1s	7TCE1d	7TCE2d	7TCE3d
Sample Date	04/17/98	04/17/98	07/01/99	07/01/99	07/01/99	06/26/99	06/29/99	06/29/99	06/29/99

Notes:
J - Estimated value.
U - Not detected.
R - Result is rejected and unusable.
UJ - Reported quantitation limit is qualified as estimated.
ug/L - micrograms per liter.
NA - Not Analyzed.
Not included in Appendix IX compounds

TABLE 2-4

SUMMARY OF ORGANIC DETECTIONS IN GROUNDWATER
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	TCE Investigation								
Site ID	TW4	TW4	TWA	TWA	TWB	TWB	TWC	TWC	TWE
Sample ID	7TCE4s	7TCE4d	7TCEAs	7TCEAd	7TCEBs	7TCEBd	7TCECs	7TCECd	7TCEEs
Sample Date	06/28/99	06/29/99	06/25/99	06/30/99	06/25/99	06/30/99	06/27/99	06/30/99	06/30/99
Volatile Organic Compounds (ug/L)									
1,1,1-Trichloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	50 U	5 U
1,1,2-Trichloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	50 U	5 U
1,1-Dichloroethene	5 U	5 U	5 U	5	3.8 J	5 U	5 U	50 U	5 U
1,2,3-Trichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,4-Trimethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dibromo-3-chloropropane	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dichloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	50 U	5 U
1,3,5-Trimethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acrolein	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	50 U	5 U
Chloroform	5 U	5 U	5 U	5 U	5 U	5 U	5 U	50 U	5 U
Chloromethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	100 U	10 U
cis-1,2-Dichloroethene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	50 U	5 U
Ethylbenzene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	50 U	5 U
Isopropylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene chloride	5 U	5 U	5 U	5 U	5 U	5 U	5 U	50 U	5 U
n-Butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
n-Propylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pentachloroethane	NA	NA	NA	NA	NA	NA	NA	NA	NA
p-Isopropyltoluene	NA	NA	NA	NA	NA	NA	NA	NA	NA
sec-Butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tetrachloroethene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	50 U	5 U
Toluene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	50 U	5 U
trans-1,2-Dichloroethene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	50 U	5 U
Trichloroethene	5 U	5 U	55	140	92	66	25	1,500	5 U
Xylene (m&p)	NA	NA	NA	NA	NA	NA	NA	NA	NA

TABLE 2-4

SUMMARY OF ORGANIC DETECTIONS IN GROUNDWATER
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	TCE Investigation								
Site ID	TW4	TW4	TWA	TWA	TWB	TWB	TWC	TWC	TWE
Sample ID	7TCE4s	7TCE4d	7TCEAs	7TCEAd	7TCEBs	7TCEBd	7TCECs	7TCECd	7TCEEs
Sample Date	06/28/99	06/29/99	06/25/99	06/30/99	06/25/99	06/30/99	06/27/99	06/30/99	06/30/99

Notes:
J - Estimated value.
U - Not detected.
R - Result is rejected and unusable.
UJ - Reported quantitation limit is qualified as estimated.
ug/L - micrograms per liter.
NA - Not Analyzed.
Not included in Appendix IX compounds

TABLE 2-4

SUMMARY OF ORGANIC DETECTIONS IN GROUNDWATER
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	TCE Investigation		Additional Data Collection Investigation							
Site ID	TWE	7TCEMW07	7MW07	7MW07	7MW08	7MW10	7MW20	UGW11	UGW16	UGW18
Sample ID	7TCEEsD	7TCEMW7	7MW07	7MW07D	7MW08	7MW10	7MW20	UGW11	UGW16	UGW18
Sample Date	06/30/99	07/01/99	01/13/02	01/13/02	01/13/02	01/26/02	01/26/02	01/12/02	01/12/02	01/12/02
Volatile Organic Compounds (ug/L)										
1,1,1-Trichloroethane	5 U	50 U	1,000 U	1,000 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1,2-Trichloroethane	5 U	50 U	1,000 U	1,000 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1-Dichloroethene	5 U	50 U	1,000 U	1,000 U	5 U	5 U	5 U	5 U	1.7 J	5 U
1,2,3-Trichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,4-Trimethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dibromo-3-chloropropane	NA	NA	1,000 UJ	1,000 UJ	5 J	5 U	5 U	5 UJ	5 UJ	5 UJ
1,2-Dichloroethane	5 U	50 U	1,000 U	1,000 U	5 U	5 U	5 U	5 U	5 U	5 U
1,3,5-Trimethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acrolein	NA	NA	20,000 R	20,000 R	100 J	100 R	100 R	100 R	100 R	100 R
Benzene	5 U	50 U	1,000 U	1,000 U	0.54 J	5 U	5 U	5 U	5 U	5 U
Chloroform	5 U	50 U	1,000 U	1,000 U	5 U	5 U	5 U	5 U	5 U	5 U
Chloromethane	10 U	100 U	2,000 U	2,000 U	10 U	10 U	10 U	10 U	10 U	10 U
cis-1,2-Dichloroethene	5 U	50 U	NA	NA	NA	NA	NA	NA	NA	NA
Ethylbenzene	5 U	50 U	1,000 U	1,000 U	5 U	5 U	5 U	5 U	5 U	5 U
Isopropylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene chloride	5 U	50 U	95 J	1,000 U	5 U	5 U	5 U	5 U	5 U	5 U
n-Butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
n-Propylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pentachloroethane	NA	NA	5,000 UJ	5,000 UJ	25 J	25 R	25 R	25 UJ	25 UJ	25 UJ
p-Isopropyltoluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
sec-Butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tetrachloroethene	5 U	50 U	1,000 U	1,000 U	5 U	5 U	5 U	5 U	5 U	5 U
Toluene	5 U	50 U	1,000 U	170 J	5 U	5 U	5 U	5 U	5 U	5 U
trans-1,2-Dichloroethene	5 U	50 U	1,000 U	1,000 U	5 U	5 U	5 U	5 U	5 U	5 U
Trichloroethene	5 U	1,000	28,000 J	23,000 J	0.47 J	5 U	0.59 J	0.35 J	5 U	5 U
Xylene (m&p)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

TABLE 2-4

SUMMARY OF ORGANIC DETECTIONS IN GROUNDWATER
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	TCE Investigation		Additional Data Collection Investigation							
Site ID	TWE	7TCEMW07	7MW07	7MW07	7MW08	7MW10	7MW20	UGW11	UGW16	UGW18
Sample ID	7TCEEsD	7TCEMW7	7MW07	7MW07D	7MW08	7MW10	7MW20	UGW11	UGW16	UGW18
Sample Date	06/30/99	07/01/99	01/13/02	01/13/02	01/13/02	01/26/02	01/26/02	01/12/02	01/12/02	01/12/02

Notes:
J - Estimated value.
U - Not detected.
R - Result is rejected and unusable.
UJ - Reported quantitation limit is qualified as estimated.
ug/L - micrograms per liter.
NA - Not Analyzed.
Not included in Appendix IX compounds

TABLE 2-4

SUMMARY OF ORGANIC DETECTIONS IN GROUNDWATER
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	TCE Plume Delineation and Source Investigation								
Site ID	7TCETW201	7TCETW202	7TCETW203	7TCETW203	7TCETW204	7TCETW205	7TCETW206	7TCETW207	7TCETW208
Sample ID	7TCETW201	7TCETW202	7TCETW203	7TCETW203D	7TCETW204	7TCETW205	7TCETW206	7TCETW207	7TCETW208
Sample Date	09/16/03	09/16/03	09/16/03	09/16/03	09/18/03	09/18/03	09/19/03	09/19/03	09/25/03
Volatile Organic Compounds (ug/L)									
1,1,1-Trichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	0.18 J	1 U	1 U
1,1,2-Trichloroethane	1 U	0.42 J	1 U	0.89 J	1 U	1 U	1 U	1 U	1 U
1,1-Dichloroethene	1 U	1 U	1 U	1 U	0.56 J	3.8	1 U	1 U	1 U
1,2,3-Trichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,4-Trimethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dibromo-3-chloropropane	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dichloroethane	1 U	0.51 J	1 U	0.89 J	1 U	1 U	1 U	1 U	1 U
1,3,5-Trimethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acrolein	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chloroform	1 U	1 U	1 U	1 U	1 U	1 U	0.14 U	0.14 U	1 U
Chloromethane	1 U	1.3 U	1 U	1 U	1 U	1 U	0.4 J	1 U	1 U
cis-1,2-Dichloroethene	1 U	1 U	1 U	1 U	83	1 U	0.36 J	1 U	1 U
Ethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Isopropylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene chloride	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
n-Butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
n-Propylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pentachloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
p-Isopropyltoluene	NA	NA	NA	NA	NA	NA	NA	NA	NA
sec-Butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tetrachloroethene	1 U	0.5 J	1 U	1 U	1 U	1 U	4.5	0.51 J	1 U
Toluene	NA	NA	NA	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethene	1 U	1 U	1 U	1 U	1.1	1 U	1 U	1 U	1 U
Trichloroethene	1 U	0.26 J	1 U	0.21 J	14	0.32 J	66	0.2 J	0.68 U
Xylene (m&p)	NA	NA	NA	NA	NA	NA	NA	NA	NA

TABLE 2-4

SUMMARY OF ORGANIC DETECTIONS IN GROUNDWATER
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	TCE Plume Delineation and Source Investigation								
Site ID	7TCETW201	7TCETW202	7TCETW203	7TCETW203	7TCETW204	7TCETW205	7TCETW206	7TCETW207	7TCETW208
Sample ID	7TCETW201	7TCETW202	7TCETW203	7TCETW203D	7TCETW204	7TCETW205	7TCETW206	7TCETW207	7TCETW208
Sample Date	09/16/03	09/16/03	09/16/03	09/16/03	09/18/03	09/18/03	09/19/03	09/19/03	09/25/03

Notes:
J - Estimated value.
U - Not detected.
R - Result is rejected and unusable.
UJ - Reported quantitation limit is qualified as estimated.
ug/L - micrograms per liter.
NA - Not Analyzed.
Not included in Appendix IX compounds

TABLE 2-4

SUMMARY OF ORGANIC DETECTIONS IN GROUNDWATER
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	TCE Plume Delineation and Source Investigation								
Site ID	7TCETW209	7TCETW210	7MW07	7MW08	7MW10	7MW20	7MW20	7MW21	7MW22
Sample ID	7TCETW209	7TCETW210	7MW07	7MW08	7MW10	7MW20	7MW20D	7MW21	7MW22
Sample Date	09/24/03	09/25/03	09/16/03	09/22/03	09/22/03	09/23/03	09/23/03	09/25/03	09/25/03
Volatile Organic Compounds (ug/L)									
1,1,1-Trichloroethane	1 U	1 U	100 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2-Trichloroethane	1 U	1 U	100 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1-Dichloroethene	0.87 J	1 U	100 U	1 U	1 U	1 U	1 U	1 U	5
1,2,3-Trichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,4-Trimethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dibromo-3-chloropropane	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dichloroethane	1 U	1 U	100 U	1 U	1 U	1 U	1 U	1 U	1 U
1,3,5-Trimethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acrolein	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chloroform	1 U	1 U	100 U	1 U	1 U	0.13 U	0.12 U	1 U	1 U
Chloromethane	1 U	1 U	100 U	1 U	1 U	1 U	1 U	1 U	1 U
cis-1,2-Dichloroethene	1 U	1 U	41 J	1 U	1 U	1 U	1 U	1 U	1 U
Ethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Isopropylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene chloride	5 U	5 U	500 U	5 U	5 U	5 U	5 U	5 U	5 U
n-Butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
n-Propylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pentachloroethane	5 U	5 U	500 U	5 U	5 U	5 U	5 U	5 U	5 U
p-Isopropyltoluene	NA	NA	NA	NA	NA	NA	NA	NA	NA
sec-Butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tetrachloroethene	1 U	1 U	100 U	1 U	1 U	1 U	1 U	1 U	1 U
Toluene	NA	NA	NA	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethene	1 U	1 U	100 U	1 U	1 U	1 U	1 U	1 U	1 U
Trichloroethene	1 U	1 U	1,800	0.15 J	1 U	1 U	1 U	1.4 U	0.44 U
Xylene (m&p)	NA	NA	NA	NA	NA	NA	NA	NA	NA

TABLE 2-4

SUMMARY OF ORGANIC DETECTIONS IN GROUNDWATER
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	TCE Plume Delineation and Source Investigation								
Site ID	7TCETW209	7TCETW210	7MW07	7MW08	7MW10	7MW20	7MW20	7MW21	7MW22
Sample ID	7TCETW209	7TCETW210	7MW07	7MW08	7MW10	7MW20	7MW20D	7MW21	7MW22
Sample Date	09/24/03	09/25/03	09/16/03	09/22/03	09/22/03	09/23/03	09/23/03	09/25/03	09/25/03

Notes:
J - Estimated value.
U - Not detected.
R - Result is rejected and unusable.
UJ - Reported quantitation limit is qualified as estimated.
ug/L - micrograms per liter.
NA - Not Analyzed.
Not included in Appendix IX compounds

TABLE 2-4

SUMMARY OF ORGANIC DETECTIONS IN GROUNDWATER
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	TCE Plume Delineation and Source Investigation			Number	Range	
Site ID	7MW23	7MW24	UGW11	of	of	Location
Sample ID	7MW23	7MW24	UGW11	Positive	Positive	Maximum
Sample Date	09/24/03	09/24/03	09/22/03	Detecions	Detections	Detect
Volatile Organic Compounds (ug/L)						
1,1,1-Trichloroethane	1 U	1 U	1 U	1/58	0.18J	7TCETW206 (9/19/03)
1,1,2-Trichloroethane	1 U	0.22 J	1 U	4/58	0.22J - 0.89J	7TCETW203D (9/16/03)
1,1-Dichloroethene	1 U	2.5	1 U	10/58	0.56J - 5.0	7MW22 (9/25/03), 7TCEAd (6/30/99)
1,2,3-Trichlorobenzene	NA	NA	NA	1/11	530	UGW13 (4/21/98)
1,2,4-Trimethylbenzene	NA	NA	NA	4/11	9J - 310J	UGW19 (4/17/98)
1,2-Dibromo-3-chloropropane	NA	NA	NA	1/19	5J	7MW08 (1/13/02)
1,2-Dichloroethane	1 U	1 U	1 U	2/58	0.51J - 0.89J	7TCETW203D (9/16/03)
1,3,5-Trimethylbenzene	NA	NA	NA	3/11	3J - 250J	UGW13 (4/21/98)
Acrolein	NA	NA	NA	1/1	100J	7MW08 (1/13/02)
Benzene	NA	NA	NA	2/37	0.54J - 0.8J	UGW11 (4/17/98)
Chloroform	1 U	0.55 U	20 U	1/58	2	UGW18 (4/16/98)
Chloromethane	1 U	1 U	1 U	3/58	0.4J - 13	7TCE1s (6/26/99)
cis-1,2-Dichloroethene	1 U	1.5	1 U	4/50	0.36J - 83	7TCETW204 (9/18/03)
Ethylbenzene	NA	NA	NA	2/37	2J - 86J	UGW13 (4/21/98)
Isopropylbenzene	NA	NA	NA	3/11	12J - 69J	UGW13 (4/21/98)
Methylene chloride	5 U	5 U	5 U	1/49	95J	7MW07 (1/13/02)
n-Butylbenzene	NA	NA	NA	3/11	14J - 360J	UGW13 (4/21/98)
n-Propylbenzene	NA	NA	NA	4/11	13J - 160J	UGW13 (4/21/98)
Pentachloroethane	5 U	5 U	5 U	1/27	25J	7MW08 (1/13/02)
p-Isopropyltoluene	NA	NA	NA	1/11	170J	UGW13 (4/21/98)
sec-Butylbenzene	NA	NA	NA	4/11	13J - 160J	UGW13 (4/21/98)
Tetrachloroethene	1 U	1 U	1 U	3/58	0.5J - 4.5	7TCETW206 (9/19/03)
Toluene	NA	NA	NA	1/37	170J	7MW07D (1/13/02)
trans-1,2-Dichloroethene	1 U	1 U	1 U	1/58	1.1	7TCETW204 (9/18/03)
Trichloroethene	87	1,600	1 U	27/58	0.15J - 28,000J	7MW07 (1/13/02)
Xylene (m&p)	NA	NA	NA	2/11	11J - 86J	UGW13 (4/21/98)

TABLE 2-4

SUMMARY OF ORGANIC DETECTIONS IN GROUNDWATER
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	TCE Plume Delineation and Source Investigation			Number	Range	
Site ID	7MW23	7MW24	UGW11	of	of	Location
Sample ID	7MW23	7MW24	UGW11	Positive	Positive	Maximum
Sample Date	09/24/03	09/24/03	09/22/03	Detecions	Detections	Detect

Notes:
J - Estimated value.
U - Not detected.
R - Result is rejected and unusable.
UJ - Reported quantitation limit is qualified as estimated.
ug/L - micrograms per liter.
NA - Not Analyzed.
Not included in Appendix IX compounds

TABLE 2-5

SURFACE SOIL DATA AND COPC SELECTION SUMMARY
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Contaminant	Criteria [1]		Contaminant Frequency / Range / Location			COPC Selection	
	Region III Residential Soil RBC Values		No. of Positive Detects / No. of Samples	Range of Positive Detections	Location of Maximum Detection	Selected as a COPC?	Rationale for Selection or Deletion
Volatiles (ug/kg)							
Methylene chloride	85,163	C	8/21	3.2 J - 9.1	54SS08	NO	BSL
Toluene	1,564,286	N	13/21	2.1 J - 15	54SS08,54SS14	NO	BSL
Chlorobenzene	156,429	N	1/21	18	54SS07	NO	BSL
Ethylbenzene	782,143	N	1/21	3.8 J	54SS11	NO	BSL
Styrene	1,564,286	N	4/21	2.1 J - 22	54SS11	NO	BSL
Acetone	7,039,286	N	3/21	4.2 J - 48 J	54SS10	NO	BSL
Semivolatiles (ug/kg)							
Phenanthrene	234,643	N [2]	1/21	220 J	54SS07	NO	BSL
Fluoranthene	312,857	N	2/21	420 J - 630 J	54SS07	NO	BSL
Benzo(a)anthracene	875	C	1/21	350 J	54SS07	NO	BSL
bis(2-Ethylhexyl)phthalate	45,623	C	1/21	530 J	54SS13	NO	BSL
Benzo(k)fluoranthene	8,750	C	1/21	560 J	54SS07	NO	BSL
Benzo(a)pyrene	87.5	C	1/21	580 J	54SS07	YES	ASL

Notes:

COPC - Chemical of Potential Concern
C = Carcinogenic
N = Non-Carcinogenic
J - Analyte present - Reported value is estimated
ug/kg - microgram per kilogram

Rationale Codes:
(BSL) Below Screening Level
(ASL) Above Screening Level

Shaded constituents were identified as COPCs for quantitative risk evaluation.

(1) All non-carcinogenic criteria were divided by 10 to account for potential additive effects of chemicals.
USEPA Region III COC Screening Value (derived from USEPA Region III RBC Table - April, 2004)
(2) Screening value for pyrene used as a surrogate.

TABLE 2-6

SUBSURFACE SOIL DATA AND COPC SELECTION SUMMARY
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Contaminant	Criteria (1)		Contaminant Frequency / Range / Location			COPC Selection	
	Region III Residential Soil RBC Values		No. of Positive Detects / No. of Samples	Range of Positive Detections	Location of Maximum Detection	Selected as a COPC?	Rationale for Selection or Deletion
Volatiles (ug/kg)							
1,1,2,2-Tetrachloroethane	3,194	C	1/9	210 J	54TW15A-04	NO	BSL
1,1-Dichloroethene	391,071	N	1/9	140 J	54TW15A-04	NO	BSL
1,2-Dibromo-3-chloropropane	456	C	1/9	610	54TW15A-04	YES	ASL
2-Butanone	4,692,857	N	2/9	6.2 J - 1500	54TW15A-04	NO	BSL
2-Hexanone	312,857	N	1/9	1700	54TW15A-04	NO	BSL
Acetone	7,039,286	N	6/9	18 J - 2900 J	54TW15A-04	NO	BSL
Carbon tetrachloride	4,913	C	1/9	110 J	54TW15A-04	NO	BSL
Chlorobenzene	156,429	N	1/9	110 J	54TW15A-04	NO	BSL
Ethylbenzene	782,143	N	1/9	190 J	54TW15A-04	NO	BSL
Styrene	1,564,286	N	1/9	100 J	54TW15A-04	NO	BSL
Toluene	1,564,286	N	3/9	2.6 J - 3.6 J	54SB02-02	NO	BSL
Trichloroethene	1,597	C	1/9	130 J	54TW15A-04	NO	BSL
Trichlorofluoromethane	2,346,429	N	1/9	160 J	54TW15A-04	NO	BSL
Xylenes	1,564,286	N	1/9	640	54TW15A-04	NO	BSL
Semivolatiles (ug/kg)							
2,4-Dimethylphenol	156,429	N	1/8	68 J	54TW15A-04	NO	BSL
Di-n-butylphthalate	782,143	N	1/9	57 J	54SB01-08	NO	BSL

Notes:

COPC - Chemical of Potential Concern
C = Carcinogenic
N = Non-Carcinogenic
J - Analyte present - Reported value is estimated
ug/kg - microgram per kilogram

Rationale Codes:
(ASL) Above Screening Level
(BSL) Below Screening Level

Shaded constituents were identified as COPCs for quantitative risk evaluation.

(1) All non-carcinogenic criteria were divided by 10 to account for potential additive effects of chemicals.
USEPA Region III COC Screening Value (derived from USEPA Region III RBC Table - April, 2004)

TABLE 2-7

GROUNDWATER DATA AND COPC SELECTION SUMMARY
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Contaminant	Criteria [1]	Contaminant Frequency / Range / Location			COPC Selection	
	Region III Tap Water RBC Values	No. of Positive Detects / No. of Samples	Range of Positive Detections	Location of Maximum Detection	Selected as a COPC?	Rationale for Selection or Deletion
Volatiles (ug/L)						
1,1,1-Trichloroethane	317 N	1/40	0.64 J	54TW19	NO	BSL
1,1-Dichloroethene	35.3 N	4/40	0.61 J - 1.5 J	510MW3	NO	BSL
1,2-Dichloroethane	0.116 C	5/40	0.86 J - 3 J	510DW2	YES	ASL
2-Butanone	697 N	1/40	26	510DW1	NO	BSL
Acetone	548 N	1/32	40 J	510DW1	NO	BSL
Benzene	0.336 C	5/40	2 J - 3000	54TW15	YES	ASL
Chlorobenzene	10.6 N	1/40	2 J	510MW3	NO	BSL
Chloroform	0.155 C	12/40	1.2 J - 8	54TW08	YES	ASL
Ethylbenzene	134 N	5/40	32 - 2400	54TW15	YES	ASL
Isobutanol	183 N	2/4	2600 J - 2900 J	510DW1	YES	ASL
Methylene chloride	4.10 C	2/40	0.54 J - 0.54 J	54TW03,54TW04	NO	BSL
Toluene	74.7 N	7/40	0.56 J - 400	54TW15	YES	ASL
Trichloroethene	0.0264 C	21/40	0.34 J - 230 D	510MW5	YES	ASL
Xylene	21.3 N	5/40	5.5 J - 8000	54TW15	YES	ASL
Semivolatiles (ug/L)						
2,4-Dimethylphenol	73.0 N	1/40	8.5 J	54TW15	NO	BSL
2-Methylnaphthalene	2.43 N	4/40	0.4 J - 65	54TW15	YES	ASL
4-Bromophenyl-phenylether	NE	1/40	2.2 J	54TW02	NO	NSC
Benzo(a)anthracene	0.0917 C	2/40	0.86 J - 0.95 J	510MW1	YES	ASL
Bis(2-ethylhexyl)phthalate	4.78 C	3/40	0.88 J - 3.9 J	510DW1	NO	BSL
Butylbenzylphthalate	730 N	1/40	0.77 J	510MW1	NO	BSL
Chrysene	9.17 C	2/40	1.2 J - 1.5 J	510MW1	NO	BSL
Di-n-butylphthalate	365 N	2/40	0.26 J - 0.37 J	54TW16	NO	BSL
Diethylphthalate	2,920 N	7/40	0.52 J - 2.7 J	54TW07	NO	BSL
Fluoranthene	146 N	2/40	0.44 J - 2.4 J	510MW5	NO	BSL
Fluorene	24.3 N	2/40	0.64 J - 1.6 J	54TW15	NO	BSL
Naphthalene	0.651 N	1/40	190	54TW15	YES	ASL
Phenanthrene	18.3 N [2]	1/40	0.46 J	54TW04	NO	BSL

Notes:

COPC - Chemical of Potential Concern
NE - Not Established
C = Carcinogenic
N = Non-Carcinogenic
ug/L - microgram per liter
J - Analyte present - Reported value is estimated

Rationale Codes:
(ASL) Above Screening Level
(BSL) Below Screening Level
(NSC) No Screening Criteria

Shaded constituents were identified as COPCs for quantitative risk evaluation.

(1) All non-carcinogenic criteria were divided by 10 to account for potential additive effects of chemicals.
USEPA Region III COC Screening Value (derived from USEPA Region III RBC Table - April, 2004)
(2) Screening value for pyrene used as a surrogate.

TABLE 2-8

GROUNDWATER DATA AND COPC SELECTION SUMMARY
SWMU 55--TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Contaminant	Criteria (1)		Contaminant Frequency / Range / Location			COPC Selection	
	Region III Tap Water RBC Values		No. of Positive Detects / No. of Samples	Range of Positive Detections	Location of Maximum Detection	Selected as a COPC?	Rationale for Selection or Deletion
Volatile Organic Compounds (ug/L)							
1,1,1-Trichloroethane	317	N	1/21	0.18 J	7TCETW206	NO	BSL
1,1,2-Trichloroethane	0.188	C	3/21	0.22 J - 0.89 J	7TCETW203	YES	ASL
1,1-Dichloroethene	35.3	N	5/21	0.56 J - 5	7MW22	NO	BSL
1,2-Dichloroethane	0.116	C	2/21	0.51 J - 0.89 J	7TCETW203	YES	ASL
Chloromethane (Methyl Chloride)	19.0	N	1/21	0.4 J	7TCETW206	NO	BSL
cis-1,2-Dichloroethene	6.08	N	4/21	0.36 J - 83	7TCETW204	YES	ASL
Tetrachloroethene	0.104	C	3/21	0.5 J - 4.5	7TCETW206	YES	ASL
trans-1,2-Dichloroethene	12.2	N	1/21	1.1	7TCETW204	NO	BSL
Trichloroethene	0.0264	C	10/21	0.15 J - 1800	7MW07	YES	ASL

Notes:

COPC - Chemical of Potential Concern
C = Carcinogenic
N = Non-Carcinogenic
J - Analyte present - Reported value is estimated
ug/L - microgram per liter

Rationale Codes:
(ASL) Above Screening Level
(BSL) Below Screening Level

Shaded constituents were identified as COPCs for quantitative risk evaluation.

(1) All non-carcinogenic criteria were divided by 10 to account for potential additive effects of chemicals.
USEPA Region III COC Screening Value (derived from USEPA Region III RBC Table - April, 2004)

TABLE 2-9

SUMMARY OF QUANTITATIVE CAO CALCULATIONS
EXPOSURE VIA INGESTION OF CHEMICALS IN SOIL
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, 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-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 2-9

SUMMARY OF QUANTITATIVE CAO CALCULATIONS
EXPOSURE VIA INGESTION OF CHEMICALS IN SOIL
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, 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)

TABLE 2-10

SUMMARY OF QUANTITATIVE SOIL CAO CALCULATIONS
EXPOSURE VIA INHALATION OF CHEMICALS IN PARTICULATES
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, 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:

$$Intake = \frac{CS \times IR \times FI \times ET \times EF \times ED \times (1/PEF)}{BW \times AT}$$

$$Risk = Intake \times SF$$

$$HQ = Intake/RfD$$

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)
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)

TABLE 2-10

SUMMARY OF QUANTITATIVE SOIL CAO CALCULATIONS
EXPOSURE VIA INHALATION OF CHEMICALS IN PARTICULATES
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, 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}	365 days	ED x 365 days/year (USEPA, 1991b)

TABLE 2-11

SUMMARY OF QUANTITATIVE SOIL CAO CALCULATIONS -- EXPOSURE VIA INHALATION OF VOLATILES EMITTED FROM SOIL SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP CORRECTIVE MEASURES STUDY NAVAL ACTIVITY PUERTO RICO, 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-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 2.4.1-7 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 2-11

SUMMARY OF QUANTITATIVE SOIL CAO CALCULATIONS -- EXPOSURE VIA INHALATION OF VOLATILES EMITTED FROM SOIL SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP CORRECTIVE MEASURES STUDY NAVAL ACTIVITY PUERTO RICO, 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 2.4.1-7 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}	365 days	ED x 365 days/year (USEPA, 1991b)

TABLE 2-12

SUMMARY OF SOIL-TO-AIR VOLATILIZATION FACTOR (VF) CALCULATION
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, 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, 2001b)
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, 2000)
Θ_w = Water-filled soil porosity (L_{water} / L_{soil})
= 0.20 (Default for Johnson and Ettinger model; USEPA, 2000)
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 2-13

CHEMICAL-SPECIFIC VOLATILIZATION FACTOR DATA
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

COPC Name	Solubility (a)		Di		Dw		H'		Koc	
	(mg/L)	Ref.	(cm^2/s)	Ref.	(cm^2/s)	Ref.	(atm-m^3/mol)	Ref.	(ml/g)	Ref.
VOCs										
1,2-Dibromo-3-chloropropane	1.23E+03	2	2.12E-02	2	7.02E-06	2	6.01E-03	2	1.31E+02	2
SVOCs										
Benzo(a)pyrene	1.62E-03	1	4.30E-02	1	9.00E-06	1	4.63E-05	1	1.02E+06	1

Notes
(a) - Solubility is used in computing Csat, the soil saturation constant, which is used to check the validity of the volatilization calculation (USEPA, 1996b).
1 - USEPA, 2001b
2 - Risk Assessment Information System at http://risk.lsd.ornl.gov/index.shtml

TABLE 2-14

SUMMARY OF QUANTITATIVE CAO CALCULATIONS
EXPOSURE VIA DERMAL ABSORPTION OF CHEMICALS IN SOIL
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, 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 (cm^2)
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 D 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 2-14

SUMMARY OF QUANTITATIVE CAO CALCULATIONS
EXPOSURE VIA DERMAL ABSORPTION OF CHEMICALS IN SOIL
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, 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 2-15

SUMMARY OF QUANTITATIVE CAO CALCULATIONS
EXPOSURE VIA INGESTION OF CHEMICALS IN GROUNDWATER
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, 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-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 2-16

SUMMARY OF QUANTITATIVE CAO CALCULATIONS
EXPOSURE VIA INHALATION OF VOLATILES IN GROUNDWATER
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, 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 2-17

SUMMARY OF QUANTITATIVE CAO CALCULATIONS
DERMAL ABSORPTION OF CHEMICALS IN GROUNDWATER
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, 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 2.4.1-13 and 2.4.1-14 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 2-18

DETERMINATION OF DERMAL ABSORPTION FACTOR (DAF) FOR USE IN CALCULATING DERMAL ABSORPTION OF ORGANIC CHEMICALS FROM WATER
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, 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 2-19

DERMAL ABSORPTION FACTOR PARAMETER VALUES FOR GROUNDWATER COPCs
SWMUs 54 and 55
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, 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:												
1,2-Dichloroethane	7.20E-03	4.19E-03	3.02E+01	(1)	99.00	1.60E-02	4.42E-07	3.50E-01	8.40E-01	3.13E-01	3.44E-01	1.0
cis-1,2-Dichloroethene	1.36E-02	7.67E-03	7.24E+01	(1)	96.90	2.90E-02	4.54E-07	3.67E-01	8.80E-01	3.21E-01	3.53E-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
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
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
Ethylbenzene	1.07E-01	4.83E-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
Tetrachoroethene	8.55E-02	3.28E-02	2.51E+03	(1)	165.80	1.62E-01	1.87E-07	8.92E-01	2.14E+00	4.11E-01	4.49E-01	1.0
Toluene	5.64E-02	3.06E-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:												
Benzo(a)anthracene	1.77E+00	4.54E-01	4.57E+05	(1)	228.30	2.64E+00	8.35E-08	2.00E+00	8.35E+00	5.70E+00	2.73E+00	1.0
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
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

(1) K_{ow} values are from USEPA (1992)
(2) K_{ow} values are from RAIS (2004)

TABLE 2-20

TOXICOLOGICAL DATA SUMMARY
SWMUs 54 AND 55
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

	Carcinogenic					Noncarcinogenic									
	Oral		Inhalation		Inhalation		Oral		Oral		Inhalation		Inhalation		Inhalation	
Analyte	SF (mg/kg-d)$^{-1}$		SF (mg/kg-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}	
Volatiles:																		
1,2-Dichloroethane	9.10E-02	I	9.10E-02	I	2.60E-02	I	2.00E-02	E	2.00E-02	E	1.40E-03	E	1.40E-03	E	4.90E-03	E	4.90E-03	E
cis-1,2-Dichloroethene	--		--		--		1.00E-02	E	1.00E-02	E	--		--		--		--	
1,1,2-Trichloroethane	5.70E-02	I	5.60E-02	I	1.60E-02	I	4.00E-03	I	4.00E-02	H	--		--		--		--	
Benzene	5.50E-02	I	2.90E-02	I	7.80E-03	I	4.00E-03	I	4.00E-03	I	8.60E-03	I	8.60E-03	I	3.01E-02	I	3.01E-02	I
Chloroform	--		8.10E-02	I	2.30E-02	I	1.00E-02	I	1.00E-02	I	1.40E-02	E	1.40E-02	E	4.90E-02	E	4.90E-02	E
Ethylbenzene	--		--		--	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		--		--		--		--	
Tetrachloroethene	5.40E-01	E	2.00E-02	E	5.70E-03	E	1.00E-02	I	1.00E-02	I	1.40E-01	E	1.40E-01	E	4.90E-01	E	4.90E-01	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-01	I	2.00E-01	I	2.90E-02	I	2.90E-02	I	1.00E-01	I	1.00E-01	I
Semivolatiles:																		
Benzo(a)anthracene	7.30E-01	R	--		--		--		--		--		--		--		--	
Benzo(a)pyrene	7.30E+00	I	3.10E+00	E	8.80E-01	E	--		--		--		--		--		--	
2-Methylnaphthalene	--		--		--		4.00E-03	I	4.00E-03	I	--		--		--		--	
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, 2004b)
H = HEAST (USEPA, 1997b)
E = EPA-NCEA provisional value
R = Based on relative potency to Benzo(a)pyrene (USEPA, 1993)

-- = Relevant toxicity data are unavailable
(c) = Chronic
(s) = Subchronic

TABLE 2-21

QUANTITATIVE SOIL CAOs
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Surface Soil (mg/kg)		Total Soil (mg/kg)	
COPCs	Industrial	COPCs	Construction
Semivolatiles		*Volatiles*	
Benzo(a)pyrene	2.9E+00	**1,2-Dibromo-3-chloropropane**	1.7E+01
		Semivolatiles	
		Benzo(a)pyrene	7.3E+00

COPCs in **bold** are identified in subsurface soil but not in surface soil.

TABLE 2-22

QUANTITATIVE GROUNDWATER CAOs
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

	Groundwater (ug/L)	
COPCs	Construction	Industrial
Volatiles		
1,2-Dichloroethane	1.4E+03	8.3E+02
Benzene	2.9E+03	5.5E+02
Chloroform	1.9E+03	2.5E+02
Ethylbenzene	1.1E+05	1.7E+05
Isobutanol	5.3E+06	--
Toluene	5.1E+05	5.3E+05 (1)
Trichloroethene	2.6E+02	2.2E+01
Xylenes	5.0E+04	1.5E+05
Semivolatiles		
Benzo(a)anthracene	7.7E+00	7.7E+04 (1)
2-Methylnaphthalene	1.9E+03	--
Naphthalene	1.8E+03	3.1E+04 (1)

(1) The calculated risk-based CAO exceeds the solubility, so the solubility is the CAO.
'--' Indicates that the relevant health effects criteria are unavailable.
Shaded values represent the selected CAO because they are the most conservative of the two.

Revised: August 29, 2005

TABLE 2-23

QUANTITATIVE GROUNDWATER CAOs
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Groundwater (ug/L)		
COPCs	Construction	Industrial
Volatiles		
1,2-Dichloroethane	1.4E+03	8.3E+02
cis-1,2-Dichloroethene	7.6E+04	7.4E+04
1,1,2-Trichloroethane	2.1E+03	1.7E+03
Tetrachloroethene	2.0E+02	2.9E+02
Trichloroethene	2.6E+02	2.2E+01

Shaded values represent the selected CAO because it is the most conservative of the two.

TABLE 2-24

LIST OF BIRDS REPORTED FROM NAVAL ACTIVITY PUERTO RICO
SWMU 54 –BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Common Name [1]		
Pied-billed grebe	Red-billed tropicbird	Brown pelican [2]
Brown booby	Magnificent frigatebird	Great blue heron
Louisiana heron	Snowy egret	Great egret
Striated heron	Little blue heron	Cattle egret
Least bittern	Yellow-crowned night heron	Black-crowned night heron
White-cheeked pintail	Blue-winged teal	American widgeon
Red-tailed hawk	Osprey	Merlin
Clapper rail	American coot	Caribbean coot
Common gallinule	Piping plover [3]	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 2-24

LIST OF BIRDS REPORTED FROM NAVAL AREA PUERTO RICO
SWMU 54 –BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT
NAVAL AREA PUERTO RICO, CEIBA, PUERTO RICO

Common Name [1]		
Gray kingbird	Loggerhead kingbird	Stolid flycatcher
Caribbean elaenia	Purple martin	Cave swallow
Barn swallow	Northern mockingbird	Pearly-eyed thrasher
Red-legged thrush	Black-whiskered vireo	American redstart
Parula warbler	Prairie warbler	Yellow warbler
Magnolia warbler	Cape May warbler	Black-throated blue warbler
Adelaide's warbler	Palm warbler	Black and white warbler
Ovenbird	Northern water thrush	Bananaquit
Striped-headed tanager	Shiny cowbird	Black-cowled oriole
Greater Antillean grackle	Yellow-shouldered blackbird [2]	Hooded 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 Area Puerto Rico.

TABLE 2-25

SURFACE WATER SCREENING VALUES
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Chemical	Surface Water Screening Value [1]	Reference	Comment
Volatile Organics (ug/L):			
1,1,1-Trichloroethane	312	USEPA 2001c	USEPA Region 4 chronic screening value
1,1,2-Trichloroethane	340	USEPA 2003	Minimum acute value (48-hr LC_{50} for *Pleuronectes platessa* [sand dab]) with a safety factor of 100
1,1-Dichloroethene	2,240	USEPA 2001c	USEPA Region 4 chronic screening value
1,2-Dichloroethane	1,130	USEPA 2001c	USEPA Region 4 chronic screening value
Chloromethane (Methyl chloride)	2,700	USEPA 2003	Minimum acute value (96-hr LC_{50} for *Menidia beryllina* [inland silverside]) with a safety factor of 100
Tetrachloroethene	45	USEPA 2001c	USEPA Region 4 chronic screening value
cis-1,2-dichloroethene	22,400	Buchman 1999	Acute LOEL (summation of all isomers) with a safety factor of 10
trans-1,2-dichloroethene	22,400	Buchman 1999	Acute LOEL (summation of all isomers) with a safety factor of 10
Trichloroethene	200	Buchman 1999	Acute LOEL with a safety factor of 10

Notes:

LOEL = Lowest Observed Effect Level
USEPA = United States Environmental Protection Agency
LC_{50} = Median Lethal Concentration

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

TABLE 2-26

COMPARISON OF GROUNDWATER DETECTIONS TO SURFACE WATER SCREENING VALUES
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Site ID Sample ID Sample Date	Surface Water Screening Value	7TCETW201 7TCETW201 09/16/03	7TCETW202 7TCETW202 09/16/03	7TCETW203 7TCETW203 09/16/03	7TCETW203 7TCETW203D 09/16/03	7TCETW204 7TCETW204 09/18/03	7TCETW205 7TCETW205 09/18/03	7TCETW206 7TCETW206 09/19/03
Volatile Organic Compounds (ug/L)								
1,1,1-Trichloroethane	312	1 U	1 U	1 U	1 U	1 U	1 U	0.18 J
1,1,2-Trichloroethane	340	1 U	0.42 J	1 U	0.89 J	1 U	1 U	1 U
1,1-Dichloroethene	2,240	1 U	1 U	1 U	1 U	0.56 J	3.8	1 U
1,2-Dichloroethane	1,130	1 U	0.51 J	1 U	0.89 J	1 U	1 U	1 U
Chloromethane (Methyl Chloride)	2,700	1 U	1.3 U	1 U	1 U	1 U	1 U	0.4 J
cis-1,2-Dichloroethene	22,400	1 U	1 U	1 U	1 U	83	1 U	0.36 J
Tetrachloroethene	45	1 U	0.5 J	1 U	1 U	1 U	1 U	4.5
trans-1,2-Dichloroethene	22,400	1 U	1 U	1 U	1 U	1.1	1 U	1 U
Trichloroethene	200	1 U	0.26 J	1 U	0.21 J	14	0.32 J	66

Notes:
NE = not established
ug/L = micrograms per liter
U = not detected
J = estimated concentration

TABLE 2-26

COMPARISON OF GROUNDWATER DETECTIONS TO SURFACE WATER SCREENING VALUES
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Site ID Sample ID Sample Date	Surface Water Screening Value	7TCETW207 7TCETW207 09/19/03	7TCETW208 7TCETW208 09/25/03	7TCETW209 7TCETW209 09/24/03	7TCETW210 7TCETW210 09/25/03	7MW07 7MW07 09/16/03	7MW08 7MW08 09/22/03	7MW10 7MW10 09/22/03
Volatile Organic Compounds (ug/L)								
1,1,1-Trichloroethane	312	1 U	1 U	1 U	1 U	100 U	1 U	1 U
1,1,2-Trichloroethane	340	1 U	1 U	1 U	1 U	100 U	1 U	1 U
1,1-Dichloroethene	2,240	1 U	1 U	0.87 J	1 U	100 U	1 U	1 U
1,2-Dichloroethane	1,130	1 U	1 U	1 U	1 U	100 U	1 U	1 U
Chloromethane (Methyl Chloride)	2,700	1 U	1 U	1 U	1 U	100 U	1 U	1 U
cis-1,2-Dichloroethene	22,400	1 U	1 U	1 U	1 U	41 J	1 U	1 U
Tetrachloroethene	45	0.51 J	1 U	1 U	1 U	100 U	1 U	1 U
trans-1,2-Dichloroethene	22,400	1 U	1 U	1 U	1 U	100 U	1 U	1 U
Trichloroethene	200	0.2 J	0.68 U	1 U	1 U	**1,800**	0.15 J	1 U

Notes:
NE = not established
ug/L = micrograms per liter
U = not detected
J = estimated concentration

TABLE 2-26

COMPARISON OF GROUNDWATER DETECTIONS TO SURFACE WATER SCREENING VALUES
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Site ID Sample ID Sample Date	Surface Water Screening Value	7MW20 7MW20 09/23/03	7MW20 7MW20D 09/23/03	7MW21 7MW21 09/25/03	7MW22 7MW22 09/25/03	7MW23 7MW23 09/24/03	7MW24 7MW24 09/24/03	UGW11 UGW11 09/22/03
Volatile Organic Compounds (ug/L)								
1,1,1-Trichloroethane	312	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2-Trichloroethane	340	1 U	1 U	1 U	1 U	1 U	0.22 J	1 U
1,1-Dichloroethene	2,240	1 U	1 U	1 U	5	1 U	2.5	1 U
1,2-Dichloroethane	1,130	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chloromethane (Methyl Chloride)	2,700	1 U	1 U	1 U	1 U	1 U	1 U	1 U
cis-1,2-Dichloroethene	22,400	1 U	1 U	1 U	1 U	1 U	1.5	1 U
Tetrachloroethene	45	1 U	1 U	1 U	1 U	1 U	1 U	1 U
trans-1,2-Dichloroethene	22,400	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Trichloroethene	200	1 U	1 U	1.4 U	0.44 U	87	**1,600**	1 U

Notes:
NE = not established
ug/L = micrograms per liter
U = not detected
J = estimated concentration

Revised: August 29, 2005

TABLE 2-27

FINAL COCs AND CAOs
SWMU 54 AND SWMU 55
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

SWMU/Media	COC	CAO	Observed Maximum
SWMU 54 Surface Soil (mg/kg)	*Semi-volatiles*		
	Benzo(a)pyrene	2.9E+00	0.580 J
SWMU 54 Combined Surface and Subsurface Soil (mg/kg)	*Volatiles*		
	1,2-Dibromo-3-chloropropane	1.7E+01	0.61
	Semi-volatiles		
	Benzo(a)pyrene	7.30E+00	0.580 J
SWMU 54 Groundwater (ug/L)	*Volatiles*		
	1,2-Dichloroethane	8.3E+02	2.8 J
	Benzene	5.5E+02	3,000
	Chloroform	2.5E+02	8
	Ethylbenzene	1.1E+05	2,400
	Isobutanol	5.3E+06	2,900 J
	Toluene	5.1E+05	400
	Trichloroethene	2.2E+01	230
	Xylenes	5.0E+04	8,000
	Semi-Volatiles		
	Benzo(a)anthracene	7.7E+00	0.95 J
	2-Methylnaphthalene	1.9E+03	65
	Naphthalene	1.8E+03	190
SWMU 55 Groundwater (ug/L)	*Volatiles*		
	1,2-Dichloroethane	8.3E+02	0.89 J
	cis 1,2-Dichloroethene	7.4E+04	83
	1,1,2-Trichloroethane	1.7E+03	0.89 J
	Tetrachloroethene	2.0E+02	4.5
	Trichloroethene	2.2E+01	28,000 J [(1)]

Notes:

mg/kg--milligrams/kilogram
ug/L--micrograms/Liter
[(1)] January 2002, recent concentration is 1,800 ug/L in September 2003.
Shaded cells indicate value exceeds CAO.

TABLE 2-28

PRELIMINARY CORRECTIVE MEASURES TECHNOLOGIES AND DESCRIPTIONS FOR GROUNDWATER
SWMU 54 AND SWMU 55
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

General Response Action	Corrective Measure Technology	Process Option	Description	Effectiveness
No Action	None	None		Not effective
Institutional Controls	Aquifer Use Restrictions, Groundwater Ordinance	None	Aquifer use is controlled through deed restrictions.	Effective for limiting future exposure to contaminants at the site
In- Situ Treatment	Biological	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.	Destruction through biodegradation is effective in treating most halogenated volatile organics and fuels. Dilution and adsorption reduce other classes of contaminants.
		Enhanced Bioremediation	The activity of naturally occurring microbes is stimulated 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. Mechanisms of delivery include bioventing, biosparging, and liquid delivery systems. Injection of air or air with methane, propane, or hydrogen may be done via sparging. Injection of nutrients and electron donors may be done via liquid injection.	Effective in treating VOCs, and some SVOCs; highly dependent upon the biodegradability of the contaminants; bioremediation slows at low temperatures; high constituent concentrations may initially be toxic to microbes; permeability differentials may reduce effectiveness; treatability test recommended.
		Bioaugmentation	Bioaugmentation involves the addition of microorganisms with specific metabolic capabilities along with substrate, or electron donor, if required.	Effective in treating some contaminants depending on availability of microbial cultures.
In- Situ Treatment (cont.)	Biological (cont.)	Permeable Biological Barrier	A zone of microbial activity is formed through the injection of nutrients or electron donor. Several process options are available: (1) a microbial "plug" forms with exponential growth of microbes; (2) a molasses barrier provides nutrients for microbe growth as well as a reducing environment; and (3) oxygen or hydrogen releasing compounds can be injected to form a zone of enhanced bioremediation.	Effective in treating VOCs, and some SVOCs; highly dependent upon the biodegradability of the contaminants; bioremediation slows at low temperatures; high constituent concentrations may initially be toxic to microbes; dependent on adequate characterization of groundwater flow paths.
		Phytoremediation	Select plants are grown in contaminated areas to provide reactive sites around the root zone for the breakdown of certain contaminants.	Not effective during dormant periods (e.g., winter); not effective until root zone reaches contaminated zone

TABLE 2-28

PRELIMINARY CORRECTIVE MEASURES TECHNOLOGIES AND DESCRIPTIONS FOR GROUNDWATER
SWMU 54 AND SWMU 55
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

General Response Action	Corrective Measure Technology	Process Option	Description	Effectiveness
	Physical/Chemical	Air Sparging	Air is injected into saturated matrices to remove contaminants through volatilization. Soil vapor extraction may be required to collect volatized compounds. Oxidation via ozone sparging is additional option.	Effective in treating VOCs and some SVOCs; permeability differentials may reduce effectiveness
		Direct Contact--Oxidation or Reduction, with or without fracturing	Injection of remedial agents [oxidizers (ozone, hydrogen peroxide, hypochlorites, permanganate, ORC, chlorine, and chlorine dioxide), and/or reducing agents (zero valent iron, ferrous sulfate)] to directly contact the affected areas. Hydraulic or pneumatic fracturing creates a fracture in the subsurface in the contaminated zones and allows for easier injection of the reagents.	Effective in treating some VOCs and some SVOCs depending on site geology, reagent(s) used, and concentrations.
In- Situ Treatment (cont.)	Physical/Chemical (cont.)	Permeable Reactive Barrier	A permeable barrier of zero valent iron is placed downgradient of the contaminated zone. The chemicals are reduced when placed in contact with the zero valent iron.	Effective in treating some VOCs, in particular the chlorinated compounds. Not effective for benzene or chlorobenzenes. Relies on groundwater flow through barrier for treatment.
		Thermal Wells	Electric heat (provided by electrodes) is used to increase the mobility of volatiles and facilitate extraction of contaminants from soils below the water table. The groundwater must be lowered during treatment. The process includes a system for handling off-gasses.	Effective in treating VOCs and some SVOCs
		Hot Water or Steam Enhanced Recovery	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.	Effective in treating VOCs and some SVOCs depending on site geology and hydrogeology; effective in treating shallow and/or deep contaminated areas
Collection	Extraction/Containment	Groundwater Extraction with Treatment	Groundwater is pumped to above ground and can be treated by a variety of treatment options (see ex situ biological and ex situ physical/chemical groundwater treatment technologies).	Effective for containing groundwater; long treatment time

TABLE 2-28

PRELIMINARY CORRECTIVE MEASURES TECHNOLOGIES AND DESCRIPTIONS FOR GROUNDWATER
SWMU 54 AND SWMU 55
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

General Response Action	Corrective Measure Technology	Process Option	Description	Effectiveness
Collection/Ex Situ Treatment	Biological	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 contactors and trickling filters, microorganisms are established on an inert support matrix.	Effective in treating VOCs and some SVOCs; nuisance microorganisms may colonize bioreactors, reducing effectiveness
	Physical/Chemical	Air Stripping	Volatile organics are partitioned from groundwater by increasing the surface area of the contaminated water exposed to air. Aeration methods include packed towers, diffused aeration, tray aeration, and spray aeration.	Effective in treating VOCs and some SVOCs
		Liquid Phase Carbon Adsorption	Groundwater is pumped through a series of canisters or columns containing activated carbon to which dissolved organic contaminants adsorb. Periodic replacement or regeneration of saturated carbon is required.	Effective in treating VOCs and some SVOCs
	Physical/Chemical (cont.)	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-gasses from the treatment tank.	Effective in treating VOCs and some SVOCs; turbidity decreases efficiency
Containment	Physical Barrier	Slurry Walls, sheet piling, jet grouting/grout curtain	These subsurface barriers consist of vertically excavated trenches filled with slurry. The slurry, usually a mixture of bentonite and water, hydraulically shores the trench to prevent collapse and retards groundwater flow. Sheet pilings are steel subsurface barriers that are driven into the ground and interlocked to prevent the flow of groundwater in a particular direction.	Effective at containing or diverting groundwater and contaminant flow

TABLE 2-29

PRELIMINARY SELECTIONS OF CORRECTIVE MEASURES TECHNOLOGIES
SWMU 54 AND SWMU 55
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

General Response Action	Corrective Measure Technology	Process Option	Retained (Y/N) SWMU 54/55	If not, reason
No Action	None	None	Yes--both SWMUs	
Institutional Controls	Aquifer Use Restrictions, Groundwater Ordinance	None	Yes--both SWMUs	
In- Situ Treatment	Biological	Monitored Natural Attenuation	Yes--both SWMUs	
		Enhanced Bioremediation	Yes--both SWMUs	
		Bioaugmentation	Yes--both SWMUs	
		Permeable Biological Barrier	Yes--SWMU 55 No--SWMU 54	SWMU 54 groundwater movement is too slow for this to be effective
		Phytoremediation	No	Contamination is not near the surface, long time frame (decades) is not acceptable
	Physical/Chemical	Air Sparging/In Well Aeration	No	SWMU 54 soils are too tight grained to allow effective sparging; SWMU 55 is located in bedrock, and this technology is not applicable to bedrock geology.
		Direct Contact--Oxidation or Reduction, with or without fracturing	Yes--both SWMUs	
		Permeable Reactive Barrier	Yes--SWMU 55 No--SWMU 54	SWMU 54 groundwater movement is too slow for this to be effective
In- Situ Treatment (cont.)	Physical/Chemical (cont.)	Thermal Wells	No	Soil contamination is not a concern. Cost is prohibitive for the concentration levels and risks at these sites.
		Hot Water or Steam Enhanced Recovery	No	Off-gas and vapor treatment may be required; air and water discharge permits may be required; local sources of steam and water required; likely would require simultaneous soil treatment (not necessary at these sites) or removal to be effective in acceptable implementation period.
Collection	Extraction	Groundwater Extraction with Treatment	Yes--SWMU 55 No--SWMU 54	SWMU 54 groundwater movement is too slow for this to be effective

TABLE 2-29

PRELIMINARY SELECTIONS OF CORRECTIVE MEASURES TECHNOLOGIES
SWMU 54 AND SWMU 55
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

General Response Action	Corrective Measure Technology	Process Option	Retained (Y/N) SWMU 54/55	If not, reason
Collection/Ex Situ Treatment	Biological	Bioreactors	No (1)	Other options are preferable due to the need to monitor the system closely for any disruptions in biological activity, which, when once disturbed, require significant time to re-establish.
	Physical/Chemical	Air Stripping	Yes	
		Liquid Phase Carbon Adsorption	Yes	
Collection/Ex Situ Treatment (cont.)	Physical/Chemical (cont.)	UV Oxidation	No	Other options are preferable for TCE, high cost, specialized equipment may not be available on the island.
Containment	Physical Barrier	Slurry Walls, sheet piling, jet grouting/grout curtain	No	Option not preferable for reducing contamination, only diverting it. Diversion locations may or may not be preferable to non-diverted locations.
	Extraction	Groundwater Extraction with Treatment	Yes	

(1) Ex-situ treatment options only apply to SWMU 55

TABLE 4-1
CORRECTIVE MEASURE ALTERNATIVE SUMMARY TABLE - SWMU 54

CORRECIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Alternative	EVALUATION CRITERIA									
	TECHNICAL								HUMAN HEALTH	ENVIRONMENTAL
	PERFORMANCE		RELIABILITY		IMPLEMENTABILITY			SAFETY		
	Effectiveness	Useful Life	O&M Requirements	Demonstrated/Expected	Constructability	Time				
						Implementation	*Results*			
1	**Not Applicable**	**Not Applicable**	**Not Applicable**	**Not Applicable**	**Not Applicable**	**Not Applicable**	**Not Applicable**	**Moderate to High** Groundwater concentrations are unknown with time. No active above ground oper.	**High Risk** No institutional controls to prevent exposure to unknown groundwater concentrations	**Low to Moderate Risk** No exposure pathway, but potentially no reduction in concentrations
2	**Moderate to High** Access restricted indefinitely. Naturally occurring processes to reduce site concentrations are likely to be ongoing.	**Long** Access restricted indefinitely. Naturally occurring processes to reduce site concentrations are likely to be ongoing	**High** No O and M required	**Moderate** Natural attenuation is likely to reduce concentrations with time, but is not guaranteed.	**High** Long term monitoring work plan required. Monitoring well construction easily accomplished.	**High** Less than 2 years.	**Low** Long time frame (30 + years) is likely necessary.	**High** No active above ground operations	**Low Risk** Site groundwater concentrations are known with time and risk is known. Institutional controls provide additional protection.	**Low Risk** No exposure pathway. Site groundwater concentrations are known with time and risk is known.
3	**High** Access restricted indefinitely. Enhanced bioremediation destroys contaminants of concern. MNA processes likely to be ongoing after active remediation is complete.	**Moderate to Long** Useful life of amendments is 2-3 months. Reinjection necessary. MNA likely to be ongoing.	**High** No O and M required	**Moderate** Rebound may occur after amendment injections stop. Natural attenuation is likely to reduce concentrations with time, but is not guaranteed.	**Moderate to High** UIC permit required. Pilot tests required. Injection of amendments is easily accomplished with common equipment, but may be limited by tight formation.	**Moderate** UIC permits, shipping materials, pilot study, 2-3 years implementation time	**Moderate** 3-5 years depending on success of process. MNA of remaining compounds is likely to be necessary.	**High** No active above ground operations	**Low Risk** In-situ process does not produce exposure pathway	**Low Risk** Potential geochemical changes are likely to be short term. No exposure pathway.
4	**High** Access restricted indefinitely. Oxidation destroys COCs upon contact. MNA processes likely to rebound after active remediation is complete	**Moderate to Long** Useful life of oxidant is 1 year. MNA likely to be ongoing.	**High** No O and M required	**Moderate** Rebound may occur after amendment injections stop. Natural attenuation is likely to reduce concentrations with time, but is not guaranteed.	**Moderate** UIC permit required. Pilot tests required. Injection of oxidants requires specialized equipment, and may be limited by tight formation.	**Moderate** UIC permits, shipping materials, pilot study, 2 years implementation time.	**Moderate** 2 years depending on success of process. MNA of remaining compounds is likely to be necessary.	**Moderate to High** No above ground operation. Fenton's process has slight chance of being uncontrolled.	**Low to Moderate Risk** In-situ process does not produce exposure pathway. Fenton's process has slight chance of being uncontrolled.	**Low to Moderate Risk** Potential geochemical changes are likely to be short term. No exposure pathway. Metals mobilization may occur.

LEGEND	
Green	most favorable
Blue	more favorable
Yellow	favorable
Orange	less favorable
Red	least favorable

TABLE 4-2
COMPARISON OF ALTERNATIVES - SWMU 54

CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Comparison of Alternatives on Technical Merits

Alternative	Rank	Reason
1	2	Not many technical criteria evaluated.
2	1	The only technical criteria having an effect on this alternative was time frame required for implementation.
3	2	Enhanced bioremediation is effective, fairly easily implemented
4	4	Slight chance of uncontrolled reaction provided a lower safety rating.

Comparison of Alternatives for Human Health Benefits

Alternative	Rank	Reason
1	4	No institutional controls in place to protect human health
2	1	Institutional controls protect human health, groundwater concentrations are known.
3	1	Institutional controls protect human health, groundwater concentrations are known. In situ process does not produce exposure pathway.
4	3	Slight chance of uncontrolled reaction provided a higher human health risk during implementation.

Comparison of Alternatives for Environmental Benefits

Alternative	Rank	Reason
1	4	Environmental benefits are questionable, due to unknown nature of groundwater concentrations.
2	1	No exposure pathway.
3	1	
4	1	

Comparison of Alternatives by Cost

Alternative	Rank	Cost
1	1	$0
2	2	$931,818
3	3	$1,439,208 (Benzene plume: $646,158; TCE plume: $793,050)
4	4	$1,651,836 (Benzene plume: $704,163; TCE plume $947,673)

Revised: August 29, 2005

TABLE 5-1

CORRECTIVE MEASURE ALTERNATIVE SUMMARY TABLE - SWMU 55
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Alternative	EVALUATION CRITERIA									
	TECHNICAL								HUMAN HEALTH	ENVIRONMENTAL
	PERFORMANCE		RELIABILITY		IMPLEMENTABILITY			SAFETY		
	Effectiveness	Useful Life	O&M Requirements	Demonstrated/Expected	Constructability	Time				
						Implementation	*Results*			
1	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Moderate to High Groundwater concentrations are unknown with time. No active above ground oper.	High Risk No institutional controls to prevent exposure to unknown groundwater concentrations	Moderate Risk Exposure pathway unlikely, but potentially no reduction in concentrations
2	Moderate Access restricted indefinitely. Naturally occurring processes to reduce concentrations are likely to be ongoing, but not guaranteed.	Long Access restricted indefinitely. Naturally occurring processes to reduce site concentrations are likely to be ongoing	High No O and M required	Moderate Natural attenuation is likely to reduce concentrations with time, but is not guaranteed.	High Long term monitoring work plan required. Monitoring well construction easily accomplished.	High Less than 2 years.	Low Long time frame (30 + years) is likely necessary.	High No active above ground operations	Low to Moderate Risk May not reduce to CAOs. Site groundwater concentrations are known with time and risk is known. Institutional controls provide additional protection.	Low to Moderate Risk Exposure pathway unlikely. Site groundwater concentrations are known with time and risk is known.
3	High Access restricted indefinitely. Enhanced bioremediation destroys contaminants of concern. MNA processes likely to be ongoing after active remediation is complete.	Moderate to Long Useful life of amendments is 2-3 months. Reinjection necessary. MNA likely to be ongoing.	High No O and M required	Moderate Rebound may occur after amendment injections stop. Natural attenuation is likely to reduce concentrations with time, but is not guaranteed.	Moderate to High UIC permit required. Pilot tests required. Injection of amendments is easily accomplished with common equipment.	Moderate UIC permits, shipping materials, pilot study, 2-3 years implementation time	Moderate 3-5 years depending on success of process. MNA of remaining compounds is likely to be necessary.	High No active above ground operations	Moderate Risk In-situ process does not produce exposure pathway May not reduce to CAOs. May form vinyl chloride, with a CAO not forwarded.	Moderate Risk Potential geochemical changes are likely to be short term. Exposure pathway unlikely. Vinyl chloride formation may provide negative enviro risk.
4	High Access restricted indefinitely. Oxidation destroys COCs upon contact. MNA processes likely to rebound after active remediation is complete	Moderate to Long Useful life of oxidant is 1 year. MNA likely to be ongoing.	High No O and M required	Moderate to High Rebound may occur. NAPL residual likely to be treated. Natural attenuation is likely to reduce concentrations with time, but is not guaranteed.	Moderate UIC permit required. Pilot tests required. Injection of oxidants requires specialized equipment	Moderate UIC permits, shipping materials, pilot study, 2 years implementation time.	Moderate 2 years depending on success of process. MNA of remaining compounds is likely to be necessary.	High No above ground operation.	Low to Moderate Risk May not reduce to CAOs. In-situ process does not produce exposure pathway.	Moderate Risk Potential geochemical changes are likely to be short term. Exposure pathway unlikely. Metals mobilization may occur.
5	High Access restricted indefinitely. Reduction destroys COCs upon contact. MNA processes likely to be enhanced after active remediation is complete	Moderate to Long Useful life of zero valent iron is 1 to 5 years. MNA likely to be ongoing.	High No O and M required	Moderate Rebound may occur after iron loses reactivity. Natural attenuation is likely to reduce concentrations with time, but is not guaranteed.	Moderate UIC permit may not be required. Pilot test required to evaluate radius of injection. Pneumatic injection of iron is accomplished with specialized equipment. Ground heave can be monitored.	Moderate Shipping materials, pilot study, 2 years implementation time.	Moderate 2 years depending on success of process. MNA of remaining compounds is likely to be necessary.	High No active above ground operations	Low to Moderate Risk In-situ process does not produce exposure pathway. May not reduce to CAOs.	Low to Moderate Risk Potential geochemical changes are likely to be present for a while. Exposure pathway unlikely.
6	Moderate to High Access restricted indefinitely. Extraction of groundwater may not reduce site concentrations to below CAOs, but will contain it.	Moderate to Long Equipment likely to have a useful life of 5 years and will not require replacement during this corrective measure implementation	Moderate Limited O and M required.	Moderate Containment of plume is likely. Pulsed pumping may increase removal rates.	Moderate UIC Permit required Pump and injection pilot test required. Equipment is relatively easy to obtain.	Moderate UIC permits, pilot study, 3 years implementation time.	Moderate to Low 5 years active pumping Long term monitoring for remaining compounds is likely to be necessary.	Moderate Above ground operation.	Moderate Risk Groundwater exposure is more likely due to extraction process.	Low to Moderate Risk Upgradient injection may affect contaminants at TWFF. Containment of plume makes migration to Honda even less likely.

LEGEND	
Green	most favorable
Blue	more favorable
Yellow	favorable
Orange	less favorable
Red	least favorable

Revised: August 29, 2005

TABLE 5-2

COMPARISON OF ALTERNATIVES - SWMU 55
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Comparison of Alternatives on Technical Merits

Alternative	Rank	Reason
1	1	Not many technical criteria evaluated.
2	1	The only technical criteria having an effect on this alternative was time frame required for implementation and uncertainty in performance.
3	1	Enhanced bioremediation is effective, fairly easily implemented
4	1	Performance expected to be high.
5	5	Performance expected to be high.
6	6	O and M requirements reduce safety and reliability

Comparison of Alternatives for Human Health Benefits

Alternative	Rank	Reason
1	6	Human health risk due to unknown concentrations and no institutional control
2	1	In-situ process does not produce pathway
3	4	In-situ process does not produce pathway, but vinyl chloride formation may cause risk.
4	1	In-situ process does not produce pathway
5	1	In-situ process does not produce pathway
6	4	Chance for groundwater exposure increases due to extraction.

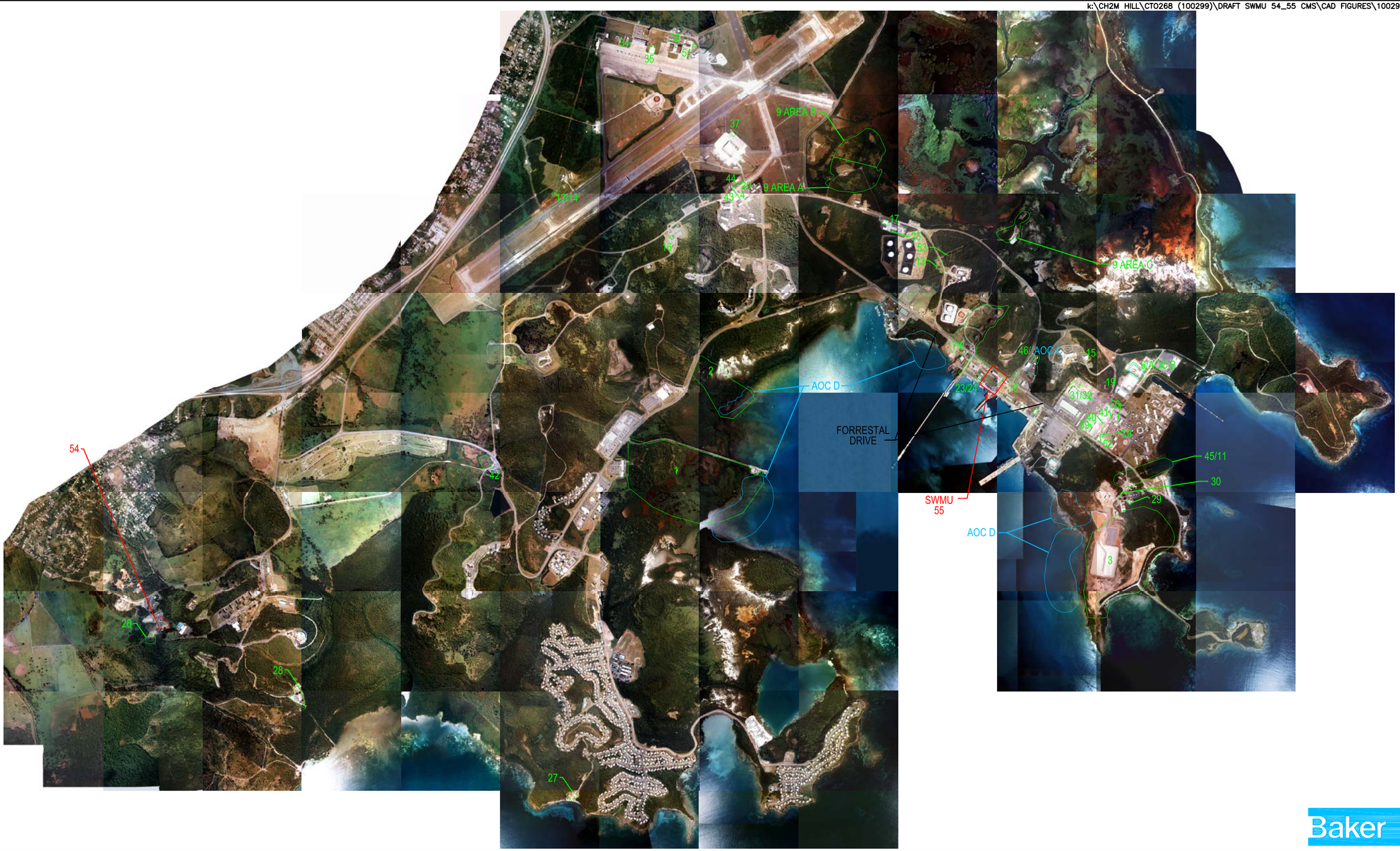
Comparison of Alternatives for Environmental Benefits

Alternative	Rank	Reason
1	4	No monitoring of downgradient wells.
2	1	Exposure not likely.
3	4	Exposure not likely. Vinyl chloride formation.
4	4	Metals mobilization may occur.
5	1	Exposure not likely.
6	1	Exposure not likely.

Comparison of Alternatives by Cost

Alternative	Rank	Cost
1	1	$0
2	2	$731,675
3	5	$1,747,770
4	3	$824,594
5	6	$2,016,609
6	4	$1,136,180

FIGURES



Baker

LEGEND

1 – SWMUs

– AREAS TO WHICH THIS REPORT PERTAINS

AOC D – AOCs

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

2500 0 1250 2500

1 inch = 2500 ft.

FIGURE 2-1
SWMU/AOC LOCATION MAP

NAVAL ACTIVITY PUERTO RICO
PUERTO RICO

k:\CH2M HILL II\CTO268 (100299)\DRAFT SWMU 54_55 CMS\CAD FIGURES\100299ch04

Baker

LEGEND

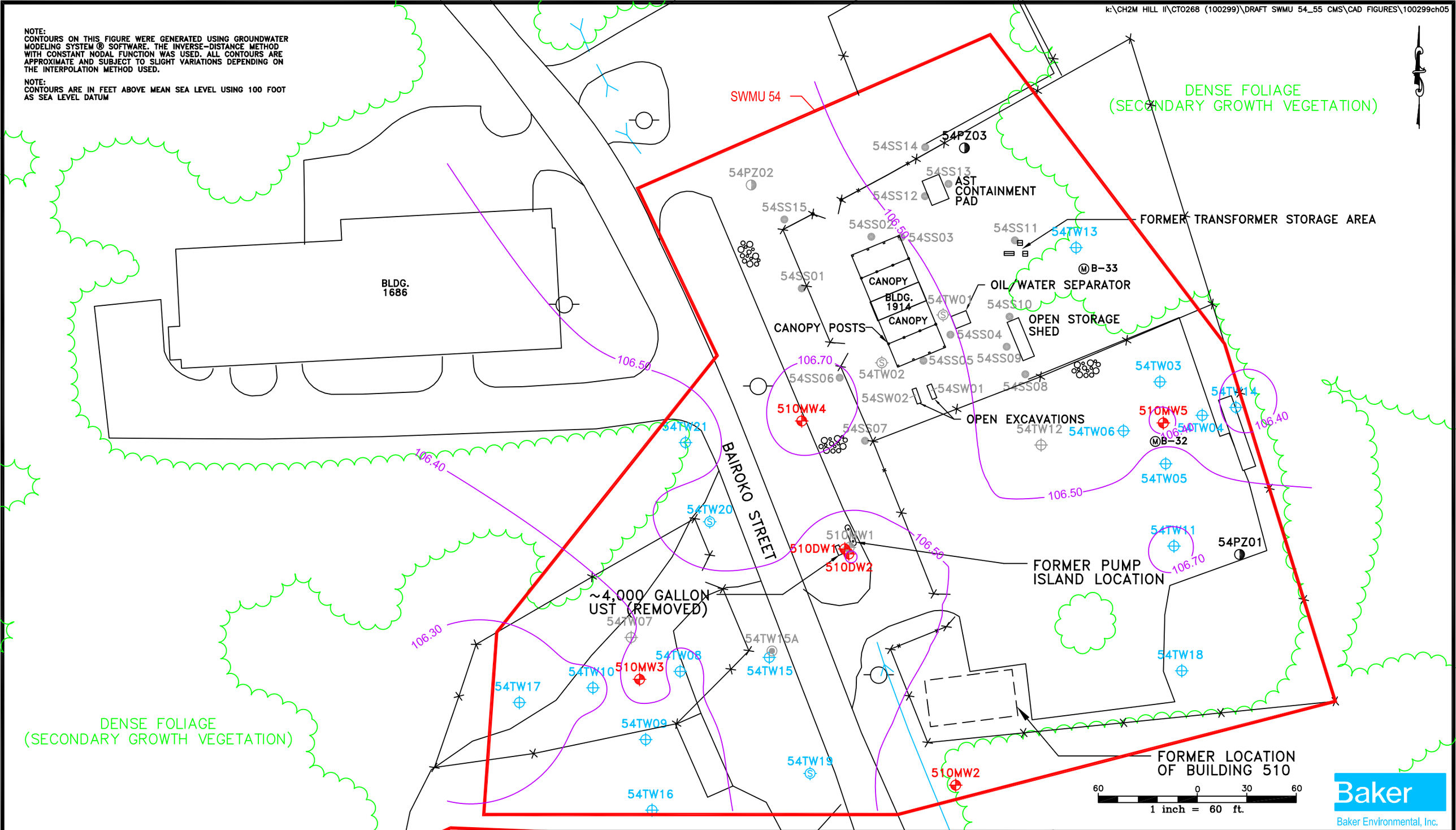
– SWMU BOUNDARY

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

FIGURE 2-2
SITE LOCATION MAP
SWMU 54, BUILDING 1914
(FORMER NEX REPAIR/MAINTENANCE SHOP)
NAVAL ACTIVITY PUERTO RICO
PUERTO RICO

NOTE:
CONTOURS ON THIS FIGURE WERE GENERATED USING GROUNDWATER MODELING SYSTEM ® SOFTWARE. THE INVERSE-DISTANCE METHOD WITH CONSTANT NODAL FUNCTION WAS USED. ALL CONTOURS ARE APPROXIMATE AND SUBJECT TO SLIGHT VARIATIONS DEPENDING ON THE INTERPOLATION METHOD USED.

NOTE:
CONTOURS ARE IN FEET ABOVE MEAN SEA LEVEL USING 100 FOOT AS SEA LEVEL DATUM



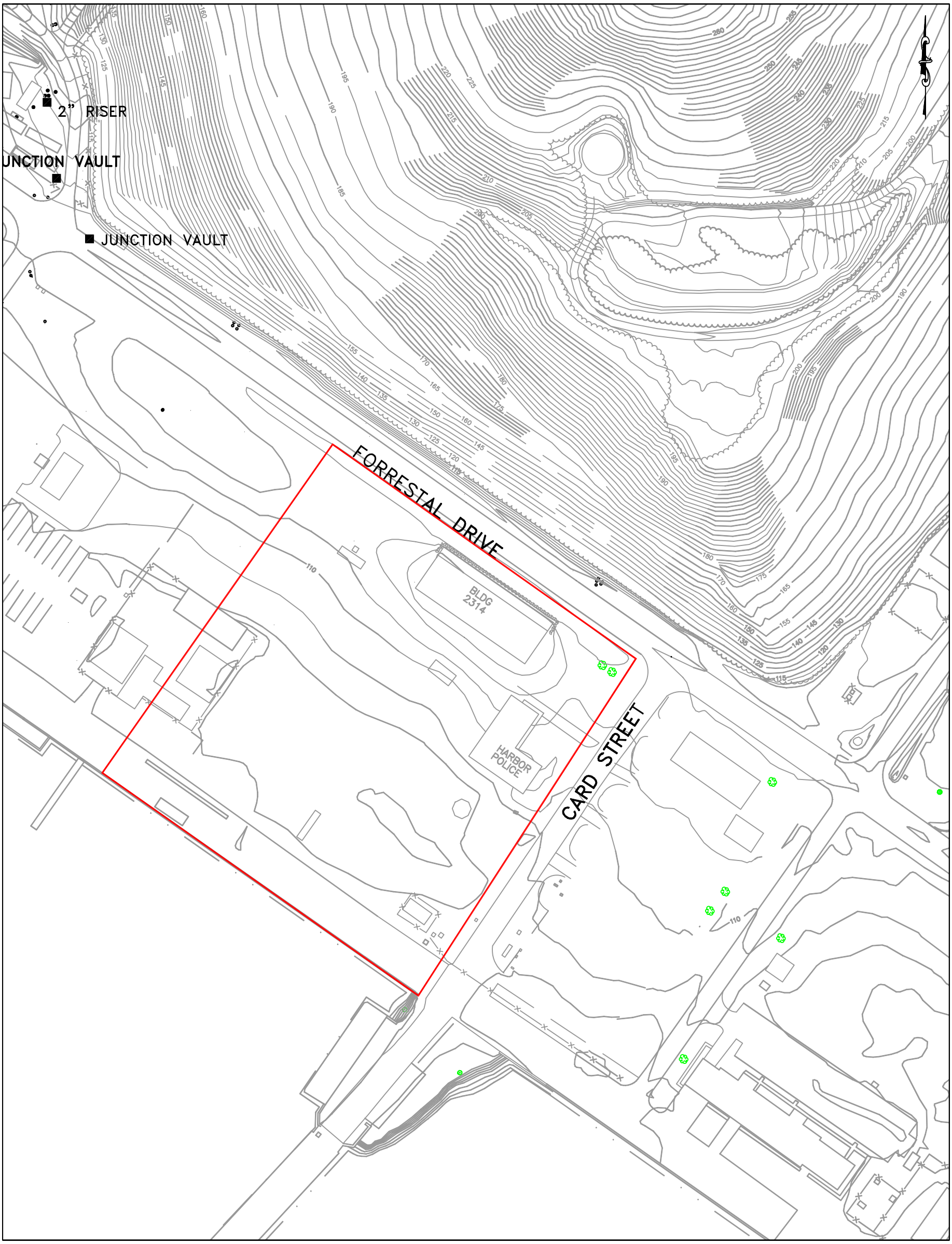
Baker
Baker Environmental, Inc.

LEGEND

- TEMPORARY PIEZOMETER LOCATION (RFI, 2002)
- SANITARY SEWER MANHOLE
- SURFACE SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- EXISTING MONITOR WELL LOCATION
- STANDING WATER SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- TEMPORARY SHALLOW MONITOR WELL LOCATION (RFI, 2002)
- TEMPORARY SHALLOW MONITOR WELL LOCATION/ SOIL SAMPLE LOCATION (RFI, 2002)
- TEMPORARY SHALLOW MONITOR WELL LOCATION/ SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- SOIL BORING LOCATION (RFI, 2002)
- FENCE LINE
- BUILDING
- TREE LINE
- EDGE OF GRAVEL
- FORMER TRANSFORMER STORAGE PALLETS
- GROUND SURFACE CONTOUR LINE
- GROUNDWATER ELEVATION CONTOUR (106.30)

SOURCE: DEPT. OF THE NAVY, SEPTEMBER 1999.

FIGURE 2-3
MODIFIED GROUNDWATER CONTOUR MAP, MARCH 3, 2002
SWMU 54, BUILDING 1914
(FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY, OCTOBER 2004
NAVAL ACTIVITY PUERTO RICO
PUERTO RICO



120 0 60 120
1 inch = 120 ft.

NOTE:
–DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

Baker

k:\CH2M HILL II\CTO268 (100299)\DRAFT SWMU 54_55 CMS\CAD FIGURES\100299ch06

SOURCE: LANTDIV, FEB. 1992/1997

LEGEND

– SWMU BOUNDARY

FIGURE 2–4
SITE LOCATION MAP
SWMU 55 – TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY, OCTOBER 2004

NAVAL ACTIVITY PUERTO RICO
PUERTO RICO

2" RISER

JUNCTION VAULT

JUNCTION VAULT

FORRESTAL DRIVE

CARD STREET

A

A'

B

B'

7TCESB09
7TCESB06A
7TCESB06
7TCESB04
7TCESB07
7TCESB05
7TCESB01
7TCESB02
7TCESB08
7TCESB03

7TCETW207
7TCETW209
7TCETW205
7TCETW206
7TCETW208
7TCETW204
7TCETW203
7TCETW202
7TCETW210
7TCETW201

7MW07
7MW22
7MW24
7MW23
7MW10
7MW21
7MW08
7MW20

TW-1
TW-2
TW-3
TW-4
TW-101
TW-102
TW-103
TW-104
TW-105

BLDG 2314

RW2
RW03
MW05
PW06
PW04
PW01
UGW05
MW02
UGW12
GW04
RW04
UGW26
UGW13
RW5
UGW18
UGW17
RW6
UGW09
UGW19
RW7
UGW16
UGW21
RW8
UGW11

NOTE:
-DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

120 0 60 120
1 inch = 120 ft.

k:\CH2M HILL II\CTO268 (100299)\DRAFT SWMU 54_55 CMS\CAD FIGURES\100299ch07

SOURCE: LANTDIV, FEB. 1992/1997

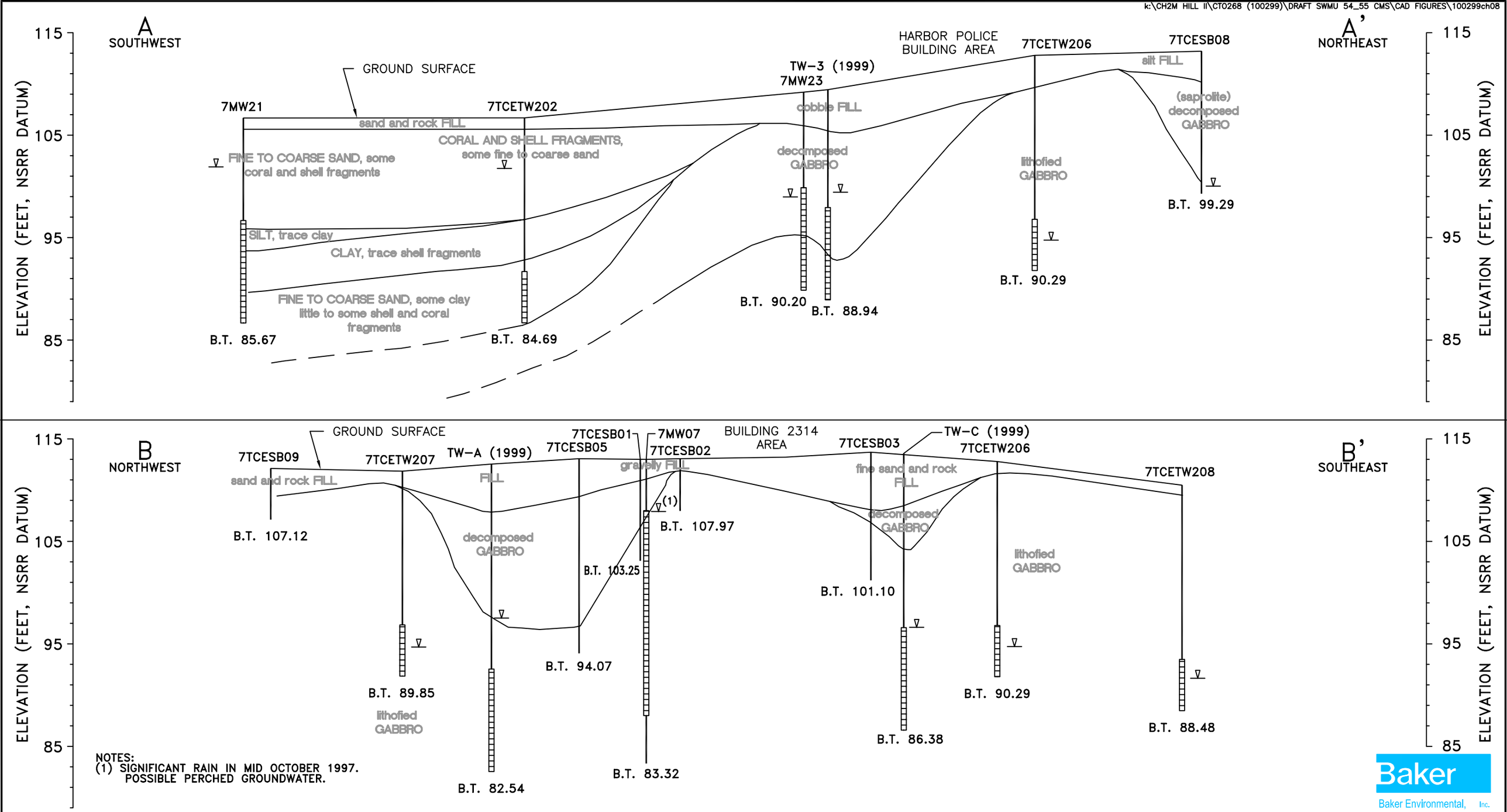
Baker

LEGEND

- EXISTING MONITOR WELL
- EXISTING MONITOR WELL SAMPLED
- TEMPORARY WELL LOCATION - 2003
- SOIL SAMPLE LOCATION - 2003
- NEW MONITOR WELL LOCATION - 2003
- TEMPORARY MONITOR WELL LOCATION (SHALLOW AND DEEP) (1999)
- TEMPORARY MONITOR WELL LOCATION (DEEP ONLY) (1999)

FIGURE 2-5
SAMPLE AND GEOLOGIC CROSS-SECTION LOCATION MAP
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY, OCTOBER 2004

NAVAL ACTIVITY PUERTO RICO
PUERTO RICO



NOTES:
(1) SIGNIFICANT RAIN IN MID OCTOBER 1997. POSSIBLE PERCHED GROUNDWATER.

Baker
Baker Environmental, Inc.

LEGEND

- GROUNDWATER ENCOUNTERED DURING DRILLING
- B.T. 83.32 — BORING TERMINATED, ELEVATION (FEET NSRR DATUM)
- GROUNDWATER MONITORING WELL SCREEN INTERVAL
- ESTIMATED
- PROJECTED

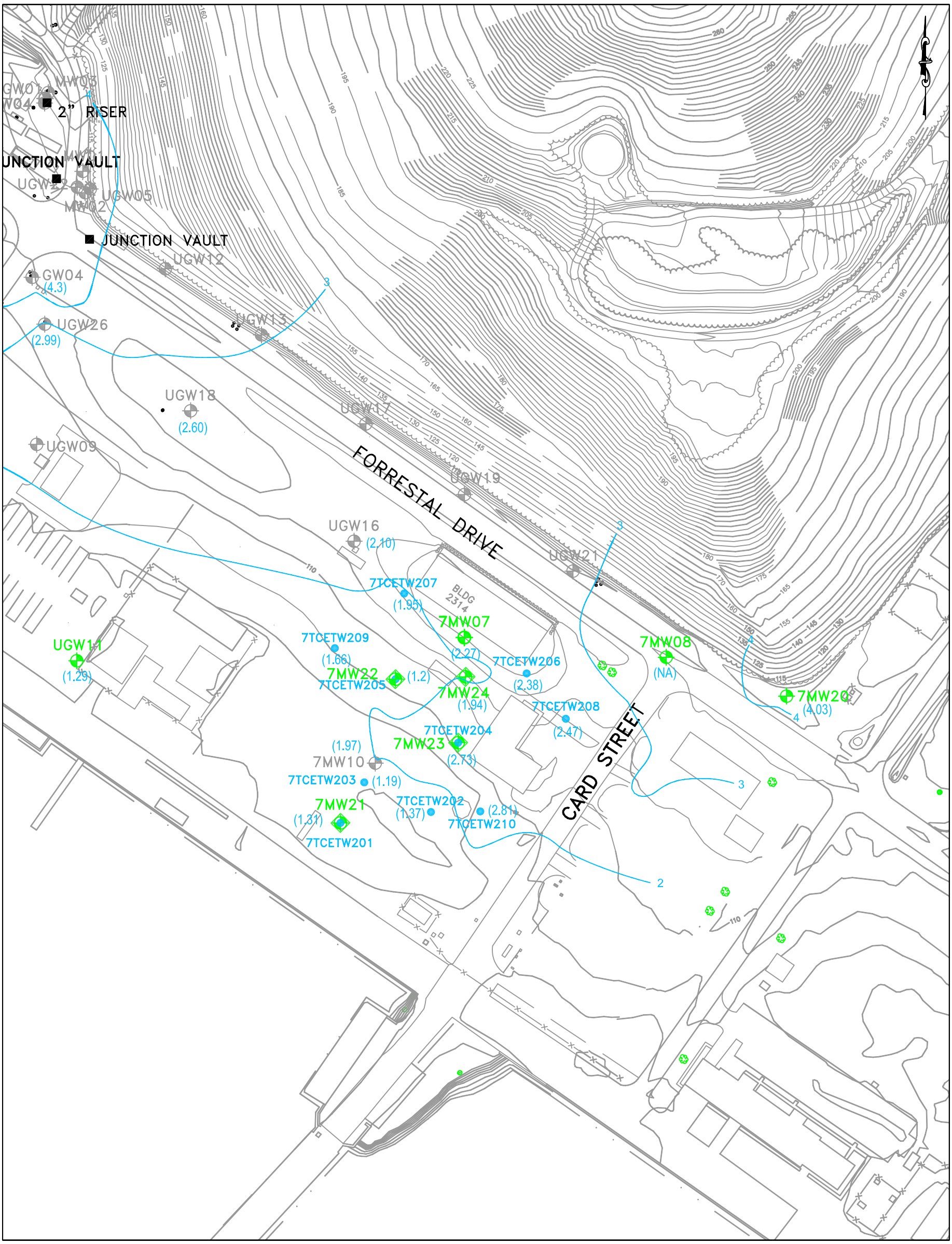
40 0 20 40 80
Horizontal Scale: 1 inch = 40 ft.

10 0 5 10 20
Vertical Scale: 1 inch = 10 ft.

THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

FIGURE 2-6
GEOLOGIC CROSS-SECTIONS A-A' AND B-B'
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY, OCTOBER 2004

NAVAL ACTIVITY PUERTO RICO
PUERTO RICO



120 0 60 120

1 inch = 120 ft.

NOTE:
–DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

Baker

k:\CH2M HILL II\CTO268 (100299)\DRAFT SWMU 54_55 CMS\CAD FIGURES\100299ch09

SOURCE: LANTDIV, FEB. 1992/1997

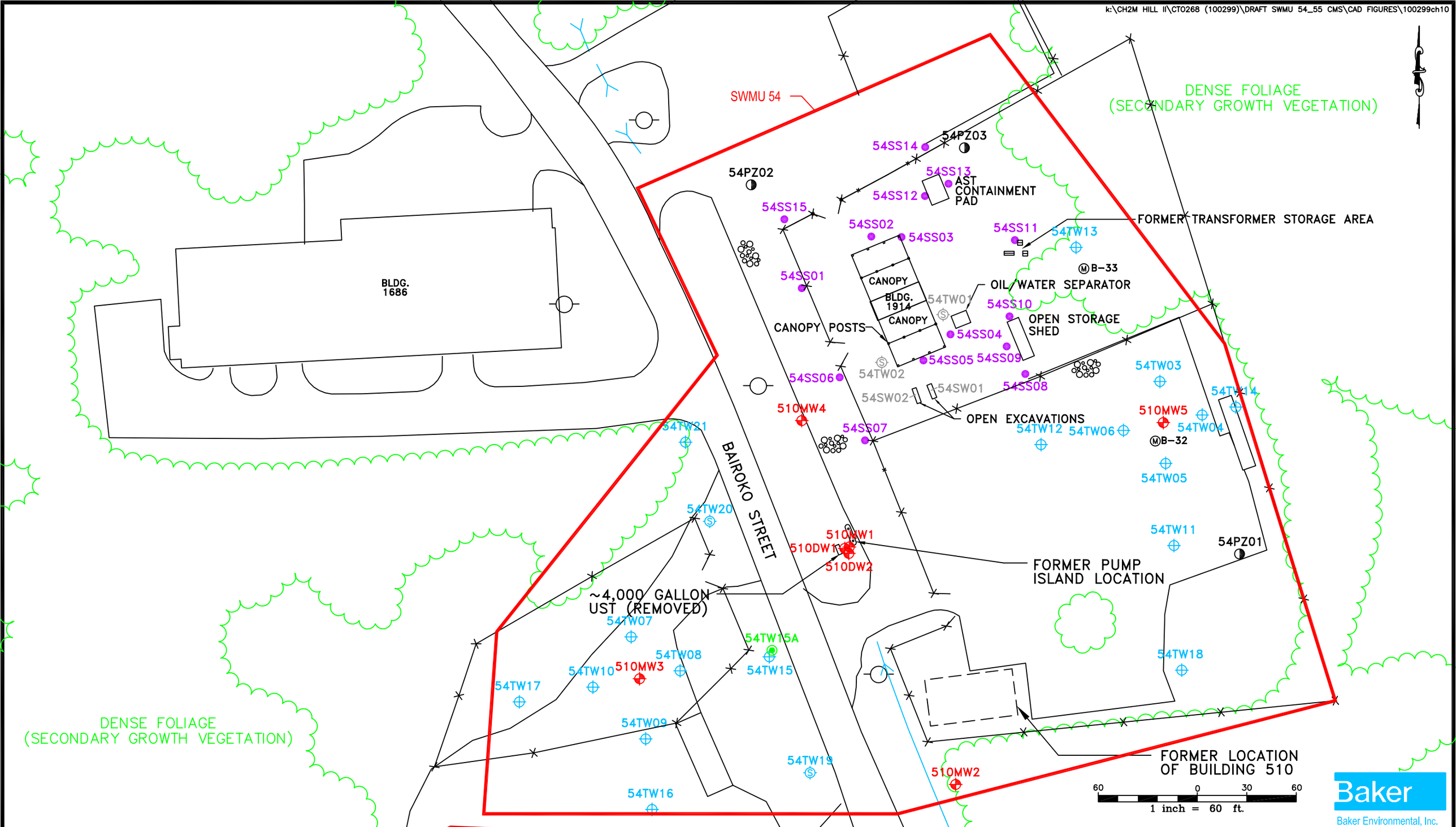
LEGEND

- EXISTING MONITOR WELL
- EXISTING MONITOR WELL – SAMPLED 2003
- TEMPORARY WELL LOCATION – 2003
- NEW MONITOR WELL LOCATION – 2003
- NA – NOT AVAILABLE
- (1.31) – GROUNDWATER ELEVATION (FEET, ABOVE MSL)
- —4— – GROUNDWATER ELEVATION CONTOUR (FEET, ABOVE MSL)

FIGURE 2–7
GROUNDWATER ELEVATIONS, SEPTEMBER 25, 2003
SWMU 55 – TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY, OCTOBER 2004

NAVAL ACTIVITY PUERTO RICO
PUERTO RICO

k:\CH2M HILL II\CTO268 (100299)\DRAFT SWMU 54_55 CMS\CAD FIGURES\100299ch10



Baker
Baker Environmental, Inc.

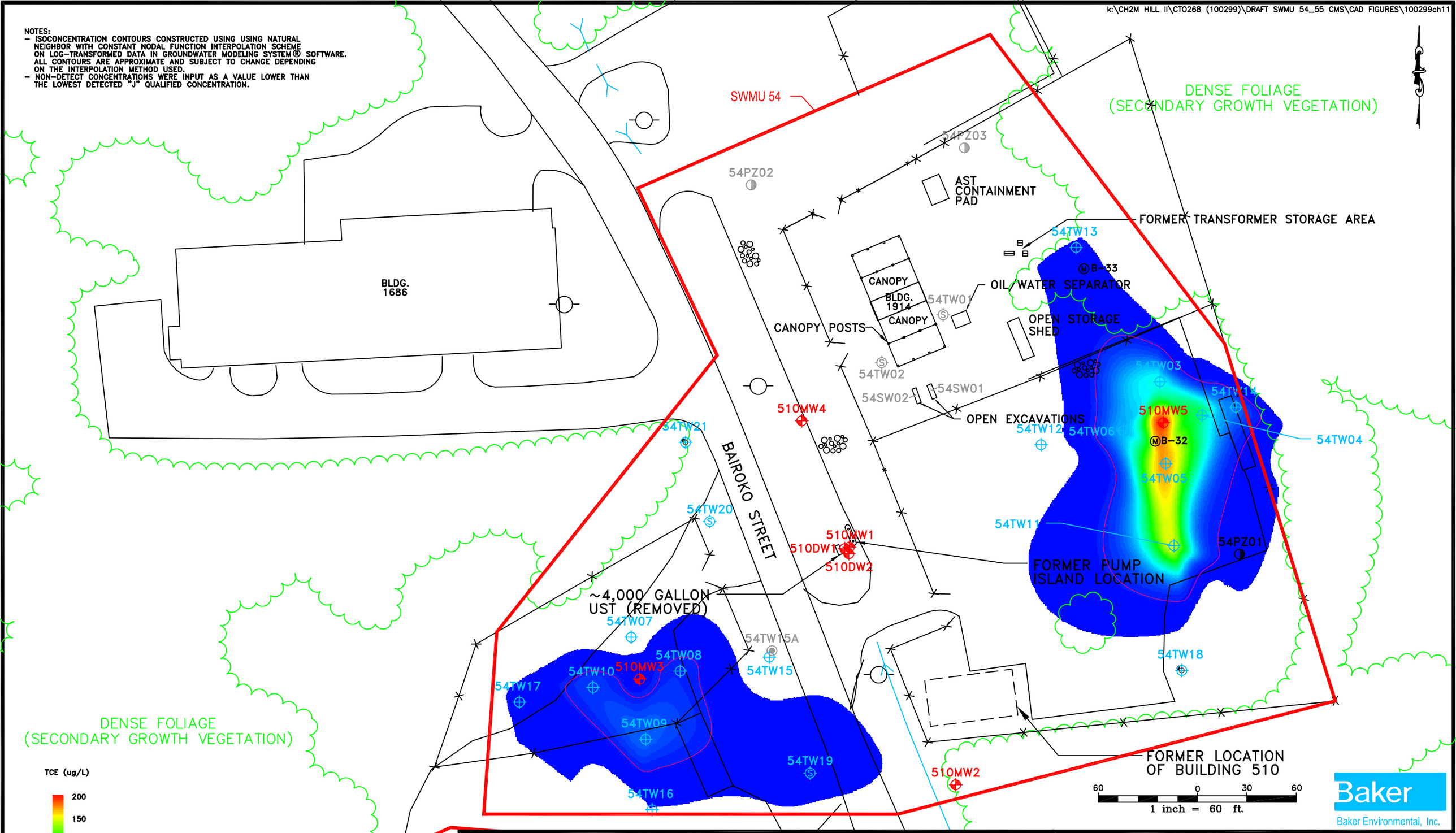
LEGEND

- TEMPORARY PIEZOMETER LOCATION (RFI, 2002)
- SANITARY SEWER MANHOLE
- SURFACE SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- EXISTING MONITOR WELL LOCATION
- STANDING WATER SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- TEMPORARY SHALLOW MONITOR WELL LOCATION (RFI, 2002)
- TEMPORARY SHALLOW MONITOR WELL LOCATION/ SOIL SAMPLE LOCATION (RFI, 2002)
- TEMPORARY SHALLOW MONITOR WELL LOCATION/ SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- SOIL BORING LOCATION (RFI, 2002)
- FENCE LINE
- BUILDING
- TREE LINE
- EDGE OF GRAVEL
- FORMER TRANSFORMER STORAGE PALLETS
- DRAINAGE DITCHES

SOURCE: DEPT. OF THE NAVY, SEPTEMBER 1999.

FIGURE 2-8
SAMPLE LOCATIONS, ALL INVESTIGATIONS
SWMU 54, BUILDING 1914
(FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY, OCTOBER 2004
NAVAL ACTIVITY PUERTO RICO
PUERTO RICO

NOTES:
- ISOCONCENTRATION CONTOURS CONSTRUCTED USING USING 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 THE INTERPOLATION METHOD USED.
- NON-DETECT CONCENTRATIONS WERE INPUT AS A VALUE LOWER THAN THE LOWEST DETECTED "J" QUALIFIED CONCENTRATION.



Baker
Baker Environmental, Inc.

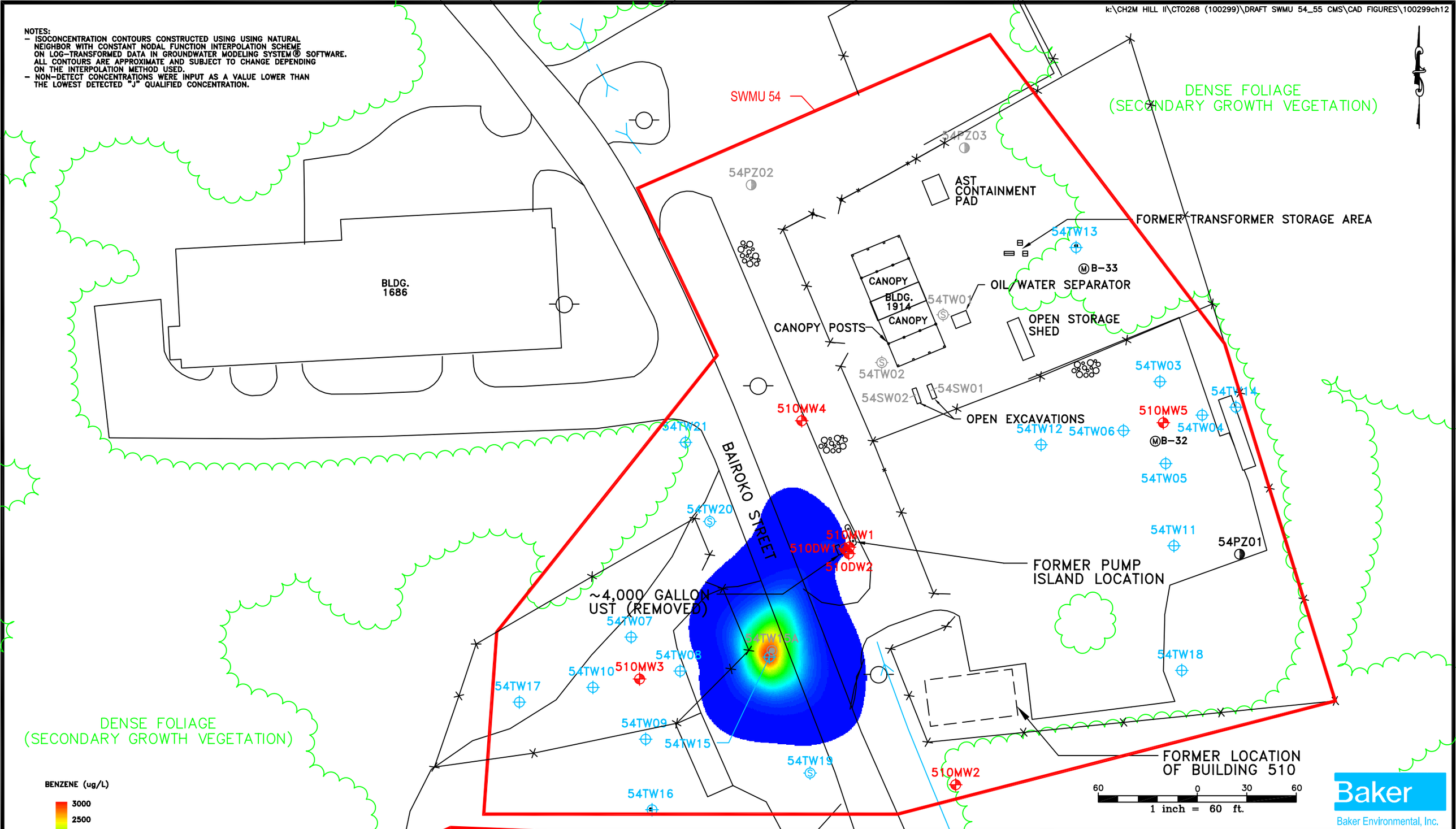
LEGEND

- TEMPORARY PIEZOMETER LOCATION (RFI, 2002)
- SANITARY SEWER MANHOLE
- EXISTING MONITOR WELL LOCATION
- STANDING WATER SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- TEMPORARY SHALLOW MONITOR WELL LOCATION (RFI, 2002)
- TEMPORARY SHALLOW MONITOR WELL LOCATION/ SOIL SAMPLE LOCATION (RFI, 2002)
- TEMPORARY SHALLOW MONITOR WELL LOCATION/ SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- SOIL BORING LOCATION (RFI, 2002)
- FENCE LINE
- BUILDING
- TREE LINE
- EDGE OF GRAVEL
- FORMER TRANSFORMER STORAGE PALLETS
- GROUND SURFACE CONTOUR LINE
- FEDERAL MCL FOR TCE = 5 ug/L

SOURCE: DEPT. OF THE NAVY, SEPTEMBER 1999.

FIGURE 2-9
TCE IN GROUNDWATER, FEBRUARY 2002
SWMU 54, BUILDING 1914
(FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY, OCTOBER 2004
NAVAL ACTIVITY PUERTO RICO
PUERTO RICO

NOTES:
- ISOCONCENTRATION CONTOURS CONSTRUCTED USING USING 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 THE INTERPOLATION METHOD USED.
- NON-DETECT CONCENTRATIONS WERE INPUT AS A VALUE LOWER THAN THE LOWEST DETECTED "J" QUALIFIED CONCENTRATION.



Baker
Baker Environmental, Inc.

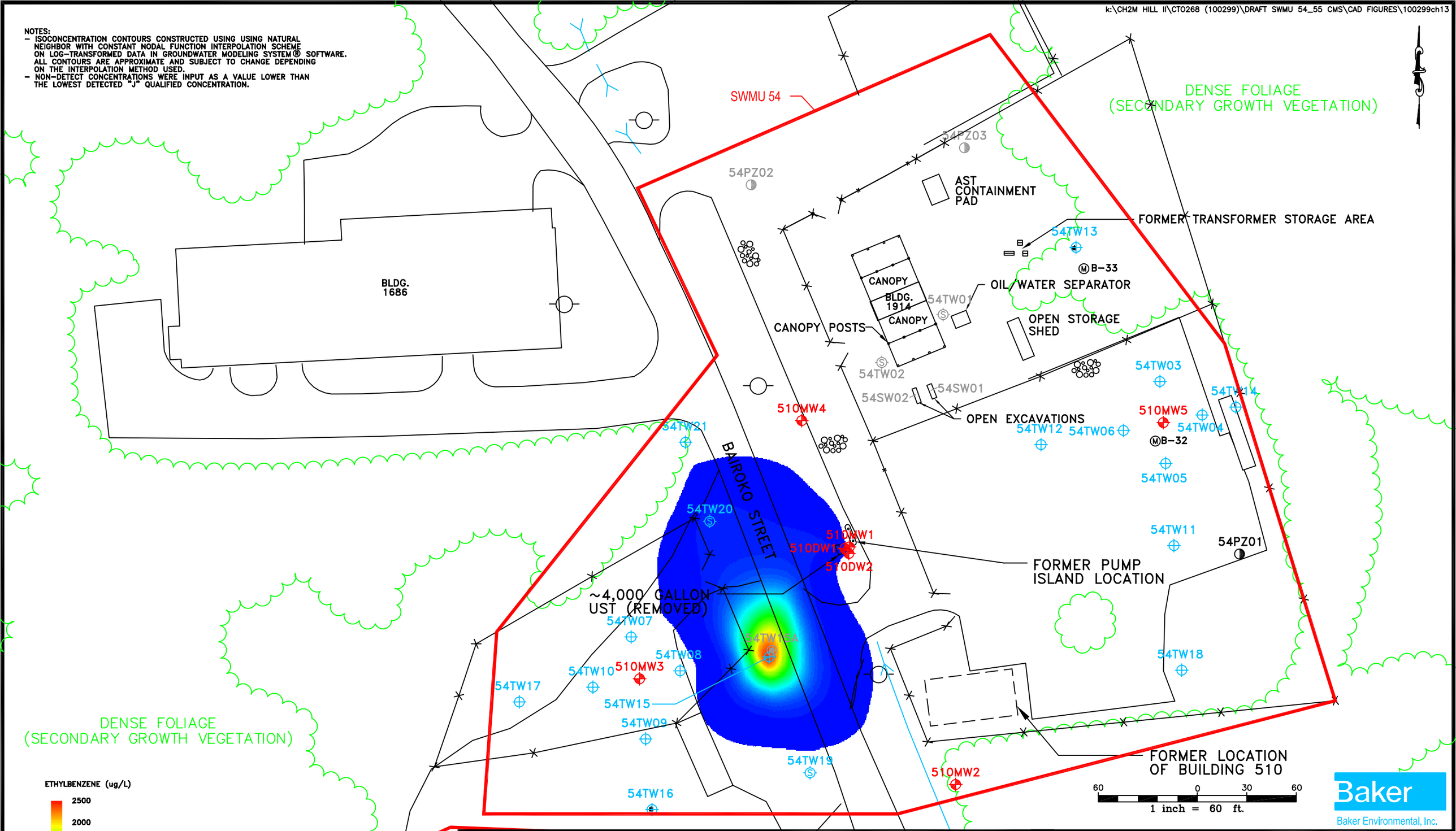
SOURCE: DEPT. OF THE NAVY, SEPTEMBER 1999.

LEGEND

- TEMPORARY PIEZOMETER LOCATION (RFI, 2002)
- SANITARY SEWER MANHOLE
- EXISTING MONITOR WELL LOCATION
- STANDING WATER SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- TEMPORARY SHALLOW MONITOR WELL LOCATION (RFI, 2002)
- TEMPORARY SHALLOW MONITOR WELL LOCATION/ SOIL SAMPLE LOCATION (RFI, 2002)
- TEMPORARY SHALLOW MONITOR WELL LOCATION/ SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- SOIL BORING LOCATION (RFI, 2002)
- FENCE LINE
- BUILDING
- TREE LINE
- EDGE OF GRAVEL
- FORMER TRANSFORMER STORAGE PALLETS
- GROUND SURFACE CONTOUR LINE

FIGURE 2-10
BENZENE IN GROUNDWATER, FEBRUARY 2002
SWMU 54, BUILDING 1914
(FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY, OCTOBER 2004
NAVAL ACTIVITY PUERTO RICO
PUERTO RICO

NOTES:
- ISOCONCENTRATION CONTOURS CONSTRUCTED USING USING 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 THE INTERPOLATION METHOD USED.
- NON-DETECT CONCENTRATIONS WERE INPUT AS A VALUE LOWER THAN THE LOWEST DETECTED "J" QUALIFIED CONCENTRATION.



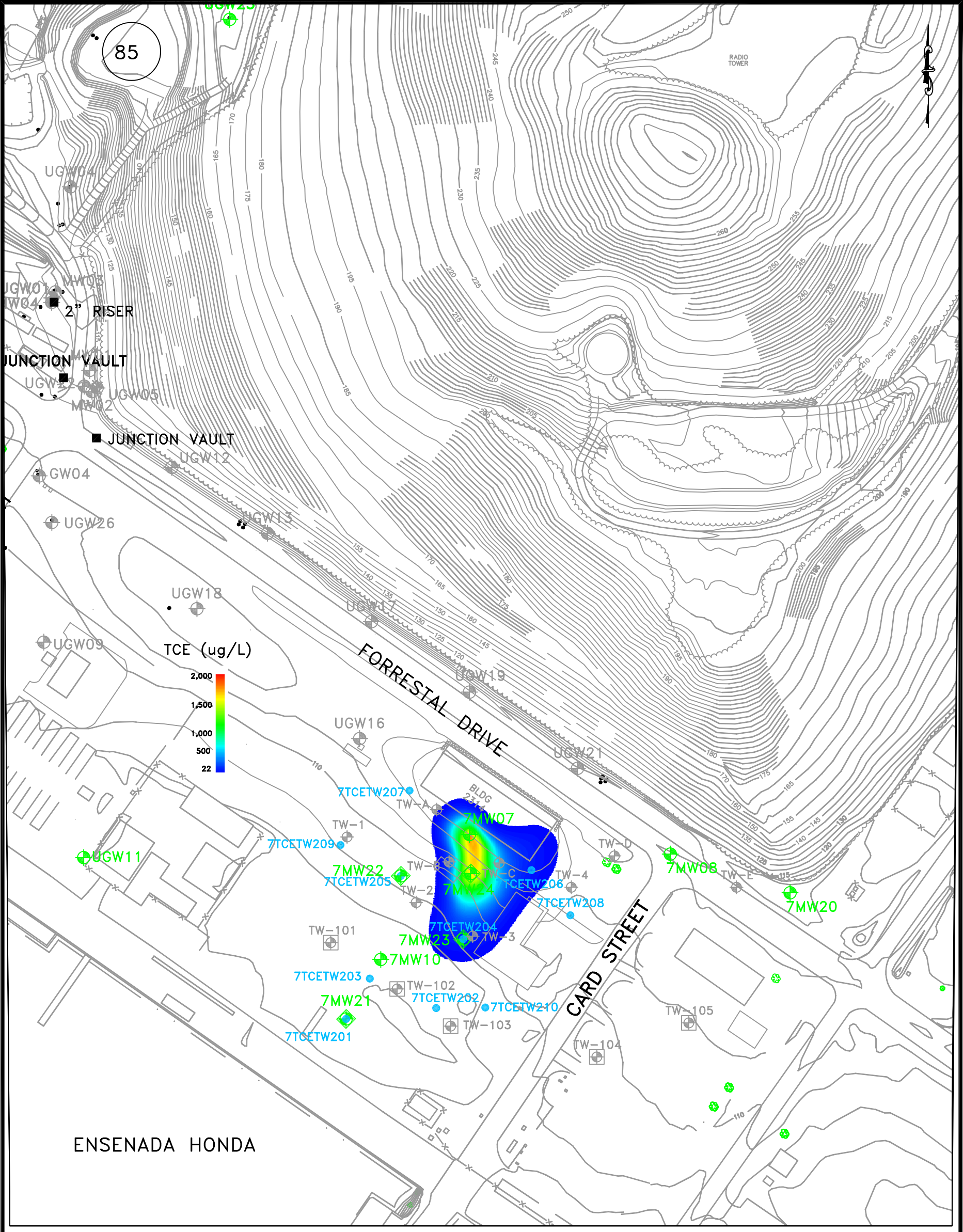
SOURCE: DEPT. OF THE NAVY, SEPTEMBER 1999.

LEGEND

- TEMPORARY PIEZOMETER LOCATION (RFI, 2002)
- SANITARY SEWER MANHOLE
- EXISTING MONITOR WELL LOCATION
- STANDING WATER SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- TEMPORARY SHALLOW MONITOR WELL LOCATION (RFI, 2002)
- TEMPORARY SHALLOW MONITOR WELL LOCATION/ SOIL SAMPLE LOCATION (RFI, 2002)
- TEMPORARY SHALLOW MONITOR WELL LOCATION/ SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- SOIL BORING LOCATION (RFI, 2002)
- FENCE LINE
- BUILDING
- TREE LINE
- EDGE OF GRAVEL
- FORMER TRANSFORMER STORAGE PALLETS
- GROUND SURFACE CONTOUR LINE

Baker
Baker Environmental, Inc.

FIGURE 2-11
ETHYLBENZENE IN GROUNDWATER, FEBRUARY 2002
SWMU 54, BUILDING 1914
(FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY, OCTOBER 2004
NAVAL ACTIVITY PUERTO RICO
PUERTO RICO



120 0 60 120
1 inch = 120 ft.

NOTE:
–DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

Baker

k:\CH2M HILL II\CTO268 (100299)\DRAFT SWMU 54_55 CMS\CAD FIGURES\100299ch14

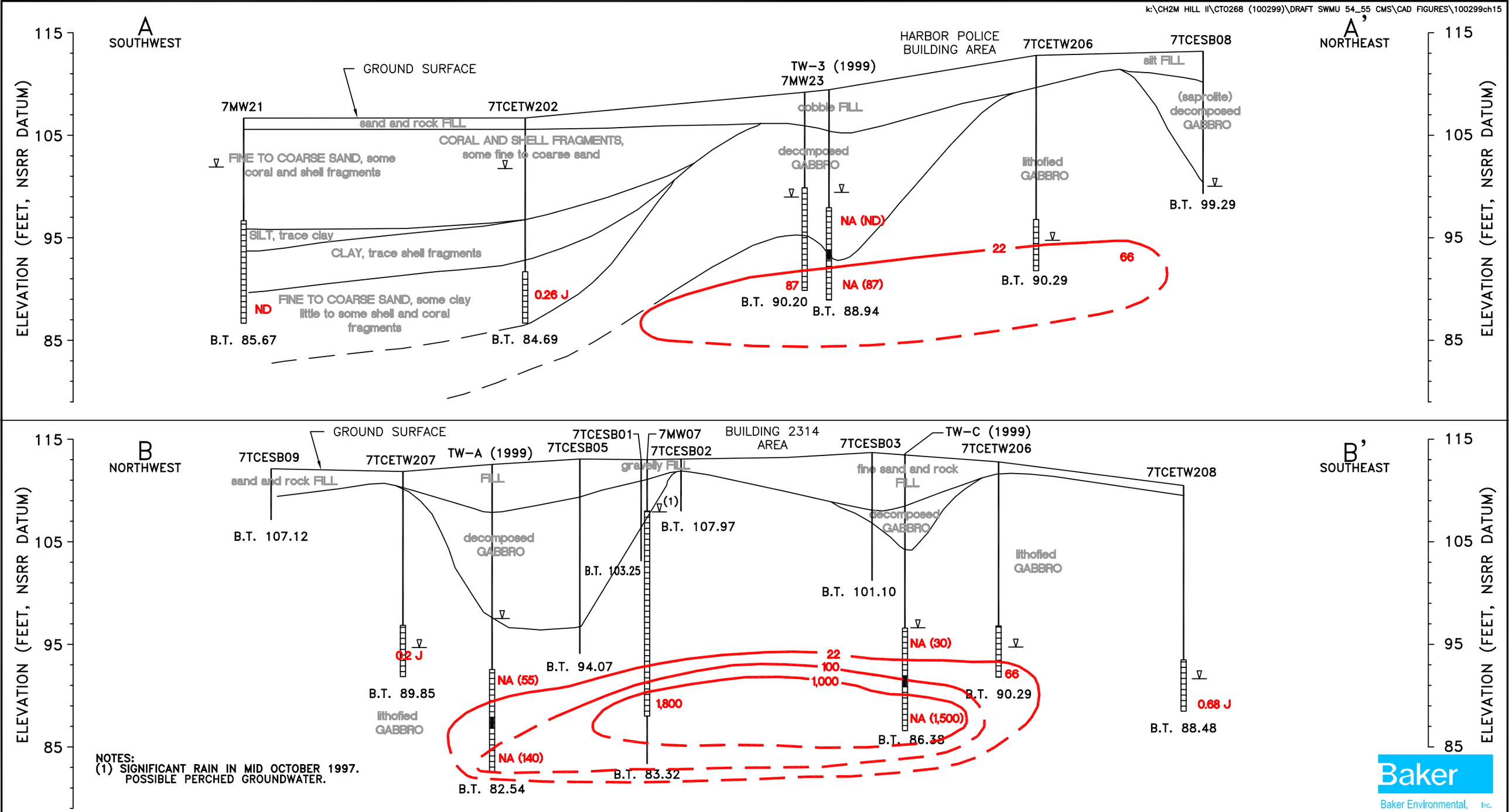
SOURCE: LANTDIV, FEB. 1992/1997

LEGEND

- EXISTING MONITOR WELL
- EXISTING MONITOR WELL – SAMPLED 2003
- TEMPORARY WELL LOCATION – 2003
- NEW MONITOR WELL LOCATION – 2003
- TEMPORARY MONITOR WELL LOCATION (SHALLOW AND DEEP) – 1999
- TEMPORARY MONITOR WELL LOCATION (DEEP ONLY) – 1999

FIGURE 2–12
TCE CONCENTRATIONS (ug/L), SEPTEMBER 2003
SWMU 55 – TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY, OCTOBER 2004

NAVAL ACTIVITY PUERTO RICO
PUERTO RICO



NOTES:
(1) SIGNIFICANT RAIN IN MID OCTOBER 1997. POSSIBLE PERCHED GROUNDWATER.

Baker
Baker Environmental, Inc.

LEGEND

▽	GROUNDWATER ENCOUNTERED DURING DRILLING
B.T. 83.32	BORING TERMINATED, ELEVATION (FEET NSRR DATUM)
▯	GROUNDWATER MONITOR WELL SCREEN INTERVAL
———	ESTIMATED CONCENTRATION CONTOUR
- - -	PROJECTED CONCENTRATION CONTOUR
ND	NOT DETECTED
NA (55)	NOT APPLICABLE (1999 CONCENTRATION, ug/L)
J	ESTIMATED CONCENTRATION
1,800	TCE CONCENTRATION (ug/L)

40 0 20 40 80
Horizontal Scale: 1 inch = 40 ft.

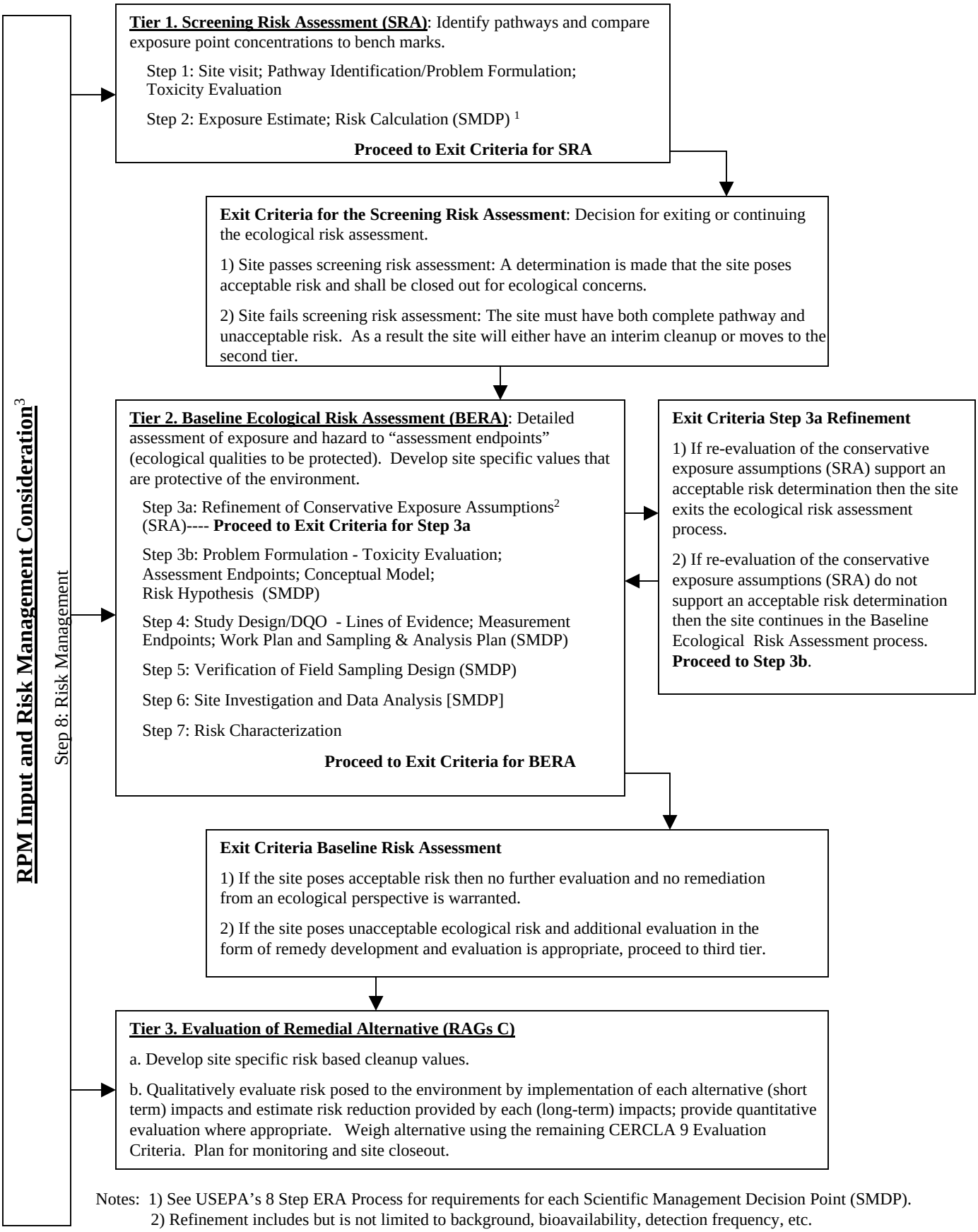
10 0 5 10 20
Vertical Scale: 1 inch = 10 ft.

THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

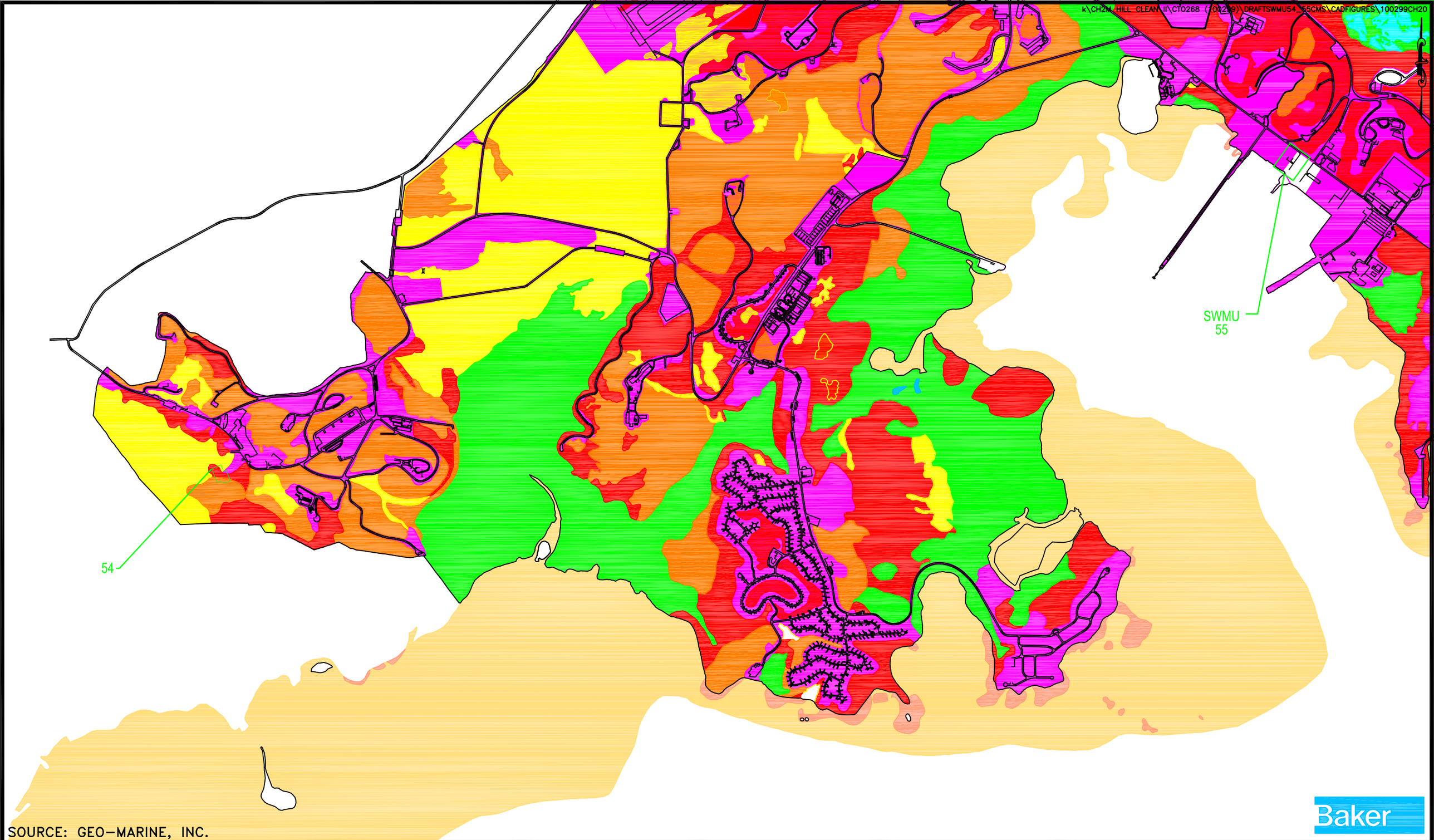
FIGURE 2-13
VERTICAL CROSS-SECTIONS, TCE CONCENTRATIONS, SEPTEMBER 2003
SWMU 55 – TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY, OCTOBER 2004

NAVAL ACTIVITY PUERTO RICO
PUERTO RICO

Figure 2-14: Navy Ecological Risk Assessment Tiered Approach



Notes: 1) See USEPA's 8 Step ERA Process for requirements for each Scientific Management Decision Point (SMDP).
2) Refinement includes but is not limited to background, bioavailability, detection frequency, etc.
3) Risk Management is incorporated throughout the tiered approach.



SOURCE: GEO-MARINE, INC.

LEGEND

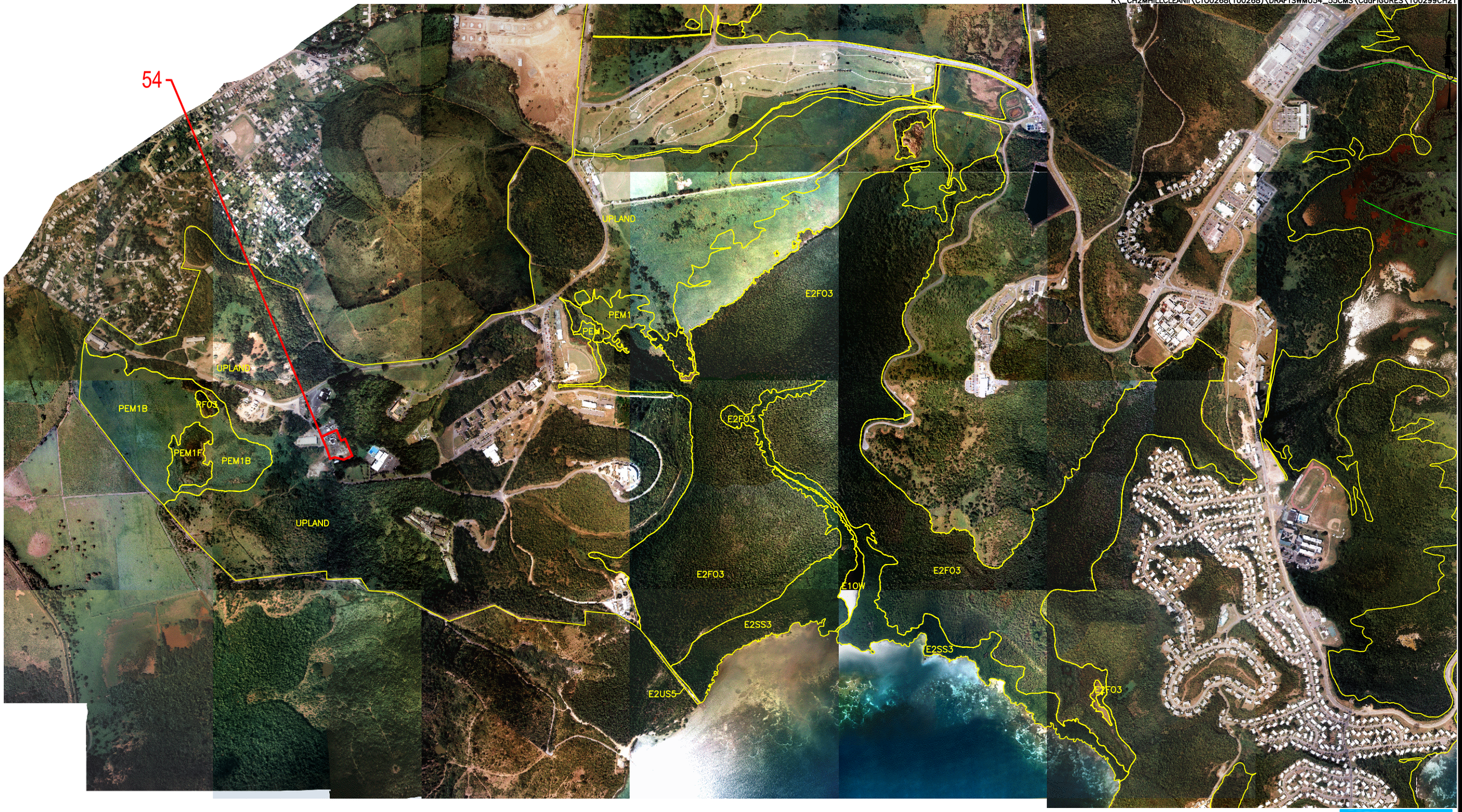
- COASTAL SCRUB FOREST
- CORAL
- GRASSLAND/WET MEADOW
- MANGROVE
- SEAGRASS
- SHALLOW FLAT
- UPLAND COASTAL FOREST
- URBAN
- WATER

600 0 300 600

1 inch = 600 ft.

FIGURE 2-15
"TERRESTRIAL AND AQUATIC HABITAT OCCURRING AT NAPR"

NAVAL ACTIVITY PUERTO RICO
CEIBA, PUERTO RICO



Baker

LEGEND

– WETLAND BOUNDARY

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

1200 0 600 1200

1 inch = 1200 ft.

FIGURE 2–16
WETLAND UNITS AT NAPR

NAVAL ACTIVITY PUERTO RICO
CEIBA, PUERTO RICO

FIGURE 2-17

THE COWARDIN WETLAND CLASSIFICATION SYSTEM

CORRECTIVE MEASURES STUDY

NAVAL ACTIVITY PUERTO RICO, PUERTO RICO

SYSTEM: M - MARINE

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

SYSTEM: E - ESTUARINE

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

SYSTEM: R - RIVERINE

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

SYSTEM: L - LACUSTRINE

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

SYSTEM: P - PALUSTRINE

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

MODIFIERS

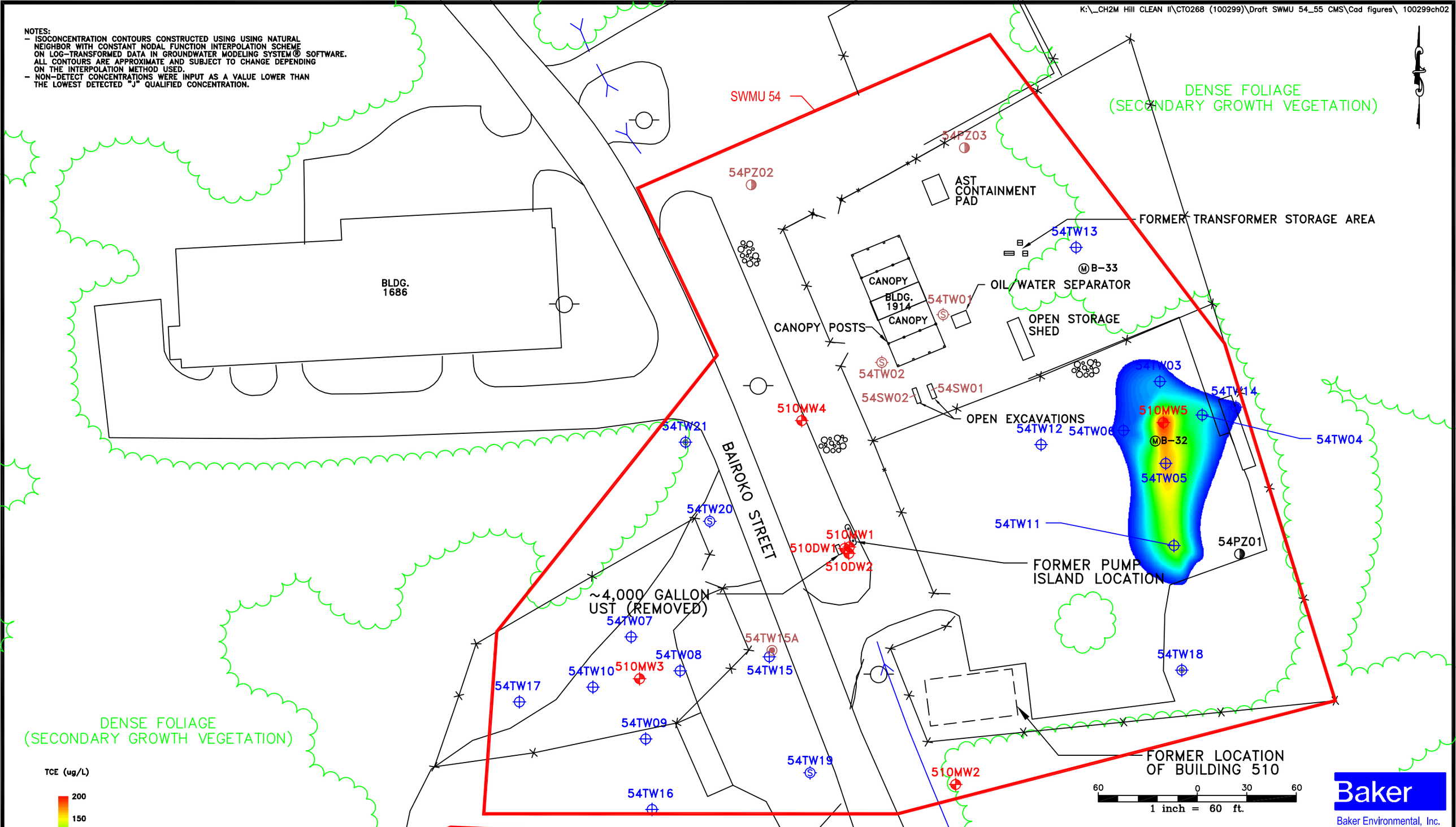
WATER REGIME				WATER CHEMISTRY			SOIL	SPECIAL
	Non-Tidal		Tidal	Coastal Salinity	Inland Salinity	pH (fresh water)		
A Temp. Flooded	H Permanently Flooded	K Artificially Flooded	*S Temporary-Tidal	1 Hyperhaline	7 Hypersaline	a Acid	g Organic	b Beaver
B Saturated	J Intermittently Flooded	L Subtidal	*R Seasonal-Tidal	2 Euhaline	8 Eusaline	1 circumneutral	n Mineral	d partially drained/ditched
C Seasonally Flooded	K Artificially Flooded	M Irregularly Flooded	*T Semipermanent- Tidal	3 Mixohaline	9 Mixosaline	i Alkaline		f Farmed
D Seasonally Flooded/ Well Drained	W Intermittently Flooded/ Temporary	N Regularly Flooded	*V Permanent-Tidal	4 Polyhaline	0 Fresh			h Diked/Impounded
E Seasonally Flooded/ Saturated	Y Saturated/Semipermanent/ Seasonal	P Irregularly Flooded	U Unknown	5 Mesohaline				r Artificial Substrate
F Semipermanently Flooded	Z Intermittently Exposed			6 Oligohaline				s Spoil
G Intermittently Exposed	Permanent			0 Fresh				x Excavated
	U Unknown							

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

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

K:_CH2M Hill CLEAN II\CT0268 (100299)\Draft SWMU 54_55 CMS\Cad figures\ 100299ch02

NOTES:
- ISOCONCENTRATION CONTOURS CONSTRUCTED USING USING 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 THE INTERPOLATION METHOD USED.
- NON-DETECT CONCENTRATIONS WERE INPUT AS A VALUE LOWER THAN THE LOWEST DETECTED "J" QUALIFIED CONCENTRATION.



BLDG. 1686

SOURCE: DEPT. OF THE NAVY, SEPTEMBER 1999.

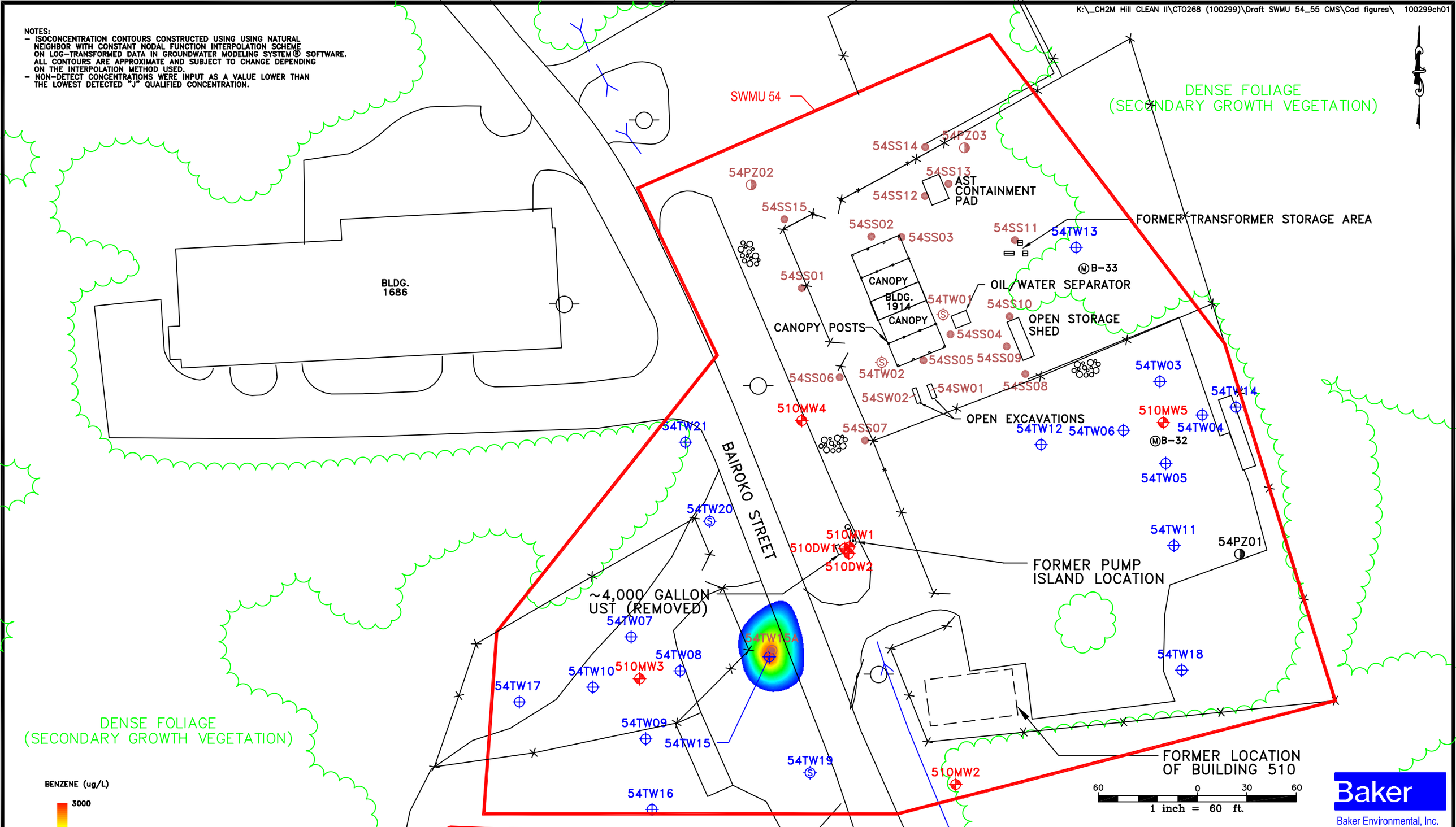
LEGEND

- TEMPORARY PIEZOMETER LOCATION (RFI, 2002)
- SANITARY SEWER MANHOLE
- EXISTING MONITOR WELL LOCATION
- STANDING WATER SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- TEMPORARY SHALLOW MONITOR WELL LOCATION (RFI, 2002)
- TEMPORARY SHALLOW MONITOR WELL LOCATION/ SOIL SAMPLE LOCATION (RFI, 2002)
- TEMPORARY SHALLOW MONITOR WELL LOCATION/ SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- SOIL BORING LOCATION (RFI, 2002)
- FENCE LINE
- BUILDING
- TREE LINE
- EDGE OF GRAVEL
- FORMER TRANSFORMER STORAGE PALLETS
- GROUND SURFACE CONTOUR LINE

FIGURE 2-19
TCE IN GROUNDWATER ABOVE CAO
SWMU 54, BUILDING 1914
(FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY, OCTOBER 2004
NAVAL ACTIVITY PUERTO RICO
PUERTO RICO

K:_CH2M Hill CLEAN II\CTO268 (100299)\Draft SWMU 54_55 CMS\Cad figures\ 100299ch01

NOTES:
- ISOCONCENTRATION CONTOURS CONSTRUCTED USING USING 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 THE INTERPOLATION METHOD USED.
- NON-DETECT CONCENTRATIONS WERE INPUT AS A VALUE LOWER THAN THE LOWEST DETECTED "J" QUALIFIED CONCENTRATION.



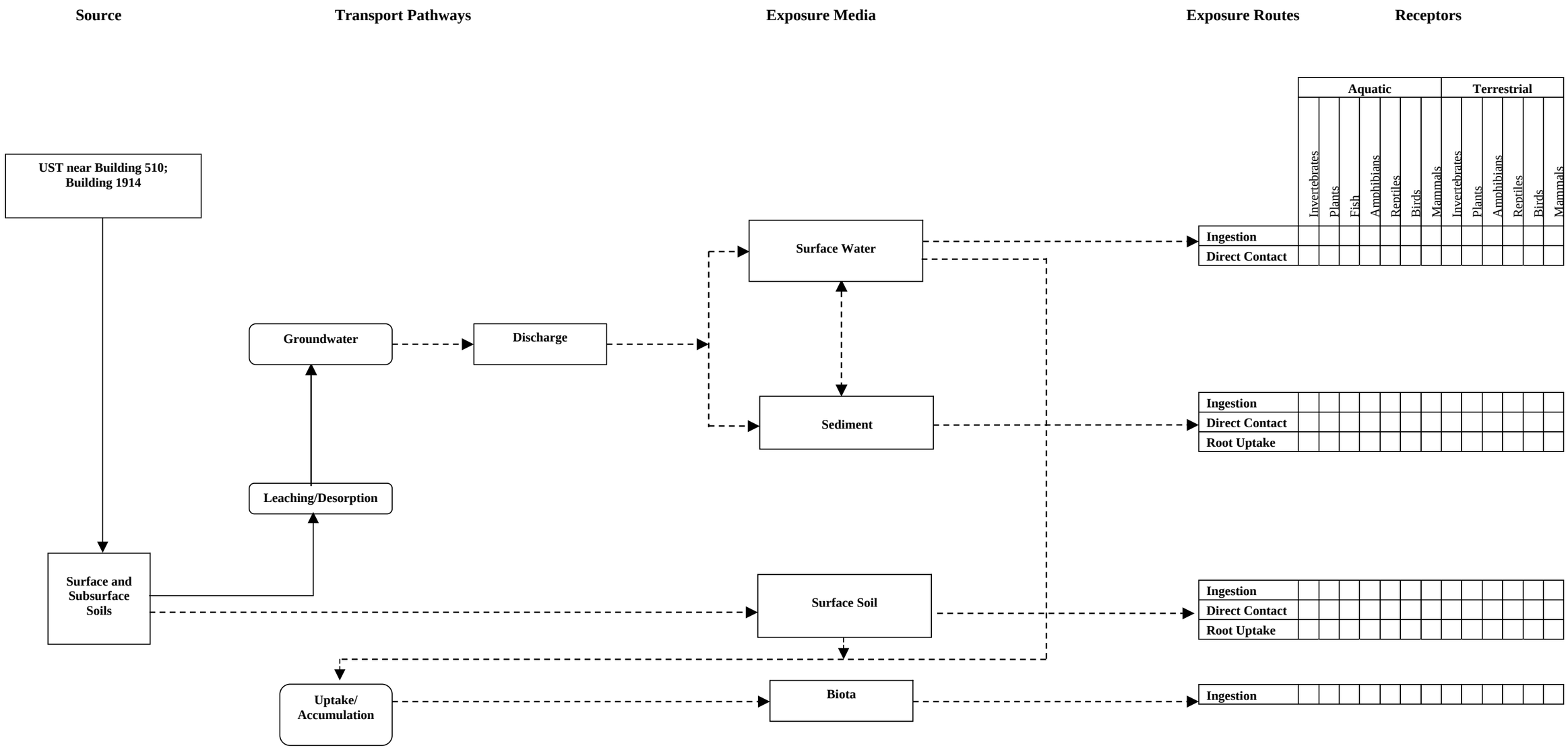
Baker
Baker Environmental, Inc.

SOURCE: DEPT. OF THE NAVY, SEPTEMBER 1999.

LEGEND

- TEMPORARY PIEZOMETER LOCATION (RFI, 2002)
- SANITARY SEWER MANHOLE
- SURFACE SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- EXISTING MONITOR WELL LOCATION
- STANDING WATER SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- TEMPORARY SHALLOW MONITOR WELL LOCATION (RFI, 2002)
- TEMPORARY SHALLOW MONITOR WELL LOCATION/ SOIL SAMPLE LOCATION (RFI, 2002)
- TEMPORARY SHALLOW MONITOR WELL LOCATION/ SOIL SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- SOIL BORING LOCATION (RFI, 2002)
- FENCE LINE
- BUILDING
- TREE LINE
- EDGE OF GRAVEL
- FORMER TRANSFORMER STORAGE PALLETS
- GROUND SURFACE CONTOUR LINE

FIGURE 2-20
BENZENE IN GROUNDWATER ABOVE CAO
SWMU 54, BUILDING 1914
(FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY, OCTOBER 2004
NAVAL ACTIVITY PUERTO RICO
PUERTO RICO



Potentially complete and significant pathway
Incomplete or insignificant pathway

FIGURE 2-18
PRELIMINARY CONCEPTUAL MODEL
SWMU 54 – BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL AREA PUERTO RICO, CEIBA, PUERTO RICO

k:\CH2M HILL II\CTO268 (100299)\DRAFT SWMU 54_55 CMS\CAD FIGURES\100299ch16

SWMU 54

DENSE FOLIAGE
(SECONDARY GROWTH VEGETATION)

AST
CONTAINMENT
PAD

FORMER TRANSFORMER STORAGE AREA

BLDG.
1686

CANOPY
BLDG.
1914
CANOPY

OIL/WATER SEPARATOR

CANOPY POSTS

OPEN STORAGE
SHED

54SW02
54SW01

OPEN EXCAVATIONS

510MW4

510MW5

BAIROKO STREET

510MW1
510DW1
510DW2

FORMER PUMP
ISLAND LOCATION

~4,000 GALLON
UST (REMOVED)

510MW3

DENSE FOLIAGE
(SECONDARY GROWTH VEGETATION)

FORMER LOCATION
OF BUILDING 510

510MW2

60 0 30 60
1 inch = 60 ft.

Baker
Baker Environmental, Inc.

SWMU 26

LEGEND

- EXISTING MONITOR WELL LOCATION
- POSSIBLE INJECTION LOCATION
- EXTENT OF CONTAMNATION ABOVE CAO'S
- STANDING WATER SAMPLE LOCATION (SAMPLING AND ANALYSIS INVESTIGATION, 2000)
- FENCE LINE
- BUILDING
- TREE LINE
- EDGE OF GRAVEL
- FORMER TRANSFORMER STORAGE PALLETS

FIGURE 3-1
INJECTION LOCATIONS, ALTERNATIVES 3 AND 4
SWMU 54, BUILDING 1914
(FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY, OCTOBER 2004
NAVAL ACTIVITY PUERTO RICO
PUERTO RICO

SOURCE: DEPT. OF THE NAVY, SEPTEMBER 1999.

2" RISER

UNCTION VAULT

JUNCTION VAULT

FORRESTAL DRIVE

BLDG 2314

HARBOR POLICE

CARD STREET

120 0 60 120

1 inch = 120 ft.

NOTE:
–DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

Baker

k:\CH2M HILL II\CTO268 (100299)\DRAFT SWMU 54_55 CMS\CAD FIGURES\100299ch17

SOURCE: LANTDIV, FEB. 1992/1997

LEGEND

– POSSIBLE INJECTION LOCATION

– EXTENT OF CONTAMNATION ABOVE CAO'S

FIGURE 3–2
INJECTION LOCATIONS, ALTERNATIVES 3 AND 4
SWMU 55 – TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY, OCTOBER 2004

NAVAL ACTIVITY PUERTO RICO
PUERTO RICO

2" RISER

UNCTION VAULT

JUNCTION VAULT

FORRESTAL DRIVE

BLDG 2314

HARBOR POLICE

CARD STREET

120 0 60 120

1 inch = 120 ft.

NOTE:
–DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

Baker

k:\CH2M HILL II\CTO268 (100299)\DRAFT SWMU 54_55 CMS\CAD FIGURES\100299ch18

SOURCE: LANTDIV, FEB. 1992/1997

LEGEND

● – POSSIBLE INJECTION LOCATION

—— – EXTENT OF CONTAMNATION ABOVE CAO'S

FIGURE 3–3
INJECTION LOCATIONS, ALTERNATIVE 5
SWMU 55 – TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY, OCTOBER 2004

NAVAL ACTIVITY PUERTO RICO
PUERTO RICO

2" RISER

JUNCTION VAULT

JUNCTION VAULT

FORRESTAL DRIVE

TREATMENT SHED

BLDG 2314

HARBOR POLICE

CARD STREET

120 0 60 120

1 inch = 120 ft.

NOTE:
–DATUM PLAN USED IS MEAN LOW WATER = 100.00 FT. AS ESTABLISHED BY U.S. NAVY SURVEY SECTION AS OF NOVEMBER 1941.

Baker

k:\CH2M HILL II\CTO268 (100299)\DRAFT SWMU 54_55 CMS\CAD FIGURES\100299ch19

SOURCE: LANTDIV, FEB. 1992/1997

LEGEND

– EXTENT OF CONTAMNATION ABOVE CAO'S
– PIPING
I – INJECTION WELL LOCATION
E – EXTRACTION WELL LOCATION

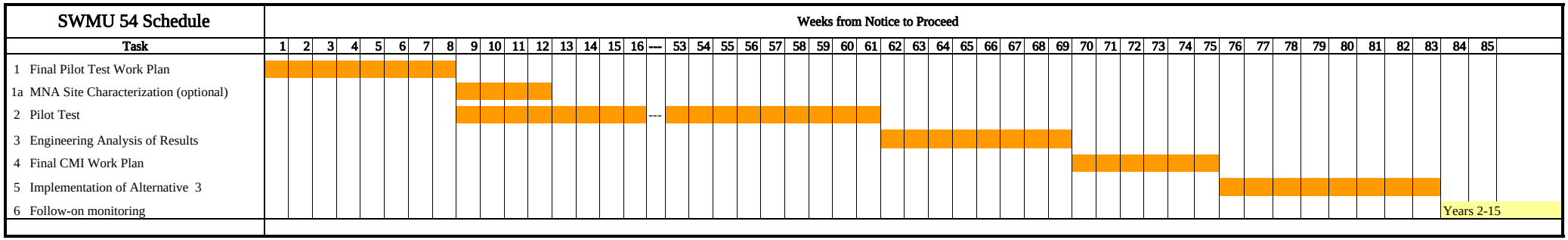
FIGURE 3–4
INJECTION LOCATIONS, ALTERNATIVE 6
SWMU 55 – TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY, OCTOBER 2004

NAVAL ACTIVITY PUERTO RICO
PUERTO RICO

Revised: August 29, 2005

FIGURE 4-1

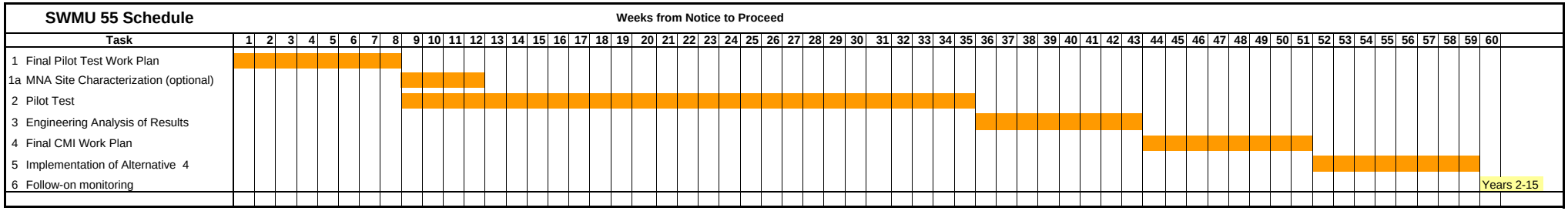
CMS PROJECT SCHEDULE--SWMU 54
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO



Revised: August 29, 2005

FIGURE 5-1

CMS PROJECT SCHEDULE--SWMU 55
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO



LIST OF APPENDICES

A Analytical Results – SWMU 54 and SWMU 55

A.1 SWMU 54, Surface Soil - Organics
A.2 SWMU 54, Subsurface Soil - Organics
A.3 SWMU 54, Groundwater - Organics
A.4 SWMU 55, Groundwater - Organics

B Johnson and Ettinger Model

C Human Health Risk Assessment Calculations

D TCE and Benzene Fact Sheets

E Alternative 2 Calculations

F Cost Estimate Backup

G Alternative 6 Calculations

APPENDIX A
Analytical Results—SWMU 54 and SWMU 55

Data Qualifiers:

U – Not Detected.
J – Estimated value.
UJ – Report quantitation limit is qualified as estimated.
R – Result is rejected and unusable.
D – Result value is based on dilution analysis.
NA – Not Analyzed.

Notes:

mg/kg – milligrams per kilogram.
µg/kg – micrograms per kilogram.
µg/L – micrograms per liter.
mg/L – milligrams per liter.
ft/bgs – feet below ground surface.

APPENDIX A.1
SWMU 54, Surface Soil - Organics

APPENDIX A.1

SUMMARY OF ANALYTICAL RESULTS, SURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation						
Site ID	54SS01	54SS02	54SS03	54SS04	54SS04	54SS05	54SS06
Sample ID	54SS01	54SS02	54SS03	54SS04	54SS04D	54SS05	54SS06
Sample Date	12/13/00	12/13/00	12/13/00	12/14/00	12/14/00	12/14/00	12/13/00
Sample Depth (ft bgs)	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0
Volatile Organic Compounds (ug/kg)							
1,1,1,2-Tetrachloroethane	5.5 U	5.4 U	6.6 U	5.6 U	5.6 U	5.4 U	5.6 U
1,1,1-Trichloroethane	5.5 U	5.4 U	6.6 U	5.6 U	5.6 U	5.4 U	5.6 U
1,1,2,2-Tetrachloroethane	5.5 U	5.4 U	6.6 U	5.6 U	5.6 U	5.4 U	5.6 U
1,1,2-Trichloroethane	5.5 U	5.4 U	6.6 U	5.6 U	5.6 U	5.4 U	5.6 U
1,1-Dichloroethane	5.5 U	5.4 U	6.6 U	5.6 U	5.6 UJ	5.4 U	5.6 U
1,1-Dichloroethene	5.5 U	5.4 U	6.6 U	5.6 U	5.6 UJ	5.4 U	5.6 U
1,2,3-Trichloropropane	5.5 U	5.4 U	6.6 U	5.6 U	5.6 U	5.4 U	5.6 U
1,2-Dibromo-3-chloropropane	11 U	11 U	13 U	11 U	11 U	11 U	11 U
1,2-Dibromoethane	5.5 U	5.4 U	6.6 U	5.6 U	5.6 U	5.4 U	5.6 U
1,2-Dichloroethane	5.5 U	5.4 U	6.6 U	5.6 U	5.6 U	5.4 U	5.6 U
1,2-Dichloropropane	5.5 U	5.4 U	6.6 U	5.6 U	5.6 U	5.4 U	5.6 U
2-Butanone	27 U	27 U	33 U	28 U	28 UJ	27 U	28 U
2-Hexanone	27 U	27 U	33 U	28 U	28 U	27 U	28 U
3-Chloro-1-propene	5.5 U	5.4 U	6.6 U	5.6 U	5.6 UJ	5.4 U	5.6 U
4-Methyl-2-pentanone	27 U	27 U	33 U	28 U	28 U	27 U	28 U
Acetone	55 U	54 U	66 U	56 U	56 UJ	54 U	56 U
Acetonitrile	220 U	220 U	260 U	220 U	220 UJ	220 U	220 U
Acrolein	110 R	110 R	130 UJ	110 UJ	110 UJ	110 UJ	110 R
Acrylonitrile	110 U	110 U	130 U	110 U	110 UJ	110 U	110 U
Benzene	5.5 U	5.4 U	6.6 U	5.6 U	5.6 U	5.4 U	5.6 U
Bromodichloromethane	5.5 U	5.4 U	6.6 U	5.6 U	5.6 U	5.4 U	5.6 U
Bromoform	5.5 U	5.4 U	6.6 U	5.6 U	5.6 U	5.4 U	5.6 U
Bromomethane	11 U	11 U	13 U	11 U	11 UJ	11 U	11 U
Carbon disulfide	5.5 U	5.4 U	6.6 U	5.6 U	5.6 UJ	5.4 U	5.6 U
Carbon tetrachloride	5.5 U	5.4 U	6.6 U	5.6 U	5.6 U	5.4 U	5.6 U
Chlorobenzene	5.5 U	5.4 U	6.6 U	5.6 U	5.6 U	5.4 U	5.6 U
Chloroethane	11 U	11 U	13 U	11 U	11 UJ	11 U	11 U
Chloroform	5.5 U	5.4 U	6.6 U	5.6 U	5.6 UJ	5.4 U	5.6 U

APPENDIX A.1

SUMMARY OF ANALYTICAL RESULTS, SURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation						
Site ID	54SS01	54SS02	54SS03	54SS04	54SS04	54SS05	54SS06
Sample ID	54SS01	54SS02	54SS03	54SS04	54SS04D	54SS05	54SS06
Sample Date	12/13/00	12/13/00	12/13/00	12/14/00	12/14/00	12/14/00	12/13/00
Sample Depth (ft bgs)	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0
Volatile Organic Compounds (ug/kg) (Cont.)							
Chloromethane	11 U	11 U	13 U	11 U	11 UJ	11 U	11 U
Chloroprene	5.5 U	5.4 U	6.6 U	5.6 U	5.6 UJ	5.4 U	5.6 U
cis-1,3-Dichloropropene	5.5 U	5.4 U	6.6 U	5.6 U	5.6 U	5.4 U	5.6 U
Dibromochloromethane	5.5 U	5.4 U	6.6 U	5.6 U	5.6 U	5.4 U	5.6 U
Dichlorodifluoromethane	5.5 U	5.4 U	6.6 U	5.6 U	5.6 UJ	5.4 U	5.6 U
Ethyl methacrylate	5.5 U	5.4 U	6.6 U	5.6 U	5.6 U	5.4 U	5.6 U
Ethylbenzene	5.5 U	5.4 U	6.6 U	5.6 U	5.6 U	5.4 U	5.6 U
Iodomethane	5.5 U	5.4 U	6.6 U	5.6 U	5.6 UJ	5.4 U	5.6 U
Isobutanol	220 U	220 U	260 U	220 U	220 UJ	220 U	220 U
Methacrylonitrile	110 U	110 U	130 U	110 U	110 UJ	110 U	110 U
Methyl methacrylate	5.5 U	5.4 U	6.6 U	5.6 U	5.6 U	5.4 U	5.6 U
Dibromomethane	5.5 U	5.4 U	6.6 U	5.6 U	5.6 U	5.4 U	5.6 U
Methylene chloride	3.2 U	5.4 U	6.8	4.2 J	4.1 J	3.2 J	5.6 U
Pentachloroethane	27 U	27 U	33 U	28 U	28 UJ	27 U	28 U
Propionitrile	110 U	110 U	130 U	110 U	110 UJ	110 U	110 U
Styrene	5.5 U	2.1 J	6.6 U	5.6 U	5.6 U	5.4 U	5.6 U
Tetrachloroethene	5.5 U	5.4 U	6.6 U	5.6 U	5.6 U	5.4 U	5.6 U
Toluene	7.8	10	2.7 J	2.1 J	5.6 U	3 J	2.7 J
trans-1,2-Dichloroethene	5.5 U	5.4 U	6.6 U	5.6 U	5.6 UJ	5.4 U	5.6 U
trans-1,3-Dichloropropene	5.5 U	5.4 U	6.6 U	5.6 U	5.6 U	5.4 U	5.6 U
trans-1,4-Dichloro-2-butene	11 U	11 U	13 U	11 U	11 U	11 U	11 U
Trichloroethene	5.5 U	5.4 U	6.6 U	5.6 U	5.6 U	5.4 U	5.6 U
Trichlorofluoromethane	5.5 U	5.4 U	6.6 U	5.6 U	5.6 UJ	5.4 U	5.6 U
Vinyl acetate	11 U	11 U	13 U	11 U	11 UJ	11 U	11 U
Vinyl chloride	11 U	11 U	13 U	11 U	11 UJ	11 U	11 U
Xylenes	11 U	11 U	13 U	11 U	11 U	11 U	11 U

APPENDIX A.1

SUMMARY OF ANALYTICAL RESULTS, SURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation						
Site ID	54SS01	54SS02	54SS03	54SS04	54SS04	54SS05	54SS06
Sample ID	54SS01	54SS02	54SS03	54SS04	54SS04D	54SS05	54SS06
Sample Date	12/13/00	12/13/00	12/13/00	12/14/00	12/14/00	12/14/00	12/13/00
Sample Depth (ft bgs)	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0
Semivolatile Organic Compounds (ug/kg)							
1,2,4,5-Tetrachlorobenzene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
1,2,4-Trichlorobenzene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
1,3,5-Trinitrobenzene	3,800 R	3,600 R	4,300 R	3,700 R	3,700 R	3,600 R	3,700 R
1,4-Dioxane	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
1,4-Naphthoquinone	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
1,4-Phenylenediamine	19,000 UJ	18,000 UJ	22,000 UJ	19,000 UJ	19,000 UJ	18,000 UJ	19,000 UJ
1-Diallate	NA	NA	NA	NA	NA	NA	NA
1-Naphthylamine	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
2,3,4,6-Tetrachlorophenol	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
2,4,5-Trichlorophenol	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
2,4,6-Trichlorophenol	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
2,4-Dichlorophenol	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
2,4-Dimethylphenol	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
2,4-Dinitrophenol	19,000 U	18,000 U	22,000 U	19,000 U	19,000 U	18,000 U	19,000 U
2,4-Dinitrotoluene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
2,6-Dichlorophenol	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
2,6-Dinitrotoluene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
2-Acetylaminofluorene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
2-Chloronaphthalene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
2-Chlorophenol	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
2-Diallate	NA	NA	NA	NA	NA	NA	NA
2-Methylnaphthalene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
2-Naphthylamine	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
2-Nitroaniline	19,000 U	18,000 U	22,000 U	19,000 U	19,000 U	18,000 U	19,000 U
2-Nitrophenol	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
2-Picoline	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
3,3'-Dichlorobenzidine	7,500 U	7,200 U	8,700 U	7,400 U	7,400 U	7,200 U	7,400 U
3,3'-Dimethylbenzidine	19,000 U	18,000 U	22,000 U	19,000 U	19,000 U	18,000 U	19,000 U

APPENDIX A.1

SUMMARY OF ANALYTICAL RESULTS, SURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation						
Site ID	54SS01	54SS02	54SS03	54SS04	54SS04	54SS05	54SS06
Sample ID	54SS01	54SS02	54SS03	54SS04	54SS04D	54SS05	54SS06
Sample Date	12/13/00	12/13/00	12/13/00	12/14/00	12/14/00	12/14/00	12/13/00
Sample Depth (ft bgs)	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0
Semivolatile Organic Compounds (ug/kg) (Cont.)							
3-Methylcholanthrene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
3-Nitroaniline	19,000 U	18,000 U	22,000 U	19,000 U	19,000 U	18,000 U	19,000 U
4,6-Dinitro-2-methylphenol	19,000 U	18,000 U	22,000 U	19,000 U	19,000 U	18,000 U	19,000 U
4-Aminobiphenyl	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
4-Bromophenyl phenyl ether	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
4-Chloro-3-methylphenol	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
4-Chloroaniline	7,500 U	7,200 U	8,700 U	7,400 U	7,400 U	7,200 U	7,400 U
4-Chlorophenylphenylether	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
4-Nitroaniline	19,000 U	18,000 U	22,000 U	19,000 U	19,000 U	18,000 U	19,000 U
4-Nitrophenol	19,000 U	18,000 U	22,000 U	19,000 U	19,000 U	18,000 U	19,000 U
4-Nitroquinoline-1-oxide	38,000 R	36,000 R	43,000 R	37,000 R	37,000 R	36,000 R	37,000 R
5-Nitro-o-toluidine	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
7,12-Dimethylbenz(a)anthracene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Acenaphthene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Acenaphthylene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Acetophenone	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
alpha,alpha-Dimethylphenethylamine	760,000 U	730,000 U	880,000 U	750,000 U	750,000 U	730,000 U	750,000 U
Aniline	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Anthracene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Aramite, Total	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Aramite-1	NA	NA	NA	NA	NA	NA	NA
Aramite-2	NA	NA	NA	NA	NA	NA	NA
Benzo(a)anthracene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Benzo(a)pyrene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Benzo(b)fluoranthene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Benzo(g,h,i)perylene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Benzo(k)fluoranthene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Benzyl alcohol	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U

APPENDIX A.1

SUMMARY OF ANALYTICAL RESULTS, SURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation						
Site ID	54SS01	54SS02	54SS03	54SS04	54SS04	54SS05	54SS06
Sample ID	54SS01	54SS02	54SS03	54SS04	54SS04D	54SS05	54SS06
Sample Date	12/13/00	12/13/00	12/13/00	12/14/00	12/14/00	12/14/00	12/13/00
Sample Depth (ft bgs)	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0
Semivolatile Organic Compounds (ug/kg) (Cont.)							
Bis(2-chloroethoxy)methane	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Bis(2-chloroethyl)ether	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
bis-(2-chloroisopropyl)ether	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Bis(2-ethylhexyl)phthalate	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Butylbenzylphthalate	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Chrysene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	250 U
Cresol (ortho)	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Cresol, m&p	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Diallate, Total	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Dibenzo(a,h)anthracene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Dibenzofuran	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Diethylphthalate	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Dimethylphthalate	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Di-n-butylphthalate	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Di-n-octyl phthalate	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Dinoseb	3,800 UJ	3,600 UJ	4,300 UJ	3,700 UJ	3,700 UJ	3,600 UJ	3,700 UJ
Ethyl methanesulfonate	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Fluoranthene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	420 J
Fluorene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Hexachlorobenzene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Hexachlorobutadiene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Hexachlorocyclopentadiene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Hexachloroethane	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Hexachlorophene	1,900,000 U	1,800,000 U	2,200,000 U	1,900,000 U	1,900,000 U	1,800,000 U	1,900,000 U
Hexachloropropene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Indeno(1,2,3-cd)pyrene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Isophorone	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Isosafrole	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U

APPENDIX A.1

SUMMARY OF ANALYTICAL RESULTS, SURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation						
Site ID	54SS01	54SS02	54SS03	54SS04	54SS04	54SS05	54SS06
Sample ID	54SS01	54SS02	54SS03	54SS04	54SS04D	54SS05	54SS06
Sample Date	12/13/00	12/13/00	12/13/00	12/14/00	12/14/00	12/14/00	12/13/00
Sample Depth (ft bgs)	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0
Semivolatile Organic Compounds (ug/kg) (Cont.)							
m-Dichlorobenzene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
m-Dinitrobenzene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Methapyrilene	760,000 U	730,000 U	880,000 U	750,000 U	750,000 U	730,000 U	750,000 U
Methyl methanesulfonate	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Naphthalene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Nitrobenzene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
N-Nitrosodiethylamine	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
N-Nitrosodimethylamine	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
N-Nitroso-di-n-butylamine	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
N-Nitroso-di-n-propylamine	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
N-Nitrosodiphenylamine	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
N-Nitrosomethylethylamine	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
N-Nitrosomorpholine	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
N-Nitrosopiperidine	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
N-Nitrosopyrrolidine	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
o-Dichlorobenzene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
o-Toluidine	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
p-Dichlorobenzene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
p-Dimethylaminoazobenzene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Pentachlorobenzene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Pentachloronitrobenzene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Pentachlorophenol	19,000 U	18,000 U	22,000 U	19,000 U	19,000 U	18,000 U	19,000 U
Phenacetin	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Phenanthrene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Phenol	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U

APPENDIX A.1

SUMMARY OF ANALYTICAL RESULTS, SURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation						
Site ID	54SS01	54SS02	54SS03	54SS04	54SS04	54SS05	54SS06
Sample ID	54SS01	54SS02	54SS03	54SS04	54SS04D	54SS05	54SS06
Sample Date	12/13/00	12/13/00	12/13/00	12/14/00	12/14/00	12/14/00	12/13/00
Sample Depth (ft bgs)	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0
Semivolatile Organic Compounds (ug/kg) (Cont.)							
Pronamide	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Pyrene	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Pyridine	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
Safrole	3,800 U	3,600 U	4,300 U	3,700 U	3,700 U	3,600 U	3,700 U
TPH (mg/kg)							
Diesel Range Organics	7.5 U	5.7 J	320	33 J	95 J	47	35
Gasoline Range Organics	0.28 U	0.27 U	0.33 U	0.29 U	0.28 U	0.27 U	0.11 J

APPENDIX A.1

SUMMARY OF ANALYTICAL RESULTS, SURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation						
Site ID	54SS07	54SS08	54SS09	54SS10	54SS11	54SS12	54SS13
Sample ID	54SS07	54SS08	54SS09	54SS10	54SS11	54SS12	54SS13
Sample Date	12/13/00	12/14/00	12/14/00	12/20/00	12/20/00	12/13/00	12/14/00
Sample Depth (ft bgs)	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0
Volatile Organic Compounds (ug/kg)							
1,1,1,2-Tetrachloroethane	5.5 U	7.8 U	5.5 U	6 U	5.6 U	5.8 U	5.6 U
1,1,1-Trichloroethane	5.5 U	7.8 U	5.5 U	6 U	5.6 U	5.8 U	5.6 U
1,1,2,2-Tetrachloroethane	5.5 U	7.8 U	5.5 U	6 U	5.6 U	5.8 U	5.6 U
1,1,2-Trichloroethane	5.5 U	7.8 U	5.5 U	6 U	5.6 U	5.8 U	5.6 U
1,1-Dichloroethane	5.5 U	7.8 U	5.5 U	6 UJ	5.6 UJ	5.8 U	5.6 U
1,1-Dichloroethene	5.5 U	7.8 U	5.5 U	6 UJ	5.6 UJ	5.8 U	5.6 U
1,2,3-Trichloropropane	5.5 U	7.8 U	5.5 U	6 U	5.6 U	5.8 U	5.6 U
1,2-Dibromo-3-chloropropane	11 U	16 U	11 U	12 U	11 U	12 UJ	11 U
1,2-Dibromoethane	5.5 U	7.8 U	5.5 U	6 U	5.6 U	5.8 U	5.6 U
1,2-Dichloroethane	5.5 U	7.8 U	5.5 U	6 U	5.6 U	5.8 U	5.6 U
1,2-Dichloropropane	5.5 U	7.8 U	5.5 U	6 U	5.6 U	5.8 U	5.6 U
2-Butanone	27 U	39 U	27 U	30 UJ	28 UJ	29 U	28 U
2-Hexanone	27 U	39 U	27 U	30 U	28 U	29 U	28 U
3-Chloro-1-propene	5.5 U	7.8 U	5.5 U	6 U	5.6 U	5.8 U	5.6 U
4-Methyl-2-pentanone	27 U	39 U	27 U	30 U	28 U	29 U	28 U
Acetone	55 U	78 U	55 U	48 J	9.6 J	58 U	4.2 J
Acetonitrile	220 U	310 U	220 U	240 U	220 U	230 U	220 U
Acrolein	110 R	160 UJ	110 UJ	120 R	110 R	120 R	110 UJ
Acrylonitrile	110 U	160 U	110 U	120 U	110 U	120 U	110 U
Benzene	5.5 U	7.8 U	5.5 U	6 U	5.6 U	5.8 U	5.6 U
Bromodichloromethane	5.5 U	7.8 U	5.5 U	6 U	5.6 U	5.8 U	5.6 U
Bromoform	5.5 U	7.8 U	5.5 U	6 U	5.6 U	5.8 U	5.6 U
Bromomethane	11 U	16 U	11 U	12 UJ	11 UJ	12 U	11 U
Carbon disulfide	5.5 U	7.8 U	5.5 U	6 U	5.6 U	5.8 U	5.6 U
Carbon tetrachloride	5.5 U	7.8 U	5.5 U	6 U	5.6 U	5.8 U	5.6 U
Chlorobenzene	18	7.8 U	5.5 U	6 U	5.6 U	5.8 U	5.6 U
Chloroethane	11 U	16 U	11 U	12 UJ	11 UJ	12 U	11 U
Chloroform	5.5 U	7.8 U	5.5 U	6 UJ	5.6 UJ	5.8 U	5.6 U

APPENDIX A.1

SUMMARY OF ANALYTICAL RESULTS, SURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation						
Site ID	54SS07	54SS08	54SS09	54SS10	54SS11	54SS12	54SS13
Sample ID	54SS07	54SS08	54SS09	54SS10	54SS11	54SS12	54SS13
Sample Date	12/13/00	12/14/00	12/14/00	12/20/00	12/20/00	12/13/00	12/14/00
Sample Depth (ft bgs)	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0
Volatile Organic Compounds (ug/kg) (Cont.)							
Chloromethane	11 U	16 U	11 U	12 UJ	11 UJ	12 U	11 U
Chloroprene	5.5 U	7.8 U	5.5 U	6 U	5.6 U	5.8 U	5.6 U
cis-1,3-Dichloropropene	5.5 U	7.8 U	5.5 U	6 U	5.6 U	5.8 U	5.6 U
Dibromochloromethane	5.5 U	7.8 U	5.5 U	6 U	5.6 U	5.8 U	5.6 U
Dichlorodifluoromethane	5.5 U	7.8 U	5.5 U	6 UJ	5.6 UJ	5.8 U	5.6 U
Ethyl methacrylate	5.5 U	7.8 U	5.5 U	6 U	5.6 U	5.8 U	5.6 U
Ethylbenzene	5.5 U	7.8 U	5.5 U	6 U	3.8 J	5.8 U	5.6 U
Iodomethane	5.5 U	7.8 U	5.5 U	6 U	5.6 U	5.8 U	5.6 U
Isobutanol	220 U	310 U	220 U	240 U	220 U	230 U	220 U
Methacrylonitrile	110 U	160 U	110 U	120 U	110 U	120 U	110 U
Methyl methacrylate	5.5 U	7.8 U	5.5 U	6 U	5.6 U	5.8 U	5.6 U
Dibromomethane	5.5 U	7.8 U	5.5 U	6 U	5.6 U	5.8 U	5.6 U
Methylene chloride	5.5 U	9.1	6.4	6 UJ	5.6 UJ	2.5 U	3.7 J
Pentachloroethane	27 U	39 U	27 U	30 U	28 U	29 UJ	28 U
Propionitrile	110 U	160 U	110 U	120 U	110 U	120 U	110 U
Styrene	5.5 U	7.8 U	2.4 J	6 U	22	5.8 U	5.6 U
Tetrachloroethene	5.5 U	7.8 U	5.5 U	6 U	5.6 U	5.8 U	5.6 U
Toluene	4.4 J	15	13	6 U	5.6 U	6.7	5.6 U
trans-1,2-Dichloroethene	5.5 U	7.8 U	5.5 U	6 UJ	5.6 UJ	5.8 U	5.6 U
trans-1,3-Dichloropropene	5.5 U	7.8 U	5.5 U	6 U	5.6 U	5.8 U	5.6 U
trans-1,4-Dichloro-2-butene	11 U	16 U	11 U	12 U	11 U	12 UJ	11 U
Trichloroethene	5.5 U	7.8 U	5.5 U	6 U	5.6 U	5.8 U	5.6 U
Trichlorofluoromethane	5.5 U	7.8 U	5.5 U	6 UJ	5.6 UJ	5.8 U	5.6 U
Vinyl acetate	11 U	16 U	11 U	12 UJ	11 UJ	12 U	11 U
Vinyl chloride	11 U	16 U	11 U	12 UJ	11 UJ	12 U	11 U
Xylenes	11 U	16 U	11 U	12 U	11 U	12 U	11 U

APPENDIX A.1

SUMMARY OF ANALYTICAL RESULTS, SURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation						
Site ID	54SS07	54SS08	54SS09	54SS10	54SS11	54SS12	54SS13
Sample ID	54SS07	54SS08	54SS09	54SS10	54SS11	54SS12	54SS13
Sample Date	12/13/00	12/14/00	12/14/00	12/20/00	12/20/00	12/13/00	12/14/00
Sample Depth (ft bgs)	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0
Semivolatile Organic Compounds (ug/kg)							
1,2,4,5-Tetrachlorobenzene	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
1,2,4-Trichlorobenzene	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
1,3,5-Trinitrobenzene	3,600 R	5,200 R	3,600 R	400 U	370 U	3,800 R	3,700 R
1,4-Dioxane	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
1,4-Naphthoquinone	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
1,4-Phenylenediamine	19,000 UJ	26,000 UJ	19,000 UJ	2,000 U	1,900 U	20,000 UJ	19,000 UJ
1-Diallate	NA	NA	NA	NA	NA	NA	NA
1-Naphthylamine	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
2,3,4,6-Tetrachlorophenol	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
2,4,5-Trichlorophenol	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
2,4,6-Trichlorophenol	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
2,4-Dichlorophenol	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
2,4-Dimethylphenol	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
2,4-Dinitrophenol	19,000 U	26,000 U	19,000 U	2,000 U	1,900 U	20,000 U	19,000 U
2,4-Dinitrotoluene	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
2,6-Dichlorophenol	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
2,6-Dinitrotoluene	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
2-Acetylaminofluorene	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
2-Chloronaphthalene	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
2-Chlorophenol	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
2-Diallate	NA	NA	NA	NA	NA	NA	NA
2-Methylnaphthalene	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
2-Naphthylamine	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
2-Nitroaniline	19,000 U	26,000 U	19,000 U	2,000 U	1,900 U	20,000 U	19,000 U
2-Nitrophenol	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
2-Picoline	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
3,3'-Dichlorobenzidine	7,200 U	10,000 U	7,200 U	800 U	730 U	7,700 U	7,400 U
3,3'-Dimethylbenzidine	19,000 U	26,000 U	19,000 U	2,000 U	1,900 U	20,000 U	19,000 U

APPENDIX A.1

SUMMARY OF ANALYTICAL RESULTS, SURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation						
Site ID	54SS07	54SS08	54SS09	54SS10	54SS11	54SS12	54SS13
Sample ID	54SS07	54SS08	54SS09	54SS10	54SS11	54SS12	54SS13
Sample Date	12/13/00	12/14/00	12/14/00	12/20/00	12/20/00	12/13/00	12/14/00
Sample Depth (ft bgs)	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0
Semivolatile Organic Compounds (ug/kg) (Cont.)							
3-Methylcholanthrene	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
3-Nitroaniline	19,000 U	26,000 U	19,000 U	2,000 U	1,900 U	20,000 U	19,000 U
4,6-Dinitro-2-methylphenol	19,000 U	26,000 U	19,000 U	2,000 U	1,900 U	20,000 U	19,000 U
4-Aminobiphenyl	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
4-Bromophenyl phenyl ether	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
4-Chloro-3-methylphenol	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
4-Chloroaniline	7,200 U	10,000 U	7,200 U	800 U	730 U	7,700 U	7,400 U
4-Chlorophenylphenylether	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
4-Nitroaniline	19,000 U	26,000 U	19,000 U	2,000 U	1,900 U	20,000 U	19,000 U
4-Nitrophenol	19,000 U	26,000 U	19,000 U	2,000 U	1,900 U	20,000 U	19,000 R
4-Nitroquinoline-1-oxide	36,000 R	52,000 R	36,000 R	4,000 R	3,700 R	38,000 R	37,000 R
5-Nitro-o-toluidine	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
7,12-Dimethylbenz(a)anthracene	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Acenaphthene	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Acenaphthylene	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Acetophenone	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
alpha,alpha-Dimethylphenethylamine	740,000 U	1,000,000 U	740,000 U	81,000 U	74,000 U	780,000 U	750,000 U
Aniline	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Anthracene	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Aramite, Total	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Aramite-1	NA	NA	NA	NA	NA	NA	NA
Aramite-2	NA	NA	NA	NA	NA	NA	NA
Benzo(a)anthracene	350 J	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Benzo(a)pyrene	580 J	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Benzo(b)fluoranthene	430 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Benzo(g,h,i)perylene	710 U	5,200 U	3,600 U	400 U	370 U	380 U	3,700 U
Benzo(k)fluoranthene	560 J	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Benzyl alcohol	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U

APPENDIX A.1

SUMMARY OF ANALYTICAL RESULTS, SURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation						
Site ID	54SS07	54SS08	54SS09	54SS10	54SS11	54SS12	54SS13
Sample ID	54SS07	54SS08	54SS09	54SS10	54SS11	54SS12	54SS13
Sample Date	12/13/00	12/14/00	12/14/00	12/20/00	12/20/00	12/13/00	12/14/00
Sample Depth (ft bgs)	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0
Semivolatile Organic Compounds (ug/kg) (Cont.)							
Bis(2-chloroethoxy)methane	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Bis(2-chloroethyl)ether	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
bis-(2-chloroisopropyl)ether	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Bis(2-ethylhexyl)phthalate	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	530 J
Butylbenzylphthalate	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Chrysene	520 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Cresol (ortho)	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Cresol, m&p	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Diallate, Total	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Dibenzo(a,h)anthracene	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Dibenzofuran	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Diethylphthalate	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Dimethylphthalate	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Di-n-butylphthalate	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Di-n-octyl phthalate	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Dinoseb	3,600 UJ	5,200 UJ	3,600 UJ	400 U	370 U	3,800 UJ	3,700 UJ
Ethyl methanesulfonate	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Fluoranthene	630 J	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Fluorene	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Hexachlorobenzene	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Hexachlorobutadiene	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Hexachlorocyclopentadiene	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Hexachloroethane	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Hexachlorophene	1,900,000 U	2,600,000 U	1,900,000 U	200,000 U	190,000 U	2,000,000 U	1,900,000 U
Hexachloropropene	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Indeno(1,2,3-cd)pyrene	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Isophorone	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Isosafrole	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U

APPENDIX A.1

SUMMARY OF ANALYTICAL RESULTS, SURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation						
Site ID	54SS07	54SS08	54SS09	54SS10	54SS11	54SS12	54SS13
Sample ID	54SS07	54SS08	54SS09	54SS10	54SS11	54SS12	54SS13
Sample Date	12/13/00	12/14/00	12/14/00	12/20/00	12/20/00	12/13/00	12/14/00
Sample Depth (ft bgs)	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0
Semivolatile Organic Compounds (ug/kg) (Cont.)							
m-Dichlorobenzene	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
m-Dinitrobenzene	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Methapyrilene	740,000 U	1,000,000 U	740,000 U	81,000 U	74,000 U	780,000 U	750,000 U
Methyl methanesulfonate	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Naphthalene	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Nitrobenzene	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
N-Nitrosodiethylamine	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
N-Nitrosodimethylamine	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
N-Nitroso-di-n-butylamine	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
N-Nitroso-di-n-propylamine	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
N-Nitrosodiphenylamine	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
N-Nitrosomethylethylamine	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
N-Nitrosomorpholine	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
N-Nitrosopiperidine	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
N-Nitrosopyrrolidine	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
o-Dichlorobenzene	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
o-Toluidine	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
p-Dichlorobenzene	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
p-Dimethylaminoazobenzene	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Pentachlorobenzene	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Pentachloronitrobenzene	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Pentachlorophenol	19,000 U	26,000 U	19,000 U	2,000 U	1,900 U	20,000 U	19,000 R
Phenacetin	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Phenanthrene	220 J	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Phenol	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U

APPENDIX A.1

SUMMARY OF ANALYTICAL RESULTS, SURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation						
Site ID	54SS07	54SS08	54SS09	54SS10	54SS11	54SS12	54SS13
Sample ID	54SS07	54SS08	54SS09	54SS10	54SS11	54SS12	54SS13
Sample Date	12/13/00	12/14/00	12/14/00	12/20/00	12/20/00	12/13/00	12/14/00
Sample Depth (ft bgs)	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0
Semivolatile Organic Compounds (ug/kg) (Cont.)							
Pronamide	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Pyrene	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Pyridine	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
Safrole	3,600 U	5,200 U	3,600 U	400 U	370 U	3,800 U	3,700 U
TPH (mg/kg)							
Diesel Range Organics	28	36	14	4 U	3.7 U	490	17 J
Gasoline Range Organics	0.27 U	0.38 U	0.27 U	0.33 UJ	0.29 U	0.28 UJ	0.28 U

APPENDIX A.1

SUMMARY OF ANALYTICAL RESULTS, SURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation				RCRA Facility Investigation		
Site ID	54SS13	54SS14	54SS15	54TW01	54TW15A	54TW19	54TW20
Sample ID	54SS13D	54SS14	54SS15	54SB01-00	54TW15A-00	54TW19-00	54TW20-00
Sample Date	12/14/00	12/13/00	12/13/00	12/15/00	03/01/02	03/02/02	03/02/02
Sample Depth (ft bgs)	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0
Volatile Organic Compounds (ug/kg)							
1,1,1,2-Tetrachloroethane	6.1 U	5.6 U	5.5 U	5.4 U	5.2 U	7.8 U	9.2 U
1,1,1-Trichloroethane	6.1 U	5.6 U	5.5 U	5.4 U	5.2 U	7.8 U	9.2 U
1,1,2,2-Tetrachloroethane	6.1 U	5.6 U	5.5 U	5.4 U	5.2 U	7.8 U	9.2 U
1,1,2-Trichloroethane	6.1 U	5.6 U	5.5 U	5.4 U	5.2 U	7.8 U	9.2 U
1,1-Dichloroethane	6.1 U	5.6 U	5.5 U	5.4 U	5.2 UJ	7.8 U	9.2 U
1,1-Dichloroethene	6.1 U	5.6 U	5.5 U	5.4 UJ	5.2 U	7.8 U	9.2 U
1,2,3-Trichloropropane	6.1 U	5.6 U	5.5 U	5.4 U	5.2 U	7.8 U	9.2 U
1,2-Dibromo-3-chloropropane	12 U	11 U	11 U	11 U	10 UJ	16 U	18 U
1,2-Dibromoethane	6.1 U	5.6 U	5.5 U	5.4 U	5.2 U	7.8 U	9.2 U
1,2-Dichloroethane	6.1 U	5.6 U	5.5 U	5.4 U	5.2 U	7.8 U	9.2 U
1,2-Dichloropropane	6.1 U	5.6 U	5.5 U	5.4 U	5.2 U	7.8 U	9.2 U
2-Butanone	30 U	28 U	27 U	27 UJ	26 U	39 U	46 U
2-Hexanone	30 U	28 U	27 U	27 U	26 U	39 U	46 U
3-Chloro-1-propene	6.1 U	5.6 U	5.5 U	5.4 U	5.2 UJ	7.8 UJ	9.2 UJ
4-Methyl-2-pentanone	30 U	28 U	27 U	27 U	26 U	39 U	46 U
Acetone	61 U	56 U	55 U	54 U	52 U	78 U	92 U
Acetonitrile	240 U	220 U	220 U	220 U	210 UJ	310 UJ	370 UJ
Acrolein	120 UJ	110 R	110 R	110 R	100 R	160 U	180 U
Acrylonitrile	120 U	110 U	110 U	110 U	100 UJ	160 U	180 U
Benzene	6.1 U	5.6 U	5.5 U	5.4 U	5.2 U	7.8 U	9.2 U
Bromodichloromethane	6.1 U	5.6 U	5.5 U	5.4 U	5.2 U	7.8 U	9.2 U
Bromoform	6.1 U	5.6 U	5.5 U	5.4 U	5.2 U	7.8 U	9.2 U
Bromomethane	12 U	11 U	11 U	11 UJ	10 UJ	16 U	18 U
Carbon disulfide	6.1 U	5.6 U	5.5 U	5.4 U	5.2 UJ	7.8 UJ	9.2 UJ
Carbon tetrachloride	6.1 U	5.6 U	5.5 U	5.4 U	5.2 U	7.8 U	9.2 U
Chlorobenzene	6.1 U	5.6 U	5.5 U	5.4 U	5.2 U	7.8 U	9.2 U
Chloroethane	12 U	11 U	11 U	11 UJ	10 U	16 U	18 U
Chloroform	6.1 U	5.6 U	5.5 U	5.4 UJ	5.2 U	7.8 U	9.2 U

APPENDIX A.1

SUMMARY OF ANALYTICAL RESULTS, SURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation				RCRA Facility Investigation		
Site ID	54SS13	54SS14	54SS15	54TW01	54TW15A	54TW19	54TW20
Sample ID	54SS13D	54SS14	54SS15	54SB01-00	54TW15A-00	54TW19-00	54TW20-00
Sample Date	12/14/00	12/13/00	12/13/00	12/15/00	03/01/02	03/02/02	03/02/02
Sample Depth (ft bgs)	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0
Volatile Organic Compounds (ug/kg) (Cont.)							
Chloromethane	12 U	11 U	11 U	11 UJ	10 U	16 U	18 U
Chloroprene	6.1 U	5.6 U	5.5 U	5.4 U	5.2 UJ	7.8 U	9.2 U
cis-1,3-Dichloropropene	6.1 U	5.6 U	5.5 U	5.4 U	5.2 U	7.8 U	9.2 U
Dibromochloromethane	6.1 U	5.6 U	5.5 U	5.4 U	5.2 U	7.8 U	9.2 U
Dichlorodifluoromethane	6.1 U	5.6 U	5.5 U	5.4 UJ	5.2 UJ	7.8 U	9.2 U
Ethyl methacrylate	6.1 U	5.6 U	5.5 U	5.4 U	5.2 U	7.8 U	9.2 U
Ethylbenzene	6.1 U	5.6 U	5.5 U	5.4 U	5.2 U	7.8 U	9.2 U
Iodomethane	6.1 U	5.6 U	5.5 U	5.4 U	5.2 UJ	7.8 U	9.2 U
Isobutanol	240 U	220 U	220 U	220 U	210 R	310 R	370 R
Methacrylonitrile	120 U	110 U	110 U	110 U	100 U	160 U	180 U
Methyl methacrylate	6.1 U	5.6 U	5.5 U	5.4 U	5.2 U	7.8 U	9.2 U
Dibromomethane	6.1 U	5.6 U	5.5 U	5.4 U	5.2 U	7.8 U	9.2 U
Methylene chloride	4 J	2.6 U	5.5 U	5.4 UJ	5.2 UJ	7.8 U	9.2 U
Pentachloroethane	30 U	28 U	27 U	27 U	26 UJ	39 UJ	46 UJ
Propionitrile	120 U	110 U	110 U	110 U	100 U	160 U	180 U
Styrene	6.1 U	2.5 J	5.5 U	5.4 U	5.2 U	7.8 U	9.2 U
Tetrachloroethene	6.1 U	5.6 U	5.5 U	5.4 U	5.2 U	7.8 U	9.2 U
Toluene	6.1 U	15	4.6 J	2.8 J	5.2 U	7.8 U	9.2 U
trans-1,2-Dichloroethene	6.1 U	5.6 U	5.5 U	5.4 UJ	5.2 UJ	7.8 U	9.2 U
trans-1,3-Dichloropropene	6.1 U	5.6 U	5.5 U	5.4 U	5.2 U	7.8 U	9.2 U
trans-1,4-Dichloro-2-butene	12 U	11 U	11 U	11 U	10 U	16 U	18 U
Trichloroethene	6.1 U	5.6 U	5.5 U	5.4 U	5.2 U	7.8 U	9.2 U
Trichlorofluoromethane	6.1 U	5.6 U	5.5 U	5.4 UJ	5.2 U	7.8 U	9.2 U
Vinyl acetate	12 U	11 U	11 U	11 UJ	10 UJ	16 U	18 U
Vinyl chloride	12 U	11 U	11 U	11 UJ	10 U	16 U	18 U
Xylenes	12 U	11 U	11 U	11 U	5.2 U	7.8 U	9.2 U

APPENDIX A.1

SUMMARY OF ANALYTICAL RESULTS, SURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation				RCRA Facility Investigation		
Site ID	54SS13	54SS14	54SS15	54TW01	54TW15A	54TW19	54TW20
Sample ID	54SS13D	54SS14	54SS15	54SB01-00	54TW15A-00	54TW19-00	54TW20-00
Sample Date	12/14/00	12/13/00	12/13/00	12/15/00	03/01/02	03/02/02	03/02/02
Sample Depth (ft bgs)	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0
Semivolatile Organic Compounds (ug/kg)							
1,2,4,5-Tetrachlorobenzene	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
1,2,4-Trichlorobenzene	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
1,3,5-Trinitrobenzene	4,000 R	3,700 R	3,600 R	3,500 R	350 UJ	560 UJ	570 UJ
1,4-Dioxane	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
1,4-Naphthoquinone	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
1,4-Phenylenediamine	21,000 UJ	19,000 UJ	19,000 UJ	18,000 UJ	1,800 U	2,900 R	2,900 R
1-Diallate	NA	NA	NA	NA	350 U	560 U	570 U
1-Naphthylamine	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
2,3,4,6-Tetrachlorophenol	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
2,4,5-Trichlorophenol	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
2,4,6-Trichlorophenol	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
2,4-Dichlorophenol	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
2,4-Dimethylphenol	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
2,4-Dinitrophenol	21,000 U	19,000 U	19,000 U	18,000 U	1,800 U	2,900 U	2,900 UJ
2,4-Dinitrotoluene	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
2,6-Dichlorophenol	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 UJ
2,6-Dinitrotoluene	4,000 U	3,700 U	3,600 U	3,500 U	350 UJ	560 U	570 U
2-Acetylaminofluorene	4,000 U	3,700 U	3,600 U	3,500 U	350 UJ	560 U	570 UJ
2-Chloronaphthalene	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
2-Chlorophenol	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
2-Diallate	NA	NA	NA	NA	350 U	560 U	570 U
2-Methylnaphthalene	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
2-Naphthylamine	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 UJ
2-Nitroaniline	21,000 U	19,000 U	19,000 U	18,000 U	1,800 U	2,900 U	2,900 U
2-Nitrophenol	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
2-Picoline	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
3,3'-Dichlorobenzidine	8,000 U	7,300 U	7,200 U	7,100 U	710 UJ	1,100 U	1,100 U
3,3'-Dimethylbenzidine	21,000 U	19,000 U	19,000 U	18,000 U	1,800 UJ	2,900 U	2,900 U

APPENDIX A.1

SUMMARY OF ANALYTICAL RESULTS, SURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation				RCRA Facility Investigation		
Site ID	54SS13	54SS14	54SS15	54TW01	54TW15A	54TW19	54TW20
Sample ID	54SS13D	54SS14	54SS15	54SB01-00	54TW15A-00	54TW19-00	54TW20-00
Sample Date	12/14/00	12/13/00	12/13/00	12/15/00	03/01/02	03/02/02	03/02/02
Sample Depth (ft bgs)	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0
Semivolatile Organic Compounds (ug/kg) (Cont.)							
3-Methylcholanthrene	4,000 U	3,700 U	3,600 U	3,500 U	350 UJ	560 U	570 U
3-Nitroaniline	21,000 U	19,000 U	19,000 U	18,000 U	1,800 U	2,900 U	2,900 U
4,6-Dinitro-2-methylphenol	21,000 U	19,000 U	19,000 U	18,000 U	1,800 U	2,900 U	2,900 UJ
4-Aminobiphenyl	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
4-Bromophenyl phenyl ether	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
4-Chloro-3-methylphenol	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
4-Chloroaniline	8,000 U	7,300 U	7,200 U	7,100 U	710 U	1,100 U	1,100 U
4-Chlorophenylphenylether	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
4-Nitroaniline	21,000 U	19,000 U	19,000 U	18,000 U	1,800 U	2,900 U	2,900 U
4-Nitrophenol	21,000 U	19,000 U	19,000 U	18,000 U	1,800 U	2,900 U	2,900 U
4-Nitroquinoline-1-oxide	40,000 R	37,000 R	36,000 R	35,000 R	3,500 R	5,600 R	5,700 R
5-Nitro-o-toluidine	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 UJ	570 UJ
7,12-Dimethylbenz(a)anthracene	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
Acenaphthene	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
Acenaphthylene	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
Acetophenone	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
alpha,alpha-Dimethylphenethylamine	820,000 U	740,000 U	740,000 U	720,000 U	72,000 UJ	110,000 UJ	120,000 UJ
Aniline	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
Anthracene	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
Aramite, Total	4,000 U	3,700 U	3,600 U	3,500 U	350 UJ	560 U	570 U
Aramite-1	NA	NA	NA	NA	350 UJ	560 U	570 U
Aramite-2	NA	NA	NA	NA	350 UJ	560 U	570 U
Benzo(a)anthracene	4,000 U	3,700 U	3,600 U	3,500 U	350 UJ	560 U	570 U
Benzo(a)pyrene	4,000 U	3,700 U	3,600 U	3,500 U	350 UJ	560 U	570 U
Benzo(b)fluoranthene	4,000 U	3,700 U	3,600 U	3,500 U	350 UJ	560 U	570 U
Benzo(g,h,i)perylene	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
Benzo(k)fluoranthene	4,000 U	3,700 U	3,600 U	3,500 U	350 UJ	560 U	570 U
Benzyl alcohol	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U

APPENDIX A.1

SUMMARY OF ANALYTICAL RESULTS, SURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation				RCRA Facility Investigation		
Site ID	54SS13	54SS14	54SS15	54TW01	54TW15A	54TW19	54TW20
Sample ID	54SS13D	54SS14	54SS15	54SB01-00	54TW15A-00	54TW19-00	54TW20-00
Sample Date	12/14/00	12/13/00	12/13/00	12/15/00	03/01/02	03/02/02	03/02/02
Sample Depth (ft bgs)	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0
Semivolatile Organic Compounds (ug/kg) (Cont.)							
Bis(2-chloroethoxy)methane	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
Bis(2-chloroethyl)ether	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
bis-(2-chloroisopropyl)ether	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
Bis(2-ethylhexyl)phthalate	4,000 U	3,700 U	3,600 U	3,500 U	350 UJ	560 U	570 U
Butylbenzylphthalate	4,000 U	3,700 U	3,600 U	3,500 U	350 UJ	560 U	570 U
Chrysene	4,000 U	3,700 U	3,600 U	3,500 U	350 UJ	560 U	570 U
Cresol (ortho)	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
Cresol, m&p	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
Diallate, Total	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
Dibenzo(a,h)anthracene	4,000 U	3,700 U	3,600 U	3,500 U	350 UJ	560 U	570 U
Dibenzofuran	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
Diethylphthalate	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
Dimethylphthalate	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
Di-n-butylphthalate	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
Di-n-octyl phthalate	4,000 U	3,700 U	3,600 U	3,500 U	350 UJ	560 U	570 U
Dinoseb	4,000 UJ	3,700 UJ	3,600 UJ	3,500 UJ	350 U	560 UJ	570 UJ
Ethyl methanesulfonate	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
Fluoranthene	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
Fluorene	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
Hexachlorobenzene	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
Hexachlorobutadiene	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
Hexachlorocyclopentadiene	4,000 U	3,700 U	3,600 U	3,500 U	350 UJ	560 U	570 U
Hexachloroethane	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
Hexachlorophene	2,100,000 U	1,900,000 U	1,900,000 U	1,800,000 U	180,000 R	290,000 U	290,000 UJ
Hexachloropropene	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 UJ	570 U
Indeno(1,2,3-cd)pyrene	4,000 U	3,700 U	3,600 U	3,500 U	350 UJ	560 U	570 U
Isophorone	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
Isosafrole	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 UJ

APPENDIX A.1

SUMMARY OF ANALYTICAL RESULTS, SURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation				RCRA Facility Investigation		
Site ID	54SS13	54SS14	54SS15	54TW01	54TW15A	54TW19	54TW20
Sample ID	54SS13D	54SS14	54SS15	54SB01-00	54TW15A-00	54TW19-00	54TW20-00
Sample Date	12/14/00	12/13/00	12/13/00	12/15/00	03/01/02	03/02/02	03/02/02
Sample Depth (ft bgs)	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0
Semivolatile Organic Compounds (ug/kg) (Cont.)							
m-Dichlorobenzene	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
m-Dinitrobenzene	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 UJ	570 UJ
Methapyrilene	820,000 U	740,000 U	740,000 U	720,000 U	72,000 U	110,000 U	120,000 U
Methyl methanesulfonate	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
Naphthalene	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
Nitrobenzene	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
N-Nitrosodiethylamine	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
N-Nitrosodimethylamine	4,000 U	3,700 U	3,600 U	3,500 UJ	350 U	560 U	570 U
N-Nitroso-di-n-butylamine	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 UJ
N-Nitroso-di-n-propylamine	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
N-Nitrosodiphenylamine	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
N-Nitrosomethylethylamine	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
N-Nitrosomorpholine	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 UJ
N-Nitrosopiperidine	4,000 U	3,700 U	3,600 U	3,500 UJ	350 U	560 U	570 U
N-Nitrosopyrrolidine	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 UJ
o-Dichlorobenzene	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
o-Toluidine	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
p-Dichlorobenzene	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
p-Dimethylaminoazobenzene	4,000 U	3,700 U	3,600 U	3,500 U	350 UJ	560 U	570 U
Pentachlorobenzene	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
Pentachloronitrobenzene	4,000 U	3,700 U	3,600 U	3,500 U	350 UJ	560 U	570 U
Pentachlorophenol	21,000 U	19,000 U	19,000 U	18,000 U	1,800 U	2,900 U	2,900 U
Phenacetin	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 UJ
Phenanthrene	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
Phenol	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U

APPENDIX A.1

SUMMARY OF ANALYTICAL RESULTS, SURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation				RCRA Facility Investigation		
Site ID	54SS13	54SS14	54SS15	54TW01	54TW15A	54TW19	54TW20
Sample ID	54SS13D	54SS14	54SS15	54SB01-00	54TW15A-00	54TW19-00	54TW20-00
Sample Date	12/14/00	12/13/00	12/13/00	12/15/00	03/01/02	03/02/02	03/02/02
Sample Depth (ft bgs)	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0	0.0 - 1.0
Semivolatile Organic Compounds (ug/kg) (Cont.)							
Pronamide	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
Pyrene	4,000 U	3,700 U	3,600 U	3,500 U	350 UJ	560 U	570 U
Pyridine	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
Safrole	4,000 U	3,700 U	3,600 U	3,500 U	350 U	560 U	570 U
TPH (mg/kg)							
Diesel Range Organics	23	32	33	3.5 U	NA	NA	NA
Gasoline Range Organics	0.32 U	0.28 UJ	0.27 U	0.27 U	NA	NA	NA

APPENDIX A.2
SWMU 54, Subsurface Soil - Organics

APPENDIX A.2

SUMMARY OF ANALYTICAL RESULTS, SUBSURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation			
Site ID	54TW01	54TW01	54TW02	54TW02
Sample ID	54SB01-05	54SB01-08	54SB02-02	54SB02-06
Sample Date	12/15/00	12/15/00	12/15/00	12/15/00
Sample Depth (ft bgs)	8.0 - 10.0	14.0 -16.0	2.0 - 4.0	10.0 - 12.0
Volatile Organic Compounds (ug/kg)				
1,1,1,2-Tetrachloroethane	6.6 U	6.8 U	6.8 U	6.9 U
1,1,1-Trichloroethane	6.6 U	6.8 U	6.8 U	6.9 U
1,1,2,2-Tetrachloroethane	6.6 U	6.8 U	6.8 U	6.9 U
1,1,2-Trichloroethane	6.6 U	6.8 U	6.8 U	6.9 U
1,1-Dichloroethane	6.6 U	6.8 U	6.8 U	6.9 U
1,1-Dichloroethene	6.6 U	6.8 U	6.8 U	6.9 U
1,2,3-Trichloropropane	6.6 U	6.8 U	6.8 U	6.9 U
1,2-Dibromo-3-chloropropane	13 U	14 U	14 U	14 U
1,2-Dibromoethane	6.6 U	6.8 U	6.8 U	6.9 U
1,2-Dichloroethane	6.6 U	6.8 U	6.8 U	6.9 U
1,2-Dichloropropane	6.6 U	6.8 U	6.8 U	6.9 U
2-Butanone	33 U	34 U	6.2 J	35 U
2-Hexanone	33 U	34 U	34 U	35 U
3-Chloro-1-propene	6.6 U	6.8 U	6.8 U	6.9 U
4-Methyl-2-pentanone	33 U	34 U	34 U	35 U
Acetone	89 J	18 J	130 J	43 J
Acetonitrile	260 U	270 U	270 U	280 U
Acrolein	130 R	140 R	140 R	140 R
Acrylonitrile	130 U	140 U	140 U	140 U
Benzene	6.6 U	6.8 U	6.8 U	6.9 U
Bromodichloromethane	6.6 U	6.8 U	6.8 U	6.9 U
Bromoform	6.6 U	6.8 U	6.8 U	6.9 U
Bromomethane	13 U	14 U	14 U	14 U
Carbon disulfide	6.6 U	6.8 U	6.8 U	6.9 U
Carbon tetrachloride	6.6 U	6.8 U	6.8 U	6.9 U
Chlorobenzene	6.6 U	6.8 U	6.8 U	6.9 U
Chloroethane	13 U	14 U	14 U	14 U
Chloroform	6.6 U	6.8 U	6.8 U	6.9 U
Chloromethane	13 U	14 U	14 U	14 U
Chloroprene	6.6 U	6.8 U	6.8 U	6.9 U
cis-1,3-Dichloropropene	6.6 U	6.8 U	6.8 U	6.9 U
Dibromochloromethane	6.6 U	6.8 U	6.8 U	6.9 U
Dibromomethane	6.6 U	6.8 U	6.8 U	6.9 U
Dichlorodifluoromethane	6.6 U	6.8 U	6.8 U	6.9 U
Ethyl methacrylate	6.6 U	6.8 U	6.8 U	6.9 U
Ethylbenzene	6.6 U	6.8 U	6.8 U	6.9 U
Iodomethane	6.6 U	6.8 U	6.8 U	6.9 U
Isobutanol	260 U	270 U	270 U	280 U
Methacrylonitrile	130 U	140 U	140 U	140 U
Methyl methacrylate	6.6 U	6.8 U	6.8 U	6.9 U
Methylene chloride	6.6 U	6.8 U	6.8 U	6.9 U
Pentachloroethane	33 U	34 U	34 U	35 U
Propionitrile	130 U	140 U	140 U	140 U

APPENDIX A.2

SUMMARY OF ANALYTICAL RESULTS, SUBSURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation			
Site ID	54TW01	54TW01	54TW02	54TW02
Sample ID	54SB01-05	54SB01-08	54SB02-02	54SB02-06
Sample Date	12/15/00	12/15/00	12/15/00	12/15/00
Sample Depth (ft bgs)	8.0 - 10.0	14.0 -16.0	2.0 - 4.0	10.0 - 12.0
Volatile Organic Compounds (ug/kg) (Cont.)				
Styrene	6.6 U	6.8 U	6.8 U	6.9 U
Tetrachloroethene	6.6 U	6.8 U	6.8 U	6.9 U
Toluene	6.6 U	2.8 J	3.6 J	2.6 J
trans-1,2-Dichloroethene	6.6 U	6.8 U	6.8 U	6.9 U
trans-1,3-Dichloropropene	6.6 U	6.8 U	6.8 U	6.9 U
trans-1,4-Dichloro-2-butene	13 U	14 U	14 U	14 U
Trichloroethene	6.6 U	6.8 U	6.8 U	6.9 U
Trichlorofluoromethane	6.6 U	6.8 U	6.8 U	6.9 U
Vinyl acetate	13 U	14 U	14 U	14 U
Vinyl chloride	13 U	14 U	14 U	14 U
Xylenes	13 U	14 U	14 U	14 U
Semivolatile Organic Compounds (ug/kg)				
1,2,4,5-Tetrachlorobenzene	430 U	450 U	440 U	460 U
1,2,4-Trichlorobenzene	430 U	450 U	440 U	460 U
1,3,5-Trinitrobenzene	430 R	450 R	440 R	460 R
1,4-Dioxane	430 U	450 U	440 U	460 U
1,4-Naphthoquinone	430 U	450 U	440 U	460 U
1,4-Phenylenediamine	2,200 UJ	2,300 UJ	2,300 UJ	2,400 UJ
1-Diallate	NA	NA	NA	NA
1-Naphthylamine	430 U	450 U	440 U	460 U
2,3,4,6-Tetrachlorophenol	430 U	450 U	440 U	460 U
2,4,5-Trichlorophenol	430 U	450 U	440 U	460 U
2,4,6-Trichlorophenol	430 U	450 U	440 U	460 U
2,4-Dichlorophenol	430 U	450 U	440 U	460 U
2,4-Dimethylphenol	430 U	450 U	440 U	460 U
2,4-Dinitrophenol	2,200 U	2,300 U	2,300 U	2,400 U
2,4-Dinitrotoluene	430 U	450 U	440 U	460 U
2,6-Dichlorophenol	430 U	450 U	440 U	460 U
2,6-Dinitrotoluene	430 U	450 U	440 U	460 U
2-Acetylaminofluorene	430 U	450 U	440 U	460 U
2-Chloronaphthalene	430 U	450 U	440 U	460 U
2-Chlorophenol	430 U	450 U	440 U	460 U
2-Diallate	NA	NA	NA	NA
2-Methylnaphthalene	430 U	450 U	440 U	460 U
2-Naphthylamine	430 U	450 U	440 U	460 U
2-Nitroaniline	2,200 U	2,300 U	2,300 U	2,400 U
2-Nitrophenol	430 U	450 U	440 U	460 U
2-Picoline	430 U	450 U	440 U	460 U
3,3'-Dichlorobenzidine	870 U	900 U	890 U	920 U
3,3'-Dimethylbenzidine	2,200 U	2,300 U	2,300 U	2,400 U
3-Methylcholanthrene	430 U	450 U	440 U	460 U
3-Nitroaniline	2,200 U	2,300 U	2,300 U	2,400 U

APPENDIX A.2

SUMMARY OF ANALYTICAL RESULTS, SUBSURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation			
Site ID	54TW01	54TW01	54TW02	54TW02
Sample ID	54SB01-05	54SB01-08	54SB02-02	54SB02-06
Sample Date	12/15/00	12/15/00	12/15/00	12/15/00
Sample Depth (ft bgs)	8.0 - 10.0	14.0 -16.0	2.0 - 4.0	10.0 - 12.0
Semivolatile Organic Compounds (ug/kg) (Cont.)				
4,6-Dinitro-2-methylphenol	2,200 U	2,300 U	2,300 U	2,400 U
4-Aminobiphenyl	430 U	450 U	440 U	460 U
4-Bromophenyl phenyl ether	430 U	450 U	440 U	460 U
4-Chloro-3-methylphenol	430 U	450 U	440 U	460 U
4-Chloroaniline	870 U	900 U	890 U	920 U
4-Chlorophenylphenylether	430 U	450 U	440 U	460 U
4-Nitroaniline	2,200 U	2,300 U	2,300 U	2,400 U
4-Nitrophenol	2,200 U	2,300 U	2,300 U	2,400 U
4-Nitroquinoline-1-oxide	4,300 R	4,500 R	4,400 R	4,600 R
5-Nitro-o-toluidine	430 U	450 U	440 U	460 U
7,12-Dimethylbenz(a)anthracene	430 U	450 U	440 U	460 U
Acenaphthene	430 U	450 U	440 U	460 U
Acenaphthylene	430 U	450 U	440 U	460 U
Acetophenone	430 U	450 U	440 U	460 U
alpha,alpha-Dimethylphenethylamine	88,000 U	92,000 U	90,000 U	93,000 U
Aniline	430 U	450 U	440 U	460 U
Anthracene	430 U	450 U	440 U	460 U
Aramite, Total	430 U	450 U	440 U	460 U
Aramite-1	NA	NA	NA	NA
Aramite-2	NA	NA	NA	NA
Benzo(a)anthracene	430 U	450 U	440 U	460 U
Benzo(a)pyrene	430 U	450 U	440 U	460 U
Benzo(b)fluoranthene	430 U	450 U	440 U	460 U
Benzo(g,h,i)perylene	430 U	450 U	440 U	460 U
Benzo(k)fluoranthene	430 U	450 U	440 U	460 U
Benzyl alcohol	430 U	450 U	440 U	460 U
Bis(2-chloroethoxy)methane	430 U	450 U	440 U	460 U
Bis(2-chloroethyl)ether	430 U	450 U	440 U	460 U
bis-(2-chloroisopropyl)ether	430 U	450 U	440 U	460 U
Bis(2-ethylhexyl)phthalate	360 U	430 U	330 U	280 U
Butylbenzylphthalate	430 U	450 U	440 U	460 U
Chrysene	430 U	450 U	440 U	460 U
Cresol (ortho)	430 U	450 U	440 U	460 U
Cresol, m&p	430 U	450 U	440 U	460 U
Diallate, Total	430 U	450 U	440 U	460 U
Dibenzo(a,h)anthracene	430 U	450 U	440 U	460 U
Dibenzofuran	430 U	450 U	440 U	460 U
Diethylphthalate	430 U	450 U	440 U	460 U
Dimethylphthalate	430 U	450 U	440 U	460 U
Di-n-butylphthalate	430 U	57 J	440 U	44 U
Di-n-octyl phthalate	430 U	450 U	440 U	460 U
Dinoseb	430 UJ	450 UJ	440 UJ	460 UJ
Ethyl methanesulfonate	430 U	450 U	440 U	460 U

APPENDIX A.2

SUMMARY OF ANALYTICAL RESULTS, SUBSURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation			
Site ID	54TW01	54TW01	54TW02	54TW02
Sample ID	54SB01-05	54SB01-08	54SB02-02	54SB02-06
Sample Date	12/15/00	12/15/00	12/15/00	12/15/00
Sample Depth (ft bgs)	8.0 - 10.0	14.0 -16.0	2.0 - 4.0	10.0 - 12.0
Semivolatile Organic Compounds (ug/kg) (Cont.)				
Fluoranthene	430 U	450 U	440 U	460 U
Fluorene	430 U	450 U	440 U	460 U
Hexachlorobenzene	430 U	450 U	440 U	460 U
Hexachlorobutadiene	430 U	450 U	440 U	460 U
Hexachlorocyclopentadiene	430 U	450 U	440 U	460 U
Hexachloroethane	430 U	450 U	440 U	460 U
Hexachlorophene	220,000 U	230,000 U	230,000 U	240,000 U
Hexachloropropene	430 U	450 U	440 U	460 U
Indeno(1,2,3-cd)pyrene	430 U	450 U	440 U	460 U
Isophorone	430 U	450 U	440 U	460 U
Isosafrole	430 U	450 U	440 U	460 U
m-Dichlorobenzene	430 U	450 U	440 U	460 U
m-Dinitrobenzene	430 U	450 U	440 U	460 U
Methapyrilene	88,000 U	92,000 U	90,000 U	93,000 U
Methyl methanesulfonate	430 U	450 U	440 U	460 U
Naphthalene	430 U	450 U	440 U	460 U
Nitrobenzene	430 U	450 U	440 U	460 U
N-Nitrosodiethylamine	430 U	450 U	440 U	460 U
N-Nitrosodimethylamine	430 UJ	450 UJ	440 UJ	460 UJ
N-Nitroso-di-n-butylamine	430 U	450 U	440 U	460 U
N-Nitroso-di-n-propylamine	430 U	450 U	440 U	460 U
N-Nitrosodiphenylamine	430 U	450 U	440 U	460 U
N-Nitrosomethylethylamine	430 U	450 U	440 U	460 U
N-Nitrosomorpholine	430 U	450 U	440 U	460 U
N-Nitrosopiperidine	430 UJ	450 UJ	440 UJ	460 UJ
N-Nitrosopyrrolidine	430 U	450 U	440 U	460 U
o-Dichlorobenzene	430 U	450 U	440 U	460 U
o-Toluidine	430 U	450 U	440 U	460 U
p-Cresol	NA	NA	NA	NA
p-Dichlorobenzene	430 U	450 U	440 U	460 U
p-Dimethylaminoazobenzene	430 U	450 U	440 U	460 U
Pentachlorobenzene	430 U	450 U	440 U	460 U
Pentachloronitrobenzene	430 U	450 U	440 U	460 U
Pentachlorophenol	2,200 U	2,300 U	2,300 U	2,400 U
Phenacetin	430 U	450 U	440 U	460 U
Phenanthrene	430 U	450 U	440 U	460 U
Phenol	430 U	450 U	440 U	460 U
Pronamide	430 U	450 U	440 U	460 U
Pyrene	430 U	450 U	440 U	460 U
Pyridine	430 U	450 U	440 U	460 U
Safrole	430 U	450 U	440 U	460 U

APPENDIX A.2

SUMMARY OF ANALYTICAL RESULTS, SUBSURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Investigation			
Site ID	54TW01	54TW01	54TW02	54TW02
Sample ID	54SB01-05	54SB01-08	54SB02-02	54SB02-06
Sample Date	12/15/00	12/15/00	12/15/00	12/15/00
Sample Depth (ft bgs)	8.0 - 10.0	14.0 -16.0	2.0 - 4.0	10.0 - 12.0
TPH (mg/kg)				
Diesel Range Organics	4.3 U	5.6 U	4.6 U	4.6 U
Gasoline Range Organics	0.33 U	0.35 U	0.34 U	0.36 U

APPENDIX A.2

SUMMARY OF ANALYTICAL RESULTS, SUBSURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation				
Site ID	54TW15A	54TW15A	54TW15A	54TW19	54TW20
Sample ID	54TW15A-02	54TW15A-02D	54TW15A-04	54TW19-05	54TW20-04
Sample Date	03/01/02	03/01/02	03/01/02	03/02/02	03/02/02
Sample Depth (ft bgs)	4.0 - 6.0	4.0 - 6.0	9.0 - 11.0	10.0 - 11.4	8.0 - 9.0
Volatile Organic Compounds (ug/kg)					
1,1,1,2-Tetrachloroethane	7.6 U	7.6 U	260 U	8 U	280 U
1,1,1-Trichloroethane	7.6 U	7.6 U	260 U	8 U	280 U
1,1,2,2-Tetrachloroethane	7.6 U	7.6 U	210 J	8 U	280 U
1,1,2-Trichloroethane	7.6 U	7.6 U	260 U	8 U	280 U
1,1-Dichloroethane	7.6 U	7.6 U	260 U	8 U	280 U
1,1-Dichloroethene	7.6 U	7.6 U	140 J	8 U	280 U
1,2,3-Trichloropropane	7.6 U	7.6 U	260 U	8 U	280 U
1,2-Dibromo-3-chloropropane	15 U	15 U	610	16 U	560 U
1,2-Dibromoethane	7.6 U	7.6 U	260 U	8 U	280 U
1,2-Dichloroethane	7.6 U	7.6 U	260 U	8 U	280 U
1,2-Dichloropropane	7.6 U	7.6 U	260 U	8 U	280 U
2-Butanone	38 U	38 U	1,500	40 U	1,400 U
2-Hexanone	38 U	38 U	1,700	40 U	1,400 U
3-Chloro-1-propene	7.6 UJ	7.6 UJ	260 U	8 UJ	280 U
4-Methyl-2-pentanone	38 U	38 U	1,300 U	40 U	1,400 U
Acetone	76 U	76 U	2,900 J	80 U	1,400 J
Acetonitrile	300 UJ	300 UJ	10,000 R	320 UJ	11,000 R
Acrolein	150 U	150 U	5,200 R	160 U	5,600 R
Acrylonitrile	150 U	150 U	5,200 U	160 U	5,600 U
Benzene	7.6 U	7.6 U	260 U	8 U	280 U
Bromodichloromethane	7.6 U	7.6 U	260 U	8 U	280 U
Bromoform	7.6 U	7.6 U	260 U	8 U	280 U
Bromomethane	15 U	15 U	520 UJ	16 U	560 UJ
Carbon disulfide	7.6 UJ	7.6 UJ	260 U	8 UJ	280 U
Carbon tetrachloride	7.6 U	7.6 U	110 J	8 U	280 U
Chlorobenzene	7.6 U	7.6 U	110 J	8 U	280 U
Chloroethane	15 U	15 U	520 U	16 U	560 U
Chloroform	7.6 U	7.6 U	260 U	8 U	280 U
Chloromethane	15 U	15 U	520 U	16 U	560 U
Chloroprene	7.6 U	7.6 U	260 U	8 U	280 U
cis-1,3-Dichloropropene	7.6 U	7.6 U	260 U	8 U	280 U
Dibromochloromethane	7.6 U	7.6 U	260 U	8 U	280 U
Dibromomethane	7.6 U	7.6 U	260 U	8 U	280 U
Dichlorodifluoromethane	7.6 U	7.6 U	260 U	8 U	280 U
Ethyl methacrylate	7.6 U	7.6 U	260 U	8 U	280 U
Ethylbenzene	7.6 U	7.6 U	190 J	8 U	280 U
Iodomethane	7.6 U	7.6 U	260 U	8 U	280 U
Isobutanol	300 R	300 R	10,000 R	320 R	11,000 R
Methacrylonitrile	150 U	150 U	5,200 U	160 U	5,600 U
Methyl methacrylate	7.6 U	7.6 U	260 U	8 U	280 U
Methylene chloride	7.6 U	7.6 U	260 U	8 U	280 U
Pentachloroethane	38 UJ	38 UJ	1,300 R	40 UJ	1,400 R
Propionitrile	150 U	150 U	5,200 U	160 U	5,600 U

APPENDIX A.2

SUMMARY OF ANALYTICAL RESULTS, SUBSURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation				
Site ID	54TW15A	54TW15A	54TW15A	54TW19	54TW20
Sample ID	54TW15A-02	54TW15A-02D	54TW15A-04	54TW19-05	54TW20-04
Sample Date	03/01/02	03/01/02	03/01/02	03/02/02	03/02/02
Sample Depth (ft bgs)	4.0 - 6.0	4.0 - 6.0	9.0 - 11.0	10.0 - 11.4	8.0 - 9.0
Volatile Organic Compounds (ug/kg) (Cont.)					
Styrene	7.6 U	7.6 U	100 J	8 U	280 U
Tetrachloroethene	7.6 U	7.6 U	260 U	8 U	280 U
Toluene	7.6 U	7.6 U	260 U	8 U	280 U
trans-1,2-Dichloroethene	7.6 U	7.6 U	260 U	8 U	280 U
trans-1,3-Dichloropropene	7.6 U	7.6 U	260 U	8 U	280 U
trans-1,4-Dichloro-2-butene	15 U	15 U	520 U	16 U	560 U
Trichloroethene	7.6 U	7.6 U	130 J	8 U	280 U
Trichlorofluoromethane	7.6 U	7.6 U	160 J	8 U	280 U
Vinyl acetate	15 U	15 U	520 U	16 U	560 U
Vinyl chloride	15 U	15 U	520 U	16 U	560 U
Xylenes	7.6 U	7.6 U	640	8 U	560 U
Semivolatile Organic Compounds (ug/kg)					
1,2,4,5-Tetrachlorobenzene	520 U	530 U	430 U	540 U	480 U
1,2,4-Trichlorobenzene	520 U	530 U	430 U	540 U	480 U
1,3,5-Trinitrobenzene	520 UJ	530 UJ	430 UJ	540 UJ	480 UJ
1,4-Dioxane	520 U	530 U	430 U	540 U	480 UJ
1,4-Naphthoquinone	520 U	530 U	430 U	540 U	480 U
1,4-Phenylenediamine	2,700 R	2,700 R	2,200 R	2,800 R	2,500 R
1-Diallate	520 U	530 U	430 U	540 U	480 U
1-Naphthylamine	520 U	530 U	430 U	540 U	480 U
2,3,4,6-Tetrachlorophenol	520 U	530 U	430 U	540 U	480 U
2,4,5-Trichlorophenol	520 U	530 U	430 U	540 U	480 U
2,4,6-Trichlorophenol	520 U	530 U	430 U	540 U	480 U
2,4-Dichlorophenol	520 U	530 U	430 U	540 U	480 U
2,4-Dimethylphenol	520 U	530 U	68 J	540 U	480 U
2,4-Dinitrophenol	2,700 U	2,700 U	2,200 U	2,800 UJ	2,500 UJ
2,4-Dinitrotoluene	520 U	530 U	430 U	540 U	480 U
2,6-Dichlorophenol	520 U	530 U	430 U	540 UJ	480 UJ
2,6-Dinitrotoluene	520 U	530 U	430 U	540 U	480 U
2-Acetylaminofluorene	520 U	530 U	430 U	540 UJ	480 UJ
2-Chloronaphthalene	520 U	530 U	430 U	540 U	480 U
2-Chlorophenol	520 U	530 U	430 U	540 U	480 U
2-Diallate	520 U	530 U	430 U	540 U	480 U
2-Methylnaphthalene	520 U	530 U	430 U	540 U	480 U
2-Naphthylamine	520 U	530 U	430 U	540 UJ	480 UJ
2-Nitroaniline	2,700 U	2,700 U	2,200 U	2,800 U	2,500 U
2-Nitrophenol	520 U	530 U	430 U	540 U	480 U
2-Picoline	520 U	530 U	430 U	540 U	480 U
3,3'-Dichlorobenzidine	1,000 U	1,100 U	860 U	1,100 U	970 U
3,3'-Dimethylbenzidine	2,700 U	2,700 U	2,200 U	2,800 U	2,500 UJ
3-Methylcholanthrene	520 U	530 U	430 U	540 U	480 U
3-Nitroaniline	2,700 U	2,700 U	2,200 U	2,800 U	2,500 U

APPENDIX A.2

SUMMARY OF ANALYTICAL RESULTS, SUBSURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation				
Site ID	54TW15A	54TW15A	54TW15A	54TW19	54TW20
Sample ID	54TW15A-02	54TW15A-02D	54TW15A-04	54TW19-05	54TW20-04
Sample Date	03/01/02	03/01/02	03/01/02	03/02/02	03/02/02
Sample Depth (ft bgs)	4.0 - 6.0	4.0 - 6.0	9.0 - 11.0	10.0 - 11.4	8.0 - 9.0
Semivolatile Organic Compounds (ug/kg) (Cont.)					
4,6-Dinitro-2-methylphenol	2,700 U	2,700 U	2,200 U	2,800 UJ	2,500 UJ
4-Aminobiphenyl	520 U	530 U	430 U	540 U	480 U
4-Bromophenyl phenyl ether	520 U	530 U	430 U	540 U	480 U
4-Chloro-3-methylphenol	520 U	530 U	430 U	540 U	480 U
4-Chloroaniline	1,000 U	1,100 U	860 U	1,100 U	970 U
4-Chlorophenylphenylether	520 U	530 U	430 U	540 U	480 U
4-Nitroaniline	2,700 U	2,700 U	2,200 U	2,800 U	2,500 U
4-Nitrophenol	2,700 U	2,700 U	2,200 U	2,800 U	2,500 U
4-Nitroquinoline-1-oxide	5,200 R	5,300 R	4,300 R	5,400 R	4,800 R
5-Nitro-o-toluidine	520 UJ	530 UJ	430 UJ	540 UJ	480 UJ
7,12-Dimethylbenz(a)anthracene	520 U	530 U	430 U	540 U	480 U
Acenaphthene	520 U	530 U	430 U	540 U	480 U
Acenaphthylene	520 U	530 U	430 U	540 U	480 U
Acetophenone	520 U	530 U	430 U	540 U	480 U
alpha,alpha-Dimethylphenethylamine	110,000 UJ	110,000 UJ	87,000 UJ	110,000 UJ	98,000 UJ
Aniline	520 U	530 U	430 U	540 U	480 U
Anthracene	520 U	530 U	430 U	540 U	480 U
Aramite, Total	520 U	530 U	430 U	540 U	480 U
Aramite-1	520 U	530 U	430 U	540 U	480 U
Aramite-2	520 U	530 U	430 U	540 U	480 U
Benzo(a)anthracene	520 U	530 U	430 U	540 U	480 U
Benzo(a)pyrene	520 U	530 U	430 U	540 U	480 UJ
Benzo(b)fluoranthene	520 U	530 U	430 U	540 U	480 UJ
Benzo(g,h,i)perylene	520 U	530 U	430 U	540 U	480 UJ
Benzo(k)fluoranthene	520 U	530 U	430 U	540 U	480 UJ
Benzyl alcohol	520 U	530 U	430 U	540 U	480 U
Bis(2-chloroethoxy)methane	520 U	530 U	430 U	540 U	480 U
Bis(2-chloroethyl)ether	520 U	530 U	430 U	540 U	480 U
bis-(2-chloroisopropyl)ether	520 U	530 U	430 U	540 U	480 U
Bis(2-ethylhexyl)phthalate	520 U	530 U	430 U	540 U	480 UJ
Butylbenzylphthalate	520 U	530 U	430 U	540 U	480 U
Chrysene	520 U	530 U	430 U	540 U	480 UJ
Cresol (ortho)	520 U	530 U	430 U	540 U	480 U
Cresol, m&p	520 U	530 U	430 U	540 U	480 U
Diallate, Total	520 U	530 U	430 U	540 U	480 U
Dibenzo(a,h)anthracene	520 U	530 U	430 U	540 U	480 UJ
Dibenzofuran	520 U	530 U	430 U	540 U	480 U
Diethylphthalate	520 U	530 U	430 U	540 U	480 U
Dimethylphthalate	520 U	530 U	430 U	540 U	480 U
Di-n-butylphthalate	520 U	530 U	430 U	540 U	480 U
Di-n-octyl phthalate	520 U	530 U	430 U	540 U	480 UJ
Dinoseb	520 UJ	530 UJ	430 UJ	540 UJ	480 UJ
Ethyl methanesulfonate	520 U	530 U	430 U	540 U	480 U

APPENDIX A.2

SUMMARY OF ANALYTICAL RESULTS, SUBSURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation				
Site ID	54TW15A	54TW15A	54TW15A	54TW19	54TW20
Sample ID	54TW15A-02	54TW15A-02D	54TW15A-04	54TW19-05	54TW20-04
Sample Date	03/01/02	03/01/02	03/01/02	03/02/02	03/02/02
Sample Depth (ft bgs)	4.0 - 6.0	4.0 - 6.0	9.0 - 11.0	10.0 - 11.4	8.0 - 9.0
Semivolatile Organic Compounds (ug/kg) (Cont.)					
Fluoranthene	520 U	530 U	430 U	540 U	480 U
Fluorene	520 U	530 U	430 U	540 U	480 U
Hexachlorobenzene	520 U	530 U	430 U	540 U	480 U
Hexachlorobutadiene	520 U	530 U	430 U	540 U	480 U
Hexachlorocyclopentadiene	520 U	530 U	430 U	540 U	480 U
Hexachloroethane	520 U	530 U	430 U	540 U	480 U
Hexachlorophene	270,000 U	270,000 U	220,000 U	280,000 UJ	250,000 UJ
Hexachloropropene	520 UJ	530 UJ	430 UJ	540 U	480 U
Indeno(1,2,3-cd)pyrene	520 U	530 U	430 U	540 U	480 UJ
Isophorone	520 U	530 U	430 U	540 U	480 U
Isosafrole	520 U	530 U	430 U	540 UJ	480 UJ
m-Dichlorobenzene	520 U	530 U	430 U	540 U	480 U
m-Dinitrobenzene	520 UJ	530 UJ	430 UJ	540 UJ	480 UJ
Methapyrilene	110,000 U	110,000 U	87,000 U	110,000 U	98,000 U
Methyl methanesulfonate	520 U	530 U	430 U	540 U	480 U
Naphthalene	520 U	530 U	430 U	540 U	480 U
Nitrobenzene	520 U	530 U	430 U	540 U	480 U
N-Nitrosodiethylamine	520 U	530 U	430 U	540 U	480 U
N-Nitrosodimethylamine	520 U	530 U	430 U	540 U	480 UJ
N-Nitroso-di-n-butylamine	520 U	530 U	430 U	540 UJ	480 UJ
N-Nitroso-di-n-propylamine	520 U	530 U	430 U	540 U	480 U
N-Nitrosodiphenylamine	520 U	530 U	430 U	540 U	480 U
N-Nitrosomethylethylamine	520 U	530 U	430 U	540 U	480 U
N-Nitrosomorpholine	520 U	530 U	430 U	540 UJ	480 UJ
N-Nitrosopiperidine	520 U	530 U	430 U	540 U	480 U
N-Nitrosopyrrolidine	520 U	530 U	430 U	540 UJ	480 UJ
o-Dichlorobenzene	520 U	530 U	430 U	540 U	480 U
o-Toluidine	520 U	530 U	430 U	540 U	480 U
p-Cresol	NA	NA	NA	NA	480 U
p-Dichlorobenzene	520 U	530 U	430 U	540 U	480 U
p-Dimethylaminoazobenzene	520 U	530 U	430 U	540 U	480 U
Pentachlorobenzene	520 U	530 U	430 U	540 U	480 U
Pentachloronitrobenzene	520 U	530 U	430 U	540 U	480 U
Pentachlorophenol	2,700 U	2,700 U	2,200 U	2,800 U	2,500 U
Phenacetin	520 U	530 U	430 U	540 UJ	480 UJ
Phenanthrene	520 U	530 U	430 U	540 U	480 U
Phenol	520 U	530 U	430 U	540 U	480 U
Pronamide	520 U	530 U	430 U	540 U	480 U
Pyrene	520 U	530 U	430 U	540 U	480 U
Pyridine	520 U	530 U	430 U	540 U	480 UJ
Safrole	520 U	530 U	430 U	540 U	480 U

APPENDIX A.2

SUMMARY OF ANALYTICAL RESULTS, SUBSURFACE SOIL - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation				
Site ID	54TW15A	54TW15A	54TW15A	54TW19	54TW20
Sample ID	54TW15A-02	54TW15A-02D	54TW15A-04	54TW19-05	54TW20-04
Sample Date	03/01/02	03/01/02	03/01/02	03/02/02	03/02/02
Sample Depth (ft bgs)	4.0 - 6.0	4.0 - 6.0	9.0 - 11.0	10.0 - 11.4	8.0 - 9.0
TPH (mg/kg)					
Diesel Range Organics	NA	NA	NA	NA	NA
Gasoline Range Organics	NA	NA	NA	NA	NA

APPENDIX A.3
SWMU 54, Groundwater - Organics

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Plan							
Site ID	510DW1	510DW2	510MW1	510MW2	510MW2	510MW3	510MW4	510MW5
Sample ID	510DW1	510DW2	510MW1	510MW2	510MW2D	510MW3	510MW4	510MW5
Sample Date	12/19/00	12/19/00	12/15/00	12/19/00	12/19/00	12/18/00	12/18/00	12/21/00
Volatile Organic Compounds (ug/L)								
1,1,1,2-Tetrachloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1,1-Trichloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1,2,2-Tetrachloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1,2-Trichloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1-Dichloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1-Dichloroethene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	0.61 J
1,2,3-Trichloropropane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,2-Dibromo-3-chloropropane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,2-Dibromoethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,2-Dichloroethane	5 U	3 J	5 U	5 U	5 U	0.86 J	5 U	5 U
1,2-Dichloropropane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
2-Butanone	26	25 U	25 U	25 U	25 U	25 U	25 U	25 U
2-Hexanone	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
3-Chloro-1-propene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
4-Methyl-2-pentanone	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
Acetone	40 J	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Acetonitrile	200 U	200 U	200 U	200 U	200 U	200 U	200 U	200 U
Acrolein	100 R	100 R	100 R	100 R	100 R	100 R	100 R	100 R
Acrylonitrile	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U
Benzene	91	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Bromodichloromethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Bromoform	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Bromomethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Carbon disulfide	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Carbon tetrachloride	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Chlorobenzene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Chloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chloroform	5 U	1.2 J	5 U	5 U	5 U	5.8	5 U	1.4 J
Chloromethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Plan							
Site ID	510DW1	510DW2	510MW1	510MW2	510MW2	510MW3	510MW4	510MW5
Sample ID	510DW1	510DW2	510MW1	510MW2	510MW2D	510MW3	510MW4	510MW5
Sample Date	12/19/00	12/19/00	12/15/00	12/19/00	12/19/00	12/18/00	12/18/00	12/21/00
Volatile Organic Compounds (ug/L) (Cont.)								
Chloroprene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
cis-1,3-Dichloropropene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Dibromochloromethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Dibromomethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Dichlorodifluoromethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Ethyl methacrylate	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Ethylbenzene	32	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Iodomethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Isobutanol	2,900 J	200 R	200 R	200 R	200 R	200 R	200 R	200 R
Methacrylonitrile	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U
Methyl methacrylate	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Methylene chloride	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Pentachloroethane	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
Propionitrile	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U
Styrene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Tetrachloroethene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Toluene	3.7 J	5 U	5 U	5 U	5 U	5 U	5 U	5 U
trans-1,2-Dichloroethene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
trans-1,3-Dichloropropene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
trans-1,4-Dichloro-2-butene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Trichloroethene	5 U	1.1 J	5 U	5 U	5 U	5.9	5 U	230 D
Trichlorofluoromethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Vinyl acetate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Vinyl chloride	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Xylenes	19	10 U	10 U	10 U	10 U	10 U	10 U	10 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Plan							
Site ID	510DW1	510DW2	510MW1	510MW2	510MW2	510MW3	510MW4	510MW5
Sample ID	510DW1	510DW2	510MW1	510MW2	510MW2D	510MW3	510MW4	510MW5
Sample Date	12/19/00	12/19/00	12/15/00	12/19/00	12/19/00	12/18/00	12/18/00	12/21/00
Semivolatile Organic Compounds (ug/L)								
1,2,4,5-Tetrachlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2,4-Trichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,3,5-Trinitrobenzene	10 U	10 U	10 R	10 R	10 R	10 U	10 U	10 U
1,4-Dioxane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,4-Naphthoquinone	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,4-Phenylenediamine	2,000 U	2,000 U	2,000 UJ	2,000 UJ	2,000 UJ	2,000 U	2,000 U	2,000 U
1-Diallate	NA	NA	NA	NA	NA	NA	NA	NA
1-Naphthylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,3,4,6-Tetrachlorophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,4,5-Trichlorophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,4,6-Trichlorophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dichlorophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dimethylphenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dinitrophenol	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
2,4-Dinitrotoluene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,6-Dichlorophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,6-Dinitrotoluene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Acetylaminofluorene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Chloronaphthalene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Chlorophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Diallate	NA	NA	NA	NA	NA	NA	NA	NA
2-Methylnaphthalene	0.4 J	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Naphthylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Nitroaniline	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
2-Nitrophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Picoline	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
3,3'-Dichlorobenzidine	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
3,3'-Dimethylbenzidine	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
3-Methylcholanthrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Plan							
Site ID	510DW1	510DW2	510MW1	510MW2	510MW2	510MW3	510MW4	510MW5
Sample ID	510DW1	510DW2	510MW1	510MW2	510MW2D	510MW3	510MW4	510MW5
Sample Date	12/19/00	12/19/00	12/15/00	12/19/00	12/19/00	12/18/00	12/18/00	12/21/00
Semivolatile Organic Compounds (ug/L) (Cont.)								
3-Nitroaniline	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
4,6-Dinitro-2-methylphenol	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
4-Aminobiphenyl	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Bromophenyl phenyl ether	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Chloro-3-methylphenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Chloroaniline	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
4-Chlorophenylphenylether	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Nitroaniline	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
4-Nitrophenol	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
4-Nitroquinoline-1-oxide	20 R	20 R	20 R	20 R	20 R	20 R	20 R	20 R
5-Nitro-o-toluidine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
7,12-Dimethylbenz(a)anthracene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Acenaphthene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Acenaphthylene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Acetophenone	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
alpha,alpha-Dimethylphenethylamine	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U
Aniline	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
Anthracene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Aramite, Total	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Aramite-1	NA	NA	NA	NA	NA	NA	NA	NA
Aramite-2	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)anthracene	10 U	10 U	0.95 J	10 U	0.86 J	10 U	10 U	10 U
Benzo(a)pyrene	10 U	10 U	2 J	1 J	1 J	10 U	10 U	10 U
Benzo(b)fluoranthene	10 U	10 U	1.7 J	0.73 J	0.76 J	10 U	10 U	10 U
Benzo(g,h,i)perylene	10 U	10 U	2.9 J	1.6 J	1.5 J	10 U	10 U	10 U
Benzo(k)fluoranthene	10 U	10 U	1.5 J	1 J	1.1 J	10 U	10 U	10 U
Benzyl alcohol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bis(2-chloroethoxy)methane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bis(2-chloroethyl)ether	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Plan							
Site ID	510DW1	510DW2	510MW1	510MW2	510MW2	510MW3	510MW4	510MW5
Sample ID	510DW1	510DW2	510MW1	510MW2	510MW2D	510MW3	510MW4	510MW5
Sample Date	12/19/00	12/19/00	12/15/00	12/19/00	12/19/00	12/18/00	12/18/00	12/21/00
Semivolatile Organic Compounds (ug/L) (Cont.)								
bis-(2-chloroisopropyl)ether	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bis(2-ethylhexyl)phthalate	3.9 J	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Butylbenzylphthalate	10 U	10 U	0.77 J	10 U	10 U	10 U	10 U	10 U
Chrysene	10 U	10 U	1.5 J	10 U	1.2 J	10 U	10 U	10 U
Cresol (ortho)	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Cresol, m&p	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Diallate, Total	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Dibenzo(a,h)anthracene	10 U	10 U	2.7 J	1.2 J	1 J	10 U	10 U	10 U
Dibenzofuran	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Diethylphthalate	0.6 J	10 U	10 U	10 U	10 U	0.52 J	10 U	10 U
Dimethylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Di-n-butylphthalate	0.48 U	0.79 U	10 U	10 U	10 U	0.42 U	0.47 U	0.34 U
Di-n-octyl phthalate	10 U	10 U	0.89 J	0.68 J	0.87 J	10 U	10 U	10 U
Dinoseb	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U
Ethyl methanesulfonate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Fluoranthene	10 U	10 U	10 U	10 U	0.44 J	10 U	10 U	2.4 J
Fluorene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorobutadiene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorocyclopentadiene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorophene	5,000 U	5,000 U	5,000 U	5,000 U	5,000 U	5,000 U	5,000 U	5,000 U
Hexachloropropene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Indeno(1,2,3-cd)pyrene	10 U	10 U	2.5 J	1.3 J	1.2 J	10 U	10 U	10 U
Isophorone	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Isosafrole	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
m-Dichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
m-Dinitrobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Methapyrilene	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Plan							
Site ID	510DW1	510DW2	510MW1	510MW2	510MW2	510MW3	510MW4	510MW5
Sample ID	510DW1	510DW2	510MW1	510MW2	510MW2D	510MW3	510MW4	510MW5
Sample Date	12/19/00	12/19/00	12/15/00	12/19/00	12/19/00	12/18/00	12/18/00	12/21/00
Semivolatile Organic Compounds (ug/L) (Cont.)								
Methyl methanesulfonate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Naphthalene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Nitrobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosodiethylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosodimethylamine	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U
N-Nitroso-di-n-butylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitroso-di-n-propylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosodiphenylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosomethylethylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosomorpholine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosopiperidine	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U
N-Nitrosopyrrolidine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
o-Dichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
o-Toluidine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
p-Dichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
p-Dimethylaminoazobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pentachlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pentachloronitrobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pentachlorophenol	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Phenacetin	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Phenanthrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Phenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pronamide	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pyrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pyridine	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Safrole	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Plan							
Site ID	510DW1	510DW2	510MW1	510MW2	510MW2	510MW3	510MW4	510MW5
Sample ID	510DW1	510DW2	510MW1	510MW2	510MW2D	510MW3	510MW4	510MW5
Sample Date	12/19/00	12/19/00	12/15/00	12/19/00	12/19/00	12/18/00	12/18/00	12/21/00
TPH (mg/L)								
Diesel Range Organics	1.2	0.59	0.33	0.2	0.21	0.37	0.84	0.1 U
Gasoline Range Organics	0.84	0.05 U	0.036 J	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Plan		RCRA Facility Investigation					
Site ID	54TW01	54TW02	510DW1	510DW1	510DW2	510MW1	510MW2	510MW3
Sample ID	54TW01	54TW02	510DW1	510DW1D	510DW2	510MW1	510MW2	510MW3
Sample Date	12/20/00	12/19/00	02/27/02	02/27/02	02/27/02	02/26/02	02/27/02	02/13/02
Volatile Organic Compounds (ug/L)								
1,1,1,2-Tetrachloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1,1-Trichloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1,2,2-Tetrachloroethane	5 U	5 U	5 UJ	5 UJ	5 UJ	5 UJ	5 UJ	5 U
1,1,2-Trichloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1-Dichloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1-Dichloroethene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	1.5 J
1,2,3-Trichloropropane	5 U	5 U	5 UJ	5 UJ	5 UJ	5 UJ	5 UJ	5 U
1,2-Dibromo-3-chloropropane	5 U	5 U	5 UJ	5 UJ	5 UJ	5 UJ	5 UJ	5 U
1,2-Dibromoethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,2-Dichloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,2-Dichloropropane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
2-Butanone	25 U	25 U	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	12 U
2-Hexanone	25 U	25 U	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 U
3-Chloro-1-propene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
4-Methyl-2-pentanone	25 U	25 U	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 U
Acetone	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Acetonitrile	200 U	200 U	200 UJ	200 UJ	200 UJ	200 UJ	200 UJ	200 U
Acrolein	100 R	100 R	100 R	100 R	100 R	100 R	100 R	100 R
Acrylonitrile	100 U	100 U	100 UJ	100 UJ	100 UJ	100 UJ	100 UJ	100 U
Benzene	5 U	5 U	92	91	5 U	5 U	5 U	5 U
Bromodichloromethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Bromoform	5 U	5 U	5 UJ	5 UJ	5 UJ	5 UJ	5 UJ	5 U
Bromomethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Carbon disulfide	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Carbon tetrachloride	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Chlorobenzene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	2 J
Chloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chloroform	5 U	5 U	7.8	7.1	5 U	5 U	5 U	5 U
Chloromethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Plan		RCRA Facility Investigation					
Site ID	54TW01	54TW02	510DW1	510DW1	510DW2	510MW1	510MW2	510MW3
Sample ID	54TW01	54TW02	510DW1	510DW1D	510DW2	510MW1	510MW2	510MW3
Sample Date	12/20/00	12/19/00	02/27/02	02/27/02	02/27/02	02/26/02	02/27/02	02/13/02
Volatile Organic Compounds (ug/L) (Cont.)								
Chloroprene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
cis-1,3-Dichloropropene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Dibromochloromethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Dibromomethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Dichlorodifluoromethane	5 U	5 U	10 U	10 U	10 U	10 U	10 U	10 U
Ethyl methacrylate	5 U	5 U	5 UJ	5 UJ	5 UJ	5 UJ	5 UJ	5 U
Ethylbenzene	5 U	5 U	64	62	5 U	5 U	5 U	5 U
Iodomethane	5 U	5 U	5 UJ	5 UJ	5 UJ	5 UJ	5 UJ	5 U
Isobutanol	200 R	200 R	200 R	200 R	200 R	200 R	200 R	200 R
Methacrylonitrile	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U
Methyl methacrylate	5 U	5 U	5 UJ	5 UJ	5 UJ	5 UJ	5 UJ	5 U
Methylene chloride	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Pentachloroethane	25 U	25 U	25 R	25 R	25 R	25 R	25 R	25 R
Propionitrile	100 U	100 U	100 UJ	100 UJ	100 UJ	100 UJ	100 UJ	100 U
Styrene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Tetrachloroethene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Toluene	5 U	5 U	5.4	5.3	5 U	5 U	0.56 J	2.5 J
trans-1,2-Dichloroethene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
trans-1,3-Dichloropropene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
trans-1,4-Dichloro-2-butene	10 U	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U
Trichloroethene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	2.8 J
Trichlorofluoromethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Vinyl acetate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Vinyl chloride	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Xylenes	10 U	10 U	14	14	10 U	10 U	10 U	10 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Plan		RCRA Facility Investigation					
Site ID	54TW01	54TW02	510DW1	510DW1	510DW2	510MW1	510MW2	510MW3
Sample ID	54TW01	54TW02	510DW1	510DW1D	510DW2	510MW1	510MW2	510MW3
Sample Date	12/20/00	12/19/00	02/27/02	02/27/02	02/27/02	02/26/02	02/27/02	02/13/02
Semivolatile Organic Compounds (ug/L)								
1,2,4,5-Tetrachlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2,4-Trichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,3,5-Trinitrobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,4-Dioxane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,4-Naphthoquinone	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,4-Phenylenediamine	2,000 U	2,000 U	2,000 R	2,000 R	2,000 R	2,000 R	2,000 R	2,000 U
1-Diallate	NA	NA	10 U	10 U	10 U	10 U	10 U	10 U
1-Naphthylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,3,4,6-Tetrachlorophenol	10 U	10 U	10 UJ	10 UJ	10 U	10 UJ	10 U	10 U
2,4,5-Trichlorophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,4,6-Trichlorophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dichlorophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dimethylphenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dinitrophenol	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
2,4-Dinitrotoluene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,6-Dichlorophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,6-Dinitrotoluene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Acetylaminofluorene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Chloronaphthalene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Chlorophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Diallate	NA	NA	10 R	10 R	10 R	10 R	10 R	10 U
2-Methylnaphthalene	10 U	10 U	0.51 J	10 U	10 U	10 U	10 U	10 U
2-Naphthylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Nitroaniline	50 U	50 U	50 UJ	50 UJ	50 U	50 UJ	50 U	50 U
2-Nitrophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Picoline	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
3,3'-Dichlorobenzidine	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
3,3'-Dimethylbenzidine	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
3-Methylcholanthrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Plan		RCRA Facility Investigation					
Site ID	54TW01	54TW02	510DW1	510DW1	510DW2	510MW1	510MW2	510MW3
Sample ID	54TW01	54TW02	510DW1	510DW1D	510DW2	510MW1	510MW2	510MW3
Sample Date	12/20/00	12/19/00	02/27/02	02/27/02	02/27/02	02/26/02	02/27/02	02/13/02
Semivolatile Organic Compounds (ug/L) (Cont.)								
3-Nitroaniline	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
4,6-Dinitro-2-methylphenol	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
4-Aminobiphenyl	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Bromophenyl phenyl ether	10 U	2.2 J	10 U	10 U	10 U	10 U	10 U	10 U
4-Chloro-3-methylphenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Chloroaniline	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
4-Chlorophenylphenylether	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Nitroaniline	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
4-Nitrophenol	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
4-Nitroquinoline-1-oxide	20 R	20 R	20 R	20 R	20 R	20 R	20 R	20 R
5-Nitro-o-toluidine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
7,12-Dimethylbenz(a)anthracene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Acenaphthene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Acenaphthylene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Acetophenone	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
alpha,alpha-Dimethylphenethylamine	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U
Aniline	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
Anthracene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Aramite, Total	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Aramite-1	NA	NA	10 U	10 U	10 U	10 U	10 U	10 U
Aramite-2	NA	NA	10 UJ	10 UJ	10 U	10 UJ	10 U	10 U
Benzo(a)anthracene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(a)pyrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(b)fluoranthene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(g,h,i)perylene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(k)fluoranthene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzyl alcohol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bis(2-chloroethoxy)methane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bis(2-chloroethyl)ether	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Plan		RCRA Facility Investigation					
Site ID	54TW01	54TW02	510DW1	510DW1	510DW2	510MW1	510MW2	510MW3
Sample ID	54TW01	54TW02	510DW1	510DW1D	510DW2	510MW1	510MW2	510MW3
Sample Date	12/20/00	12/19/00	02/27/02	02/27/02	02/27/02	02/26/02	02/27/02	02/13/02
Semivolatile Organic Compounds (ug/L) (Cont.)								
bis-(2-chloroisopropyl)ether	10 U	10 U	10 UJ	10 UJ	10 U	10 UJ	10 U	10 U
Bis(2-ethylhexyl)phthalate	10 U	10 U	10 U	10 U	10 U	0.88 J	10 U	10 U
Butylbenzylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chrysene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Cresol (ortho)	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Cresol, m&p	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Diallate, Total	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Dibenzo(a,h)anthracene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Dibenzofuran	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Diethylphthalate	0.68 J	10 U	10 U	10 U	10 U	10 U	1.3 J	10 U
Dimethylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Di-n-butylphthalate	0.84 U	0.8 U	10 U	10 U	10 U	10 U	10 U	10 U
Di-n-octyl phthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Dinoseb	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Ethyl methanesulfonate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Fluoranthene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Fluorene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorobutadiene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorocyclopentadiene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorophene	5,000 U	5,000 U	5,000 UJ	5,000 UJ	5,000 R	5,000 U	5,000 R	5,000 U
Hexachloropropene	10 U	10 U	10 U	10 U	10 U	10 UJ	10 U	10 U
Indeno(1,2,3-cd)pyrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Isophorone	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Isosafrole	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
m-Dichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
m-Dinitrobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Methapyrilene	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Plan		RCRA Facility Investigation					
Site ID	54TW01	54TW02	510DW1	510DW1	510DW2	510MW1	510MW2	510MW3
Sample ID	54TW01	54TW02	510DW1	510DW1D	510DW2	510MW1	510MW2	510MW3
Sample Date	12/20/00	12/19/00	02/27/02	02/27/02	02/27/02	02/26/02	02/27/02	02/13/02
Semivolatile Organic Compounds (ug/L) (Cont.)								
Methyl methanesulfonate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Naphthalene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Nitrobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosodiethylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosodimethylamine	10 U	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U
N-Nitroso-di-n-butylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitroso-di-n-propylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosodiphenylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosomethylethylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosomorpholine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosopiperidine	10 U	10 U	10 UJ	10 UJ	10 U	10 UJ	10 U	10 U
N-Nitrosopyrrolidine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
o-Dichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
o-Toluidine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
p-Dichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
p-Dimethylaminoazobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pentachlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pentachloronitrobenzene	10 U	10 U	10 UJ	10 UJ	10 U	10 UJ	10 U	10 U
Pentachlorophenol	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Phenacetin	10 U	10 U	10 UJ	10 UJ	10 U	10 UJ	10 U	10 U
Phenanthrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Phenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pronamide	10 U	10 U	10 UJ	10 UJ	10 U	10 UJ	10 U	10 U
Pyrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pyridine	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Safrole	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Sampling and Analysis Plan		RCRA Facility Investigation					
Site ID	54TW01	54TW02	510DW1	510DW1	510DW2	510MW1	510MW2	510MW3
Sample ID	54TW01	54TW02	510DW1	510DW1D	510DW2	510MW1	510MW2	510MW3
Sample Date	12/20/00	12/19/00	02/27/02	02/27/02	02/27/02	02/26/02	02/27/02	02/13/02
TPH (mg/L)								
Diesel Range Organics	6.7	1.6	NA	NA	NA	NA	NA	NA
Gasoline Range Organics	0.13	0.05 U	NA	NA	NA	NA	NA	NA

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation							
Site ID	510MW4	510MW5	54PZ01	54TW03	54TW04	54TW05	54TW06	54TW07
Sample ID	510MW4	510MW5	54PZ01	54TW03	54TW04	54TW05	54TW06	54TW07
Sample Date	02/26/02	02/13/02	02/20/02	02/14/02	02/14/02	02/14/02	02/15/02	02/15/02
Volatile Organic Compounds (ug/L)								
1,1,1,2-Tetrachloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1,1-Trichloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1,2,2-Tetrachloroethane	5 UJ	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1,2-Trichloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1-Dichloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1-Dichloroethene	5 U	0.79 J	5 U	0.8 J	5 U	5 U	5 U	5 U
1,2,3-Trichloropropane	5 UJ	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,2-Dibromo-3-chloropropane	5 UJ	5 U	5 U	5 UJ	5 UJ	5 UJ	5 U	5 U
1,2-Dibromoethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,2-Dichloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	2.8 J
1,2-Dichloropropane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
2-Butanone	25 UJ	25 U	25 U	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ
2-Hexanone	25 UJ	25 U	25 U	25 U	25 U	25 U	25 U	25 U
3-Chloro-1-propene	5 U	5 U	5 U	5 UJ	5 UJ	5 UJ	5 U	5 U
4-Methyl-2-pentanone	25 UJ	25 U	25 U	25 U	25 U	25 U	25 UJ	25 UJ
Acetone	50 U	50 U	50 U	50 U	50 U	50 U	50 R	50 R
Acetonitrile	200 UJ	200 U	200 UJ	200 UJ	200 UJ	200 UJ	200 UJ	200 UJ
Acrolein	100 R	100 R	100 R	100 R	100 R	100 R	100 R	100 R
Acrylonitrile	100 UJ	100 U	100 UJ	100 UJ	100 UJ	100 UJ	100 U	100 U
Benzene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Bromodichloromethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Bromoform	5 UJ	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Bromomethane	10 U	10 U	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
Carbon disulfide	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Carbon tetrachloride	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Chlorobenzene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Chloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chloroform	5 U	5 U	5 U	5 U	2.1 J	2.9 J	5 U	5 U
Chloromethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation							
Site ID	510MW4	510MW5	54PZ01	54TW03	54TW04	54TW05	54TW06	54TW07
Sample ID	510MW4	510MW5	54PZ01	54TW03	54TW04	54TW05	54TW06	54TW07
Sample Date	02/26/02	02/13/02	02/20/02	02/14/02	02/14/02	02/14/02	02/15/02	02/15/02
Volatile Organic Compounds (ug/L) (Cont.)								
Chloroprene	5 U	5 U	5 UJ	5 UJ	5 UJ	5 UJ	5 UJ	5 UJ
cis-1,3-Dichloropropene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Dibromochloromethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Dibromomethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Dichlorodifluoromethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Ethyl methacrylate	5 UJ	5 U	5 U	5 UJ	5 UJ	5 U	5 U	5 U
Ethylbenzene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Iodomethane	5 UJ	5 U	5 UJ	5 U	5 U	5 U	5 U	5 U
Isobutanol	200 R	200 R	200 R	200 R	200 R	200 R	200 R	200 R
Methacrylonitrile	100 U	100 U	100 U	100 UJ	100 UJ	100 UJ	100 U	100 U
Methyl methacrylate	5 UJ	5 U	5 U	5 UJ	5 UJ	5 UJ	5 U	5 U
Methylene chloride	5 U	5 U	5 U	0.54 J	0.54 J	5 U	5 U	5 U
Pentachloroethane	25 R	25 R	25 UJ	25 U	25 U	25 U	25 U	25 U
Propionitrile	100 UJ	100 U	100 UJ	100 UJ	100 UJ	100 UJ	100 UJ	100 UJ
Styrene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Tetrachloroethene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Toluene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
trans-1,2-Dichloroethene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
trans-1,3-Dichloropropene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
trans-1,4-Dichloro-2-butene	10 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
Trichloroethene	5 U	190	2.4 J	53	84	170 D	34	5 U
Trichlorofluoromethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Vinyl acetate	10 U	10 U	10 U	10 UJ	10 UJ	10 UJ	10 U	10 U
Vinyl chloride	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Xylenes	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation							
Site ID	510MW4	510MW5	54PZ01	54TW03	54TW04	54TW05	54TW06	54TW07
Sample ID	510MW4	510MW5	54PZ01	54TW03	54TW04	54TW05	54TW06	54TW07
Sample Date	02/26/02	02/13/02	02/20/02	02/14/02	02/14/02	02/14/02	02/15/02	02/15/02
Semivolatile Organic Compounds (ug/L)								
1,2,4,5-Tetrachlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2,4-Trichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,3,5-Trinitrobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,4-Dioxane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,4-Naphthoquinone	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,4-Phenylenediamine	2,000 R	2,000 U	2,000 R	2,000 R	2,000 R	2,000 R	2,000 R	2,000 R
1-Diallate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1-Naphthylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,3,4,6-Tetrachlorophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ
2,4,5-Trichlorophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,4,6-Trichlorophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dichlorophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dimethylphenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dinitrophenol	50 U	50 U	50 U	50 UJ	50 UJ	50 U	50 UJ	50 UJ
2,4-Dinitrotoluene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,6-Dichlorophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,6-Dinitrotoluene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Acetylaminofluorene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Chloronaphthalene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Chlorophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Diallate	10 R	10 U	10 R	10 R	10 R	10 R	10 R	10 R
2-Methylnaphthalene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Naphthylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Nitroaniline	50 U	50 U	50 U	50 U	50 U	50 U	50 UJ	50 UJ
2-Nitrophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Picoline	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
3,3'-Dichlorobenzidine	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
3,3'-Dimethylbenzidine	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
3-Methylcholanthrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation							
Site ID	510MW4	510MW5	54PZ01	54TW03	54TW04	54TW05	54TW06	54TW07
Sample ID	510MW4	510MW5	54PZ01	54TW03	54TW04	54TW05	54TW06	54TW07
Sample Date	02/26/02	02/13/02	02/20/02	02/14/02	02/14/02	02/14/02	02/15/02	02/15/02
Semivolatile Organic Compounds (ug/L) (Cont.)								
3-Nitroaniline	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
4,6-Dinitro-2-methylphenol	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
4-Aminobiphenyl	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Bromophenyl phenyl ether	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Chloro-3-methylphenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Chloroaniline	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
4-Chlorophenylphenylether	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Nitroaniline	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
4-Nitrophenol	50 U	50 U	50 U	50 UJ	50 UJ	50 U	50 U	50 U
4-Nitroquinoline-1-oxide	20 R	20 R	20 R	20 U	20 U	20 R	20 R	20 R
5-Nitro-o-toluidine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
7,12-Dimethylbenz(a)anthracene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Acenaphthene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Acenaphthylene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Acetophenone	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
alpha,alpha-Dimethylphenethylamine	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U
Aniline	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
Anthracene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Aramite, Total	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Aramite-1	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Aramite-2	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(a)anthracene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(a)pyrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(b)fluoranthene	10 U	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U
Benzo(g,h,i)perylene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(k)fluoranthene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzyl alcohol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bis(2-chloroethoxy)methane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bis(2-chloroethyl)ether	10 U	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation							
Site ID	510MW4	510MW5	54PZ01	54TW03	54TW04	54TW05	54TW06	54TW07
Sample ID	510MW4	510MW5	54PZ01	54TW03	54TW04	54TW05	54TW06	54TW07
Sample Date	02/26/02	02/13/02	02/20/02	02/14/02	02/14/02	02/14/02	02/15/02	02/15/02
Semivolatile Organic Compounds (ug/L) (Cont.)								
bis-(2-chloroisopropyl)ether	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bis(2-ethylhexyl)phthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Butylbenzylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chrysene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Cresol (ortho)	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Cresol, m&p	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Diallate, Total	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Dibenzo(a,h)anthracene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Dibenzofuran	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Diethylphthalate	0.86 J	10 U	10 U	10 U	10 U	10 U	10 U	2.7 J
Dimethylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Di-n-butylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Di-n-octyl phthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Dinoseb	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Ethyl methanesulfonate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Fluoranthene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Fluorene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorobutadiene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorocyclopentadiene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorophene	5,000 R	5,000 U	5,000 U	5,000 U	5,000 U	5,000 U	5,000 U	5,000 U
Hexachloropropene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Indeno(1,2,3-cd)pyrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Isophorone	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Isosafrole	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
m-Dichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
m-Dinitrobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Methapyrilene	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation							
Site ID	510MW4	510MW5	54PZ01	54TW03	54TW04	54TW05	54TW06	54TW07
Sample ID	510MW4	510MW5	54PZ01	54TW03	54TW04	54TW05	54TW06	54TW07
Sample Date	02/26/02	02/13/02	02/20/02	02/14/02	02/14/02	02/14/02	02/15/02	02/15/02
Semivolatile Organic Compounds (ug/L) (Cont.)								
Methyl methanesulfonate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Naphthalene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Nitrobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosodiethylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosodimethylamine	10 UJ	10 U	10 UJ	10 U	10 U	10 UJ	10 UJ	10 UJ
N-Nitroso-di-n-butylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitroso-di-n-propylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosodiphenylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosomethylethylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosomorpholine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosopiperidine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosopyrrolidine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
o-Dichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
o-Toluidine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
p-Dichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
p-Dimethylaminoazobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pentachlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pentachloronitrobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pentachlorophenol	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Phenacetin	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Phenanthrene	10 U	10 U	10 U	10 U	0.46 J	10 U	10 U	10 U
Phenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pronamide	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pyrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pyridine	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Safrole	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation							
Site ID	510MW4	510MW5	54PZ01	54TW03	54TW04	54TW05	54TW06	54TW07
Sample ID	510MW4	510MW5	54PZ01	54TW03	54TW04	54TW05	54TW06	54TW07
Sample Date	02/26/02	02/13/02	02/20/02	02/14/02	02/14/02	02/14/02	02/15/02	02/15/02
TPH (mg/L)								
Diesel Range Organics	NA	NA	NA	NA	NA	NA	NA	NA
Gasoline Range Organics	NA	NA	NA	NA	NA	NA	NA	NA

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation							
Site ID	54TW08	54TW09	54TW09	54TW10	54TW11	54TW11	54TW12	54TW13
Sample ID	54TW08	54TW09	54TW09D	54TW10	54TW11	54TW11D	54TW12	54TW13
Sample Date	02/15/02	02/15/02	02/15/02	02/15/02	02/18/02	02/18/02	02/19/02	02/19/02
Volatile Organic Compounds (ug/L)								
1,1,1,2-Tetrachloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1,1-Trichloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 UJ	5 UJ
1,1,2,2-Tetrachloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1,2-Trichloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1-Dichloroethane	5 U	5 U	5 U	5 U	5 UJ	5 UJ	5 U	5 U
1,1-Dichloroethene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,2,3-Trichloropropane	5 U	5 U	5 U	5 U	5 UJ	5 UJ	5 U	5 U
1,2-Dibromo-3-chloropropane	5 U	5 U	5 U	5 U	5 UJ	5 UJ	5 UJ	5 UJ
1,2-Dibromoethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,2-Dichloroethane	2.2 J	5 U	5 U	1.2 J	5 U	5 U	5 UJ	5 UJ
1,2-Dichloropropane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
2-Butanone	25 UJ	25 UJ	25 UJ	25 UJ	25 U	25 U	25 UJ	25 UJ
2-Hexanone	25 U	25 U	25 U	25 U	25 UJ	25 UJ	25 UJ	25 UJ
3-Chloro-1-propene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
4-Methyl-2-pentanone	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ	25 UJ
Acetone	50 R	50 R	50 R	50 R	50 R	50 R	50 UJ	50 UJ
Acetonitrile	200 UJ	200 UJ	200 UJ	200 UJ	200 U	200 U	200 UJ	200 UJ
Acrolein	100 R	100 R	100 R	100 R	100 R	100 R	100 R	100 R
Acrylonitrile	100 U	100 U	100 U	100 U	100 U	100 U	100 UJ	100 UJ
Benzene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Bromodichloromethane	5 U	5 U	5 U	5 U	5 U	5 U	5 UJ	5 UJ
Bromoform	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Bromomethane	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 UJ	10 UJ
Carbon disulfide	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Carbon tetrachloride	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Chlorobenzene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Chloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chloroform	8	4.5 J	4.3 J	6.4	5 U	5 U	5 U	5 U
Chloromethane	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation							
Site ID	54TW08	54TW09	54TW09	54TW10	54TW11	54TW11	54TW12	54TW13
Sample ID	54TW08	54TW09	54TW09D	54TW10	54TW11	54TW11D	54TW12	54TW13
Sample Date	02/15/02	02/15/02	02/15/02	02/15/02	02/18/02	02/18/02	02/19/02	02/19/02
Volatile Organic Compounds (ug/L) (Cont.)								
Chloroprene	5 UJ	5 UJ	5 UJ	5 UJ	5 U	5 U	5 UJ	5 UJ
cis-1,3-Dichloropropene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Dibromochloromethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Dibromomethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Dichlorodifluoromethane	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U
Ethyl methacrylate	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Ethylbenzene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Iodomethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Isobutanol	200 R	200 R	200 R	200 R	200 R	200 R	200 R	200 R
Methacrylonitrile	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U
Methyl methacrylate	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Methylene chloride	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Pentachloroethane	25 U	25 U	25 U	25 U	25 R	25 R	25 U	25 U
Propionitrile	100 UJ	100 UJ	100 UJ	100 UJ	100 U	100 U	100 UJ	100 U
Styrene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Tetrachloroethene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Toluene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
trans-1,2-Dichloroethene	5 U	5 U	5 U	5 U	5 UJ	5 UJ	5 U	5 U
trans-1,3-Dichloropropene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
trans-1,4-Dichloro-2-butene	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U
Trichloroethene	8	20	19	11	140	150	5 U	1.1 J
Trichlorofluoromethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Vinyl acetate	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 UJ	10 UJ
Vinyl chloride	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Xylenes	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation							
Site ID	54TW08	54TW09	54TW09	54TW10	54TW11	54TW11	54TW12	54TW13
Sample ID	54TW08	54TW09	54TW09D	54TW10	54TW11	54TW11D	54TW12	54TW13
Sample Date	02/15/02	02/15/02	02/15/02	02/15/02	02/18/02	02/18/02	02/19/02	02/19/02
Semivolatile Organic Compounds (ug/L)								
1,2,4,5-Tetrachlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2,4-Trichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,3,5-Trinitrobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,4-Dioxane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,4-Naphthoquinone	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,4-Phenylenediamine	2,000 R	2,000 R	2,000 R	2,000 R	2,000 R	2,000 R	2,000 R	2,000 R
1-Diallate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1-Naphthylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,3,4,6-Tetrachlorophenol	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U
2,4,5-Trichlorophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,4,6-Trichlorophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dichlorophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dimethylphenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dinitrophenol	50 UJ	50 UJ	50 UJ	50 UJ	50 U	50 U	50 U	50 U
2,4-Dinitrotoluene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,6-Dichlorophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,6-Dinitrotoluene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Acetylaminofluorene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Chloronaphthalene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Chlorophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Diallate	10 R	10 R	10 R	10 R	10 R	10 R	10 R	10 R
2-Methylnaphthalene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Naphthylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Nitroaniline	50 UJ	50 UJ	50 UJ	50 UJ	50 U	50 U	50 U	50 U
2-Nitrophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Picoline	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
3,3'-Dichlorobenzidine	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
3,3'-Dimethylbenzidine	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
3-Methylcholanthrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation							
Site ID	54TW08	54TW09	54TW09	54TW10	54TW11	54TW11	54TW12	54TW13
Sample ID	54TW08	54TW09	54TW09D	54TW10	54TW11	54TW11D	54TW12	54TW13
Sample Date	02/15/02	02/15/02	02/15/02	02/15/02	02/18/02	02/18/02	02/19/02	02/19/02
Semivolatile Organic Compounds (ug/L) (Cont.)								
3-Nitroaniline	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
4,6-Dinitro-2-methylphenol	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
4-Aminobiphenyl	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Bromophenyl phenyl ether	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Chloro-3-methylphenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Chloroaniline	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
4-Chlorophenylphenylether	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Nitroaniline	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
4-Nitrophenol	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
4-Nitroquinoline-1-oxide	20 R	20 R	20 R	20 R	20 R	20 R	20 R	20 R
5-Nitro-o-toluidine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
7,12-Dimethylbenz(a)anthracene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Acenaphthene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Acenaphthylene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Acetophenone	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
alpha,alpha-Dimethylphenethylamine	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U
Aniline	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
Anthracene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Aramite, Total	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Aramite-1	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Aramite-2	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(a)anthracene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(a)pyrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(b)fluoranthene	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U
Benzo(g,h,i)perylene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(k)fluoranthene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzyl alcohol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bis(2-chloroethoxy)methane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bis(2-chloroethyl)ether	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U	10 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation							
Site ID	54TW08	54TW09	54TW09	54TW10	54TW11	54TW11	54TW12	54TW13
Sample ID	54TW08	54TW09	54TW09D	54TW10	54TW11	54TW11D	54TW12	54TW13
Sample Date	02/15/02	02/15/02	02/15/02	02/15/02	02/18/02	02/18/02	02/19/02	02/19/02
Semivolatile Organic Compounds (ug/L) (Cont.)								
bis-(2-chloroisopropyl)ether	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 U	10 U
Bis(2-ethylhexyl)phthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Butylbenzylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chrysene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Cresol (ortho)	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Cresol, m&p	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Diallate, Total	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Dibenzo(a,h)anthracene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Dibenzofuran	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Diethylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Dimethylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Di-n-butylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	0.26 J	10 U
Di-n-octyl phthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Dinoseb	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Ethyl methanesulfonate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Fluoranthene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Fluorene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorobutadiene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorocyclopentadiene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorophene	5,000 U	5,000 U	5,000 U	5,000 U	5,000 U	5,000 U	5,000 U	5,000 U
Hexachloropropene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Indeno(1,2,3-cd)pyrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Isophorone	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Isosafrole	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
m-Dichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
m-Dinitrobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Methapyrilene	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation							
Site ID	54TW08	54TW09	54TW09	54TW10	54TW11	54TW11	54TW12	54TW13
Sample ID	54TW08	54TW09	54TW09D	54TW10	54TW11	54TW11D	54TW12	54TW13
Sample Date	02/15/02	02/15/02	02/15/02	02/15/02	02/18/02	02/18/02	02/19/02	02/19/02
Semivolatile Organic Compounds (ug/L) (Cont.)								
Methyl methanesulfonate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Naphthalene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Nitrobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosodiethylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosodimethylamine	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
N-Nitroso-di-n-butylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitroso-di-n-propylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosodiphenylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosomethylethylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosomorpholine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosopiperidine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosopyrrolidine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
o-Dichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
o-Toluidine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
p-Dichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
p-Dimethylaminoazobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pentachlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pentachloronitrobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pentachlorophenol	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Phenacetin	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Phenanthrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Phenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pronamide	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pyrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pyridine	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Safrole	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation							
Site ID	54TW08	54TW09	54TW09	54TW10	54TW11	54TW11	54TW12	54TW13
Sample ID	54TW08	54TW09	54TW09D	54TW10	54TW11	54TW11D	54TW12	54TW13
Sample Date	02/15/02	02/15/02	02/15/02	02/15/02	02/18/02	02/18/02	02/19/02	02/19/02
TPH (mg/L)								
Diesel Range Organics	NA	NA	NA	NA	NA	NA	NA	NA
Gasoline Range Organics	NA	NA	NA	NA	NA	NA	NA	NA

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation							
Site ID	54TW14	54TW15	54TW16	54TW17	54TW18	54TW19	54TW20	54TW21
Sample ID	54TW14	54TW15	54TW16	54TW17	54TW18	54TW19	54TW20	54TW21
Sample Date	02/19/02	02/19/02	02/19/02	02/21/02	02/21/02	03/03/02	03/03/02	03/05/02
Volatile Organic Compounds (ug/L)								
1,1,1,2-Tetrachloroethane	5 U	120 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1,1-Trichloroethane	5 UJ	120 UJ	5 UJ	5 U	5 U	0.64 J	5 U	5 U
1,1,2,2-Tetrachloroethane	5 U	120 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1,2-Trichloroethane	5 U	120 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1-Dichloroethane	5 U	120 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1-Dichloroethene	5 U	120 U	5 U	5 U	5 U	5 U	5 U	5 U
1,2,3-Trichloropropane	5 U	120 U	5 U	5 U	5 U	5 U	5 U	5 UJ
1,2-Dibromo-3-chloropropane	5 UJ	120 UJ	5 UJ	5 U	5 U	5 U	5 U	5 UJ
1,2-Dibromoethane	5 U	120 U	5 U	5 U	5 U	5 U	5 U	5 U
1,2-Dichloroethane	5 UJ	120 UJ	5 UJ	5 U	5 U	5 U	5 U	5 U
1,2-Dichloropropane	5 U	120 U	5 U	5 U	5 U	5 U	5 U	5 U
2-Butanone	25 UJ	620 UJ	25 UJ	25 UJ	25 UJ	25 U	25 U	25 UJ
2-Hexanone	25 UJ	620 UJ	25 UJ	25 U	25 U	25 U	25 U	25 UJ
3-Chloro-1-propene	5 U	120 U	5 U	5 U	5 U	5 U	5 U	5 UJ
4-Methyl-2-pentanone	25 UJ	620 UJ	25 UJ	25 U	25 U	25 U	25 U	25 U
Acetone	50 UJ	1,200 UJ	50 UJ	50 U	50 U	50 UJ	50 UJ	50 UJ
Acetonitrile	200 UJ	5,000 UJ	200 UJ	200 UJ	200 UJ	200 UJ	200 UJ	200 UJ
Acrolein	100 R	2,500 R	100 R	100 R	100 R	100 R	100 R	100 R
Acrylonitrile	100 UJ	2,500 UJ	100 UJ	100 U	100 U	100 U	100 U	100 U
Benzene	5 U	3,000	5 U	5 U	5 U	5 U	2 J	5 U
Bromodichloromethane	5 UJ	120 UJ	5 UJ	5 U	5 U	5 U	5 U	5 U
Bromoform	5 U	120 U	5 U	5 U	5 U	5 UJ	5 UJ	5 UJ
Bromomethane	10 UJ	250 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
Carbon disulfide	5 U	120 U	5 U	5 U	5 U	5 U	5 U	5 U
Carbon tetrachloride	5 U	120 U	5 U	5 U	5 U	5 U	5 U	5 U
Chlorobenzene	5 U	120 U	5 U	5 U	5 U	5 U	5 U	5 U
Chloroethane	10 U	250 U	10 U	10 U	10 U	10 U	10 U	10 U
Chloroform	1.8 J	120 U	5 U	5 U	5 U	5 U	5 U	5 U
Chloromethane	10 U	250 U	10 U	10 U	10 U	10 U	10 U	10 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation							
Site ID	54TW14	54TW15	54TW16	54TW17	54TW18	54TW19	54TW20	54TW21
Sample ID	54TW14	54TW15	54TW16	54TW17	54TW18	54TW19	54TW20	54TW21
Sample Date	02/19/02	02/19/02	02/19/02	02/21/02	02/21/02	03/03/02	03/03/02	03/05/02
Volatile Organic Compounds (ug/L) (Cont.)								
Chloroprene	5 UJ	120 UJ	5 UJ	5 U	5 U	5 U	5 U	5 UJ
cis-1,3-Dichloropropene	5 U	120 U	5 U	5 U	5 U	5 U	5 U	5 U
Dibromochloromethane	5 U	120 U	5 U	5 U	5 U	5 U	5 U	5 U
Dibromomethane	5 U	120 U	5 U	5 U	5 U	5 U	5 U	5 U
Dichlorodifluoromethane	10 U	250 U	10 U	10 U	10 U	10 U	10 U	10 U
Ethyl methacrylate	5 U	120 U	5 U	5 U	5 U	5 U	5 U	5 U
Ethylbenzene	5 U	2,400	5 U	5 U	5 U	5 U	68	5 U
Iodomethane	5 U	120 U	5 U	5 UJ	5 UJ	5 U	5 U	5 UJ
Isobutanol	200 R	2,600 J	200 R	200 U	200 U	200 R	200 R	200 R
Methacrylonitrile	100 U	2,500 U	100 U	100 U	100 U	100 U	100 U	100 U
Methyl methacrylate	5 U	120 U	5 U	5 U	5 U	5 U	5 U	5 UJ
Methylene chloride	5 U	120 U	5 U	5 U	5 U	5 U	5 U	5 U
Pentachloroethane	25 U	620 U	25 U	25 UJ	25 UJ	25 U	25 U	25 UJ
Propionitrile	100 UJ	2,500 U	100 U	100 U	100 U	100 U	100 U	100 UJ
Styrene	5 U	120 U	5 U	5 U	5 U	5 U	5 U	5 U
Tetrachloroethene	5 U	120 U	5 U	5 U	5 U	5 U	5 U	5 U
Toluene	5 U	400	5 U	5 U	5 U	5 U	0.76 J	5 U
trans-1,2-Dichloroethene	5 U	120 U	5 U	5 U	5 U	5 U	5 U	5 U
trans-1,3-Dichloropropene	5 U	120 U	5 U	5 U	5 U	5 U	5 U	5 U
trans-1,4-Dichloro-2-butene	10 U	250 U	10 U	10 U	10 U	10 U	10 U	10 UJ
Trichloroethene	25	120 U	0.34 J	1.3 J	5 U	3.2 J	5 U	5 U
Trichlorofluoromethane	5 U	120 U	5 U	5 U	5 U	5 U	5 U	5 U
Vinyl acetate	10 UJ	250 UJ	10 UJ	10 U	10 U	10 U	10 U	10 UJ
Vinyl chloride	10 U	250 U	10 U	10 U	10 U	10 U	10 U	10 U
Xylenes	10 U	8,000	10 U	10 U	10 U	10 U	5.5 J	10 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation							
Site ID	54TW14	54TW15	54TW16	54TW17	54TW18	54TW19	54TW20	54TW21
Sample ID	54TW14	54TW15	54TW16	54TW17	54TW18	54TW19	54TW20	54TW21
Sample Date	02/19/02	02/19/02	02/19/02	02/21/02	02/21/02	03/03/02	03/03/02	03/05/02
Semivolatile Organic Compounds (ug/L)								
1,2,4,5-Tetrachlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2,4-Trichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,3,5-Trinitrobenzene	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 UJ
1,4-Dioxane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,4-Naphthoquinone	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,4-Phenylenediamine	2,000 R	2,000 R	2,000 R	2,000 R	2,000 R	2,000 R	2,000 R	2,000 R
1-Diallate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1-Naphthylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,3,4,6-Tetrachlorophenol	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
2,4,5-Trichlorophenol	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
2,4,6-Trichlorophenol	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dichlorophenol	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dimethylphenol	10 U	8.5 J	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dinitrophenol	50 U	50 UJ	50 U	50 U	50 U	50 U	50 U	50 U
2,4-Dinitrotoluene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2,6-Dichlorophenol	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
2,6-Dinitrotoluene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Acetylaminofluorene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Chloronaphthalene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Chlorophenol	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
2-Diallate	10 R	10 R	10 R	10 R	10 R	10 U	10 U	10 U
2-Methylnaphthalene	10 U	65	10 U	10 U	10 U	10 U	1.2 J	10 U
2-Naphthylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Nitroaniline	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
2-Nitrophenol	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
2-Picoline	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
3,3'-Dichlorobenzidine	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
3,3'-Dimethylbenzidine	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
3-Methylcholanthrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation							
Site ID	54TW14	54TW15	54TW16	54TW17	54TW18	54TW19	54TW20	54TW21
Sample ID	54TW14	54TW15	54TW16	54TW17	54TW18	54TW19	54TW20	54TW21
Sample Date	02/19/02	02/19/02	02/19/02	02/21/02	02/21/02	03/03/02	03/03/02	03/05/02
Semivolatile Organic Compounds (ug/L) (Cont.)								
3-Nitroaniline	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
4,6-Dinitro-2-methylphenol	50 U	50 UJ	50 U	50 U	50 U	50 UJ	50 U	50 UJ
4-Aminobiphenyl	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Bromophenyl phenyl ether	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Chloro-3-methylphenol	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
4-Chloroaniline	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
4-Chlorophenylphenylether	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Nitroaniline	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
4-Nitrophenol	50 U	50 UJ	50 U	50 U	50 U	50 U	50 U	50 U
4-Nitroquinoline-1-oxide	20 R	20 R	20 R	20 R	20 R	20 R	20 R	20 R
5-Nitro-o-toluidine	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 UJ
7,12-Dimethylbenz(a)anthracene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Acenaphthene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Acenaphthylene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Acetophenone	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
alpha,alpha-Dimethylphenethylamine	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U	2,000 UJ	2,000 UJ	2,000 UJ
Aniline	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
Anthracene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Aramite, Total	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Aramite-1	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Aramite-2	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(a)anthracene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(a)pyrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(b)fluoranthene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(g,h,i)perylene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(k)fluoranthene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzyl alcohol	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Bis(2-chloroethoxy)methane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bis(2-chloroethyl)ether	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation							
Site ID	54TW14	54TW15	54TW16	54TW17	54TW18	54TW19	54TW20	54TW21
Sample ID	54TW14	54TW15	54TW16	54TW17	54TW18	54TW19	54TW20	54TW21
Sample Date	02/19/02	02/19/02	02/19/02	02/21/02	02/21/02	03/03/02	03/03/02	03/05/02
Semivolatile Organic Compounds (ug/L) (Cont.)								
bis-(2-chloroisopropyl)ether	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bis(2-ethylhexyl)phthalate	10 U	10 U	10 U	10 U	10 U	10 U	1 J	10 U
Butylbenzylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chrysene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Cresol (ortho)	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Cresol, m&p	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Diallate, Total	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Dibenzo(a,h)anthracene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Dibenzofuran	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Diethylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	0.96 J
Dimethylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Di-n-butylphthalate	10 U	10 U	0.37 J	10 U	10 U	10 U	10 U	10 U
Di-n-octyl phthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Dinoseb	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 UJ
Ethyl methanesulfonate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Fluoranthene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Fluorene	10 U	1.6 J	10 U	10 U	10 U	10 U	0.64 J	10 U
Hexachlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorobutadiene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorocyclopentadiene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorophene	5,000 U	5,000 U	5,000 U	5,000 U	5,000 U	5,000 U	5,000 U	5,000 U
Hexachloropropene	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 UJ
Indeno(1,2,3-cd)pyrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Isophorone	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Isosafrole	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
m-Dichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
m-Dinitrobenzene	10 U	10 U	10 U	10 U	10 U	10 UJ	10 UJ	10 UJ
Methapyrilene	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U	2,000 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation							
Site ID	54TW14	54TW15	54TW16	54TW17	54TW18	54TW19	54TW20	54TW21
Sample ID	54TW14	54TW15	54TW16	54TW17	54TW18	54TW19	54TW20	54TW21
Sample Date	02/19/02	02/19/02	02/19/02	02/21/02	02/21/02	03/03/02	03/03/02	03/05/02
Semivolatile Organic Compounds (ug/L) (Cont.)								
Methyl methanesulfonate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Naphthalene	10 U	190	10 U	10 U	10 U	10 U	10 U	10 U
Nitrobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosodiethylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosodimethylamine	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	10 U	10 U	10 U
N-Nitroso-di-n-butylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitroso-di-n-propylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosodiphenylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosomethylethylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosomorpholine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosopiperidine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosopyrrolidine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
o-Dichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
o-Toluidine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
p-Dichlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
p-Dimethylaminoazobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pentachlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pentachloronitrobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pentachlorophenol	50 U	50 UJ	50 U	50 U	50 U	50 U	50 U	50 U
Phenacetin	10 U	10 U	10 U	10 U	10 U	10 UJ	10 U	10 UJ
Phenanthrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Phenol	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U
Pronamide	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pyrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Pyridine	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
Safrole	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U

APPENDIX A.3

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	RCRA Facility Investigation							
Site ID	54TW14	54TW15	54TW16	54TW17	54TW18	54TW19	54TW20	54TW21
Sample ID	54TW14	54TW15	54TW16	54TW17	54TW18	54TW19	54TW20	54TW21
Sample Date	02/19/02	02/19/02	02/19/02	02/21/02	02/21/02	03/03/02	03/03/02	03/05/02
TPH (mg/L)								
Diesel Range Organics	NA	NA	NA	NA	NA	NA	NA	NA
Gasoline Range Organics	NA	NA	NA	NA	NA	NA	NA	NA

APPENDIX A.4
SWMU 55, Groundwater - Organics

APPENDIX A.4

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	CMS Investigation							
Site ID	7MW07	7MW07	7MW08	7MW08	UGW11	UGW13	UGW16	UGW17
Sample ID	7MW07	7MW07D	7MW08	7MW08D	UGW11	UGW13	UGW16	UGW17
Sample Date	04/19/98	04/19/98	04/18/98	04/18/98	04/17/98	04/21/98	04/16/98	04/21/98
Volatile Organic Compounds (ug/L)								
1,1,1,2-Tetrachloroethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
1,1,1-Trichloroethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
1,1,2,2-Tetrachloroethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
1,1,2-Trichloroethane	0.5	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
1,1-Dichloroethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
1,1-Dichloroethene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	2	50 UJ
1,1-Dichloropropene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
1,2,3-Trichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	530	0.5 U	50 UJ
1,2,3-Trichloropropane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
1,2,4-Trichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
1,2,4-Trimethylbenzene	0.5 U	0.5 U	0.5 U	0.5 U	9 J	12 UJ	0.5 U	150 J
1,2-Dibromo-3-chloropropane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
1,2-Dibromoethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
1,2-Dichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
1,2-Dichloroethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
1,2-Dichloropropane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
1,3,5-Trimethylbenzene	0.5 U	0.5 U	0.5 U	0.5 U	3 J	250 J	0.5 U	50 UJ
1,3-Dichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
1,3-Dichloropropane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
1,4-Dichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
2,2-Dichloropropane	0.5 U	0.5 U	0.5 R	0.5 R	0.5 UJ	12 UJ	0.5 U	50 UJ
2-Butanone	NA	NA	NA	NA	NA	NA	NA	NA
2-Chlorotoluene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
2-Hexanone	NA	NA	NA	NA	NA	NA	NA	NA
3-Chloro-1-propene	NA	NA	NA	NA	NA	NA	NA	NA
4-Chlorotoluene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
4-Methyl-2-pentanone	NA	NA	NA	NA	NA	NA	NA	NA
Acetone	NA	NA	NA	NA	NA	NA	NA	NA
Acetonitrile	NA	NA	NA	NA	NA	NA	NA	NA

APPENDIX A.4

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	CMS Investigation							
Site ID	7MW07	7MW07	7MW08	7MW08	UGW11	UGW13	UGW16	UGW17
Sample ID	7MW07	7MW07D	7MW08	7MW08D	UGW11	UGW13	UGW16	UGW17
Sample Date	04/19/98	04/19/98	04/18/98	04/18/98	04/17/98	04/21/98	04/16/98	04/21/98
Volatile Organic Compounds (ug/L) (Cont.)								
Acrolein	NA	NA	NA	NA	NA	NA	NA	NA
Acrylonitrile	NA	NA	NA	NA	NA	NA	NA	NA
Benzene	0.5 U	0.5 U	0.5 U	0.5 U	0.8 J	12 UJ	0.5 U	50 UJ
Bromobenzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
Bromochloromethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
Bromodichloromethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
Bromoform	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
Bromomethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
Carbon disulfide	NA	NA	NA	NA	NA	NA	NA	NA
Carbon tetrachloride	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
Chlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
Chloroethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
Chloroform	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
Chloromethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
Chloroprene	NA	NA	NA	NA	NA	NA	NA	NA
cis-1,3-Dichloropropene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
Dibromochloromethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
Dibromomethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
Dichlorodifluoromethane	0.5 UJ	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
Ethyl methacrylate	NA	NA	NA	NA	NA	NA	NA	NA
Ethylbenzene	0.5 U	0.5 U	0.5 U	0.5 U	2 J	86 J	0.5 U	50 UJ
Hexchlorobutadiene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
Iodomethane	NA	NA	NA	NA	NA	NA	NA	NA
Isobutanol	NA	NA	NA	NA	NA	NA	NA	NA
Isopropylbenzene	0.5 U	0.5 U	0.5 U	0.5 U	12 J	69 J	0.5 U	50 UJ
Methacrylonitrile	NA	NA	NA	NA	NA	NA	NA	NA
Methyl methacrylate	NA	NA	NA	NA	NA	NA	NA	NA
Methylene chloride	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
n-Butylbenzene	0.5 U	0.5 U	0.5 U	0.5 U	14 J	360 J	0.5 U	92 J

APPENDIX A.4

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	CMS Investigation							
Site ID	7MW07	7MW07	7MW08	7MW08	UGW11	UGW13	UGW16	UGW17
Sample ID	7MW07	7MW07D	7MW08	7MW08D	UGW11	UGW13	UGW16	UGW17
Sample Date	04/19/98	04/19/98	04/18/98	04/18/98	04/17/98	04/21/98	04/16/98	04/21/98
Volatile Organic Compounds (ug/L) (Cont.)								
n-Propylbenzene	0.5 U	0.5 U	0.5 U	0.5 U	20 J	150 J	0.5 U	50 UJ
o-Xylene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
Pentachloroethane	NA	NA	NA	NA	NA	NA	NA	NA
p-Isopropyltoluene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	170 J	0.5 U	50 UJ
Propionitrile	NA	NA	NA	NA	NA	NA	NA	NA
sec-Butylbenzene	0.5 U	0.5 U	0.5 U	0.5 U	13 J	160 J	0.5 U	62 J
Styrene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
tert-Butylbenzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
Tetrachloroethene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
Toluene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
trans-1,2-Dichloroethene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
trans-1,3-Dichloropropene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
trans-1,4-Dichloro-2-butene	NA	NA	NA	NA	NA	NA	NA	NA
Trichloroethene	2,000 J	2,100	3	2	0.5 UJ	12 UJ	0.5 U	50 UJ
Trichlorofluoromethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
Vinyl acetate	NA	NA	NA	NA	NA	NA	NA	NA
Vinyl chloride	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	12 UJ	0.5 U	50 UJ
Xylene (m&p)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	86 J	0.5 U	50 UJ
Xylenes	NA	NA	NA	NA	NA	NA	NA	NA

APPENDIX A.4

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	CMS Investigation			TCE Investigation				
Site ID	UGW18	UGW19	UGW21	TW102	TW104	TW105	TW1	TW1
Sample ID	UGW18	UGW19	UGW21	7TCE102	7TCE104	7TCE105	7TCE1s	7TCE1d
Sample Date	04/16/98	04/17/98	04/17/98	07/01/99	07/01/99	07/01/99	06/26/99	06/29/99
Volatile Organic Compounds (ug/L)								
1,1,1,2-Tetrachloroethane	0.5 U	5 UJ	250 U	NA	NA	NA	NA	NA
1,1,1-Trichloroethane	0.5 U	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U
1,1,2,2-Tetrachloroethane	0.5 U	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U
1,1,2-Trichloroethane	0.5 U	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U
1,1-Dichloroethane	0.5 U	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U
1,1-Dichloroethene	0.5 U	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U
1,1-Dichloropropene	0.5 U	5 UJ	250 U	NA	NA	NA	NA	NA
1,2,3-Trichlorobenzene	0.5 U	5 UJ	250 U	NA	NA	NA	NA	NA
1,2,3-Trichloropropane	0.5 U	5 UJ	250 U	NA	NA	NA	NA	NA
1,2,4-Trichlorobenzene	0.5 U	5 UJ	250 U	NA	NA	NA	NA	NA
1,2,4-Trimethylbenzene	0.5 U	310 J	260	NA	NA	NA	NA	NA
1,2-Dibromo-3-chloropropane	0.5 U	5 UJ	250 U	NA	NA	NA	NA	NA
1,2-Dibromoethane	0.5 U	5 UJ	250 U	NA	NA	NA	NA	NA
1,2-Dichlorobenzene	0.5 U	5 UJ	250 U	NA	NA	NA	NA	NA
1,2-Dichloroethane	0.5 U	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U
1,2-Dichloropropane	0.5 U	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U
1,3,5-Trimethylbenzene	0.5 U	72 J	250 U	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	0.5 U	5 UJ	250 U	NA	NA	NA	NA	NA
1,3-Dichloropropane	0.5 U	5 UJ	250 U	NA	NA	NA	NA	NA
1,4-Dichlorobenzene	0.5 U	5 UJ	250 U	NA	NA	NA	NA	NA
2,2-Dichloropropane	0.5 U	5 UJ	250 U	NA	NA	NA	NA	NA
2-Butanone	NA	NA	NA	25 U	25 U	25 U	25 U	25 U
2-Chlorotoluene	0.5 U	5 UJ	250 U	NA	NA	NA	NA	NA
2-Hexanone	NA	NA	NA	25 U	25 U	25 U	25 U	25 U
3-Chloro-1-propene	NA	NA	NA	NA	NA	NA	NA	NA
4-Chlorotoluene	0.5 U	5 UJ	250 U	NA	NA	NA	NA	NA
4-Methyl-2-pentanone	NA	NA	NA	25 U	25 U	25 U	25 U	25 U
Acetone	NA	NA	NA	50 U	50 U	50 U	50 R	50 R
Acetonitrile	NA	NA	NA	NA	NA	NA	NA	NA

APPENDIX A.4

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	CMS Investigation			TCE Investigation				
Site ID	UGW18	UGW19	UGW21	TW102	TW104	TW105	TW1	TW1
Sample ID	UGW18	UGW19	UGW21	7TCE102	7TCE104	7TCE105	7TCE1s	7TCE1d
Sample Date	04/16/98	04/17/98	04/17/98	07/01/99	07/01/99	07/01/99	06/26/99	06/29/99
Volatile Organic Compounds (ug/L) (Cont.)								
Acrolein	NA	NA	NA	NA	NA	NA	NA	NA
Acrylonitrile	NA	NA	NA	NA	NA	NA	NA	NA
Benzene	0.5 U	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U
Bromobenzene	0.5 U	5 UJ	250 U	NA	NA	NA	NA	NA
Bromochloromethane	0.5 U	5 UJ	250 U	NA	NA	NA	NA	NA
Bromodichloromethane	0.5 U	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U
Bromoform	0.5 U	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U
Bromomethane	0.5 U	5 UJ	250 U	10 U	10 U	10 U	10 U	10 U
Carbon disulfide	NA	NA	NA	5 U	5 U	5 U	5 U	5 U
Carbon tetrachloride	0.5 U	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U
Chlorobenzene	0.5 U	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U
Chloroethane	0.5 U	5 UJ	250 U	10 U	10 U	10 U	10 U	10 U
Chloroform	2	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U
Chloromethane	0.5 U	5 UJ	250 U	10 U	10 U	10 U	13	10 U
Chloroprene	NA	NA	NA	NA	NA	NA	NA	NA
cis-1,3-Dichloropropene	0.5 U	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U
Dibromochloromethane	0.5 U	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U
Dibromomethane	0.5 U	5 UJ	250 U	NA	NA	NA	NA	NA
Dichlorodifluoromethane	0.5 U	5 UJ	250 UJ	NA	NA	NA	NA	NA
Ethyl methacrylate	NA	NA	NA	NA	NA	NA	NA	NA
Ethylbenzene	0.5 U	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U
Hexchlorobutadiene	0.5 U	5 UJ	250 U	NA	NA	NA	NA	NA
Iodomethane	NA	NA	NA	NA	NA	NA	NA	NA
Isobutanol	NA	NA	NA	NA	NA	NA	NA	NA
Isopropylbenzene	0.5 U	15 J	250 U	NA	NA	NA	NA	NA
Methacrylonitrile	NA	NA	NA	NA	NA	NA	NA	NA
Methyl methacrylate	NA	NA	NA	NA	NA	NA	NA	NA
Methylene chloride	0.5 U	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U
n-Butylbenzene	0.5 U	5 UJ	250 U	NA	NA	NA	NA	NA

APPENDIX A.4

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	CMS Investigation			TCE Investigation				
Site ID	UGW18	UGW19	UGW21	TW102	TW104	TW105	TW1	TW1
Sample ID	UGW18	UGW19	UGW21	7TCE102	7TCE104	7TCE105	7TCE1s	7TCE1d
Sample Date	04/16/98	04/17/98	04/17/98	07/01/99	07/01/99	07/01/99	06/26/99	06/29/99
Volatile Organic Compounds (ug/L) (Cont.)								
n-Propylbenzene	0.5 U	18 J	250 U	NA	NA	NA	NA	NA
o-Xylene	0.5 U	5 UJ	250 U	NA	NA	NA	NA	NA
Pentachloroethane	NA	NA	NA	NA	NA	NA	NA	NA
p-Isopropyltoluene	0.5 U	27 UJ	250 U	NA	NA	NA	NA	NA
Propionitrile	NA	NA	NA	NA	NA	NA	NA	NA
sec-Butylbenzene	0.5 U	21 J	250 U	NA	NA	NA	NA	NA
Styrene	0.5 U	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U
tert-Butylbenzene	0.5 U	5 UJ	250 U	NA	NA	NA	NA	NA
Tetrachloroethene	0.5 U	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U
Toluene	0.5 U	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U
trans-1,2-Dichloroethene	0.5 U	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U
trans-1,3-Dichloropropene	0.5 U	5 UJ	250 U	5 U	5 U	5 U	5 U	5 U
trans-1,4-Dichloro-2-butene	NA	NA	NA	NA	NA	NA	NA	NA
Trichloroethene	0.5 U	5 UJ	250 U	5.4	5 U	5 U	5 U	5 U
Trichlorofluoromethane	0.5 U	5 UJ	250 U	NA	NA	NA	NA	NA
Vinyl acetate	NA	NA	NA	NA	NA	NA	NA	NA
Vinyl chloride	0.5 U	5 UJ	250 U	10 U	10 U	10 U	10 U	10 U
Xylene (m&p)	0.5 U	11 J	250 U	NA	NA	NA	NA	NA
Xylenes	NA	NA	NA	10 U	10 U	10 U	10 U	10 U

APPENDIX A.4

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	TCE Investigation							
Site ID	TW2	TW3	TW4	TW4	TWA	TWA	TWB	TWB
Sample ID	7TCE2d	7TCE3d	7TCE4s	7TCE4d	7TCEAs	7TCEAd	7TCEBs	7TCEBd
Sample Date	06/29/99	06/29/99	06/28/99	06/29/99	06/25/99	06/30/99	06/25/99	06/30/99
Volatile Organic Compounds (ug/L)								
1,1,1,2-Tetrachloroethane	NA	NA	NA	NA	NA	NA	NA	NA
1,1,1-Trichloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1,2,2-Tetrachloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1,2-Trichloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1-Dichloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,1-Dichloroethene	5 U	3 J	5 U	5 U	5 U	5	3.8 J	5 U
1,1-Dichloropropene	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3-Trichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3-Trichloropropane	NA	NA	NA	NA	NA	NA	NA	NA
1,2,4-Trichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA
1,2,4-Trimethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dibromo-3-chloropropane	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dibromoethane	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dichloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,2-Dichloropropane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
1,3,5-Trimethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichloropropane	NA	NA	NA	NA	NA	NA	NA	NA
1,4-Dichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA
2,2-Dichloropropane	NA	NA	NA	NA	NA	NA	NA	NA
2-Butanone	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
2-Chlorotoluene	NA	NA	NA	NA	NA	NA	NA	NA
2-Hexanone	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
3-Chloro-1-propene	NA	NA	NA	NA	NA	NA	NA	NA
4-Chlorotoluene	NA	NA	NA	NA	NA	NA	NA	NA
4-Methyl-2-pentanone	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U
Acetone	50 R	50 R	50 U	50 R	50 U	50 U	50 U	50 U
Acetonitrile	NA	NA	NA	NA	NA	NA	NA	NA

APPENDIX A.4

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	TCE Investigation							
Site ID	TW2	TW3	TW4	TW4	TWA	TWA	TWB	TWB
Sample ID	7TCE2d	7TCE3d	7TCE4s	7TCE4d	7TCEAs	7TCEAd	7TCEBs	7TCEBd
Sample Date	06/29/99	06/29/99	06/28/99	06/29/99	06/25/99	06/30/99	06/25/99	06/30/99
Volatile Organic Compounds (ug/L) (Cont.)								
Acrolein	NA	NA	NA	NA	NA	NA	NA	NA
Acrylonitrile	NA	NA	NA	NA	NA	NA	NA	NA
Benzene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Bromobenzene	NA	NA	NA	NA	NA	NA	NA	NA
Bromochloromethane	NA	NA	NA	NA	NA	NA	NA	NA
Bromodichloromethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Bromoform	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Bromomethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Carbon disulfide	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Carbon tetrachloride	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Chlorobenzene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Chloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chloroform	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Chloromethane	10 U	9 J	10 U	10 U	10 U	10 U	10 U	10 U
Chloroprene	NA	NA	NA	NA	NA	NA	NA	NA
cis-1,3-Dichloropropene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Dibromochloromethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Dibromomethane	NA	NA	NA	NA	NA	NA	NA	NA
Dichlorodifluoromethane	NA	NA	NA	NA	NA	NA	NA	NA
Ethyl methacrylate	NA	NA	NA	NA	NA	NA	NA	NA
Ethylbenzene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Hexchlorobutadiene	NA	NA	NA	NA	NA	NA	NA	NA
Iodomethane	NA	NA	NA	NA	NA	NA	NA	NA
Isobutanol	NA	NA	NA	NA	NA	NA	NA	NA
Isopropylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
Methacrylonitrile	NA	NA	NA	NA	NA	NA	NA	NA
Methyl methacrylate	NA	NA	NA	NA	NA	NA	NA	NA
Methylene chloride	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
n-Butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA

APPENDIX A.4

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	TCE Investigation							
Site ID	TW2	TW3	TW4	TW4	TWA	TWA	TWB	TWB
Sample ID	7TCE2d	7TCE3d	7TCE4s	7TCE4d	7TCEAs	7TCEAd	7TCEBs	7TCEBd
Sample Date	06/29/99	06/29/99	06/28/99	06/29/99	06/25/99	06/30/99	06/25/99	06/30/99
Volatile Organic Compounds (ug/L) (Cont.)								
n-Propylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
o-Xylene	NA	NA	NA	NA	NA	NA	NA	NA
Pentachloroethane	NA	NA	NA	NA	NA	NA	NA	NA
p-Isopropyltoluene	NA	NA	NA	NA	NA	NA	NA	NA
Propionitrile	NA	NA	NA	NA	NA	NA	NA	NA
sec-Butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
Styrene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
tert-Butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
Tetrachloroethene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Toluene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
trans-1,2-Dichloroethene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
trans-1,3-Dichloropropene	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
trans-1,4-Dichloro-2-butene	NA	NA	NA	NA	NA	NA	NA	NA
Trichloroethene	5 U	44	5 U	5 U	55	140	92	66
Trichlorofluoromethane	NA	NA	NA	NA	NA	NA	NA	NA
Vinyl acetate	NA	NA	NA	NA	NA	NA	NA	NA
Vinyl chloride	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Xylene (m&p)	NA	NA	NA	NA	NA	NA	NA	NA
Xylenes	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U

APPENDIX A.4

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	TCE Investigation					Additional Data Collection Investigation		
Site ID	TWC	TWC	TWE	TWE	7TCEMW07	7MW07	7MW07	7MW08
Sample ID	7TCECs	7TCECd	7TCEEs	7TCEEsD	7TCEMW7	7MW07	7MW07D	7MW08
Sample Date	06/27/99	06/30/99	06/30/99	06/30/99	07/01/99	01/13/02	01/13/02	01/13/02
Volatile Organic Compounds (ug/L)								
1,1,1,2-Tetrachloroethane	NA	NA	NA	NA	NA	1,000 U	1,000 U	5 U
1,1,1-Trichloroethane	5 U	50 U	5 U	5 U	50 U	1,000 U	1,000 U	5 U
1,1,2,2-Tetrachloroethane	5 U	50 U	5 U	5 U	50 U	1,000 U	1,000 U	5 U
1,1,2-Trichloroethane	5 U	50 U	5 U	5 U	50 U	1,000 U	1,000 U	5 U
1,1-Dichloroethane	5 U	50 U	5 U	5 U	50 U	1,000 U	1,000 U	5 U
1,1-Dichloroethene	5 U	50 U	5 U	5 U	50 U	1,000 U	1,000 U	5 U
1,1-Dichloropropene	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3-Trichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3-Trichloropropane	NA	NA	NA	NA	NA	1,000 U	1,000 U	5 U
1,2,4-Trichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA
1,2,4-Trimethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dibromo-3-chloropropane	NA	NA	NA	NA	NA	1,000 UJ	1,000 UJ	5 J
1,2-Dibromoethane	NA	NA	NA	NA	NA	1,000 U	1,000 U	5 U
1,2-Dichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dichloroethane	5 U	50 U	5 U	5 U	50 U	1,000 U	1,000 U	5 U
1,2-Dichloropropane	5 U	50 U	5 U	5 U	50 U	1,000 U	1,000 U	5 U
1,3,5-Trimethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichloropropane	NA	NA	NA	NA	NA	NA	NA	NA
1,4-Dichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA
2,2-Dichloropropane	NA	NA	NA	NA	NA	NA	NA	NA
2-Butanone	25 U	250 U	25 U	25 U	250 U	5,000 U	5,000 U	25 U
2-Chlorotoluene	NA	NA	NA	NA	NA	NA	NA	NA
2-Hexanone	25 U	250 U	25 U	25 U	250 U	5,000 U	5,000 U	25 U
3-Chloro-1-propene	NA	NA	NA	NA	NA	1,000 U	1,000 U	5 U
4-Chlorotoluene	NA	NA	NA	NA	NA	NA	NA	NA
4-Methyl-2-pentanone	25 U	250 U	25 U	25 U	250 U	5,000 U	5,000 U	25 U
Acetone	50 R	500 U	50 U	50 U	500 U	10,000 U	10,000 U	50 U
Acetonitrile	NA	NA	NA	NA	NA	40,000 UJ	40,000 UJ	200 U

APPENDIX A.4

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	TCE Investigation					Additional Data Collection Investigation		
Site ID	TWC	TWC	TWE	TWE	7TCEMW07	7MW07	7MW07	7MW08
Sample ID	7TCECs	7TCECd	7TCEEs	7TCEEsD	7TCEMW7	7MW07	7MW07D	7MW08
Sample Date	06/27/99	06/30/99	06/30/99	06/30/99	07/01/99	01/13/02	01/13/02	01/13/02
Volatile Organic Compounds (ug/L) (Cont.)								
Acrolein	NA	NA	NA	NA	NA	20,000 R	20,000 R	100 J
Acrylonitrile	NA	NA	NA	NA	NA	20,000 UJ	20,000 UJ	100 U
Benzene	5 U	50 U	5 U	5 U	50 U	1,000 U	1,000 U	0.54 J
Bromobenzene	NA	NA	NA	NA	NA	NA	NA	NA
Bromochloromethane	NA	NA	NA	NA	NA	NA	NA	NA
Bromodichloromethane	5 U	50 U	5 U	5 U	50 U	1,000 U	1,000 U	5 U
Bromoform	5 U	50 U	5 U	5 U	50 U	1,000 U	1,000 U	5 U
Bromomethane	10 U	100 U	10 U	10 U	100 U	2,000 UJ	2,000 UJ	10 UJ
Carbon disulfide	5 U	50 U	5 U	5 U	50 U	1,000 U	1,000 U	5 U
Carbon tetrachloride	5 U	50 U	5 U	5 U	50 U	1,000 U	1,000 U	5 U
Chlorobenzene	5 U	50 U	5 U	5 U	50 U	1,000 U	1,000 U	5 U
Chloroethane	10 U	100 U	10 U	10 U	100 U	2,000 U	2,000 U	10 U
Chloroform	5 U	50 U	5 U	5 U	50 U	1,000 U	1,000 U	5 U
Chloromethane	10 U	100 U	10 U	10 U	100 U	2,000 U	2,000 U	10 U
Chloroprene	NA	NA	NA	NA	NA	1,000 U	1,000 U	5 U
cis-1,3-Dichloropropene	5 U	50 U	5 U	5 U	50 U	1,000 U	1,000 U	5 U
Dibromochloromethane	5 U	50 U	5 U	5 U	50 U	1,000 U	1,000 U	5 U
Dibromomethane	NA	NA	NA	NA	NA	1,000 U	1,000 U	5 U
Dichlorodifluoromethane	NA	NA	NA	NA	NA	2,000 U	2,000 U	10 U
Ethyl methacrylate	NA	NA	NA	NA	NA	1,000 U	1,000 U	5 U
Ethylbenzene	5 U	50 U	5 U	5 U	50 U	1,000 U	1,000 U	5 U
Hexchlorobutadiene	NA	NA	NA	NA	NA	NA	NA	NA
Iodomethane	NA	NA	NA	NA	NA	1,000 U	1,000 U	5 U
Isobutanol	NA	NA	NA	NA	NA	40,000 U	40,000 U	200 R
Isopropylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
Methacrylonitrile	NA	NA	NA	NA	NA	20,000 UJ	20,000 UJ	100 U
Methyl methacrylate	NA	NA	NA	NA	NA	1,000 U	1,000 U	5 U
Methylene chloride	5 U	50 U	5 U	5 U	50 U	95 J	1,000 U	5 U
n-Butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA

APPENDIX A.4

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	TCE Investigation					Additional Data Collection Investigation		
Site ID	TWC	TWC	TWE	TWE	7TCEMW07	7MW07	7MW07	7MW08
Sample ID	7TCECs	7TCECd	7TCEEs	7TCEEsD	7TCEMW7	7MW07	7MW07D	7MW08
Sample Date	06/27/99	06/30/99	06/30/99	06/30/99	07/01/99	01/13/02	01/13/02	01/13/02
Volatile Organic Compounds (ug/L) (Cont.)								
n-Propylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
o-Xylene	NA	NA	NA	NA	NA	NA	NA	NA
Pentachloroethane	NA	NA	NA	NA	NA	5,000 UJ	5,000 UJ	25 J
p-Isopropyltoluene	NA	NA	NA	NA	NA	NA	NA	NA
Propionitrile	NA	NA	NA	NA	NA	20,000 U	20,000 U	100 U
sec-Butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
Styrene	5 U	50 U	5 U	5 U	50 U	1,000 U	1,000 U	5 U
tert-Butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
Tetrachloroethene	5 U	50 U	5 U	5 U	50 U	1,000 U	1,000 U	5 U
Toluene	5 U	50 U	5 U	5 U	50 U	1,000 U	170 J	5 U
trans-1,2-Dichloroethene	5 U	50 U	5 U	5 U	50 U	1,000 U	1,000 U	5 U
trans-1,3-Dichloropropene	5 U	50 U	5 U	5 U	50 U	1,000 U	1,000 U	5 U
trans-1,4-Dichloro-2-butene	NA	NA	NA	NA	NA	2,000 U	2,000 U	10 U
Trichloroethene	25	1,500	5 U	5 U	1,000	28,000 J	23,000 J	0.47 J
Trichlorofluoromethane	NA	NA	NA	NA	NA	1,000 U	1,000 U	5 U
Vinyl acetate	NA	NA	NA	NA	NA	2,000 U	2,000 U	10 U
Vinyl chloride	10 U	100 U	10 U	10 U	100 U	2,000 U	2,000 U	10 U
Xylene (m&p)	NA	NA	NA	NA	NA	NA	NA	NA
Xylenes	10 U	100 U	10 U	10 U	100 U	2,000 U	2,000 U	10 U

APPENDIX A.4

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Additional Data Collection Investigation					TCE Plume Delineation and Source Investigation		
Site ID	7MW10	7MW20	UGW11	UGW16	UGW18	7TCETW201	7TCETW202	7TCETW203
Sample ID	7MW10	7MW20	UGW11	UGW16	UGW18	7TCETW201	7TCETW202	7TCETW203
Sample Date	01/26/02	01/26/02	01/12/02	01/12/02	01/12/02	09/16/03	09/16/03	09/16/03
Volatile Organic Compounds (ug/L)								
1,1,1,2-Tetrachloroethane	5 U	5 U	5 U	5 U	5 U	NA	NA	NA
1,1,1-Trichloroethane	5 U	5 U	5 U	5 U	5 U	1 U	1 U	1 U
1,1,2,2-Tetrachloroethane	5 U	5 U	5 U	5 U	5 U	NA	NA	NA
1,1,2-Trichloroethane	5 U	5 U	5 U	5 U	5 U	1 U	0.42 J	1 U
1,1-Dichloroethane	5 U	5 U	5 U	5 U	5 U	1 U	1 U	1 U
1,1-Dichloroethene	5 U	5 U	5 U	1.7 J	5 U	1 U	1 U	1 U
1,1-Dichloropropene	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3-Trichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3-Trichloropropane	5 U	5 U	5 U	5 U	5 U	NA	NA	NA
1,2,4-Trichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA
1,2,4-Trimethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dibromo-3-chloropropane	5 U	5 U	5 UJ	5 UJ	5 UJ	NA	NA	NA
1,2-Dibromoethane	5 U	5 U	5 U	5 U	5 U	NA	NA	NA
1,2-Dichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dichloroethane	5 U	5 U	5 U	5 U	5 U	1 U	0.51 J	1 U
1,2-Dichloropropane	5 U	5 U	5 U	5 U	5 U	NA	NA	NA
1,3,5-Trimethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichloropropane	NA	NA	NA	NA	NA	NA	NA	NA
1,4-Dichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA
2,2-Dichloropropane	NA	NA	NA	NA	NA	NA	NA	NA
2-Butanone	25 U	25 U	25 U	25 U	25 U	NA	NA	NA
2-Chlorotoluene	NA	NA	NA	NA	NA	NA	NA	NA
2-Hexanone	25 U	25 U	25 U	25 U	25 U	NA	NA	NA
3-Chloro-1-propene	5 U	5 U	5 U	5 U	5 U	NA	NA	NA
4-Chlorotoluene	NA	NA	NA	NA	NA	NA	NA	NA
4-Methyl-2-pentanone	25 U	25 U	25 U	25 U	25 U	NA	NA	NA
Acetone	50 U	50 U	50 U	50 U	50 U	NA	NA	NA
Acetonitrile	200 UJ	200 UJ	200 UJ	200 UJ	200 UJ	NA	NA	NA

APPENDIX A.4

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Additional Data Collection Investigation					TCE Plume Delineation and Source Investigation		
Site ID	7MW10	7MW20	UGW11	UGW16	UGW18	7TCETW201	7TCETW202	7TCETW203
Sample ID	7MW10	7MW20	UGW11	UGW16	UGW18	7TCETW201	7TCETW202	7TCETW203
Sample Date	01/26/02	01/26/02	01/12/02	01/12/02	01/12/02	09/16/03	09/16/03	09/16/03
Volatile Organic Compounds (ug/L) (Cont.)								
Acrolein	100 R	100 R	100 R	100 R	100 R	NA	NA	NA
Acrylonitrile	100 U	100 U	100 UJ	100 UJ	100 UJ	NA	NA	NA
Benzene	5 U	5 U	5 U	5 U	5 U	NA	NA	NA
Bromobenzene	NA	NA	NA	NA	NA	NA	NA	NA
Bromochloromethane	NA	NA	NA	NA	NA	NA	NA	NA
Bromodichloromethane	5 U	5 U	5 U	5 U	5 U	NA	NA	NA
Bromoform	5 U	5 U	5 U	5 U	5 U	NA	NA	NA
Bromomethane	10 U	10 U	10 UJ	10 UJ	10 UJ	NA	NA	NA
Carbon disulfide	5 U	5 U	5 U	5 U	5 U	NA	NA	NA
Carbon tetrachloride	5 U	5 U	5 U	5 U	5 U	NA	NA	NA
Chlorobenzene	5 U	5 U	5 U	5 U	5 U	NA	NA	NA
Chloroethane	10 U	10 U	10 U	10 U	10 U	NA	NA	NA
Chloroform	5 U	5 U	5 U	5 U	5 U	1 U	1 U	1 U
Chloromethane	10 U	10 U	10 U	10 U	10 U	1 U	1.3 U	1 U
Chloroprene	5 U	5 U	5 U	5 U	5 U	NA	NA	NA
cis-1,3-Dichloropropene	5 U	5 U	5 U	5 U	5 U	NA	NA	NA
Dibromochloromethane	5 U	5 U	5 U	5 U	5 U	NA	NA	NA
Dibromomethane	5 U	5 U	5 U	5 U	5 U	NA	NA	NA
Dichlorodifluoromethane	10 U	10 U	10 U	10 U	10 U	NA	NA	NA
Ethyl methacrylate	5 U	5 U	5 U	5 U	5 U	NA	NA	NA
Ethylbenzene	5 U	5 U	5 U	5 U	5 U	NA	NA	NA
Hexchlorobutadiene	NA	NA	NA	NA	NA	NA	NA	NA
Iodomethane	5 U	5 U	5 U	5 U	5 U	NA	NA	NA
Isobutanol	200 R	200 R	200 U	200 U	200 U	NA	NA	NA
Isopropylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
Methacrylonitrile	100 U	100 U	100 UJ	100 UJ	100 UJ	NA	NA	NA
Methyl methacrylate	5 U	5 U	5 U	5 U	5 U	NA	NA	NA
Methylene chloride	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
n-Butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA

APPENDIX A.4

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	Additional Data Collection Investigation					TCE Plume Delineation and Source Investigation		
Site ID	7MW10	7MW20	UGW11	UGW16	UGW18	7TCETW201	7TCETW202	7TCETW203
Sample ID	7MW10	7MW20	UGW11	UGW16	UGW18	7TCETW201	7TCETW202	7TCETW203
Sample Date	01/26/02	01/26/02	01/12/02	01/12/02	01/12/02	09/16/03	09/16/03	09/16/03
Volatile Organic Compounds (ug/L) (Cont.)								
n-Propylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
o-Xylene	NA	NA	NA	NA	NA	NA	NA	NA
Pentachloroethane	25 R	25 R	25 UJ	25 UJ	25 UJ	5 U	5 U	5 U
p-Isopropyltoluene	NA	NA	NA	NA	NA	NA	NA	NA
Propionitrile	100 U	100 U	100 U	100 U	100 U	NA	NA	NA
sec-Butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
Styrene	5 U	5 U	5 U	5 U	5 U	NA	NA	NA
tert-Butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
Tetrachloroethene	5 U	5 U	5 U	5 U	5 U	1 U	0.5 J	1 U
Toluene	5 U	5 U	5 U	5 U	5 U	NA	NA	NA
trans-1,2-Dichloroethene	5 U	5 U	5 U	5 U	5 U	1 U	1 U	1 U
trans-1,3-Dichloropropene	5 U	5 U	5 U	5 U	5 U	NA	NA	NA
trans-1,4-Dichloro-2-butene	10 U	10 U	10 U	10 U	10 U	NA	NA	NA
Trichloroethene	5 U	0.59 J	0.35 J	5 U	5 U	1 U	0.26 J	1 U
Trichlorofluoromethane	5 U	5 U	5 U	5 U	5 U	NA	NA	NA
Vinyl acetate	10 U	10 U	10 U	10 U	10 U	NA	NA	NA
Vinyl chloride	10 U	10 U	10 U	10 U	10 U	1 U	1 U	1 U
Xylene (m&p)	NA	NA	NA	NA	NA	NA	NA	NA
Xylenes	10 U	10 U	10 U	10 U	10 U	NA	NA	NA

APPENDIX A.4

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	TCE Plume Delineation and Source Investigation							
Site ID	7TCETW203	7TCETW204	7TCETW205	7TCETW206	7TCETW207	7TCETW208	7TCETW209	7TCETW210
Sample ID	7TCETW203D	7TCETW204	7TCETW205	7TCETW206	7TCETW207	7TCETW208	7TCETW209	7TCETW210
Sample Date	09/16/03	09/18/03	09/18/03	09/19/03	09/19/03	09/25/03	09/24/03	09/25/03
Volatile Organic Compounds (ug/L)								
1,1,1,2-Tetrachloroethane	NA	NA	NA	NA	NA	NA	NA	NA
1,1,1-Trichloroethane	1 U	1 U	1 U	0.18 J	1 U	1 U	1 U	1 U
1,1,2,2-Tetrachloroethane	NA	NA	NA	NA	NA	NA	NA	NA
1,1,2-Trichloroethane	0.89 J	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1-Dichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1-Dichloroethene	1 U	0.56 J	3.8	1 U	1 U	1 U	0.87 J	1 U
1,1-Dichloropropene	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3-Trichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3-Trichloropropane	NA	NA	NA	NA	NA	NA	NA	NA
1,2,4-Trichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA
1,2,4-Trimethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dibromo-3-chloropropane	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dibromoethane	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dichloroethane	0.89 J	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloropropane	NA	NA	NA	NA	NA	NA	NA	NA
1,3,5-Trimethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichloropropane	NA	NA	NA	NA	NA	NA	NA	NA
1,4-Dichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA
2,2-Dichloropropane	NA	NA	NA	NA	NA	NA	NA	NA
2-Butanone	NA	NA	NA	NA	NA	NA	NA	NA
2-Chlorotoluene	NA	NA	NA	NA	NA	NA	NA	NA
2-Hexanone	NA	NA	NA	NA	NA	NA	NA	NA
3-Chloro-1-propene	NA	NA	NA	NA	NA	NA	NA	NA
4-Chlorotoluene	NA	NA	NA	NA	NA	NA	NA	NA
4-Methyl-2-pentanone	NA	NA	NA	NA	NA	NA	NA	NA
Acetone	NA	NA	NA	NA	NA	NA	NA	NA
Acetonitrile	NA	NA	NA	NA	NA	NA	NA	NA

APPENDIX A.4

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	TCE Plume Delineation and Source Investigation							
Site ID	7TCETW203	7TCETW204	7TCETW205	7TCETW206	7TCETW207	7TCETW208	7TCETW209	7TCETW210
Sample ID	7TCETW203D	7TCETW204	7TCETW205	7TCETW206	7TCETW207	7TCETW208	7TCETW209	7TCETW210
Sample Date	09/16/03	09/18/03	09/18/03	09/19/03	09/19/03	09/25/03	09/24/03	09/25/03
Volatile Organic Compounds (ug/L) (Cont.)								
Acrolein	NA	NA	NA	NA	NA	NA	NA	NA
Acrylonitrile	NA	NA	NA	NA	NA	NA	NA	NA
Benzene	NA	NA	NA	NA	NA	NA	NA	NA
Bromobenzene	NA	NA	NA	NA	NA	NA	NA	NA
Bromochloromethane	NA	NA	NA	NA	NA	NA	NA	NA
Bromodichloromethane	NA	NA	NA	NA	NA	NA	NA	NA
Bromoform	NA	NA	NA	NA	NA	NA	NA	NA
Bromomethane	NA	NA	NA	NA	NA	NA	NA	NA
Carbon disulfide	NA	NA	NA	NA	NA	NA	NA	NA
Carbon tetrachloride	NA	NA	NA	NA	NA	NA	NA	NA
Chlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA
Chloroethane	NA	NA	NA	NA	NA	NA	NA	NA
Chloroform	1 U	1 U	1 U	0.14 U	0.14 U	1 U	1 U	1 U
Chloromethane	1 U	1 U	1 U	0.4 J	1 U	1 U	1 U	1 U
Chloroprene	NA	NA	NA	NA	NA	NA	NA	NA
cis-1,3-Dichloropropene	NA	NA	NA	NA	NA	NA	NA	NA
Dibromochloromethane	NA	NA	NA	NA	NA	NA	NA	NA
Dibromomethane	NA	NA	NA	NA	NA	NA	NA	NA
Dichlorodifluoromethane	NA	NA	NA	NA	NA	NA	NA	NA
Ethyl methacrylate	NA	NA	NA	NA	NA	NA	NA	NA
Ethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
Hexchlorobutadiene	NA	NA	NA	NA	NA	NA	NA	NA
Iodomethane	NA	NA	NA	NA	NA	NA	NA	NA
Isobutanol	NA	NA	NA	NA	NA	NA	NA	NA
Isopropylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
Methacrylonitrile	NA	NA	NA	NA	NA	NA	NA	NA
Methyl methacrylate	NA	NA	NA	NA	NA	NA	NA	NA
Methylene chloride	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
n-Butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA

APPENDIX A.4

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	TCE Plume Delineation and Source Investigation							
Site ID	7TCETW203	7TCETW204	7TCETW205	7TCETW206	7TCETW207	7TCETW208	7TCETW209	7TCETW210
Sample ID	7TCETW203D	7TCETW204	7TCETW205	7TCETW206	7TCETW207	7TCETW208	7TCETW209	7TCETW210
Sample Date	09/16/03	09/18/03	09/18/03	09/19/03	09/19/03	09/25/03	09/24/03	09/25/03
Volatile Organic Compounds (ug/L) (Cont.)								
n-Propylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
o-Xylene	NA	NA	NA	NA	NA	NA	NA	NA
Pentachloroethane	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
p-Isopropyltoluene	NA	NA	NA	NA	NA	NA	NA	NA
Propionitrile	NA	NA	NA	NA	NA	NA	NA	NA
sec-Butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
Styrene	NA	NA	NA	NA	NA	NA	NA	NA
tert-Butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
Tetrachloroethene	1 U	1 U	1 U	4.5	0.51 J	1 U	1 U	1 U
Toluene	NA	NA	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethene	1 U	1.1	1 U	1 U	1 U	1 U	1 U	1 U
trans-1,3-Dichloropropene	NA	NA	NA	NA	NA	NA	NA	NA
trans-1,4-Dichloro-2-butene	NA	NA	NA	NA	NA	NA	NA	NA
Trichloroethene	0.21 J	14	0.32 J	66	0.2 J	0.68 U	1 U	1 U
Trichlorofluoromethane	NA	NA	NA	NA	NA	NA	NA	NA
Vinyl acetate	NA	NA	NA	NA	NA	NA	NA	NA
Vinyl chloride	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Xylene (m&p)	NA	NA	NA	NA	NA	NA	NA	NA
Xylenes	NA	NA	NA	NA	NA	NA	NA	NA

APPENDIX A.4

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	TCE Plume Delineation and Source Investigation									
Site ID	7MW07	7MW08	7MW10	7MW20	7MW20	7MW21	7MW22	7MW23	7MW24	UGW11
Sample ID	7MW07	7MW08	7MW10	7MW20	7MW20D	7MW21	7MW22	7MW23	7MW24	UGW11
Sample Date	09/16/03	09/22/03	09/22/03	09/23/03	09/23/03	09/25/03	09/25/03	09/24/03	09/24/03	09/22/03
Volatile Organic Compounds (ug/L)										
1,1,1,2-Tetrachloroethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,1,1-Trichloroethane	100 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2,2-Tetrachloroethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,1,2-Trichloroethane	100 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	0.22 J	1 U
1,1-Dichloroethane	100 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1-Dichloroethene	100 U	1 U	1 U	1 U	1 U	1 U	5	1 U	2.5	1 U
1,1-Dichloropropene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3-Trichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,3-Trichloropropane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,4-Trichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,4-Trimethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dibromo-3-chloropropane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dibromoethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dichloroethane	100 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloropropane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,3,5-Trimethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichloropropane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,4-Dichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,2-Dichloropropane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-Butanone	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-Chlorotoluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-Hexanone	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3-Chloro-1-propene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4-Chlorotoluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4-Methyl-2-pentanone	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acetone	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acetonitrile	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

APPENDIX A.4

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	TCE Plume Delineation and Source Investigation									
Site ID	7MW07	7MW08	7MW10	7MW20	7MW20	7MW21	7MW22	7MW23	7MW24	UGW11
Sample ID	7MW07	7MW08	7MW10	7MW20	7MW20D	7MW21	7MW22	7MW23	7MW24	UGW11
Sample Date	09/16/03	09/22/03	09/22/03	09/23/03	09/23/03	09/25/03	09/25/03	09/24/03	09/24/03	09/22/03
Volatile Organic Compounds (ug/L) (Cont.)										
Acrolein	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acrylonitrile	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bromobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bromochloromethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bromodichloromethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bromoform	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bromomethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Carbon disulfide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Carbon tetrachloride	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chloroethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chloroform	100 U	1 U	1 U	0.13 U	0.12 U	1 U	1 U	1 U	0.55 U	20 U
Chloromethane	100 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chloroprene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
cis-1,3-Dichloropropene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibromochloromethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibromomethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dichlorodifluoromethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ethyl methacrylate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Ethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hexchlorobutadiene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Iodomethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Isobutanol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Isopropylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methacrylonitrile	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methyl methacrylate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene chloride	500 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
n-Butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

APPENDIX A.4

SUMMARY OF ANALYTICAL RESULTS, GROUNDWATER - ORGANICS
SWMU 55 - TCE PLUME NEAR TOW WAY FUEL FARM
CORRECTIVE MEASURES STUDY
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Investigation	TCE Plume Delineation and Source Investigation									
Site ID	7MW07	7MW08	7MW10	7MW20	7MW20	7MW21	7MW22	7MW23	7MW24	UGW11
Sample ID	7MW07	7MW08	7MW10	7MW20	7MW20D	7MW21	7MW22	7MW23	7MW24	UGW11
Sample Date	09/16/03	09/22/03	09/22/03	09/23/03	09/23/03	09/25/03	09/25/03	09/24/03	09/24/03	09/22/03
Volatile Organic Compounds (ug/L) (Cont.)										
n-Propylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
o-Xylene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pentachloroethane	500 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
p-Isopropyltoluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Propionitrile	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
sec-Butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Styrene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
tert-Butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tetrachloroethene	100 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Toluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethene	100 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
trans-1,3-Dichloropropene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
trans-1,4-Dichloro-2-butene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Trichloroethene	1,800	0.15 J	1 U	1 U	1 U	1.4 U	0.44 U	87	1,600	1 U
Trichlorofluoromethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vinyl acetate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vinyl chloride	100 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Xylene (m&p)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Xylenes	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

APPENDIX B
Johnson and Ettinger Model

APPENDIX B – Use of the Johnson and Ettinger (1991) Model for Vapor Intrusion into Buildings from Groundwater for SWMUs 54 and 55, Naval Activity Puerto Rico

I.1 Introduction

Volatilization of contaminants in groundwater, and the subsequent mass transport of these vapors into indoor spaces is a potential inhalation exposure pathway at SWMUs 54 and 55. Johnson and Ettinger (1991) introduced a screening-level model which incorporates both convective and diffusive mechanisms for estimating the transport of contaminant vapors emanating from subsurface soils or groundwater into indoor spaces located directly above or in close proximity to the contaminant source. The Johnson and Ettinger model is a one-dimensional analytical solution to convective and diffusive vapor transport and provides an estimated attenuation coefficient relating the vapor concentration in the indoor space to the vapor concentration at the contaminant source. Inputs to the model include chemical properties of the contaminant, saturated and unsaturated zone soil properties, and structural properties of the building (USEPA, 2000).

EPA (2000) placed the Johnson and Ettinger model into MICROSOFT EXCEL spreadsheets and provided a "User's Guide" for instructions on using the model. For SWMUs 54 and 55, the tier-2 groundwater model is used in its risk-based concentration mode. Default variables were used unless when site-specific conditions suggested otherwise. The fundamentals of the model, the equation derivations, discussion of sensitivity of the model to input parameters, detailed model application and examples are well presented in the "User's Guide" (USEPA, 2000) and will not be summarized here. The principal changes between this model and the original Johnson and Ettinger (1991) version are in the soil water retention parameters and the soil saturated hydraulic conductivity values.

The following sections describe the site-specific parameters used for SWMUs 54 and 55 and a brief discussion of site-specific parameter sensitivity. These parameters are identical to those used for the site-specific assessment made as part of the Task 1 CMS for the Tow Way Fuel Farm (Baker, 2003). SWMU 55 is within the boundaries of the Tow Way Fuel Farm Site and the conditions at SWMU 54 are similar enough to warrant its use as a hypothetical but realistic model given that the site-specific data from SWMU 54 are not available. The model results follow the text and are simply printouts of the DATENTER and RESULTS worksheets in the GWTIER2 (with site-specific modifications) workbook for each groundwater COPC with inhalation toxicity criteria.

I.2 Site-Specific Parameters

The DATENTER worksheet shows all of the model parameters, while the CHEMPROPS worksheet shows all of the chemical properties necessary for the model. The following site-specific parameters are used for SWMUs 54 and 55 (as described for the Tow Way Fuel Farm site (Baker, 2003)), replacing the default parameters.

- Depth to groundwater - 300 cm is used for the site-specific depth to groundwater replacing the default value of 400 cm. The depth is based on the approximate average of measured depths from eleven monitoring wells located south of Forrestal Drive. The data includes ten measurements from each well between April 27, 1999 and March 18, 2000. The average depth to groundwater varies for the eleven wells from seven to thirteen feet below ground level.

  The area south of Forrestal Drive is included in the model for two reasons. The first is that it is flat and already has buildings on it and is suitable for potential new buildings. The area north of Forrestal Drive is hilly and has few buildings. The second is that the depth to groundwater is considerably more shallow to the south so that volatilization is more conservatively modeled.

- Thickness of soil layers - The model includes three layers of soil above the groundwater surface. The default thickness of these layers from top to bottom is 300 cm, 50 cm, and 50 cm. Based on the logs for seven borings advanced during the CMS Investigation, there is no apparent structure to the soil in the region south of Forrestal Drive. Therefore, it was assumed that the layers are each 100 cm (i.e., a total of 300 cm).

- Soil type by layer - The model uses the SCS soil textural classification system. Seven samples from the CMS Investigation with grain-size analysis were plotted on the SCS classification triangle provided in the model. The SCS type is based on the percent sand, silt, and clay (gravel was included with sand). Of the seven samples two were silt loams, two clay loams, two loams, and one on the line between clay loam and loam. The silt loam and clay loam classifications produce nearly the same acceptable groundwater result, so the silt loam was assumed for all three layers of soil. The default soil type for the model was sandy clay and clay.

- Building characteristics - For building dimensions, the office building near the corner of Forrestal Drive and Palau Street at the TWFF was used. The dimensions are 3,000 cm, by 1,800 cm, by 244 cm (or 8 feet). This differs from the default average two story residence size used in the model of 961 cm, by 961 cm, by 488 cm. Other building characteristics assumed such as slab-on-grade construction, are default values.

- Indoor air exchange rate - This parameter is in units of total building air exchanges per hour. It is used with the building dimensions to calculate the building ventilation rate. The default value, based on the 50th percentile of measurements of U.S. homes, is 0.45/hr. The site-specific value is one exchange per hour based on a calculation converting the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) standard 62-1989 for office buildings of 20 $ft.^3$/min. per seven persons per 1,000 $ft.^2$ to $ft.^3$/hr. and comparing to the TWFF office building dimensions. This number is conservative compared to the 2/hr. recommended by Michigan Department of Environmental Quality's for air exchange rate for commercial/industrial buildings (MDEQ, 1998). The justification for the value is that approximately one exchange per hour is contributed from mechanical system rates for total supply air in a general office that will be supplemented by factors such as natural ventilation, infiltration, and occupancy entrance and egress.

- Averaging time and exposure duration - These standard risk assessment parameters were reduced from the 30 years default to 25 years to account for industrial exposure rather than residential. Both values are high-end selections (90 to 95th percentile) from distributions of data on duration of occupancy and duration of employment.

- Added chemicals - The model uses ancillary worksheets to display intermediate calculations, lookup tables, and chemical properties. The User's Guide includes instructions on how to add chemical and toxicological properties for chemicals that are not included in the model's lookup tables (VLOOKUP). Data from VLOOKUP are retrieved by CAS number into other worksheets in the model. Data was added into VLOOKUP for 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, chloromethane, isopropylbenzene, and methyl tert-butyl ether. Data requirements included CAS number, organic carbon partition coefficient, diffusivities in air and water, solubility, Henry's constant, Henry's constant reference temperature, boiling point, critical temperature, enthalpy of vaporization at the boiling point, unit risk, and reference concentration.

I.3 Model Uncertainty and Sensitivity

In their article, Johnson and Ettinger (1991) reported that the model results were in qualitative agreement with published experimental case histories and in good quantitative and qualitative agreement with three-dimensional numerical modeling of radon transport into homes (USEPA, 2000). That being said the model is still only a screening-level model with gross assumptions about complex chemical and physical processes. These assumptions and uncertainties related to individual parameters used in the model cause the results to be highly uncertain. Some of the model assumptions that are probably significant in this application at the TWFF are: all vapors originating from below the building will enter the building unless

the floors and walls are perfect vapor barriers; diffusion dominates vapor transport between the contaminant source and the building zone of influence; all soil properties are laterally homogeneous; the model does not account for degradation of contaminants; the building ventilation rates and dynamic pressure differences between building interior and soil are constants; and vapor transport occurs in the absence of convective water movement in the soil column (i.e., evaporation or infiltration), and in absence of mechanical dispersion (USEPA, 2000). An empirical study was performed that compared modeled results using Johnson and Ettinger with measured concentrations inside of buildings. (Fitzpatrick and Fitzgerald, 1997) this study showed that the model tended to over-predict non-chlorinated chemicals (e.g., benzene and toluene) and under-predicted chlorinated chemicals. The authors suspected the cause of this discrepancy to be the significant biodegradation of the non-chlorinated volatiles.

A simple sensitivity analysis was done on the TWFF model by changing single model parameters and noting the difference in the result (i.e., the groundwater concentration that produce an acceptable concentration in the overlying building).

- Soil class - Changing the soil class from silty loam to a clay loam had nearly no effect. While changing to a more permeable loam, decreased the concentration by a factor of more than two and one-half.

- Depth to groundwater - Reducing the depth from three meters to two had virtually no effect on the result.

- Water-filled porosity - Changing from the default surface porosity (an associated increases in two layers towards the groundwater) from 0.2 to 0.15 decreased the concentration by about ten percent.

- Building dimensions - Changing from the measured TWFF building to the default home produced an increase in the resulting concentration of 45 percent.

- Soil-building pressure differential - Changing from the 40 g/cm-s^2 default to a potentially more realistic value of 20 g/cm- s^2 increased the calculated concentration nearly 50 percent.

- Indoor air exchange rate - Modifying this parameter produced a linear effect. Doubling the air exchange rate doubled the concentration.

DATA ENTRY SHEET

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

GW-ADV
Version 2.3; 03/01

YES [X]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [ ]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
107062		1,2-Dichloroethane

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Totals must add up to value of L_{WT} (cell D28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
10	15	300	100	100	100	C	sil	sil		

MORE ↓

ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
1.5	0.43	0.2	1.7	0.43	0.27	1.7	0.43	0.3

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)
15	40	3000	1800	244	0.1	1

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
8.33E+02	NA	8.33E+02	8.52E+06	8.33E+02

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)
MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

GW-ADV
Version 2.3; 03/01

YES [X]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [ ]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
79005		1,1,2-Trichloroethane

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell D28)							
10	15	300	100	100	100	C	sil	sil		

MORE ↓

ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
1.5	0.43	0.2	1.7	0.43	0.27	1.7	0.43	0.3

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)
15	40	3000	1800	244	0.1	1

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
1.69E+03	NA	1.69E+03	4.42E+06	1.69E+03

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)
MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

GW-ADV
Version 2.3; 03/01

YES [X]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [ ]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
71432		Benzene

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Totals must add up to value of L_{WT} (cell D28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
10	15	300	100	100	100	C	sil	sil		

MORE ↓

ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
1.5	0.43	0.2	1.7	0.43	0.27	1.7	0.43	0.3

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)
15	40	3000	1800	244	0.1	1

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
5.50E+02	NA	5.50E+02	1.75E+06	5.50E+02

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)
MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

GW-ADV
Version 2.3; 03/01

YES [X]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [ ]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (μg/L)	Chemical
56553		Benz(a)anthracene

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell D28)							
10	15	300	100	100	100	C	sil	sil		

MORE ↓

ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
1.5	0.43	0.2	1.7	0.43	0.27	1.7	0.43	0.3

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s^2)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)
15	40	3000	1800	244	0.1	1

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
7.70E+04	NA	7.70E+04	9.40E+00	NOC

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)
MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.
NOC = NOT OF CONCERN. The groundwater conc. at or above the solubility limit is not of concern for this pathway.
MESSAGE: Risk/HQ or risk-based groundwater concentration is based on a route-to-route extrapolation.

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

GW-ADV
Version 2.3; 03/01

YES [X]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [ ]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
156592		cis-1,2-Dichloroethylene

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell D28)							
10	15	300	100	100	100	C	sil	sil		

MORE ↓

ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
1.5	0.43	0.2	1.7	0.43	0.27	1.7	0.43	0.3

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)
15	40	3000	1800	244	0.1	1

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
NA	7.42E+04	7.42E+04	3.50E+06	7.42E+04

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)
MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.

MESSAGE: Risk/HQ or risk-based groundwater concentration is based on a route-to-route extrapolation.

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

GW-ADV
Version 2.3; 03/01

YES [X]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [ ]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
67663		Chloroform

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell D28)							
10	15	300	100	100	100	C	sil	sil		

MORE ↓

ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
1.5	0.43	0.2	1.7	0.43	0.27	1.7	0.43	0.3

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)
15	40	3000	1800	244	0.1	1

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
2.51E+02	NA	2.51E+02	7.92E+06	2.51E+02

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)
MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

GW-ADV
Version 2.3; 03/01

YES [X]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [ ]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
100414		Ethylbenzene

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell D28)							
10	15	300	100	100	100	C	silt	sil		

MORE ↓

ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
1.5	0.43	0.2	1.7	0.43	0.27	1.7	0.43	0.3

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)
15	40	3000	1800	244	0.1	1

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
NA	1.40E+06	1.40E+06	1.69E+05	NOC

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)
MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.
NOC = NOT OF CONCERN. The groundwater conc. at or above the solubility limit is not of concern for this pathway.

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

GW-ADV
Version 2.3; 03/01

YES [X]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [ ]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
91203		Naphthalene

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell D28)							
10	15	300	100	100	100	C	sil	sil		

MORE ↓

ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
1.5	0.43	0.2	1.7	0.43	0.27	1.7	0.43	0.3

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)
15	40	3000	1800	244	0.1	1

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
NA	7.08E+04	7.08E+04	3.10E+04	NOC

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)
MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.
NOC = NOT OF CONCERN. The groundwater conc. at or above the solubility limit is not of concern for this pathway.

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

GW-ADV
Version 2.3; 03/01

YES [X]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [ ]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
127184		Tetrachloroethylene

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell D28)							
10	15	300	100	100	100	C	sil	sil		

MORE ↓

ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
1.5	0.43	0.2	1.7	0.43	0.27	1.7	0.43	0.3

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)
15	40	3000	1800	244	0.1	1

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
2.89E+02	NA	2.89E+02	2.00E+05	2.89E+02

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)
MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

GW-ADV
Version 2.3; 03/01

YES [X]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [ ]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
108883		Toluene

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell D28)							
10	15	300	100	100	100	C	sil	sil		

MORE ↓

ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
1.5	0.43	0.2	1.7	0.43	0.27	1.7	0.43	0.3

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)
15	40	3000	1800	244	0.1	1

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
NA	5.70E+05	5.70E+05	5.26E+05	NOC

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)
MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.
NOC = NOT OF CONCERN. The groundwater conc. at or above the solubility limit is not of concern for this pathway.

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

GW-ADV
Version 2.3; 03/01

YES [X]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [ ]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
79016		Trichloroethylene

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell D28)							
10	15	300	100	100	100	C	sil	sil		

MORE ↓

ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
1.5	0.43	0.2	1.7	0.43	0.27	1.7	0.43	0.3

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)
15	40	3000	1800	244	0.1	1

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
2.24E+01	NA	2.24E+01	1.10E+06	2.24E+01

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)
MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.

SCROLL DOWN TO "END"

END

DATA ENTRY SHEET

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

GW-ADV
Version 2.3; 03/01

YES [X]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [ ]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
106423		p-Xylene

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Totals must add up to value of L_{WT} (cell D28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
10	15	300	100	100	100	C	sil	sil		

MORE ↓

ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
1.5	0.43	0.2	1.7	0.43	0.27	1.7	0.43	0.3

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)
15	40	3000	1800	244	0.1	1

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	25	25	250	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

RESULTS SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
NA	1.51E+05	1.51E+05	1.85E+05	1.51E+05

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)
MESSAGE: The values of Csource and Cbuilding on the INTERCALCS worksheet are based on unity and do not represent actual values.

SCROLL DOWN TO "END"

END

APPENDIX C
Human Health Risk Assessment Calculations

TABLE C-1

CORRECTIVE ACTION OBJECTIVES (CAOs)
SOIL INGESTION - FUTURE INDUSTRIAL WORKER
CORRECTIVE MEASURES STUDY
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

SF	Rfd	Analyte	CAOs (mg/kg) at Target Risk Levels			CAOs (mg/kg) at Target HQ = 1.0
			1E-06	1E-05	1E-04	
		Semivolatiles:				
7.3E+00		Benzo(a)pyrene	7.84E-01	7.84E+00	7.84E+01	--

'--' Indicates that the relevant health effects criteria are unavailable.

Variable	Units	Value
Risk	none	1E-06
BWa	kg	70
ATNC	days	9125
ATC	days	25550
IRa	mg/day	50
CF	kg/mg	1E-06
FI	none	1
EF	days/yr	250
EDa	yrs	25
HI	none	1

TABLE C-2

CORRECTIVE ACTION OBJECTIVES (CAOs)
DUST INHALATION - FUTURE INDUSTRIAL WORKER
CORRECTIVE MEASURES STUDY
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

SF	Rfd	Analyte	CAOs (mg/kg) at Target Risk Levels			CAOs (mg/kg) at Target HQ = 1.0
			1E-06	1E-05	1E-04	
		Semivolatiles:	--	--	--	--
3.1E+00		Benzo(a)pyrene	9.59E+03	9.59E+04	9.59E+05	--

'--' Indicates that the relevant health effects criteria are unavailable.

Variable	Units	Value
Risk	none	1E-06
ATNC	days	9125
ATC	days	25550
ET	hrs/day	8
EF	days/yr	250
ED	yrs	25
HI	none	1
BW	kg	70
IR	m3/hour	1.3

TABLE C-3

CORRECTIVE ACTION OBJECTIVES (CAOs)
VAPOR INHALATION - FUTURE INDUSTRIAL WORKER
CORRECTIVE MEASURES STUDY
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

SF	Rfd	VF (m3/kg)	Analyte	CAOs (mg/kg) at Target Risk Levels			CAOs (mg/kg) at
				1E-06	1E-05	1E-04	Target HQ = 1.0
			Semivolatiles:				
3.1E+00		3.89E+07	Benzo(a)pyrene	3.46E+02	3.46E+03	3.46E+04	--

'--' Indicates that the relevant health effects criteria are unavailable.

Variable	Units	Value
Risk	none	1E-06
ATNC	days	9125
ATC	days	25550
ET	hrs/day	8
EF	days/yr	250
ED	yrs	25
HI	none	1
BW	kg	70
IR	m^3/hour	1.3

TABLE C-4

CORRECTIVE ACTION OBJECTIVES (CAOs)
SOIL DERMAL ABSORPTION - FUTURE INDUSTRIAL WORKER
CORRECTIVE MEASURES STUDY
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

SF	Rfd	Dermal SF	Dermal RfD	G-I Abs.	Der. ABS	Analyte	CAOs (mg/kg) at Target Risk Levels			CAOs (mg/kg) at
							1E-06	1E-05	1E-04	Target HQ = 1.0
						Semivolatiles:				
7.30E+00		7.3E+00		1.0E+00	0.13	Benzo(a)pyrene	4.57E-01	4.57E+00	4.57E+01	--

'--' Indicates that the relevant health effects criteria are unavailable.

Variable	Units	Value
Risk	none	1E-06
BW	kg	70
ATNC	days	9125
ATC	days	25550
AF	mg/cm^2	0.2
CF	kg/mg	1E-06
SA	cm^2	3300
EV	events/day	1
EF	days/yr	250
ED	yrs	25
HI	none	1

TABLE C-5

CORRECTIVE ACTION OBJECTIVES (CAOs) - SURFACE SOIL (mg/kg)
FUTURE LAND USE - INDUSTRIAL WORKER
CORRECTIVE MEASURES STUDY
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

	Ingestion	Dermal	Inhalation-Vapor	Inhalation-Dust	Combination (a)
Semivolatiles:					
Benzo(a)pyrene	7.84E+00	4.57E+00	-- (c)	9.59E+04	2.89E+00 (d)

'--' Indicates that the relevant health effects criteria are unavailable.

(a) - Values are based on 1/[(1/Ingestion CAO) + (1/Dermal CAO) + (1/Inhalation CAO)].

(b) - Carcinogenic and noncarcinogenic effects cannot be combined. Therefore, the more conservative carcinogenic-based CAO from inhalation exposure is listed.

(c) - No value is used because the vapor-based model is not applicable if it exceeds the saturation limit (C_{sat}).

(d) - Target risk is 1×10^{-5} for benzo(a)pyrene but 1×10^{-6} for all other analytes (see text for details).

TABLE C-6

CORRECTIVE ACTION OBJECTIVES (CAOs)
SOIL INGESTION - FUTURE CONSTRUCTION WORKER
CORRECTIVE MEASURES STUDY
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

			CAOs (mg/kg) at Target Risk Levels			CAOs (mg/kg) at
SF	Rfd	Analyte	1E-06	1E-05	1E-04	Target HQ = 1.0
		Volatiles:				
1.4E+00		**1,2-Dibromo-3-chloropropane**	7.10E+01	7.10E+02	7.10E+03	--
		Semivolatiles:				
7.3E+00		Benzo(a)pyrene	1.36E+01	1.36E+02	1.36E+03	--

'--' Indicates that the relevant health effects criteria are unavailable.

COPCs in bold are identified in subsurface soil but not in surface soil.

Variable	Units	Value
Risk	none	1E-06
BW	kg	70
ATNC	days	365
ATC	days	25550
IR	mg/day	100
CF	kg/mg	1E-06
FI	none	1
EF	days/yr	180
ED	yrs	1
HI	none	1

TABLE C-7

CORRECTIVE ACTION OBJECTIVES (CAOs)
DUST INHALATION - FUTURE CONSTRUCTION WORKER
CORRECTIVE MEASURES STUDY
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

			CAOs (mg/kg) at Target Risk Levels			CAOs (mg/kg) at
SF	Rfd	Analyte	1E-06	1E-05	1E-04	Target HQ = 1.0
		Volatiles:				
2.4E-03	5.7E-05	**1,2-Dibromo-3-chloropropane**	4.30E+08	4.30E+09	4.30E+10	8.40E+05
		Semivolatiles:				
3.10E+00		Benzo(a)pyrene	3.33E+05	3.33E+06	3.33E+07	--

'--' Indicates that the relevant health effects criteria are unavailable.
COPCs in **bold** are identified in subsurface soil but not in surface soil.

Variable	Units	Value
Risk	none	1E-06
ATNC	days	365
ATC	days	25550
ET	hrs/day	8
EF	days/yr	180
ED	yrs	1
HI	none	1.0
BW	kg	70
IR	m^3/hour	1.30

TABLE C-8

CORRECTIVE ACTION OBJECTIVES (CAOs)
VAPOR INHALATION - FUTURE CONSTRUCTION WORKER
CORRECTIVE MEASURES STUDY
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

SF	Rfd	VF (m^3/kg)	Analyte	CAOs (mg/kg) at Target Risk Levels 1E-06	1E-05	1E-04	CAOs (mg/kg) at Target HQ = 1.0
			Volatiles:				
2.4E-03	5.7E-05	2.2E+04	**1,2-Dibromo-3-chloropropane**	8.76E+03	8.76E+04	8.76E+05	1.71E+01
			Semivolatiles:				
3.1E+00		7.8E+06	Benzo(a)pyrene	2.40E+03	2.40E+04	2.40E+05	--

'--' Indicates that the relevant health effects criteria are unavailable.
COPCs in **bold** are identified in subsurface soil but not in surface soil.

Variable	Units	Value
Risk	none	1E-06
ATNC	days	365
ATC	days	25550
ET	hrs/day	8
EF	days/yr	180
ED	yrs	1
HI	none	1.0
BW	kg	70
IR	m^3/hour	1.30

TABLE C-9

CORRECTIVE ACTION OBJECTIVES (CAOs)
SOIL DERMAL ABSORPTION - FUTURE CONSTRUCTION WORKER
CORRECTIVE MEASURES STUDY
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

SF	Rfd	Dermal SF	Dermal RfD	G-I Abs.	Der. ABS	Analyte	CAOs (mg/kg) at Target Risk Levels 1E-06	1E-05	1E-04	CAOs (mg/kg) at Target HQ = 1.0
						Volatiles:				
1.4E+00						1,2-Dibromo-3-chloropropane	NA	NA	NA	--
						Semivolatiles:				
7.3E+00		7.3E+00		1.0E+00	0.13	Benzo(a)pyrene	1.59E+01	1.59E+02	1.59E+03	--

'--' Indicates that the relevant health effects criteria are unavailable.

NA - Not applicable as volatiles not recommended for quantitative evaluation by USEPA (2001a)

COPCs in bold are identified in subsurface soil but not in surface soil.

Variable	Units	Value
Risk	none	1E-06
BWa	kg	70
ATNC	days	365
ATC	days	25550
AF	mg/cm^2	0.2
CF	kg/mg	1E-06
SA	cm^2	3300
EV	events/day	1
EF	days/yr	180
EDa	yrs	1
HI	none	1

TABLE C-10

CORRECTIVE ACTION OBJECTIVES (CAOs) --TOTAL SOIL (mg/kg)
FUTURE LAND USE--CONSTRUCTION WORKER
CORRECTIVE MEASURES STUDY
SWMU 54 - BUILDING 1914 (FORMER NEX REPAIR/MAINTENANCE SHOP)
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Analyte	Ingestion	Dermal	Inhalation-Vapor	Inhalation-Dust	Combination (a)
Volatiles:					
1,2-Dibromo-3-chloropropane	7.10E+01	NA	1.71E+01	8.40E+05	1.71E+01 (b)
Semivolatiles:					
Benzo(a)pyrene	1.36E+01	1.59E+01	-- (c)	3.33E+05	7.33E+00

'--' Indicates that the relevant health effects criteria are unavailable.

(a) - Values are based on 1/[(1/Ingestion CAO) + (1/Dermal CAO) + (1/Inhalation CAO)].

(b) - Value is based on inhalation of vapor pathway only for noncarcinogenic effects which is less than and cannot be combined with the other pathways that are based on carcinogenic effects.

(c) - No value is used because the vapor-based model is not applicable if it exceeds the saturation limit (C_{sat}).

NA - Not applicable because dermal absorption does not apply to volatiles (USEPA, 2001a).

COPCs in **bold** are identified in surface soil but not in subsurface soil.

TABLE C-11

CORRECTIVE ACTION OBJECTIVES (CAOs)
GROUNDWATER INGESTION - FUTURE CONSTRUCTION WORKER
CORRECTIVE MEASURES STUDY
SWMUs 54 and 55
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

SF	RfD	Analyte	CAOs (µg/L) at Target Risk Levels			CAOs (µg/L) at Target HQ = 1.0
			1E-06	1E-05	1E-04	
		Volatiles:				
9.1E-02	2E-02	1,2-Dichloroethane	2.18E+04	2.18E+05	2.18E+06	5.68E+05
	1E-02	cis-1,2-Dichloroethene				2.84E+05
5.7E-02	4E-02	1,1,2-Trichloroethane	3.49E+04	3.49E+05	3.49E+06	1.14E+06
5.5E-02	4E-03	Benzene	3.61E+04	3.61E+05	3.61E+06	1.14E+05
	1E-02	Chloroform	--	--	--	2.84E+05
	1E-01	Ethylbenzene	--	--	--	2.84E+06
	3E-01	Isobutanol	--	--	--	8.52E+06
5.4E-01	1E-02	Tetrachloroethene	3.68E+03	3.68E+04	3.68E+05	2.84E+05
	2E+00	Toluene	--	--	--	5.68E+07
4.0E-01	3E-04	Trichloroethene	4.97E+03	4.97E+04	4.97E+05	8.52E+03
	2E-01	Xylenes	--	--	--	5.68E+06
		Semivolatiles:				
7.3E-01		Benzo(a)anthracene	2.72E+03	2.72E+04	2.72E+05	--
	4E-03	2-Methylnaphthalene	--	--	--	1.14E+05
	2E-02	Naphthalene	--	--	--	5.68E+05

'--' Indicates that the relevant health effects criteria are unavailable.

Variable	Units	Value
Risk	none	1E-06
BW	kg	70
ATNC	days	365
ATC	days	25550
IR	l/day	0.05
EF	days/yr	18
ED	yrs	1
HI	none	1
CF	mg/ug	0.001

TABLE C-12

CORRECTIVE ACTION OBJECTIVES (CAOs)
GROUNDWATER INHALATION OF VAPORS - FUTURE CONSTRUCTION WORKER
CORRECTIVE MEASURES STUDY
SWMUs 54 and 55
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

SFi	RfDi	Analyte	CAOs (µg/L) at Target Risk Levels			CAOs (µg/L) at
			1E-06	1E-06	1E-06	Target HQ = 1.0
		Volatiles:				
9.1E-02	1.4E-03	1,2-Dichloroethane	1.68E+03	1.68E+04	1.68E+05	3.06E+03
		cis-1,2-Dichloroethene	--	--	--	--
5.6E-02		1,1,2-Trichloroethane	2.73E+03	2.73E+04	2.73E+05	--
2.9E-02	8.6E-03	Benzene	5.27E+03	5.27E+04	5.27E+05	1.88E+04
8.1E-02	1.4E-02	Chloroform	1.89E+03	1.89E+04	1.89E+05	3.06E+04
	2.9E-01	Ethylbenzene	--	--	--	6.33E+05
		Isobutanol	--	--	--	--
2.0E-02	1.4E-01	Tetrachloroethene	7.64E+03	7.64E+04	7.64E+05	3.06E+05
	2.6E-01	Toluene	--	--	--	5.68E+05
4.0E-01	1.0E-02	Trichloroethene	3.82E+02	3.82E+03	3.82E+04	2.18E+04
	2.9E-02	Xylenes	--	--	--	6.33E+04
		Semivolatiles:				
		Benzo(a)anthracene	--	--	--	--
		2-Methylnaphthalene	--	--	--	--
	9.0E-04	Naphthalene	--	--	--	1.97E+03

'--' Indicates that the relevant health effects criteria are unavailable.

N/A - Not applicable because volatilization model only applies to organics.

Variable	Value	Units
CF	1.E-03	mg/ug
EV	1	event/day
EF	18	days/yr
ED	1	years
BW	70	kg
ATC	25550	days
ATNC	365	days
IR	1.3	m^3/hr
ET	1	hr/event
K	0.5	none
Risk	1E-06	none
HI	1	none

TABLE C-13

CORRECTIVE ACTION OBJECTIVES (CAOs)
GROUNDWATER DERMAL ABSORPTION - FUTURE CONSTRUCTION WORKER
CORRECTIVE MEASURES STUDY
SWMUs 54 and 55
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

SF	Sfder	RfD	RfDder	GIabs	DAF	Analyte	CAOs (µg/L) at Target Risk Levels 1E-06	1E-05	1E-04	CAOs (µg/L) at Target HQ = 1.0
						Volatiles:				
9.1E-02	9.1E-02	1E-02	1.0E-02	1.0E+00	7.20E-03	1,2-Dichloroethane	1.52E+04	1.52E+05	1.52E+06	1.97E+05
		1E-02	1.0E-02	1.0E+00	1.36E-02	cis-1,2-Dichloroethene	--	--	--	1.04E+05
5.7E-02	5.7E-02	4E-03	4.0E-03	1.0E+00	1.35E-02	1,1,2-Trichloroethane	1.29E+04	1.29E+05	1.29E+06	4.19E+04
5.5E-02	5.5E-02	4E-03	4.0E-03	1.0E+00	2.39E-02	Benzene	7.57E+03	7.57E+04	7.57E+05	2.38E+04
		1E-02	1.0E-02	1.0E+00	1.31E-02	Chloroform	--	--	--	1.08E+05
		1E-01	1.0E-01	1.0E+00	1.07E-01	Ethylbenzene	--	--	--	1.33E+05
		3E-01	3.0E-01	1.0E+00	2.96E-03	Isobutanol	--	--	--	1.44E+07
5.4E-01	5.4E-01	1E-02	1.0E-02	1.0E+00	8.55E-02	Tetrachloroethene	2.15E+02	2.15E+03	2.15E+04	1.66E+04
		2E+00	2.0E+00	1.0E+00	5.64E-02	Toluene	--	--	--	5.03E+06
4.0E-01	4.0E-01	3E-04	3.0E-04	1.0E+00	2.41E-02	Trichloroethene	1.03E+03	1.03E+04	1.03E+05	1.77E+03
		2E-01	2.0E-01	1.0E+00	1.17E-01	Xylenes	--	--	--	2.43E+05
						Semivolatiles:				
7.3E-01	7.3E-01			1.0E+00	1.77E+00	Benzo(a)anthracene	7.68E+00	7.68E+01	7.68E+02	--
		4E-03	4.0E-03	1.0E+00	3.02E-01	2-Methylnaphthalene	--	--	--	1.88E+03
		2E-02	2.0E-02	1.0E+00	9.36E-02	Naphthalene	--	--	--	3.03E+04

'--' Indicates that the relevant health effects criteria are unavailable.

Variable	Value	Units
SA (RME)	10000	cm2
EV	1	event/day
EF	18	days/yr
ED (RME)	1	years
BW	70	kg
ATC	25550	days
ATNC (RME)	365	days
Cfm	1E-03	mg/ug
CFv	1E-03	l/cm3
Kp (inorg.)	0.001	cm/hr
T (RME)	1	hour/event
Risk	1E-06	none
HI	1	none

TABLE C-14

CORRECTIVE ACTION OBJECTIVES (CAOs) - GROUNDWATER (µg/L)
FUTURE LAND USE - CONSTRUCTION WORKER
CORRECTIVE MEASURES STUDY
SWMUs 54 and 55
NAVAL ACTIVITY PUERTO RICO, CEIBA, PUERTO RICO

Analyte	Ingestion	Inhalation	Dermal	Combination (a)	
Volatiles:					
1,2-Dichloroethane	2.18E+04	1.68E+03	1.52E+04	1.41E+03	
cis-1,2-Dichloroethene	2.84E+05	--	1.04E+05	7.64E+04	
1,1,2-Trichloroethane	3.49E+04	2.73E+03	1.29E+04	2.12E+03	
Benzene	3.61E+04	5.27E+03	7.57E+03	2.86E+03	
Chloroform	2.84E+05	1.89E+03	1.08E+05	1.89E+03	(b)
Ethylbenzene	2.84E+06	6.33E+05	1.33E+05	1.06E+05	
Isobutanol	8.52E+06	--	1.44E+07	5.35E+06	
Tetrachloroethene	3.68E+03	7.64E+03	2.15E+02	1.98E+02	
Toluene	5.68E+07	5.68E+05	5.03E+06	5.06E+05	
Trichloroethene	4.97E+03	3.82E+02	1.03E+03	2.64E+02	
Xylenes	5.68E+06	6.33E+04	2.43E+05	4.98E+04	
Semivolatiles:					
Benzo(a)anthracene	2.72E+03	--	7.68E+00	7.65E+00	
2-Methylnaphthalene	1.14E+05	--	1.88E+03	1.85E+03	
Naphthalene	5.68E+05	1.97E+03	3.03E+04	1.84E+03	

'--' Indicates that the relevant health effects criteria are unavailable.
(a) - Values are based on 1/[(1/Ingestion CAO) + (1/Dermal CAO) + (1/Inhalation CAO)].
(b) - Carcinogenic and noncarcinogenic effects cannot be combined. Therefore, the more conservative carcinogenic-based CAO from inhalation exposure is listed.

APPENDIX D
TCE and Benzene Fact Sheets

Chemical Fact Sheet

Chemical Abstract Number (CAS #)	79016
Synonyms	Trichloroethylene
	Trichloroethene
	Ethene, trichloro
	Ethylene trichloride
	TCE
Analytical Methods	EPA Method 502.2
	EPA Method 503.1
	EPA Method 524.1
	EPA Method 524.2
	EPA Method 601
	EPA Method 624
	EPA Method 8010B
	EPA Method 8021A
	EPA Method 8240B
	EPA Method 8260A
Molecular Formula	C_2HCl_3
	IN DEGREASING, IN DRY CLEANING; IN MFG ORG CHEM & PHARMACEUTICALS IN GAS PURIFICATION, AS A SOLVENT OF SULFUR & PHOSPHORUS REFRIGERANT & HEAT EXCHANGE LIQUID; DILUENT IN PAINTS & ADHESIVES; TEXTILE PROCESSING; AEROSPACE OPERATIONS (FLUSHING LIQUID OXYGEN) CLEANING

Use	SOLVENT, ESP IN VAPOR DEGREASING CHAIN TERMINATOR IN PRODN OF POLYVINYL CHLORIDE SWELLING AGENT IN DISPERSE DYEING OF POLYESTERS AGENT IN REMOVAL OF BASTING THREADS IN TEXTILE PROCESSING CHEM INT FOR 1,1,2,2-TETRACHLOROETHYL SULFENYL CHLORIDE SOLVENT IN ADHESIVES & PAINT-STRIPPING FORMULATIONS HEAT TRANSFER MEDIUM-EG, IN CASE HARDENING OF METALS SOLVENT BASE FOR METAL PHOSPHATIZING SYSTEMS SOLVENT IN CHARACTERIZATION TEST FOR ASPHALT ENTRAINER FOR RECOVERY OF FORMIC ACID EXTRACTION SOLVENT-EG, FOR CAFFEINE Used as household cleaner; with trichloroethane it is used in most typewriter correction fluid. /SRP: Former use Used in wool-fabric scouring Extractant for spice oleoresins. Intermediate in the production of pentachloroethane. Carrier solvent for the active ingredients of insecticides, and fungicides. Medication (Vet): Inhalation anesthetic. Former use
Consumption Patterns	Demand: (1982): 240 million pounds; (1983): Est 235 million pounds; 1987: Est 215 million pounds. Vapor degreasing of fabricated metal parts, 80%; chemical intermediate, 5%; miscellaneous used, 5%; exports, 10% (1985) Vapor degreasing of fabricated metal parts, 66%; chemical intermediates, miscellaneous domestic uses, 5%; exports, 22%. CLEANING SOLVENT, 89%; CHAIN TERMINATOR, 9%; OTHER, 2% (1980 EST)
Apparent Color	CLEAR, COLORLESS, OR BLUE MOBILE LIQUID
Odor	Ethereal odor ; CHLOROFORM-LIKE ODOR ; Sweet odor
Boiling Point	87 DEG C
Melting Point	-73 DEG C
Molecular Weight	131.40
Density	1.4649 @ 20 DEG C/4 DEG C
Odor Threshold Concentration	10 mg/l (in water) Purity not specified 5.00X10-1 mg/l (liquid) (detection in water) 2.14X10 1 ppm (recognition in air) (chemically pure)
Sensitivity Data	Exposure to trichloroethylene vapor may cause irritation of the eyes, nose, and throat. Liquid: irritating to skin and eyes.
Drinking	SURFACE WATER: 1-24 ppb industrial rivers in US, with Lake

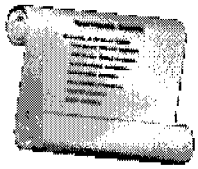
Water Impact Erie - 188 ppb, 88 of

DISCLAIMER - Please Read

Return to :

Alphabetical List of Compounds

List of Compounds by CAS Number



List of Services

Spectrum Laboratories Homepage

Chemical Fact Sheet

Chemical Abstract Number (CAS #)	71432
Synonyms	Benzene
	Cyclohexatriene
	Benzol
Analytical Methods	EPA Method 502.2
	EPA Method 503.1
	EPA Method 524.1
	EPA Method 524.2
	EPA Method 602
	EPA Method 624
	EPA Method 8020A
	EPA Method 8021A
	EPA Method 8240B
	EPA Method 8260A
Molecular Formula	C_6H_6
	MFR MEDICINAL CHEM, DYES, ORG CMPD, ARTIFICIAL LEATHER, LINOLEUM, OIL CLOTH, VARNISHES, LACQUERS; SOLVENT FOR WAXES, RESINS, OILS USE AS SOLVENT IS NOW DISCOURAGED Used for printing & lithography, paint, rubber, dry cleaning, adhesives & coatings, detergents Extraction and rectification; preparation and use of inks in the graphic arts industries; as a thinner for paints; as a degreasing agent CHEM INT FOR ETHYLBENZENE, CUMENE, CYCLOHEXANE, NITROBENZENE, MALEIC ANHYDRIDE,

Use	CHLOROBENZENES, DETERGENT ALKYLATE, ANTHRAQUINONE, BENZENE HEXACHLORIDE, BENZENE SULFONIC ACID, BIPHENYL, HYDROQUINONE, & RESORCINOL /Benzol for pesticidal uses has been cancelled. It was in use alone or in formulations for screwworm control on animals. It was an ingredient of some early grain fumigants In the tire industry (McMichael et al, 1975), & in shoe factories (Aksoy et al, 1974), benzene is used extensively. Used primarily as a raw material in the synthesis of styrene (polystyrene plastics and synthetic rubber), phenol (phenolic resins), cyclohexane (nylon), aniline, maleic anhydride (polyester resins), alkylbenzenes (detergents), chlorobenzenes, and other products used in the production of drugs, dyes, insecticides, and plastics.
Consumption Patterns	Consumption by chemical industry in USA, 1977: 1.4 billion gallons annually. CHEM INT FOR ETHYLBENZENE, 49.1%; CHEM INT FOR CUMENE, 18.4%; CHEM INT FOR CYCLOHEXANE, 15.1%; CHEM INT FOR NITROBENZENE, 4.5%; CHEM INT FOR MALEIC ANHYDRIDE, 2.8%; CHEM INT FOR CHLOROBENZENES, 2.5%; CHEM INT FOR DETERGENT ALKYLATE, 2.4%; EXPORTS, 2.7%; OTHER USES, 2.5% (1981 NON-GASOLINE USES) Demand: (1980) 1,586 Million Gal; Projected demand for (1984): 1,708 Million Gal BENZENE RANKED 17TH IN 1981 & 1982 IN THE TOP 50 CHEMICAL PRODUCTION: BILLIONS OF LB: 7.87 (1982), 9.61 (1981). Ethylbenzene/styrene, 52%; cumene/phenol, 22%; clyclohexane, 15%; nitrobenzene/aniline, 4.5%; detergent alkylate, 2.5%; chlorobenzenes, maleic anhydride and other, 3%; exports, 1% (1984) USA benzene demand is projected to climb from 3.8% in 1987, to 5.7 million tons, and reach 6 million tons in 1990 (1987 and 1990) In future, coal will increasingly replace petroleum & natural gas as a source of hydrocarbons both for fuel & petrochemicals. Processes such as USA Steel Corporation's Clean Coke process, which yields 38% coke & 20% chemical by-products compared to 73% coke & 2% chemical by-products in conventional coking technology, should soon be used commercially. New coking, liquefaction, & gasification processes for coal are all potential sources of benzene. CHEMICAL PROFILE: Benzene. Ethylbenzene/styrene, 55%; cumene/phenol, 21%; cyclohexane, 14%; nitrobenzene/aniline, 5%; detergent alkylate, 3%; chlorobenzenes, exports and others, 2%. CHEMICAL PROFILE:

	Benzene. Demand: 1986: 1,603 million gal; 1987: 1,667 million gal; 1991 projected/: 1,790 million gal. (Includes imports; 155 million gal were imported in 1986.)
Apparent Color	CLEAR, COLORLESS LIQ ; RHOMBIC PRISMS
Odor	AROMATIC ODOR
Boiling Point	80.1 DEG C
Melting Point	5.5 DEG C
Molecular Weight	78.11
Density	0.8787 AT 15 DEG C/4 DEG C
Odor Threshold Concentration	BENZENE HAS DISTINCTIVE SRP: AROMATIC ODOR HOWEVER /WARNING PROPERTIES ARE INADEQUATE SINCE 100 PPM HAS IRRITATION RATING OF 0 & ODOR INTENSITY BETWEEN 1 & 2. 4.68 PPM In air: 4.9 mg/cu m (characteristic odor), in water: 2.0 mg/l.
Sensitivity Data	Benzene is irritant to skin
	Benzene will enter the atmosphere primarily from fugitive emissions and exhaust connected with its use in gasoline. Another important source is emissions associated with its production and use as an industrial intermediate. In addition, there are discharges into water from industrial effluents and losses during spills. If benzene is released to soil, it will be subject to rapid volatilization near the surface and that which does not evaporate will be highly to very highly mobile in the soil and may leach to groundwater. It may be subject to biodegradation based on reported biodegradation of 24% and 47% of the initial 20 ppm benzene in a base-rich para-brownish soil in 1 and 10 weeks, respectively. It may be subject to biodegradation in shallow, aerobic groundwaters, but probably not under anaerobic conditions. If benzene is released to water, it will be subject to rapid volatilization; the half-life for evaporation in a wind-wave tank with a moderate wind speed of 7.09 m/sec was 5.23 hrs; the estimated half-life for volatilization of benzene from a model river one meter deep flowing 1 m/sec with a wind velocity of 3 m/sec is estimated to be 2.7 hrs at 20 deg C. It will not be expected to significantly adsorb to sediment, bioconcentrate in aquatic

Environmental Impact	organisms or hydrolyze. It may be subject to biodegradation based on a reported biodegradation half-life of 16 days in an aerobic river die-away test. In a marine ecosystem biodegradation occurred in 2 days after an acclimation period of 2 days and 2 weeks in the summer and spring, respectively, whereas no degradation occurred in winter. According to one experiment, benzene has a half-life of 17 days due to photodegradation which could contribute to benzene's removal in situations of cold water, poor nutrients, or other conditions less conductive to microbial degradation. If benzene is released to the atmosphere, it will exist predominantly in the vapor phase. Gas-phase benzene will not be subject to direct photolysis but it will react with photochemically produced hydroxyl radicals with a half-life of 13.4 days calculated using an experimental rate constant for the reaction. The reaction time in polluted atmospheres which contain nitrogen oxides or sulfur dioxide is accelerated with the half-life being reported as 4-6 hours. Products of photooxidation include phenol, nitrophenols, nitrobenzene, formic acid, and peroxyacetyl nitrate. Benzene is fairly soluble in water and is removed from the atmosphere in rain. The primary routes of exposure are inhalation of contaminated air, especially in areas with high traffic, and in the vicinity of gasoline service stations and consumption of contaminated drinking water.
	TERRESTRIAL FATE: If benzene is released to soil it will be subject to rapid volatilization near the surface. That which does not evaporate will be highly to very highly mobile in soil and may leach to groundwater. The effective half-lives for volatilization without water evaporation from soil to benzene uniformly distributed to 1 and 10 cm in soil were 7.2 and 38.4 days, respectively . It may be subject to biodegradation based on reported biodegradation of 24% and 47% of the initial 20 ppm benzene in a based-rich para-brownish soil in 1 and 10 weeks, respectively . It may be subject to biodegradation in shallow, aerobic groundwaters, but probably not under anaerobic conditions. AQUATIC FATE: If benzene is released to water, it will be subject to rapid volatilization; the half-life for evaporation in a wind-wave tank with a wind speed of 7.09 m/sec was 5.23 hrs ; the estimated half-life for volatilization of benzene from a model river one meter deep flowing 1 m/sec with a wind velocity of 3 m/sec is estimated to be 2.7 hrs at 20 deg C. It will not be expected to significantly adsorb to sediment,

Environmental Fate	bioconcentrate in aquatic organisms or hydrolyze. It may be subject to biodegradation based on a reported biodegradation half-life of 16 days in an aerobic river die-away test . In a marine ecosystem, biodegradation occurred in 2 days after an acclimation period of 2 days and 2 weeks in the summer and spring, respectively, whereas no degradation occurred in winter . AQUATIC FATE: Evaporation was the primary loss mechanism in winter in a mesocosm experiment which simulated a northern bay where the half-life was 13 days . In spring and summer the half-lives were 23 and 3.1 days, respectively . In these cases biodegradation plays a major role and takes about 2 days . However, acclimation is critical and this takes much longer in the colder water in spring . According to one experiment, benzene has a half-life of 17 days due to photegradation which could contribute to benzene's removal. In situations of cold water, poor nutrients, or other conditions less conducive to microbial, photolysis will play a important role in degradation. ATMOSPHERIC FATE: If benzene is released to the atmosphere, it will exist predominantly in the vapor phase . Gas-phase benzene will not be subject to direct photolysis but it will react with photochemically produced hydroxyl radicals with a half-life of 13.4 days calculated using an experimental rate constant for the reaction. The reaction time in polluted atmospheres which contain nitrogen oxides or sulfur dioxide is accelerated with the half-life being reported as 4-6 hours . Products of photooxidation include phenol, nitrophenols, nitrobenzene, formic acid, and peroxyacetyl nitrate. Benzene is fairly soluble in water and is removed from the atmosphere in rain .
	DRINKING WATER: 113 public supplies, 1976, 7 sites pos, avg of positive sites <0.2 ppb . 5 USA cities, 1974-5, 0-0.3 ppb . Contaminated drinking water wells in NY, NJ, CT, 30-300 ppb; highest concn in drinking water from surface source, 4.4 ppb . 3 surveys of community water supplies: 0 of 111 pos; 7 of 113 pos, mean 4 ppb; 4 of 16 pos (0.95 ppb-max) . USA Groundwater Supply Survey (GWS, 1982, finished drinking water), 466 samples selected at random from 1000 in survey, 0.6% pos, 3 ppb median, 15 ppb max . Wisconsin drinking water wells, data through Jun 1984, 1174 community wells, 0.34% pos, 617 private wells, 2.9% pos(6). GROUNDWATER: Chalk Aquifer (UK), 210 m from petrol storage, 1-10 ppb; Chalk Aquifer (UK), 120 m from petrol storage, >250

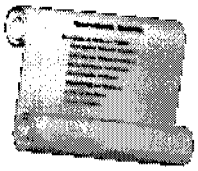
Drinking Water Impact	ppb; Chalk Aquifer (UK), 10 m from petrol storage, 1250 ppb; distances refer to benzene movement in groundwater . SURFACE WATER: 14 heavily industrialized with basins, 1975-1976, 20% samples >1 ppb and between 1 and 7 ppb . Lake Erie, 1975-6, 0-1 ppb, 1 of 2 sites positive; Lake Michigan, 1975-6, 0-7 ppb, 5 of 7 sites positive . 700 random sites in US, 1975, 5.4 ppb avg . US EPA STORET database, 1,271 samples, 15.0% pos, 5.0 ppb median . SEAWATER: 5-15 parts per trillion Gulf of Mexico, 1977, unpolluted areas; 5-175 parts per trillion, Gulf of Mexico, 1977, anthropogenic influence . RAIN/SNOW: Detected in rainwater in Japan and in the UK (87.2 ppb)(1,2). Benzene occurs in both ground water and surface public water supplies with higher levels occurring in ground water supplies. Based upon Federal drinking water surveys, approximately 1.3% of all ground water systems are estimated to contain benzene at levels greater than 0.5 ug/l. The highest level reported in the surveys for ground water was 80 ug/l. Approximately 3% of all surface water system are estimated to be contaminated at levels higher than 0.5 ug/l. None of the systems are expected to contain levels higher than 5 ug/l. EFFL: Wastewater from coal preparation plants, 0.3-48 ppb ; wastewater from plants which manufacture or use benzene <1-179 parts per trillion ; stack emissions from coking plants (Czechoslovakia), 15-50 ppm ; stack emission estimates from chemical plants using emissions and worst case modeling at 150 m from source, less than or equal to 5 ppm . Groundwater at 178 CERCLA hazardous waste sites, 11.2% pos . US EPA STORET database, 1,474 samples, 16.4% pos, 2.50 ppb median . Industries in which mean or max levels in raw wastewater exceeded 1 ppm are (number of samples, percent pos, mean, max, in ppm): raw wastewater: auto and other laundries (20 samples, 70% pos, <1.4 ppm mean, 23 ppm max), iron and steal manufacturing (mfg) (9 samples, 77.8% pos, <8.0 mean, 46 max), aluminum forming (32 samples, 56.2% pos, 0.70 mean, 2.1 max), photographic equipment/supplies (48 samples, 54.2% pos, 0.16 mean, 2.1 max), pharmaceutical mfg (9 samples, 100% pos, 12 mean, 87 max), organic chemical/plastics mfg (number of samples not reported (NR), 63 detections, 22, NR), paint and ink formulation (36 samples, 63.9% pos, 1.2 mean, 9.9 max), petroleum refining (11 samples, number of pos NR, <0.10, 2.4), rubber processing (4 samples, 100% pos, 0.60 mean, 3.4 max), timber products processing (14 samples, 92.9% pos, 0.2 mean, 2.8 max); treated wastewater: auto and other

	laundries (4 samples, 50% pos, 0.1 ppm mean, 0.2 ppm max), iron and steal manufacturing (mfg) (13 samples, 76.9% pos, <14 mean, 120 max), aluminum forming (21 samples, 81.0% pos, <0.0058 mean, 0.040 max), photographic equipment/supplies (4 samples, 100% pos, 0.016 mean, 0.021 max), pharmaceutical mfg (6 samples, 100% pos, 1.8 mean, 10 max), organic chemical/plastics mfg (number of samples not reported (NR), 42 detections, 26, max NR), paint and ink formulation (24 samples, 62.5% pos, 0.39 mean, 3.8 max), petroleum refining (13 samples, NR, NR, 0.012), rubber processing (5 samples, 100% pos, <0.0077 mean, 0.010 max), timber products processing (5 samples, 60% pos, 0.010 mean, 0.033 max) . Industrial sources of wastewater pollution from benzene in ug/l (avg; range): coal mining (2.6; 0-15), textile mills (<5; 0-200), timber products processing (350; 0-2,800), petroleum refining (>100; ND), paint and ink formulation (1,200; 0-9,900), gum and wood chemicals (180; 0-710), rubber processing (610; 0-3,400), auto and other laundries (840; 0-23,000), pharmaceuticals (220; 0-2,100), ore mining and dressing (2.1; 0-4.2), steam electric power (45, ND), foundries (200; ND), leather tanning and finishing (19; 0-150), nonferrous metals (11; 0-160), iron and steel (2,000; 0-43,000). From table

DISCLAIMER - Please Read
Return to :

Alphabetical List of Compounds

List of Compounds by CAS Number


List of Services

Spectrum Laboratories Homepage

APPENDIX E
Alternative 2 Calculations

SWMU 54—Modeling

General input parameters:

- Seepage Velocity: 1 ft/year
- Effective Porosity: 0.3
- Longitudinal Dispersivity: ~8 feet
- Ratio of Transverse to Longitudinal: 0.1
- Soil Bulk Density: 1.6 kg/L
- Fraction Organic Carbon: 0.0018
- Source thickness in Saturated Zone: 25 feet

BIOCHLOR specific input parameters:

- TCE Source Width: 60 feet
- TCE Source Concentration: 200 ug/L
- TCE Organic Carbon Partition Coefficient (Koc): 130 L/Kg
- DCE Koc : 120 L/kg
- VC Koc: 16 L/kg
- TCE half life: 4 years
- DCE half life: 7 years
- VC half life: 7.1 years

BIOSCREEN specific input parameters:

- Benzene Source Concentration: 0.5 to 3 mg/L (slice across plume)
- Benzene Source Width: 40 feet
- Benzene half life: 10 years
- DO: 1 mg/L
- Nitrate: 1 mg/L
- Fe+2: 0.5 mg/L
- SO4: 10 mg/L
- CH4: 0.2 mg/L

BIOCHLOR Natural Attenuation Decision Support System

Version 2.2
Excel '97

SWMU 54
Run Name

Data Input Instructions:

115 → 1. Enter value directly....or
↑ *or* 2. Calculate by filling in gray
0.02 cells. Press Enter, then C
(To restore formulas, hit "Restore Formulas" button)
Variable* → Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: Ethenes ◉ Ethanes ○

1. ADVECTION

Seepage Velocity*	Vs	1.0	(ft/yr)
or			
Hydraulic Conductivity	K		(cm/sec)
Hydraulic Gradient	i		(ft/ft)
Effective Porosity	n	0.3	(-)

2. DISPERSION

Alpha x*	8.0227	(ft)
(Alpha y) / (Alpha x)*	0.1	(-)
(Alpha z) / (Alpha x)*	1.E-03	(-)

Calc. Alpha x

3. ADSORPTION

Retardation Factor* → R

or

Soil Bulk Density, rho	1.6	(kg/L)		
FractionOrganicCarbon, foc	1.8E-3	(-)		
Partition Coefficient	Koc			
PCE		(L/kg)	1.00	(-)
TCE	130	(L/kg)	2.25	(-)
DCE	125	(L/kg)	2.20	(-)
VC	16	(L/kg)	1.15	(-)
ETH		(L/kg)	1.00	(-)
Common R (used in model)* =			**1.15**	

4. BIOTRANSFORMATION

-1st Order Decay Coefficient*

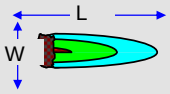
Zone 1	λ (1/yr)	half-life (yrs)	Yield
PCE → TCE	0.000		0.79
TCE → DCE	0.173	4.00	0.74
DCE → VC	0.099	7.00	0.64
VC → ETH	0.098	7.10	0.45

Zone 2	λ (1/yr)	half-life (yrs)
PCE → TCE	0.000	
TCE → DCE	0.000	
DCE → VC	0.000	
VC → ETH	0.000	

λ HELP

5. GENERAL

Simulation Time*	30	(yr)
Modeled Area Width*	100	(ft)
Modeled Area Length*	500	(ft)
Zone 1 Length*	500	(ft)
Zone 2 Length*	0	(ft)



Zone 2= L - Zone 1

6. SOURCE DATA

TYPE: Continuous
Single Planar

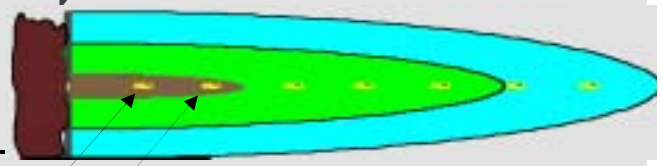
Source Options

Source Thickness in Sat. Zone* 25 (ft)

Width* (ft) Y1 60

Conc. (mg/L)*	C1	k_s* (1/yr)
PCE		0
TCE	.2	0
DCE	.0	0
VC	.0	0
ETH	0	0

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations



View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

7. FIELD DATA FOR COMPARISON

PCE Conc. (mg/L)											
TCE Conc. (mg/L)											
DCE Conc. (mg/L)											
VC Conc. (mg/L)											
ETH Conc. (mg/L)											
Distance from Source (ft)											
Date Data Collected											

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE | RUN ARRAY | Help | Restore Formulas | RESET | SEE OUTPUT | Paste Example

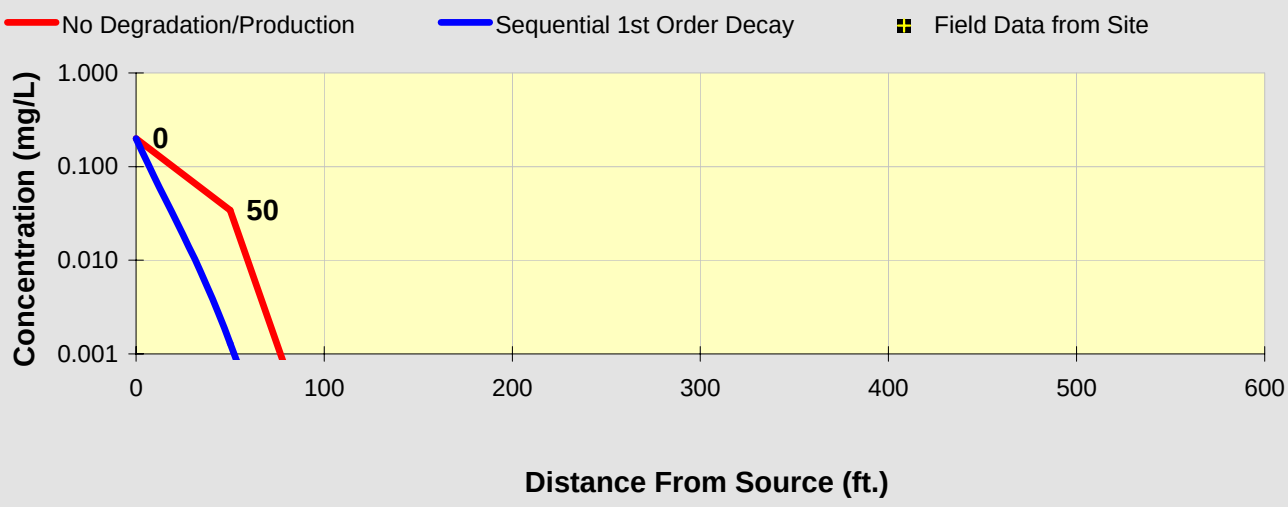
DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

Distance from Source (ft)

TCE	0	50	100	150	200	250	300	350	400	450	500
No Degradation	0.200	0.034	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biotransformation	0.2000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Monitoring Well Locations (ft)

Field Data from Site											



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

30.0 Years

Log ⟺ Linear

Return to Input

To All

To Array

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellenc

Version 1.4

swmu 54

Benzene

Run Name

Data Input Instructions:

115 → *1. Enter value directly....or*

↑ *or*

0.02 → *2. Calculate by filling in grey cells below. (To restore formulas, hit button below).*

Variable* → *Data used directly in model.*

20 → *Value calculated by model. (Don't enter any data).*

1. HYDROGEOLOGY

Seepage Velocity*	*Vs*	1.0	*(ft/yr)*
or		↑ *or*	
Hydraulic Conductivity	*K*		*(cm/sec)*
Hydraulic Gradient	*i*		*(ft/ft)*
Porosity	*n*	0.3	*(-)*

2. DISPERSION

Longitudinal Dispersivity*	*alpha x*	8.6	*(ft)*
Transverse Dispersivity*	*alpha y*	0.9	*(ft)*
Vertical Dispersivity*	*alpha z*	0.0	*(ft)*
or		↑ *or*	
Estimated Plume Length	*Lp*	1450	*(ft)*

3. ADSORPTION

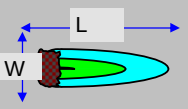
Retardation Factor*	*R*	1.2	*(-)*
or		↑ *or*	
Soil Bulk Density	*rho*	1.7	*(kg/l)*
Partition Coefficient	*Koc*	38	*(L/kg)*
FractionOrganicCarbon	*foc*	8.0E-4	*(-)*

4. BIODEGRADATION

1st Order Decay Coeff*	*lambda*	6.9E-2	*(per yr)*
or		↑ *or*	
Solute Half-Life	*t-half*	10.00	*(year)*
or Instantaneous Reaction Model			
Delta Oxygen*	*DO*	1	*(mg/L)*
Delta Nitrate*	*NO3*	1	*(mg/L)*
Observed Ferrous Iron*	*Fe2+*	0.5	*(mg/L)*
Delta Sulfate*	*SO4*	10	*(mg/L)*
Observed Methane*	*CH4*	0.2	*(mg/L)*

5. GENERAL

Modeled Area Length*	200	*(ft)*
Modeled Area Width*	100	*(ft)*
Simulation Time*	30	*(yr)*



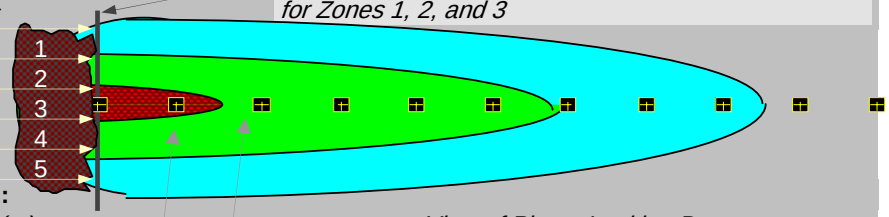
6. SOURCE DATA

Source Thickness in Sat.Zone* 20 *(ft)*

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3

Source Zones:

Width* (ft)	Conc. (mg/L)*
5	0.5
10	1
10	3
10	1
5	0.5



View of Plume Looking Down

Source Halflife (see Help):

Infinite	Infinite	*(yr)*
Inst. React. ↖ ↑	1st Order	
Soluble Mass	Infinite	*(Kg)*
In Source NAPL, Soil		

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

TCE - Average from 1993 to 1996

Concentration (mg/L)											
Dist. from Source (ft)											

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE

View Output

RUN ARRAY

View Output

Help

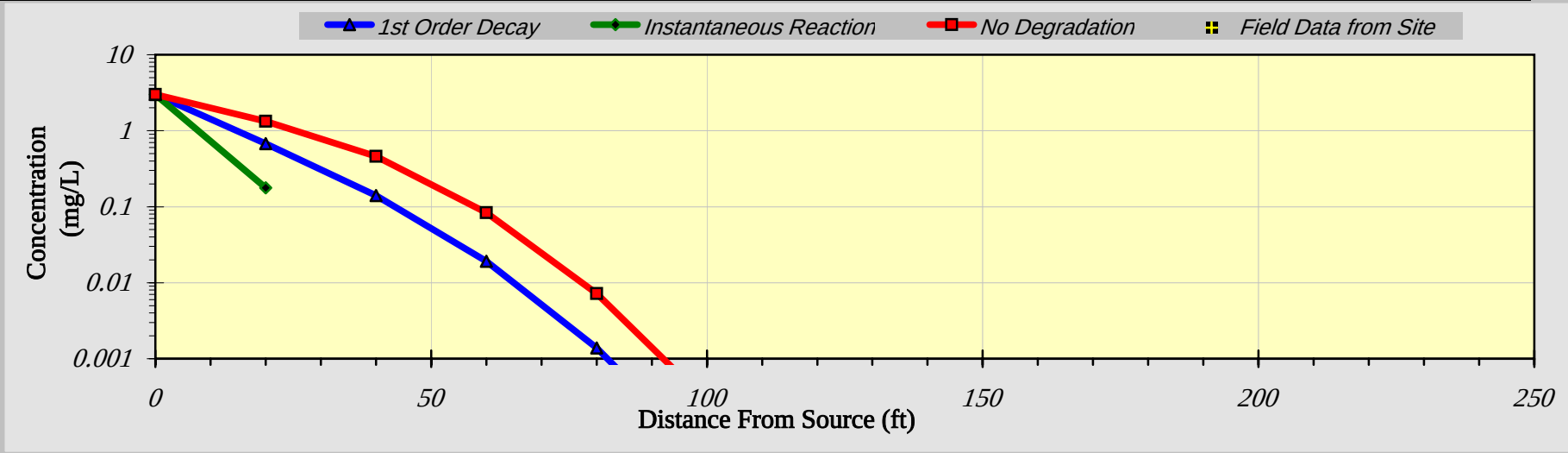
Recalculate This Sheet

Paste Example Dataset

Restore Formulas for Vs, Dispersivities, R, lambda, other

DISSOLVED CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft) 0	20	40	60	80	100	120	140	160	180	200
No Degradation	3.000	1.335	0.459	0.084	0.007	0.000	0.000	0.000	0.000	0.000	0.000
1st Order Decay	3.000	0.676	0.140	0.019	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Inst. Reaction	3.000	0.177	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site											



Calculate Animation

Time:
30 Years

Return to Input

Recalculate This Sheet

SWMU 55—Modeling

General input parameters:

- Seepage Velocity: 52 ft/year
- Effective Porosity: 0.2
- Longitudinal Dispersivity: ~8 feet
- Ratio of Transverse to Longitudinal: 0.1
- Soil Bulk Density: 1.6 kg/L
- Fraction Organic Carbon: 0.0018
- Source thickness in Saturated Zone: 25 feet

BIOCHLOR specific input parameters:

- TCE Source Width: 60 feet
- TCE Source Concentration: 2000 ug/L
- TCE Organic Carbon Partition Coefficient (Koc): 130 L/Kg
- DCE Koc : 120 L/kg
- VC Koc: 16 L/kg
- TCE half life: 4 years
- DCE half life: 7 years
- VC half life: 7.1 years

BIOCHLOR Natural Attenuation Decision Support System

Version 2.2
Excel '97

SWMU 55
Run Name

Data Input Instructions:

115 → 1. Enter value directly....or
↑ *or* 2. Calculate by filling in gray
0.02 cells. Press Enter, then C
(To restore formulas, hit "Restore Formulas" button)
Variable* → Data used directly in model.

Test if Biotransformation is Occurring → Natural Attenuation Screening Protocol

TYPE OF CHLORINATED SOLVENT: Ethenes ◉ Ethanes ○

1. ADVECTION

Seepage Velocity*	Vs	52.0	(ft/yr)
or			
Hydraulic Conductivity	K		(cm/sec)
Hydraulic Gradient	i		(ft/ft)
Effective Porosity	n	0.2	(-)

2. DISPERSION

Alpha x*	8.0227	(ft)
(Alpha y) / (Alpha x)*	0.1	(-)
(Alpha z) / (Alpha x)*	1.E-03	(-)

Calc. Alpha x

3. ADSORPTION

Retardation Factor* → R

or

Soil Bulk Density, rho	1.6	(kg/L)		
FractionOrganicCarbon, foc	1.8E-3	(-)		
Partition Coefficient	Koc			
PCE		(L/kg)	1.00	(-)
TCE	130	(L/kg)	2.87	(-)
DCE	125	(L/kg)	2.80	(-)
VC	16	(L/kg)	1.23	(-)
ETH		(L/kg)	1.00	(-)
Common R (used in model)* =			**1.23**	

4. BIOTRANSFORMATION

-1st Order Decay Coefficient*

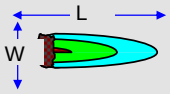
Zone 1	λ (1/yr)	half-life (yrs)	Yield
PCE → TCE	0.000		0.79
TCE → DCE	0.173	4.00	0.74
DCE → VC	0.099	7.00	0.64
VC → ETH	0.098	7.10	0.45

Zone 2	λ (1/yr)	half-life (yrs)
PCE → TCE	0.000	
TCE → DCE	0.000	
DCE → VC	0.000	
VC → ETH	0.000	

λ HELP

5. GENERAL

Simulation Time*	5	(yr)
Modeled Area Width*	300	(ft)
Modeled Area Length*	500	(ft)
Zone 1 Length*	500	(ft)
Zone 2 Length*	0	(ft)



Zone 2= L - Zone 1

6. SOURCE DATA

TYPE: Continuous
Single Planar

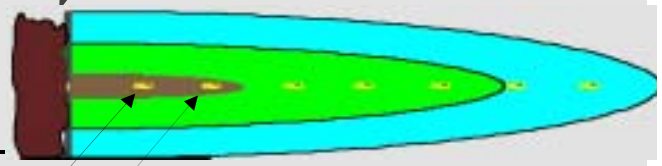
Source Options

Source Thickness in Sat. Zone* 25 (ft)

Width* (ft) Y1 60

Conc. (mg/L)*	C1	k_s* (1/yr)
PCE		0
TCE	2.0	0
DCE	.0	0
VC	.0	0
ETH	0	0

Vertical Plane Source: Determine Source Well Location and Input Solvent Concentrations



View of Plume Looking Down

Observed Centerline Conc. at Monitoring Wells

7. FIELD DATA FOR COMPARISON

PCE Conc. (mg/L)											
TCE Conc. (mg/L)											
DCE Conc. (mg/L)											
VC Conc. (mg/L)											
ETH Conc. (mg/L)											
Distance from Source (ft)											
Date Data Collected											

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE | RUN ARRAY | Help | Restore Formulas | RESET | SEE OUTPUT | Paste Example

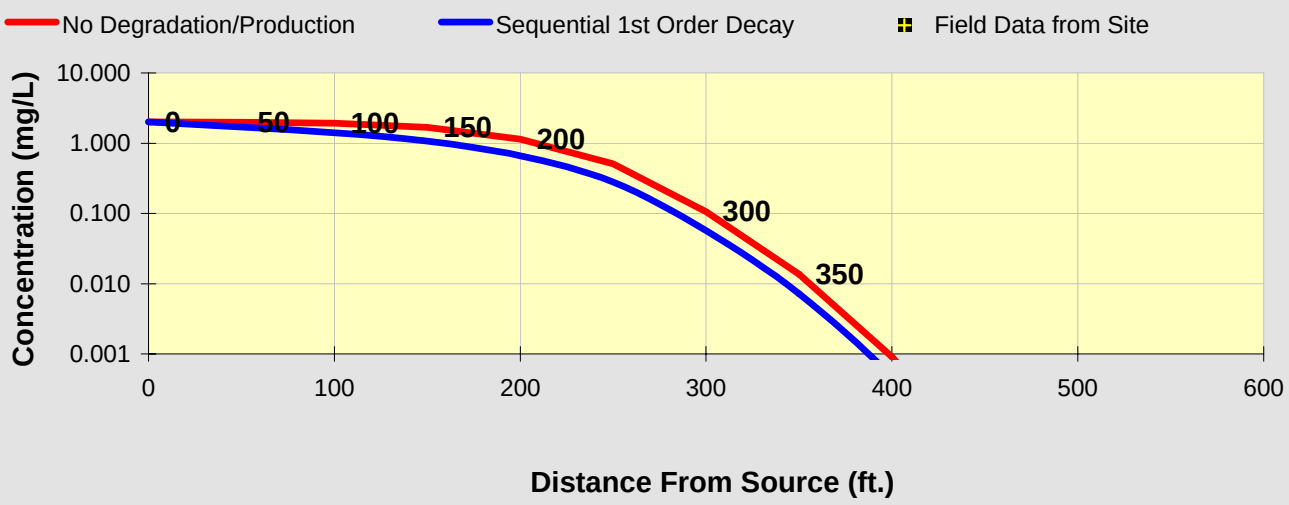
DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (mg/L) at Z=0

Distance from Source (ft)

TCE	0	50	100	150	200	250	300	350	400	450	500
No Degradation	2.000	1.996	1.932	1.685	1.144	0.507	0.106	0.014	0.001	0.000	0.000
Biotransformation	2.0000	1.698	1.405	1.072	0.662	0.281	0.057	0.007	0.000	0.000	0.000

Monitoring Well Locations (ft)

Field Data from Site											



See PCE

See TCE

See DCE

See VC

See ETH

Prepare Animation

Time:

5.0 Years

Log ⇔ Linear

Return to Input

To All

To Array

APPENDIX F
Cost Estimate Backup

SWMU 54 ALTERNATIVE 2: INSTITUTIONAL CONTROLS AND MONITORED NATURAL ATTENUATION
ORDER OF MAGNITUDE COST ESTIMATE (1)

Naval Activity Puerto Rico, Cieba, Puerto Rico

Cost Item	Quantity	Units	Unit Cost	Total Cost	Assumptions (Basis of Cost Estimate)
DIRECT CAPITAL COSTS					
I. Full-Scale MNA Implementation					
A. Mobilization/Demobilizatior	2	EA	$5,000	$10,000	Estimated (1 mobilization for characterization and 1 for well installatio
B. Site Characterization for MNA	1	LS	$60,000	$60,000	Estimate, includes one repor
C. Installation of 11 Monitoring Wells (25 feet deep	11	EA	$5,000	$55,000	Engineering Estimate
Subtotal - Direct Capital Costs				$125,000	
Scope & Bid Contingency				$43,750	35% total contingency (25% scope and 10 % bid contingencie
TOTAL - DIRECT CAPITAL COSTS				$168,750	
PROFESSIONAL SERVICES					
I. Project Management	1	LS	$10,125	$10,125	Assume 6% of total direct capital cos
II. Engineering Support, including MNA Plan and Contingency Plan	1	LS	$20,250	$20,250	Assume 12% of total direct capital cos
III. Construction Oversight	1	LS	$20,250	$20,250	Assume 12% of total direct capital cos
IV Institutional Controls, including legal	1	LS	$20,000	$20,000	Engineering Estimate
TOTAL - PROFESSIONAL SERVICES COSTS				$70,625	
ANNUAL OPERATION & MAINTENANCE COSTS					
I. Quarterly Monitoring-- Per year for 2 years					
A. Sampling Labor	4	events	$7,000	$28,000	14 wells, 2 technicians, 5 days, 10 hr/day @ $70/hour (includes prep/travel tim
B. Expenses	4	events	$4,900	$19,600	Travels costs, per diem, equipment costs, shipping, et
C. Analytical Costs	64	samples	$500	$32,000	16 samples per event for VOCs, gases, sulfate, nitrate/nitirite, chloride (14 wells + 2 QA/Q
D. Reporting	1	report	$7,500	$7,500	One annual repor
TOTAL - ANNUAL QUARTERLY MONITORING				$87,100	
II. Semi Annual Monitoring-- Per year for 10 years					
A. Sampling Labor	2	events	$7,000	$14,000	14 wells, 2 technicians, 5 days, 10 hr/day @ $70/hour (includes prep/travel tim
B. Expenses	2	events	$4,900	$9,800	Travels costs, per diem, equipment costs, shipping, et
C. Analytical Costs	32	samples	$500	$16,000	16 samples per event for VOCs, gases, sulfate, nitrate/nitrite, chloride (14 wells + 2 QA/Q
D. Reporting	1	report	$5,000	$5,000	One annual repor
E. Project Managemen	1	LS	$5,000	$5,000	
TOTAL - SEMI ANNUAL MONITORING				$49,800	
III. Annual Monitoring (Year 13-30), assume 4 wells dropped from program					
A. Sampling Labor	1	events	$5,600	$5,600	10 wells, 2 technicians, 4 days, 10 hr/day @ $70/hour (includes prep/travel tim
B. Expenses	1	events	$4,500	$4,500	Travels costs, per diem, equipment costs, shipping, et
C. Analytical Costs	11	samples	$500	$5,500	11 samples per event for VOCs, gases, sulfate, nitrate/nitrite, chloride (10 wells + 1 QA/Q
D. Reporting	1	report	$4,000	$4,000	One annual repor
E. Project Managemen	1	LS	$2,500	$2,500	
TOTAL - LONG-TERM MONITORING				$22,100	
TOTAL PROJECT COST SUMMARY					
DIRECT CAPITAL COSTS				$168,750	
PROFESSIONAL SERVICES COSTS				$70,625	
PRESENT WORTH OF QUARTERLY MONITORING, YEAR 1				$87,100	Initial year is year (
PRESENT WORTH OF QUARTERLY MONITORING, YEAR 2				$82,952	2nd year of quarterly monitorin
PRESENT WORTH OF MNA, SEMI-ANNUAL AND ANNUAL				$522,390	Assume long-term monitoring for next 28 years at 5% discount ra
TOTAL PROJECT COST				$931,818	

Note:
(1) Estimated accuracy of cost estimate is -30% to +50%. Cost estimate is to be used primarily for comparison of costs relative to other alternat

SWMU 55 ALTERNATIVE 2: INSTITUTIONAL CONTROLS AND MONITORED NATURAL ATTENUATION
ORDER OF MAGNITUDE COST ESTIMATE (1)

Naval Activity Puerto Rico, Cieba, Puerto Rico

Cost Item	Quantity	Units	Unit Cost	Total Cost	Assumptions (Basis of Cost Estimate)
DIRECT CAPITAL COSTS					
I. Full-Scale MNA Implementation					
A. Mobilization/Demobilizatior	2	EA	$5,000	$10,000	Estimated (1 mobilization for characterization and 1 for well installatio
B. Site Characterization for MNA	1	LS	$30,000	$30,000	Estimate, includes one repor
C. Installation of 3 Monitoring Wells (35 feet deep	3	EA	$5,000	$15,000	Engineering Estimate
Subtotal - Direct Capital Costs				$55,000	
Scope & Bid Contingency				$19,250	35% total contingency (25% scope and 10 % bid contingencie
TOTAL - DIRECT CAPITAL COSTS				$74,250	
PROFESSIONAL SERVICES					
I. Project Management	1	LS	$4,455	$4,455	Assume 6% of total direct capital cos
II. Engineering Support, including MNA Plan and Contingency Plan	1	LS	$8,910	$8,910	Assume 12% of total direct capital cos
III. Construction Oversight	1	LS	$8,910	$8,910	Assume 12% of total direct capital cos
IV Institutional Controls, including legal	1	LS	$20,000	$20,000	Engineering Estimate
TOTAL - PROFESSIONAL SERVICES COSTS				$42,275	
ANNUAL OPERATION & MAINTENANCE COSTS					
I. Quarterly Monitoring-- Per year for 2 years					
A. Sampling Labor	4	events	$5,600	$22,400	8 wells, 2 technicians, 4days, 10 hr/day @ $70/hour (includes prep/travel tim
B. Expenses	4	events	$4,500	$18,000	Travels costs, per diem, equipment costs, shipping, et
C. Analytical Costs	36	samples	$500	$18,000	9 samples per event for VOCs, gases, sulfate, nitrate/nitirite, chloride (8 wells + 1 QA/Q
D. Reporting	1	report	$7,500	$7,500	One annual repor
TOTAL - ANNUAL QUARTERLY MONITORING				$65,900	
II. Semi Annual Monitoring-- Per year for 10 years					
A. Sampling Labor	2	events	$5,600	$11,200	8 wells, 2 technicians, 4 days, 10 hr/day @ $70/hour (includes prep/travel tim
B. Expenses	2	events	$4,500	$9,000	Travels costs, per diem, equipment costs, shipping, et
C. Analytical Costs	18	samples	$500	$9,000	9 samples per event for VOCs, gases, sulfate, nitrate/nitrite, chloride (8 wells + 1 QA/Q
D. Reporting	1	report	$5,000	$5,000	One annual repor
E. Project Managemen	1	LS	$5,000	$5,000	
TOTAL - SEMI ANNUAL MONITORING				$39,200	
III. Annual Monitoring (Year 13-30), assume 2 wells dropped from program					
A. Sampling Labor	1	events	$5,600	$5,600	6 wells, 2 technicians,4 days, 10 hr/day @ $70/hour (includes prep/travel tim
B. Expenses	1	events	$4,500	$4,500	Travels costs, per diem, equipment costs, shipping, et
C. Analytical Costs	8	samples	$500	$4,000	7 samples per event for VOCs, gases, sulfate, nitrate/nitrite, chloride (6 wells + 1 QA/Q
D. Reporting	1	report	$4,000	$4,000	One annual repor
E. Project Managemen	1	LS	$2,500	$2,500	
TOTAL - LONG-TERM MONITORING				$20,600	
TOTAL PROJECT COST SUMMARY					
DIRECT CAPITAL COSTS				$74,250	
PROFESSIONAL SERVICES COSTS				$42,275	
PRESENT WORTH OF QUARTERLY MONITORING, YEAR 1				$65,900	Initial year is year (
PRESENT WORTH OF QUARTERLY MONITORING, YEAR 2				$62,762	2nd year of quarterly monitorin
PRESENT WORTH OF MNA, SEMI-ANNUAL AND ANNUAL				$433,838	Assume long-term monitoring for next 28 years at 5% discount ra
TOTAL PROJECT COST				$679,025	

Note:
(1) Estimated accuracy of cost estimate is -30% to +50%. Cost estimate is to be used primarily for comparison of costs relative to other alternat

SWMU 54 ALTERNATIVE 3: INSTITUTIONAL CONTROLS, ENHANCED BIOREMEDIATION WITH ORC, AND MNA
ORDER OF MAGNITUDE COST ESTIMATE--Benzene Plume (1)

Naval Activity Puerto Rico, Ceiba, Puerto Rico

Cost Item	Quantity	Units	Unit Cost	Total Cost	Assumptions (Basis of Cost Estimate)
DIRECT CAPITAL COSTS					
I. Full-Scale Enhanced Bioremediation System					
A. Mobilization/Demobilization	2	EA	$5,000	$10,000	Estimated (1 mobilization for pilot study, and 1 for injection program
B. Temporary water supply	1	LS	$5,000	$5,000	Estimate - piping & connections for water suppl
C On-site Injection Program (total of 1 injection)	1	EA	$25,000	$25,000	Vendor estimate
D ORC costs	4650	pounds	$9	$46,850	Cost for ORC, determined using Regenesis spreadsheet, $5k added for shippin
E Pilot test Injection, including monitoring	1	LS	$75,000	$75,000	Engineering Estimate
F Installation of monitoring wells	4	EA	$5,000	$20,000	Engineering Estimate
Subtotal - Direct Capital Costs				$181,850	
Scope & Bid Contingency				$63,648	35% total contingency (25% scope and 10 % bid contingencies)
TOTAL - DIRECT CAPITAL COSTS				$245,498	
PROFESSIONAL SERVICES					
I. Project Management	1	LS	$14,730	$14,730	Assume 6% of total direct capital cost
II Institutional Controls, including legal	1	LS	$20,000	$20,000	Engineering Estimate
III. Remedial Design/Engineering Support	1	LS	$29,460	$29,460	Assume 12% of total direct capital cost
IV. Construction Oversight	1	LS	$29,460	$29,460	Assume 12% of total direct capital cost
V UIC Permitting for Injection	1	LS	$10,000	$10,000	Estimated UIC Permit required for Injection to Groundwater
TOTAL - PROFESSIONAL SERVICES COSTS				$103,649	
ANNUAL OPERATION & MAINTENANCE COSTS					
I Baseline Monitoring (before 1st injection)					
A. Sampling Labor	1	events	$5,600	$5,600	6 wells, 2 technicians, 4 days, 10 hr/day @ $70/hour (includes prep/travel time)
B. Expenses	1	events	$4,500	$4,500	Travels costs, per diem, equipment costs, shipping, etc.
C. Analytical Costs	7	samples	$500	$3,500	7 samples per event for VOCs, sulfate, nitrate/nitrite, methane(6 wells + 1 QA/QC)
D. Reporting	1	report	$2,500	$2,500	One baseline report
TOTAL - BASELINE MONITORING				$16,100	
II Performance Monitoring (Quarterly for 1 year)					
A. Sampling Labor	4	events	$5,600	$22,400	6 wells, 2 technicians, 4 days, 10 hr/day @ $70/hour (includes prep/travel time)
B. Expenses	4	events	$4,500	$18,000	Travels costs, per diem, equipment costs, shipping, etc.
C. Analytical Costs	28	samples	$500	$14,000	7 samples per event for VOCs, sulfate, nitrate/nitrite, methane (6wells + 1 QA/QC)
D. Reporting	1	report	$7,500	$7,500	One annual report
TOTAL - PERFORMANCE MONITORING				$61,900	
III. Monitored Natural Attenuation (annual for 14 additional years)					
A. Sampling Labor	1	events	$5,600	$5,600	6 wells, 2 technicians, 4 days, 10 hr/day @ $70/hour (includes prep/travel time)
B. Expenses	1	events	$4,500	$4,500	Travels costs, per diem, equipment costs, shipping, etc.
C. Analytical Costs	7	samples	$500	$3,500	7 samples per event for VOCs,sulfate, nitrate/nitrite, methane (6wells + 1 QA/QC)
D. Reporting	1	report	$5,000	$5,000	One annual report
E Long-Term Project Management	1	LS	$2,500	$2,500	Long-term project management
TOTAL - LONG-TERM MONITORING				$21,100	
TOTAL PROJECT COST SUMMARY					
DIRECT CAPITAL COSTS				$245,498	
PROFESSIONAL SERVICES COSTS				$103,649	
PRESENT WORTH OF BASELINE MONITORING				$16,100	Baseline monitoring done in first year
PRESENT WORTH OF PERFORMANCE MONITORING				$61,900	Assume performance monitoring done in first year (includes 4 events).
PRESENT WORTH OF LONG-TERM MONITORING				$219,011	Assume long-term monitoring for next 14 years at 5% discount rate.
TOTAL PROJECT COST				$646,158	

Note:
(1) Estimated accuracy of cost estimate is -30% to +50%. Cost estimate is to be used primarily for comparison of costs relative to other alternatives.

SWMU 54 ALTERNATIVE 3: INSTITUTIONAL CONTROLS, ENHANCED REDUCTIVE DECHLORINATION, AND MNA
ORDER OF MAGNITUDE COST ESTIMATE--TCE Plume [1]

Naval Activity Puerto Rico, Cieba, Puerto Rico

Cost Item	Quantity	Units	Unit Cost	Total Cost	Assumptions (Basis of Cost Estimate)
DIRECT CAPITAL COSTS					
I. Full-Scale Enhanced Reductive Dechlorination System					
A. Mobilization/Demobilizatior	2	EA	$5,000	$10,000	Estimated (1 mobilization for pilot study, and 1 for injection prograı
B. Temporary water suppl	1	LS	$5,000	$5,000	Estimate - piping & connections for water suppl
C On-site Injection Program (total of 2 injections	2	EA	$25,000	$50,000	Vendor estimate - assumes four injection
D Lactate --60 % solution (total of 2 injections)[2]	70	55 gal drum	$600	$52,000	Cost for lactate, 35 drums/event, based on filling 5% available pore space with 6% solution of diluted lactate, $10K added for shippin
E Bench Test	1	LS	$15,000	$15,000	Engineering Estimate
F Pilot test Injection, including monitorin	1	LS	$75,000	$75,000	Engineering Estimate
G Installation of Monitoring well	7	EA	$5,000	$35,000	Engineering Estimate
Subtotal - Direct Capital Costs				$242,000	
Scope & Bid Contingency				$84,700	35% total contingency (25% scope and 10 % bid contingencie
TOTAL - DIRECT CAPITAL COSTS				$326,700	
PROFESSIONAL SERVICES					
I. Project Management	1	LS	$19,602	$19,602	Assume 6% of total direct capital cos
II Institutional Controls, including legal	1	LS	$20,000	$20,000	Engineering Estimate
III Remedial Design/Engineering Support	1	LS	$39,204	$39,204	Assume 12% of total direct capital cos
IV Construction Oversight	1	LS	$39,204	$39,204	Assume 12% of total direct capital cos
V UIC Permitting for Injection	1	LS	$10,000	$10,000	Estimated UIC Permit required for Injection to Groundwate
TOTAL - PROFESSIONAL SERVICES COSTS				$128,010	
ANNUAL OPERATION & MAINTENANCE COSTS					
I Baseline Monitoring (before 1st injection)					
A. Sampling Labo	1	events	$5,600	$5,600	8 wells, 2 technicians, 4 days, 10 hr/day @ $70/hour (includes prep/travel tim
B. Expenses	1	events	$4,500	$4,500	Travels costs, per diem, equipment costs, shipping, et
C. Analytical Costs	9	samples	$500	$4,500	9 samples per event for VOCs, sulfate, nitrate/nitrite, gases, chloride(8 wells + 1QA/Q
D. Reporting	1	report	$2,500	$2,500	One baseline repor
TOTAL - BASELINE MONITORING				$17,100	
II Performance Monitoring (quarterly for 1 year)					
A. Sampling Labo	4	events	$5,600	$22,400	8 wells, 2 technicians, 4 days, 10 hr/day @ $70/hour (includes prep/travel tim
B. Expenses	4	events	$4,500	$18,000	Travels costs, per diem, equipment costs, shipping, et
C. Analytical Costs	36	samples	$500	$18,000	9 samples per event for VOCs, gases, sulfate, nitrate/nitrite, chloride (8 wells +1 QA/Q
D. Reporting	1	report	$7,500	$7,500	One annual repor
TOTAL - PERFORMANCE MONITORING				$65,900	
III Monitored Natural Attenuation (Annual for 14 additional years)					
A. Sampling Labo	1	events	$5,600	$5,600	8 wells, 2 technicians, 4 days, 10 hr/day @ $70/hour (includes prep/travel tim
B. Expenses	1	events	$4,500	$4,500	Travels costs, per diem, equipment costs, shipping, et
C. Analytical Costs	9	samples	$500	$4,500	9 samples per event for VOCs, gases, sulfate, nitrate/nitrite, chloride (8 wells + 1 QA/Q
D. Reporting	1	report	$7,500	$7,500	One annual repor
E Long-Term Project Managemen	1	LS	$2,500	$2,500	Long-term project managemer
TOTAL - LONG-TERM MONITORING				$24,600	
TOTAL PROJECT COST SUMMARY					
DIRECT CAPITAL COSTS				$326,700	
PROFESSIONAL SERVICES COSTS				$128,010	
PRESENT WORTH OF BASELINE MONITORING				$17,100	Baseline monitoring done in first yea
PRESENT WORTH OF PERFORMANCE MONITORING				$65,900	Assume performance monitoring during first year.
PRESENT WORTH OF LONG-TERM MONITORING				$255,340	Assume long-term monitoring for next 14 years at 5% discount ra
TOTAL PROJECT COST				$793,050	

Note:
(1) Estimated accuracy of cost estimate is -30% to +50%. Cost estimate is to be used primarily for comparison of costs relative to other alternat
(2) Lactate assumed for CMS; actual electron donor dependent on results of bench test

SWMU 55 ALTERNATIVE 3: INSTITUTIONAL CONTROLS, ENHANCED REDUCTIVE DECHLORINATION, AND MNA
ORDER OF MAGNITUDE COST ESTIMATE [1]

Naval Activity Puerto Rico, Cieba, Puerto Rico

Cost Item	Quantity	Units	Unit Cost	Total Cost	Assumptions (Basis of Cost Estimate)
DIRECT CAPITAL COSTS					
I. Full-Scale Enhanced Reductive Dechlorination System					
A. Mobilization/Demobilization	2	EA	$5,000	$10,000	Estimated (1 mobilization for pilot study, and 1 for injection program
B. Temporary water supply	1	LS	$5,000	$5,000	Estimate - piping & connections for water supply
C. Install 30 Injection Wells (35 ft deep)	30	EA	$5,000	$150,000	Engineering Estimate
D On-site Injection Program (total of 4 injections)	4	EA	$25,000	$100,000	Vendor estimate
E Lactate --60 % solution (total of 4 injections)[2]	550	drum	$600	$350,000	Cost for lactate, 138 drums/event, based on filling 5% available pore space with 6% solution of diluted lactate, $20K added for shipping
F Bioaugmentation (assume 2 injections)	180	liter	$450	$81,000	Vendor estimate, 3 Liters per location, 2 injection events
G Bench Test	1	LS	$15,000	$15,000	Engineering Estimate
H Pilot test Injection, including monitoring	1	LS	$75,000	$75,000	Engineering Estimate
Subtotal - Direct Capital Costs				$786,000	
Scope & Bid Contingency				$275,100	35% total contingency (25% scope and 10 % bid contingencies)
TOTAL - DIRECT CAPITAL COSTS				$1,061,100	
PROFESSIONAL SERVICES					
I. Project Management	1	LS	$63,666	$63,666	Assume 6% of total direct capital cost
II Institutional Controls, including legal	1	LS	$20,000	$20,000	Engineering Estimate
III. Remedial Design/Engineering Support	1	LS	$127,332	$127,332	Assume 12% of total direct capital cost
IV. Construction Oversight	1	LS	$127,332	$127,332	Assume 12% of total direct capital cost
V UIC Permitting for Injection	1	LS	$10,000	$10,000	Estimated UIC Permit required for Injection to Groundwater
TOTAL - PROFESSIONAL SERVICES COSTS				$348,330	
ANNUAL OPERATION & MAINTENANCE COSTS					
I Baseline Monitoring (before 1st injection)					
A. Sampling Labor	1	events	$5,600	$5,600	8 wells, 2 technicians, 4 days, 10 hr/day @ $70/hour (includes prep/travel time
B. Expenses	1	events	$4,500	$4,500	Travels costs, per diem, equipment costs, shipping, etc
C. Analytical Costs	9	samples	$500	$4,500	9 samples per event for VOCs, sulfate, nitrate/nitrite, gases, chloride(8 wells + 1 QA/QC
D. Reporting	1	report	$2,500	$2,500	One baseline report
TOTAL - BASELINE MONITORING				$17,100	
II Performance Monitoring (quarterly for 1 year)					
A. Sampling Labor	4	events	$5,600	$22,400	8 wells, 2 technicians, 4 days, 10 hr/day @ $70/hour (includes prep/travel time
B. Expenses	4	events	$4,500	$18,000	Travels costs, per diem, equipment costs, shipping, etc
C. Analytical Costs	36	samples	$500	$18,000	9 samples per event for VOCs, gases, sulfate, nitrate/nitrite, chloride (8 wells + 1 QA/QC
D. Reporting	1	report	$7,500	$7,500	One annual report
TOTAL - PERFORMANCE MONITORING				$65,900	
III Monitored Natural Attenuation (Annual for 14 additional years)					
A. Sampling Labor	1	events	$5,600	$5,600	8 wells, 2 technicians,4 days, 10 hr/day @ $70/hour (includes prep/travel time
B. Expenses	1	events	$4,500	$4,500	Travels costs, per diem, equipment costs, shipping, etc
C. Analytical Costs	9	samples	$500	$4,500	9 samples per event for VOCs, sulfate, nitrate/nitrite, gases, chloride(8 wells +1QA/QC
D. Reporting	1	report	$7,500	$7,500	One annual report
E Long-Term Project Managemen	1	LS	$2,500	$2,500	Long-term project managemen
TOTAL - LONG-TERM MONITORING				$24,600	
TOTAL PROJECT COST SUMMARY					
DIRECT CAPITAL COSTS				$1,061,100	
PROFESSIONAL SERVICES COSTS				$348,330	
PRESENT WORTH OF BASELINE MONITORING				$17,100	Baseline monitoring done in first year
PRESENT WORTH OF PERFORMANCE MONITORING				$65,900	Assume performance monitoring during first year
PRESENT WORTH OF LONG-TERM MONITORING				$255,340	Assume long-term monitoring for next 14 years at 5% discount rate
TOTAL PROJECT COST				$1,747,770	

Note:
(1) Estimated accuracy of cost estimate is -30% to +50%. Cost estimate is to be used primarily for comparison of costs relative to other alternative
(2) Lactate assumed for CMS; actual electron donor dependent on results of bench test

SWMU 54 ALTERNATIVE 4: INSTITUTIONAL CONTROLS, CHEMICAL OXIDATION, AND MNA
ORDER OF MAGNITUDE COST ESTIMATE ¯benzene plume [1]

Naval Activity Puerto Rico, Ceiba, Puerto Rico

Cost Item	Quantity	Units	Unit Cost	Total Cost	Assumptions (Basis of Cost Estimate)
DIRECT CAPITAL COSTS					
I Full-Scale Fentons Injection Program					
A. Mobilization/Demobilization	2	EA	$25,000	$50,000	Vendor estimate (equipment, travel, per diem, vehicles for 2 injection events)
B Injection Well Installation	1	LS	$25,000	$25,000	Vendor and engineering estimate--design and materials, driller, oversite
C Fenton's On-site Injection Program (2 injections)	2	EA	$20,000	$40,000	Vendor estimate (injection equip, field crew labor, office support)
D. Fenton's Reagent (2 injections)	1	LS	$22,760	$22,760	Cost for 36,000 lbs 50% hydrogen peroxide, includes shipping
E Pilot Test	1	LS	$80,000	$80,000	Engineering and vendor Estimate, includes sampling
Fentons Injection Program Total				$217,760	
Subtotal - Direct Capital Costs				$217,760	
Scope & Bid Contingency				$76,216	35% total contingency (25% scope and 10 % bid contingencies)
TOTAL - DIRECT CAPITAL COSTS				$293,976	
PROFESSIONAL SERVICES					
I. Project Management	1	LS	$29,398	$29,398	Assume 10% of total direct capital cost
II Institutional Controls, including legal	1	LS	$20,000	$20,000	Engineering Estimate
III. Remedial Design/Engineering Support	1	LS	$58,795	$58,795	Assume 20% of total direct capital cost
IV. Construction Oversight	1	LS	$35,277	$35,277	Assume 12% of total direct capital cost
V UIC Permitting for Injection	1	LS	$10,000	$10,000	Estimated UIC Permit required for Injection to Groundwater
TOTAL - PROFESSIONAL SERVICES COSTS				$153,470	
ANNUAL OPERATION & MAINTENANCE COSTS					
I Baseline Monitoring (before 1st injection)					
A. Sampling Labor	1	events	$5,600	$5,600	6 wells, 2 technicians, 4 days, 10 hr/day @ $70/hour (includes prep/travel time)
B. Expenses	1	events	$4,500	$4,500	Travels costs, per diem, equipment costs, shipping, etc.
C. Analytical Costs	7	samples	$300	$2,100	7samples per event for VOCs, sulfate, nitrate/nitrite, methane(6 wells + 1 QA/QC)
D. Reporting	1	report	$2,500	$2,500	One baseline report
TOTAL - BASELINE MONITORING				$14,700	
II Performance Monitoring (Quarterly for 1 year)					
A. Sampling Labor	4	events	$5,600	$22,400	6 wells, 2 technicians, 4 days, 10 hr/day @ $70/hour (includes prep/travel time)
B. Expenses	4	events	$4,500	$18,000	Travels costs, per diem, equipment costs, shipping, etc.
C. Analytical Costs	28	samples	$300	$8,400	7 samples per event for VOCs, sulfate, nitrate/nitrite, methane (6wells + 1 QA/QC)
D. Reporting	1	report	$7,500	$7,500	One annual report
TOTAL - PERFORMANCE MONITORING				$56,300	
III. Monitored Natural Attenuation (annual for 14 additional years)					
A. Sampling Labor	1	events	$5,600	$5,600	6 wells, 2 technicians, 4 days, 10 hr/day @ $70/hour (includes prep/travel time)
B. Expenses	1	events	$4,500	$4,500	Travels costs, per diem, equipment costs, shipping, etc.
C. Analytical Costs	7	samples	$300	$2,100	7 samples per event for VOCs,sulfate, nitrate/nitrite, methane (6wells + 1 QA/QC)
D. Reporting	1	report	$5,000	$5,000	One annual report
E Long-Term Project Management	1	LS	$2,500	$2,500	Long-term project management
TOTAL - LONG-TERM MONITORING				$19,700	
TOTAL PROJECT COST SUMMARY					
DIRECT CAPITAL COSTS				$293,976	
PROFESSIONAL SERVICES COSTS				$153,470	
PRESENT WORTH OF BASELINE MONITORING				$14,700	Baseline monitoring done in first year.
PRESENT WORTH PERFORMANCE MONITORING				$56,300	Assume performance monitoring done in first year (includes 4 events).
PRESENT WORTH OF LONG-TERM MONITORING				$185,717	Assume long-term monitoring for next 14 years at 5% discount rate.
TOTAL PROJECT COST				$704,163	

Note: (1) Estimated accuracy of cost estimate is -30% to +50%. Cost estimate is to be used primarily for comparison of costs relative to other response action alternatives.

SWMU 54 ALTERNATIVE 4: INSTITUTIONAL CONTROLS, CHEMICAL OXIDATION, AND MNA
ORDER OF MAGNITUDE COST ESTIMATE ¯TCE plume (1)

Naval Activity Puerto Rico, Ceiba, Puerto Rico

Cost Item	Quantity	Units	Unit Cost	Total Cost	Assumptions (Basis of Cost Estimate)
DIRECT CAPITAL COSTS					
I Full-Scale Fentons Injection Program					
A. Mobilization/Demobilization	2	EA	$25,000	$50,000	Vendor estimate (equipment, travel, per diem, vehicles for 2 injection events)
B Injection Well Installation	1	LS	$55,000	$55,000	Vendor and engineering estimate--design and materials, driller, oversite
C Fenton's On-site Injection Program (2 injections)	2	EA	$35,000	$70,000	Vendor estimate (injection equip, field crew labor, office support)
D. Fenton's Reagent (2 injections)	1	LS	$39,430	$39,430	Cost for 63,000 lbs 50% hydrogen peroxide, includes shipping
E Pilot Test	1	LS	$100,000	$100,000	Engineering and vendor Estimate, includes sampling
Fentons Injection Program Total				$314,430	
Subtotal - Direct Capital Costs				$314,430	
Scope & Bid Contingency				$110,051	35% total contingency (25% scope and 10 % bid contingencies)
TOTAL - DIRECT CAPITAL COSTS				$424,481	
PROFESSIONAL SERVICES					
I. Project Management	1	LS	$42,448	$42,448	Assume 10% of total direct capital cost
II Institutional Controls, including legal	1	LS	$20,000	$20,000	Engineering Estimate
III. Remedial Design/Engineering Support	1	LS	$84,896	$84,896	Assume 20% of total direct capital cost
IV. Construction Oversight	1	LS	$50,938	$50,938	Assume 12% of total direct capital cost
V UIC Permitting for Injection	1	LS	$10,000	$10,000	Estimated UIC Permit required for Injection to Groundwater
TOTAL - PROFESSIONAL SERVICES COSTS				$208,282	
ANNUAL OPERATION & MAINTENANCE COSTS					
I Baseline Monitoring (before 1st injection)					
A. Sampling Labor	1	events	$5,600	$5,600	8 wells, 2 technicians, 4 days, 10 hr/day @ $70/hour (includes prep/travel time)
B. Expenses	1	events	$4,500	$4,500	Travels costs, per diem, equipment costs, shipping, etc.
C. Analytical Costs	9	samples	$500	$4,500	9 samples per event for VOCs, sulfate, nitrate/nitrite, gases, chloride(8 wells + 1QA/QC)
D. Reporting	1	report	$2,500	$2,500	One baseline report
TOTAL - BASELINE MONITORING				$17,100	
II Performance Monitoring (quarterly for 1 year)					
A. Sampling Labor	4	events	$5,600	$22,400	8 wells, 2 technicians, 4 days, 10 hr/day @ $70/hour (includes prep/travel time)
B. Expenses	4	events	$4,500	$18,000	Travels costs, per diem, equipment costs, shipping, etc.
C. Analytical Costs	36	samples	$500	$18,000	9 samples per event for VOCs, gases, sulfate, nitrate/nitrite, chloride (8 wells + 1 QA/QC)
D. Reporting	1	report	$7,500	$7,500	One annual report
TOTAL - PERFORMANCE MONITORING				$65,900	
III Monitored Natural Attenuation (Annual for 14 additional years)					
A. Sampling Labor	1	events	$5,600	$5,600	8 wells, 2 technicians, 4 days, 10 hr/day @ $70/hour (includes prep/travel time)
B. Expenses	1	events	$4,500	$4,500	Travels costs, per diem, equipment costs, shipping, etc.
C. Analytical Costs	9	samples	$500	$4,500	9 samples per event for TCL VOCs (8 wells + 1 QA/QC)
D. Reporting	1	report	$7,500	$7,500	One annual report
E Long-Term Project Management	1	LS	$2,500	$2,500	Long-term project management
TOTAL - LONG-TERM MONITORING				$24,600	
TOTAL PROJECT COST SUMMARY					
DIRECT CAPITAL COSTS				$424,481	
PROFESSIONAL SERVICES COSTS				$208,282	
PRESENT WORTH OF BASELINE MONITORING				$17,100	Baseline monitoring done in first year.
PRESENT WORTH PERFORMANCE MONITORING				$65,900	Assume performance monitoring done in first year (includes 4 events).
PRESENT WORTH OF LONG-TERM MONITORING				$231,911	Assume long-term monitoring for next 14 years at 5% discount rate.
TOTAL PROJECT COST				$947,673	

Note: (1) Estimated accuracy of cost estimate is -30% to +50%. Cost estimate is to be used primarily for comparison of costs relative to other response action alternatives.

SWMU 55 ALTERNATIVE 4: INSTITUTIONAL CONTROLS, CHEMICAL OXIDATION, AND MNA
ORDER OF MAGNITUDE COST ESTIMATE (1)

Naval Activity Puerto Rico, Ceiba, Puerto Rico

Cost Item	Quantity	Units	Unit Cost	Total Cost	Assumptions (Basis of Cost Estimate)
DIRECT CAPITAL COSTS					
A. Mobilization/Demobilization	1	EA	$28,250	$28,250	Vendor estimate (equipment, travel, per diem, vehicles for 1 injection event)
B Injection Well Installation	1	LS	$90,000	$90,000	Vendor and engineering estimate--design and materials, driller, oversite
C Permanganate On-site Injection Program (1 injection)	1	EA	$21,600	$21,600	Vendor estimate (injection equip, field crew labor, office support)
D. Sodium Permangante Reagent (1 injection)	1	LS	$8,376	$10,376	Cost for 2043 pounds of 40% sodium permangate, includes $2K for shipping
E Pilot Test	1	LS	$100,000	$100,000	Engineering and vendor Estimate, includes sampling
Permanganate Injection Program Total				$250,226	
Subtotal - Direct Capital Costs				$250,226	
Scope & Bid Contingency				$87,579	35% total contingency (25% scope and 10 % bid contingencies)
TOTAL - DIRECT CAPITAL COSTS				$337,805	
PROFESSIONAL SERVICES					
I. Project Management	1	LS	$33,781	$33,781	Assume 10% of total direct capital cost
II Institutional Controls, including legal	1	LS	$20,000	$20,000	Engineering Estimate
III. Remedial Design/Engineering Support	1	LS	$67,561	$67,561	Assume 20% of total direct capital cost
IV. Construction Oversight	1	LS	$40,537	$40,537	Assume 12% of total direct capital cost
V UIC Permitting for Injection	1	LS	$10,000	$10,000	Estimated UIC Permit required for Injection to Groundwater
TOTAL - PROFESSIONAL SERVICES COSTS				$171,878	
ANNUAL OPERATION & MAINTENANCE COSTS					
I Baseline Monitoring (before 1st injection)					
A. Sampling Labor	1	events	$5,600	$5,600	8 wells, 2 technicians, 4 days, 10 hr/day @ $70/hour (includes prep/travel time)
B. Expenses	1	events	$4,500	$4,500	Travels costs, per diem, equipment costs, shipping, etc.
C. Analytical Costs	9	samples	$500	$4,500	9 samples per event for VOCs, sulfate, nitrate/nitrite, gases, chloride(8 wells +1QA/QC)
D. Reporting	1	report	$2,500	$2,500	One baseline report
TOTAL - BASELINE MONITORING				$17,100	
II Performance Monitoring (quarterly for 1 year)					
A. Sampling Labor	4	events	$5,600	$22,400	8 wells, 2 technicians, 4 days, 10 hr/day @ $70/hour (includes prep/travel time)
B. Expenses	4	events	$4,500	$18,000	Travels costs, per diem, equipment costs, shipping, etc.
C. Analytical Costs	36	samples	$500	$18,000	9 samples per event for VOCs, gases, sulfate, nitrate/nitrite, chloride (8 wells + 1 QA/QC)
D. Reporting	1	report	$7,500	$7,500	One annual report
TOTAL - PERFORMANCE MONITORING				$65,900	
III Monitored Natural Attenuation (Annual for 14 additional years)					
A. Sampling Labor	1	events	$5,600	$5,600	8 wells, 2 technicians, 4 days, 10 hr/day @ $70/hour (includes prep/travel time)
B. Expenses	1	events	$4,500	$4,500	Travels costs, per diem, equipment costs, shipping, etc.
C. Analytical Costs	9	samples	$500	$4,500	9 samples per event for VOCs, sulfate, nitrate/nitrite, gases, chloride(8 wells + 1QA/QC)
D. Reporting	1	report	$7,500	$7,500	One annual report
E Long-Term Project Management	1	LS	$2,500	$2,500	Long-term project management
TOTAL - LONG-TERM MONITORING				$24,600	
TOTAL PROJECT COST SUMMARY					
DIRECT CAPITAL COSTS				$337,805	
PROFESSIONAL SERVICES COSTS				$171,878	
PRESENT WORTH OF BASELINE MONITORING				$17,100	Baseline monitoring done in first year.
PRESENT WORTH PERFORMANCE MONITORING				$65,900	Assume performance monitoring done in first year (includes 4events).
PRESENT WORTH OF LONG-TERM MONITORING				$231,911	Assume long-term monitoring for next 14 years at 5% discount rate.
TOTAL PROJECT COST				$824,594	

Note: (1) Estimated accuracy of cost estimate is -30% to +50%. Cost estimate is to be used primarily for comparison of costs relative to other response action alternatives.

SWMU 55 ALTERNATIVE 5: INSTITUTIONAL CONTROLS, ZERO VALENT IRON INJECTION, AND MNA
ORDER OF MAGNITUDE COST ESTIMATE (1)

Naval Activity Puerto Rico, Cieba, Puerto Rico

Cost Item	Quantity	Units	Unit Cost	Total Cost	Assumptions (Basis of Cost Estimate)
DIRECT CAPITAL COSTS					
I. Full-Scale Zero Valent Iron Injection					
A. Mobilization/Demobilization	1	EA	$75,000	$75,000	Estimated (1 mobilization for pilot study, and 1 for injection program
B. Temporary water supply	1	LS	$5,000	$5,000	Estimate - piping & connections for water supply
C. Install 30 boreholes (35 ft deep)	30	EA	$2,500	$75,000	Engineering Estimate
D On-site Injection Program, including materials	1	EA	$604,000	$604,000	Vendor estimate
H Pilot test Injection of 6 holes, inc. mob/demob, materials	1	LS	$210,000	$210,000	Vendor estimate
Subtotal - Direct Capital Costs				$969,000	
Scope & Bid Contingency				$339,150	35% total contingency (25% scope and 10 % bid contingencies
TOTAL - DIRECT CAPITAL COSTS				$1,308,150	
PROFESSIONAL SERVICES					
I. Project Management	1	LS	$78,489	$78,489	Assume 6% of total direct capital cost
II Institutional Controls, including legal	1	LS	$20,000	$20,000	Engineering Estimate
III. Remedial Design/Engineering Support	1	LS	$130,815	$130,815	Assume 10% of total direct capital cost
IV. Construction Oversight	1	LS	$130,815	$130,815	Assume 10% of total direct capital cost
V UIC Permitting for Injection	1	LS	$10,000	$10,000	Estimated UIC Permit required for Injection to Groundwate
TOTAL - PROFESSIONAL SERVICES COSTS				$370,119	
ANNUAL OPERATION & MAINTENANCE COSTS					
I Baseline Monitoring (before 1st injection)					
A. Sampling Labor	1	events	$5,600	$5,600	8 wells, 2 technicians, 4 days, 10 hr/day @ $70/hour (includes prep/travel time
B. Expenses	1	events	$4,500	$4,500	Travels costs, per diem, equipment costs, shipping, etc
C. Analytical Costs	9	samples	$500	$4,500	9 samples per event for VOCs, sulfate, nitrate/nitrite, gases, chloride(8 wells + 1 QA/QC
D. Reporting	1	report	$2,500	$2,500	One baseline report
TOTAL - BASELINE MONITORING				$17,100	
II Performance Monitoring (quarterly for 1 year)					
A. Sampling Labor	4	events	$5,600	$22,400	8 wells, 2 technicians, 4 days, 10 hr/day @ $70/hour (includes prep/travel time
B. Expenses	4	events	$4,500	$18,000	Travels costs, per diem, equipment costs, shipping, etc
C. Analytical Costs	36	samples	$500	$18,000	9 samples per event for VOCs, gases, sulfate, nitrate/nitrite, chloride (8 wells + 1 QA/QC
D. Reporting	1	report	$7,500	$7,500	One annual report
TOTAL - PERFORMANCE MONITORING				$65,900	
III Monitored Natural Attenuation (Annual for 14 additional years)					
A. Sampling Labor	1	events	$5,600	$5,600	8 wells, 2 technicians,4 days, 10 hr/day @ $70/hour (includes prep/travel time
B. Expenses	1	events	$4,500	$4,500	Travels costs, per diem, equipment costs, shipping, etc
C. Analytical Costs	9	samples	$500	$4,500	9 samples per event for VOCs, sulfate, nitrate/nitrite, gases, chloride(8 wells +1QA/QC
D. Reporting	1	report	$7,500	$7,500	One annual report
E Long-Term Project Managemen	1	LS	$2,500	$2,500	Long-term project managemen
TOTAL - LONG-TERM MONITORING				$24,600	
TOTAL PROJECT COST SUMMARY					
DIRECT CAPITAL COSTS				$1,308,150	
PROFESSIONAL SERVICES COSTS				$370,119	
PRESENT WORTH OF BASELINE MONITORING				$17,100	Baseline monitoring done in first year
PRESENT WORTH OF PERFORMANCE MONITORING				$65,900	Assume performance monitoring during first year
PRESENT WORTH OF LONG-TERM MONITORING				$255,340	Assume long-term monitoring for next 14 years at 5% discount rate
TOTAL PROJECT COST				$2,016,609	

Note:
(1) Estimated accuracy of cost estimate is -30% to +50%. Cost estimate is to be used primarily for comparison of costs relative to other alternative

SWMU 55 ALTERNATIVE 6: INSTITUTIONAL CONTROLS, EXTRACTION AND TREATMENT, REINJECTION, AND LTM
ORDER OF MAGNITUDE COST ESTIMATE (1)

Naval Activity Puerto Rico, Ceiba, Puerto Rico

Cost Item	Quantity	Units	Unit Cost	Total Cost	Assumptions (Basis of Cost Estimate)
DIRECT CAPITAL COSTS					
I. Extraction Well and Treatment System					
A. Mobilization/Demobilization	1	LS	$15,000	$15,000	Estimate
B. Well Construction	4	EA	$7,500	$30,000	Estimate
C. Extraction Well Submersible Pumps	2	EA	$2,000	$4,000	4-in submersible pump (head<121', 21-32 gpm) w/controls, Mean Env 2004 (33-23-0542)
D. 24-Hour Pump Test in Extraction Wells (7MW07 and 7MW24), includ	1	LS	$35,000	$35,000	Estimate (based on similar pump tests at other sites)
E. Injection well pump test	1	LS	$20,000	$20,000	Estimate
F. Liquid Phase Carbon Absorbers (series operation)	2	EA	$6,000	$12,000	Means Env 2004 33-13-2009 (includes cost, shipping, install & testing)
G Riser piping and connections	1	EA	$700	$700	140 LF 1" PVC plus connections (Engineering Estimate)
H Transport Pipe Trenching/Backfill/Compaction	500	LF	$5.48	$2,740	Means Site Work 2001 (A12.3-110-1340)
I Piping 2" PVC	500	LF	$4.34	$2,170	Means Env 2004 19-01-0204
I Treatment System Building	150	SF	$75	$11,250	Means Mechanical 2004 (17100-970)
J Transfer Pump (1/2 HP) and Piping	1	LS	$3,000	$3,000	Estimate
K Remote Telemetry Equipment	1	EA	$4,500	$4,500	Vendor Estimate
L Mechanical/Electrical - Lighting & Controls & Telephone Lines	1	LS	$15,000	$15,000	Estimate
Subtotal - Direct Capital Costs				$155,360	
Scope & Bid Contingency				$54,376	35% total contingency (20% scope and 15 % bid contingencies)
TOTAL - DIRECT CAPITAL COSTS				$209,736	
PROFESSIONAL SERVICES					
I. Project Management	1	LS	$20,974	$20,974	Assume 10% of total direct capital costs
II. Remedial Design/Engineering Support	1	LS	$52,434	$52,434	Assume 25% of total direct capital costs
III. Construction Oversight	1	LS	$31,460	$31,460	Assume 15% of total direct capital costs
IV. UIC Permit	1	LS	$10,000	$10,000	Estimated
V Institutional Controls	1	LS	$20,000	$20,000	Estimated
TOTAL - PROFESSIONAL SERVICES COSTS				$134,868	
ANNUAL OPERATION AND MAINTENANCE COSTS-- per year for 5 years					
I. Operation and Maintenance Labor & Materials					
A. Activated Carbon Change-out System	1	LS	$2,500	$2,500	Estimate
B. System Operation (Labor and Subcontractors)	1	LS	$36,400	$36,400	2 hr/day, 5 day/week, 52 weeks/yr, $70/hour., assume local contractor
C Electricity/Phone Service	1	LS	$6,000	$6,000	Electric power (motors, controls, and heat) and telephone service
D. Project Management	1	LS	$10,000	$10,000	Estimate
II Bi-Weekly Treatment System Monitoring					
A. Sampling Labor	24	events	$280	$6,720	1 technicians, 1 days, 4 hr/day @ $70/hour (includes prep/travel time), assume local
B. Expenses	24	events	$300	$7,200	Travels costs, per diem, equipment costs, shipping, etc.
C. Analytical Costs	48	samples	$125	$6,000	2 samples per event for TCL VOCs (influent and effluent)
D. Metals analysis	12	sample	$125	$1,500	One metals analysis per month
E. Monthly Report to NAPR	12	reports	$420	$5,040	1 technician, 6 hrs/month @ $70/hour (for preparation of monthly report)
F. Yearly Reporting	1	reports	$3,000	$3,000	One annual report
TOTAL - ANNUAL O&M COSTS				$84,360	
SEMI-ANNUAL LONG TERM MONITORING COSTS-- per year for 25 years					
II. Groundwater Monitoring					
A. Sampling Labor	2	event	$7,000	$14,000	8 wells, 2 technicians, 4 days, 10 hr/day @ $70/hour (includes prep/travel time)
B. Expenses	2	event	$4,500	$9,000	Travels costs, per diem, equipment costs, shipping, etc.
C. Analytical Costs	18	samples	$125	$2,250	9 samples per event for TCL VOCs (8 wells + 1 QA/QC samples)
D. Reporting	1	report	$2,500	$2,500	One annual report
E. Long Term Project Management	1	LS	$2,500	$2,500	Estimate
TOTAL - ANNUAL LTM COSTS				$30,250	
TOTAL PROJECT COST SUMMARY					
DIRECT CAPITAL COSTS				$209,736	
PROFESSIONAL SERVICES COSTS				$134,868	
PRESENT WORTH OF ANNUAL O&M COSTS				$365,235	Assumes O&M for 5 years at 5% discount rate.
PRESENT WORTH OF LTM COSTS				$426,342	Assumes LTM for 25 years at 5% discount rate.
TOTAL PROJECT COST				$1,136,180	(2)

Note:
(1) Estimated accuracy of cost estimate is -30% to +50%. Cost estimate is to be used primarily for comparison of costs relative to other response action alternatives.
(2) Dismantling of system not included

APPENDIX G
Alternative 6 Calculations

S.O. No. CTO 268

Subject: SWMU 55 CMS

Appendix G

Sheet No. 1 of 2

Drawing No.

Computed by CLH Checked By Date 10/11/04

Baker

VOLUME OF GROUNDWATER EXTRACTED IN 5 YEARS

Given Q = 20 gallon/minute

Eff = 80%

VOLUME = Q * Time * efficiency

$= 20 \frac{gal}{min} \left(60 \frac{min}{hr}\right)\left(24 \frac{hr}{day}\right)\left(365 \frac{day}{year}\right)(5\,yr)(0.8)$

$V = 42{,}048{,}000$ gallons

PORE VOLUME IN AREA OF INFLUENCE

GIVEN: Radius of influence = 30 feet

2 extraction wells

DEPTH OF AQUIFER INFLUENCED = 25'

Porosity = 0.3

Pore Volume = $\pi r^2 d \cdot n$

$= (2)\pi(30\,ft)^2(25\,ft)(0.3)\left(7.48 \frac{gal}{ft^3}\right)$

$= 317{,}238$ gallons

PORE VOLUMES EXTRACTED

$= \frac{\text{TOTAL VOLUME}}{\text{VOLUME/pore volume}}$

$= \frac{42 \times 10^6 \text{ gal}}{320{,}000 \text{ gal}}$

= 132 pore volumes

S.O. No. CTO 268

Subject: Swmu 55 CMS

Appendix G

Sheet No. 2 of 2

Drawing No.

Computed by CLH Checked By Date 10/11/04

Baker

MASS IN EXTRACTED GROUNDWATER

Assume TCE concentration of 100 ug/L

Mass = Concentration * volume

$= 100 \frac{ug}{L} * 42 \times 10^6 \text{ gal} * 3.92 \frac{L}{gal} * 1 \times 10^{-9} \frac{g}{ug}$

Mass = 16.5 g

MASS IN DISSOLVED PHASE IN-SITU GROUNDWATER

GIVEN: AFFECTED AREA = 150' x 180' x 25' depth (Section 2.5)

AVERAGE CONCENTRATION = 500 ug/L

POROSITY = 0.3

Mass = Concentration * volume

$= 500 \frac{ug}{L} * 150 ft * 180 ft * 25 ft * 0.3 * 3.92 \frac{L}{gal} * 7.48 \frac{gal}{ft^3} * 1 \times 10^{-9} \frac{g}{ug}$

Mass = 2.97 g

Baker
Baker Environmental, Inc.

TEST BORING AND WELL CONSTRUCTION RECORD

PROJECT: Tow Way Fuel Farm SWMU 7
CTO NO.: 0277 BORING NO.: 7MW07

SAMPLE TYPE

S = Split Spoon
T = Shelby Tube
R = Air Rotary
D = Denison
A = Auger
W = Wash
C = Core
P = Piston
N = No Sample

DEFINITIONS

SPT = Standard Penetration Test (ASTM D-1586)(Blows/0.5')
RQD = Rock Quality Designation (%)
Lab. Class. = USCS (ASTM D-2487) or AASHTO (ASTM D-3282)
Lab. Moist. = Moisture Content (ASTM D-2216) Dry Weight Basis

Depth (ft.)	Samp. Type and No.	Samp. Rec. (ft. & %)	SPT or RQD	Lab Class. or Pen. Rate	PID (ppm) BG/PS	Visual Description	Well Installation Detail	Elevation (ft. MSL)
						Continued from Sheet 1		
11	AN							
12								
13								
14	S-3	1.25 / 2.0	12 37		0.5/0.5	Lt. Brn Rock w/ some silt and Trace clay and Trace Sand. Wet. 7MW07-03 TPH DRO/GRO Grain Size		
15	1710	63%	50/5"					
16								
17								
18								
19	S-4	1.67 / 2.0	20 21			Lt. Brn. Rock, angular to Subangular w/ Some silt Trace clay. wet. 7MW07-04 TPH DRO/GRO		
20	1755	83%	50/6"					
21								
22								
23								
24	S-5	0.83 / 2.0	28 40		0.5/2.0	Lt. Brn/Gray Rock, angular to Subangular, Fragmented w/ some clay. wet. 7MW07-05 TPH DRO/GRO		
25	10/22 0800	42%	50/3"				Bottom of Screen @ 25' bgs	
26								
27								
28								
29	S-6	0.83 / 2.0	26 25		0.5/0.5	Lt. Brn. Rock w/ Trace to Little clay & Trace sand. wet. RX. is angular to subangular. 7MW07-06 TPH DRO/GRO		
30	10/22 0905	42%	16 7					

END OF BORING 30'

DRILLING CO.: Soil Tech BAKER REP.: J. Tepsic
DRILLER: Jorge' Diaz BORING NO.: 7MW07 SHEET 2 OF

Baker
Baker Environmental, Inc.

TEST BORING AND WELL CONSTRUCTION RECORD

PROJECT: Tow Way Fuel Farm SWMU 7
CTO NO.: 0277
BORING NO.: 7MW07
COORDINATES: EAST: NORTH:
ELEVATION: SURFACE: TOP OF PVC CASING:

RIG: Mobil B-90

	SPLIT SPOON	CASING	AUGERS	CORE BARREL
SIZE (DIAM.)	3"		8 1/4"	
LENGTH	2'		5'	
TYPE	STD		HSA	
HAMMER WT.	140 lbs			
FALL	30"			
STICK UP				

DATE	PROGRESS (FT.)	WEATHER	WATER DEPTH (FT.)	TIME
10/21/97	20' 10/21 10' 10/22	mostly sunny 85-90°	10.3'	10/22 24hr.

REMARKS: Located South of Bldg. # 2314

SAMPLE TYPE

S = Split Spoon
T = Shelby Tube
R = Air Rotary
D = Denison
A = Auger
W = Wash
C = Core
P = Piston
N = No Sample

Well Information	Diam.	Type	Top Depth (ft.)	Bottom Depth (ft.)
Riser	6"	PVC	-2.5 Stick-up	5
Screen 0.020 sbt	6"	PVC	5	25

Depth (ft.)	Samp. Type and No.	Samp. Rec. (ft. & %)	SPT or RQD	Lab Class. or Pen. Rate	PID (ppm) BG/PS	Visual Description (0'=0 PD.)	Well Installation Detail	Elevation (ft. MSL)
1	? AN					Auger to 3' bgs No Sample 3'=WBL.	Bentonite @ 1' bgs	
2								
3							Sand @ 3' bgs	
4	S-1 1621	0.5/2.0 25%	9 8 4 4		0.5/0.5	Lt. Brn/Gray Rock, angular to sltly. Rounded. Some silt, Dry to wet @ tip of sample, water @ 5.0' bgs *		
5							Top of Screen @ 5' bgs	
6	AN							
7								
8								
9	S-2 1645	0.83/2.0 42%	3 1 50/5"		0.5/0.5	Lt. Brn. Rock and Silt, moist to wet. Sample 7MW07-02 TPH DRO/GRO Grain size		
10								

Match to Sheet 2

DRILLING CO.: Soil Tech
DRILLER: Jorge Diaz
BAKER REP.: J. Tepsic
BORING NO.: 7MW07
SHEET 1 OF 2

* Alot of rain @ NSRR last week, Possibly Perched Zone, Probably Not True Watertable

Baker
Baker Environmental

TEST BORING AND WELL CONSTRUCTION RECORD

PROJECT: TCE Plume Delineation and Source Investigation
PROJ. NO.: 100299 FI.ZZ
BORING NO.: 7MW24
COORDINATES: EAST: 782602.790
NORTH: 145455.23
ELEVATION: SURFACE: 110.56
TOP OF PVC CASING: 110.34

Rig: Simco 2800	Split Spoon	Casing	Augers	Air Hammer	Date	Progress (Ft.)	Weather	Depth to Water (Ft.)
Size (ID)	2-in	--	--	4-in	9/23/2003	0.0 - 22.0	M sunny, lt wind, 80s	15.0
Length	2-ft	--	--	3.5-ft				
Type	S Steel	--	--	--				
Hammer Wt.	140-lbs	--	--	--				
Fall	30-in	--	--	--				

Remarks:

SAMPLE TYPE
S = Split Spoon A = Auger
T = Shelby Tube W = Wash
R = Air Rotary C = Core
D = Direct Push P = Piston
N = No Sample

WELL INFORMATION

Type	Diam.	Top Depth (Ft.)	Bottom Depth (Ft.)
Sch. 40 PVC Casing	2-in	0.0	12.0
Sch. 40 PVC Screen (10-slot)	2-in	12.0	22.0

Depth (Ft.)	Sample Type & No.	Sample Rec. (Ft.,%)	SPT	Lab ID	PID (ppm) ps/bg	Visual Description	Well Installation Detail	Elevation (Ft. MSL)
1						F/C SAND and GRAVEL (FILL)		
2						GABBRO frag (f gravel, some f/c sand-sized); black & gray (lithofied BEDROCK)		
3								
4								
5								
6	R-N	--	--	--	--		6.0	104.56
7						f sand, little silt; brown; weathered zone		
8							8.0	102.56
9						less weathered, f/c sand, little f gravel; brown, trace black & gray		
10						Match to Sheet 2		

DRILLING CO.: GeoWorks, Inc.
DRILLER: William Rolon
BAKER REP.: Mark K. DeJohn
BORING NO.: 7MW24 SHEET 1 OF 2

Baker
Baker Environmental

TEST BORING AND WELL CONSTRUCTION RECORD

PROJECT: TCE Plume Delineation and Source Investigation
CTO NO.: 100299 FI.ZZ
BORING NO.: 7MW24

SAMPLE TYPE
S = Split Spoon A = Auger
T = Shelby Tube W = Wash
R = Air Rotary C = Core
D = Denison P = Piston N = No Sample

DEFINITIONS
SPT = Standard Penetration Test (ASTM D1586)
PID = Photo Ionization Detector Measurement
MSL = Mean Sea Level
ps/bg = point source/background

Depth (Ft.)	Sample Type & No.	Sample Rec. (Ft.,%)	SPT	Lab ID	PID (ppm) ps/bg	Visual Description	Well Installation Detail	Elevation (Ft. MSL)
11								
12							12.0	98.56
13								
14						f/c sand; brown; moist		
15						f gravel, some f/c sand; brown & gray; wet		
16	R-N	--	--	--	--			
17						f gravel; black, brown & gray; good water flow in return		
18								
19								
20						f gravel, trace c gravel; black & gray, little brown		
21								
22						22.0	22.0	88.56
23						BOH at 22.0-ft		
24								
25								
26								
27								
28								
29								
30								

DRILLING CO.: GeoWorks, Inc.
DRILLER: William Rolon
BAKER REP.: Mark K. DeJohn
BORING NO.: 7MW24
SHEET 2 OF 2