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REMEDIAL ACTION PLAN FOR TRUMBO POINT FUEL FARM NAS KEY WEST FL
12/1/1999
HARDING LAWSON ASSOCIATES

REMEDIAL ACTION PLAN

TRUMBO POINT FUEL FARM

NAVAL AIR STATION KEY WEST
TRUMBO POINT ANNEX, KEY WEST, FLORIDA

UNIT IDENTIFICATION CODE: N00213
CONTRACT NO.: N62467-89-D-0317/095

DECEMBER 1999

SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
NORTH CHARLESTON, SOUTH CAROLINA 29418

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December 1999

CERTIFICATION OF TECHNICAL
DATA CONFORMITY (MAY 1987)

The Contractor, Harding Lawson Associates, hereby certifies that, to the best of its knowledge and belief, the technical data delivered herewith under Contract No. N62467-89-D-0317/095 are complete and accurate and comply with all requirements of this contract.

DATE: December 15, 1999

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(DFAR 252.227-7036)

KW-TPFF.RAP
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FOREWORD

To meet its mission objectives, the U.S. Navy performs a variety of operations, some requiring the use, handling, storage, and/or disposal of hazardous materials. Through accidental spills or leaks, or as a result of conventional methods of past disposal, hazardous materials may have entered the environment in ways unacceptable by current standards. With growing knowledge of the long-term effects of hazardous materials on the environment, the Department of Defense initiated various programs to investigate and remediate conditions related to suspected past releases of hazardous materials at their facilities.

One of these programs is the Comprehensive Long-Term Environmental Action, Navy Underground Storage Tank (UST) program. This program complies with Subtitle I of the Resource Conservation and Recovery Act, and the Hazardous and Solid Waste Amendments of 1984. In addition, the UST program complies with all appropriate State and local storage tank regulations as they pertain to each naval facility.

The UST program includes the following activities:

- registration and management of Navy and Marine Corps storage tank systems,
- contamination assessment planning,
- site field investigations,
- preparation of contamination assessment reports,
- remedial (corrective) action planning,
- implementation of the remedial action plans, and
- tank and pipeline closures.

The Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM) manages the UST program, and the U.S. Environmental Protection Agency and the Florida Department of Environmental Protection oversee the Navy UST program at Naval Air Station (NAS) Key West.

Questions regarding this report should be addressed to the Commanding Officer, NAS Key West in Key West, Florida, or to SOUTHNAVFACENGCOM, Byas Glover, Code 18410, at (843) 820-5651.

EXECUTIVE SUMMARY

The purpose of this Remedial Action Plan (RAP) is to recommend a plan for remediation of petroleum and arsenic contamination at the Trumbo Point Fuel Farm (TPFF) area, including Piers D1, D2, and D3, at Naval Air Station Key West in Key West, Florida. A risk-based approach has been used to establish human health and ecological risk factors for the guidance of remedial efforts for the petroleum-related contamination in the soil and groundwater and arsenic in surface soil in accordance with the requirements of Chapter 62-770, Florida Administrative Code.

This RAP presents the rationale for the remedial actions recommended for implementation at the TPFF. This RAP includes a plan to accomplish the following tasks:

- reduce petroleum contaminant source(s) using multiphase extraction, passive product removal, and source area excavation;
- excavate all areas of arsenic contaminated surface soil which exceed the site-specific background concentration of 6.9 mg/kg; and
- natural attenuation monitoring of potential groundwater contaminant pathways so that appropriate measures can be taken if contamination threatens human or ecological receptors.

TABLE OF CONTENTS

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West, Florida

Chapter	Title	Page No.
1.0	INTRODUCTION	1-1
1.1	PURPOSE	1-2
2.0	BACKGROUND	2-1
2.1	SITE DESCRIPTION	2-1
2.2	SITE HISTORY AND CURRENT SITE ACTIVITIES AND CONDITIONS	2-5
2.3	CAR SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS	2-6
2.3.1	CAR Summary	2-6
2.3.2	CAR Conclusions	2-11
2.3.3	CAR Recommendations	2-11
3.0	REMEDIAL ALTERNATIVE SELECTION	3-1
3.1	SITE PARTITIONING	3-1
3.1.1	Site Activities	3-1
3.1.2	Physical Site Characteristics	3-1
3.1.3	Site Land-use Areas	3-3
3.1.3.1	Pier D1	3-3
3.1.3.2	Piers D2 and D3	3-3
3.1.3.3	USCG Station	3-3
3.1.3.4	Key West Pipeline Company Tank Area (ASTs)	3-3
3.1.3.5	Navy Tank Area	3-4
3.1.4	Basis for Alternative Cleanup Target Levels	3-4
3.2	CHEMICALS OF CONCERN	3-4
3.3	SUMMARY OF HUMAN HEALTH AND ECOLOGICAL RISK EVALUATION	3-4
3.3.1	Summary of Human Health Risk Evaluation	3-5
3.3.2	Summary of Ecological Risk Evaluation	3-6
3.3.3	Total Risk Analysis	3-7
3.4	CLEANUP TARGET LEVELS	3-7
3.5	EXTENT OF CONTAMINATION	3-7
3.5.1	Groundwater Contamination	3-8
3.5.2	Soil Contamination	3-8
3.5.2.1	Subsurface Soil	3-8
3.5.2.2	Surface Soil	3-8
3.5.3	Free Product	3-8
3.5.4	Sediment	3-13
3.6	SITE-SPECIFIC LIMITATIONS TO ALTERNATIVES	3-13
3.7	REMEDIAL STRATEGY	3-13
4.0	RECOMMENDED REMEDIAL ACTION	4-1
4.1	*EX SITU* SOIL WASHING	4-1
4.1.1	Pretreatment Sampling	4-1
4.1.2	Excavation	4-1
4.1.3	Soil Washing	4-1
4.1.4	Confirmatory Sampling	4-4

TABLE OF CONTENTS (Continued)

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West, Florida

Chapter	Title	Page No.
4.2	EXCAVATION	4-4
4.2.1	Confirmatory Sampling	4-4
4.2.2	Disposal	4-4
4.3	MULTIPHASE EXTRACTION	4-4
4.4	IN-WELL PASSIVE FREE PRODUCT REMOVAL	4-12
4.5	MONITORED NATURAL ATTENUATION	4-15
4.5.1	Monitoring Well Locations	4-15
4.5.2	Groundwater Sampling	4-17
4.5.3	Reporting	4-17
4.6	LAND-USE CONTROLS	4-17
4.7	RECOVERY WELL INSTALLATION	4-20
5.0	COST ESTIMATE	5-1
6.0	SCHEDULE	6-1
7.0	DOCUMENTATION	7-1
8.0	PROFESSIONAL REVIEW CERTIFICATION	8-1

REFERENCES

APPENDICES

Appendix A: Risk Evaluation
Appendix B: Remedial Alternatives Considered
Appendix C: Design Calculations
Appendix D: Vendor Information
Appendix E: April 1999 Surface Soil Sampling Data
Appendix F: Basis of Design
Appendix G: Remedial Action Plan Checklist
Appendix H: Cost Estimate

LIST OF FIGURES

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West, Florida

Figure	Title	Page No.
2-1	Site Location Map	2-2
2-2	Site Plan Map	2-3
2-3	Site Utility Plan Map	2-4
2-4	Volatile Organic Compounds in Subsurface Soil	2-7
2-5	Arsenic in Surface Soil Above Background	2-9
2-6	Benzene, Total Volatile Organic Aromatics, and Total Naphthalenes Concentrations in Groundwater	2-10
3-1	Land Use Areas	3-2
3-2	Product Contaminated Soil Areas	3-9
4-1	Subsurface Soil Excavation Areas	4-2
4-2	Soil Treatment Precess Flow Diagram	4-3
4-3	Surface Soil Cap Layout	4-5
4-4	Existing and New Monitoring/Recovery Wells	4-6
4-5	Vacuum Enhanced Extraction Well Detail	4-9
4-6	Multiphase Extraction Decision Tree	4-11
4-7	Passive Free Product Recovery Decision Tree	4-13
4-8	Natural Attenuation Data, April 1999	4-16
4-9	Typical Shallow Monitoring Well Construction Detail	4-21

LIST OF TABLES

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West, Florida

Table	Title	Page No.
3-1	Characteristics of Product - Contaminated Areas	3-10
4-1	Multiphase Free Product Recovery	4-7
4-2	Passive Free Product Recovery	4-14
4-3	Natural Attenuation Monitoring Wells	4-15
4-4	Groundwater Monitoring Parameters	4-18

GLOSSARY

ABB-ES	ABB Environmental Services, Inc.
AST	aboveground storage tank
AVGAS	aviation gasoline
bls	below land surface
CA	contamination assessment
CAR	Contamination Assessment Report
CLEAN	Comprehensive Long-Term Environmental Action, Navy
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
HLA	Harding Lawson Associates
JP	jet propellant
MTBE	methyl tert-butyl ether
$\mu g/\ell$	micrograms per liter
MOA	memorandum of agreement
MOGAS	motor gasoline
NAS	Naval Air Station
OVA	organic vapor analyzer
PAH	polynuclear aromatic hydrocarbons
PCA	preliminary contamination assessment
PCB	polychlorinated biphenyl
RAP	Remedial Action Plan
SOUTHNAV-FACENGCOM	Southern Division, Naval Facilities Engineering Command
TPFF	Trumbo Point Fuel Farm
TRPH	total recoverable petroleum hydrocarbons
USCG	U. S. Coast Guard
USEPA	U.S. Environmental Protection Agency
UST	underground storage tank
VOA	volatile organic aromatics
VOC	volatile organic compound

1.0 INTRODUCTION

The Trumbo Point Fuel Farm (TPFF) has been used as a fuel storage and distribution point by the Navy since 1942. The TPFF is the location of several aboveground storage tanks (ASTs), associated pipelines and various pump houses used to transport fuel to and from the ASTs. In addition to the various fuel pipelines, which are still active at the site, a large number of abandoned buried fuel pipelines are also present on the site. Fuels reported to have been stored and transported at the site include No. 6 fuel oil, Bunker C oil, diesel fuel, aviation gasoline (AVGAS), jet propellant (JP)-4 and JP-5 jet fuels, motor gasoline (MOGAS), waste oil, and hydraulic fluids. According to Navy personnel, the TPFF is currently used to store and dispense diesel fuel marine, JP-5 fuel, and MOGAS.

The land currently occupied by the U.S. Coast Guard (USCG) facility was previously owned and operated by Naval Air Station (NAS) Key West. The property was leased by the Navy to the USCG in 1983. The facility primarily consists of two concrete piers (D-2 and D-3) and various buildings used to house operational and support services (maintenance shops, administration offices, living quarters, etc.). Pier D-1, located west of Trumbo Road and adjacent to the USCG property, is currently owned and operated by NAS Key West. Ships docking at Pier D-2 off-load fuel for storage at the TPFF. Fuel dispensers on Piers D-2 and D-3 are used to support USCG operations.

Harding Lawson Associates (HLA) conducted a preliminary contamination assessment (PCA) in August 1993 to verify the findings of previous investigations and to assess soil and groundwater contamination in areas not well documented during the previous investigations. The HLA PCA was conducted from July through October 1993. At the request of the Navy, the area of investigation also included parts of the USCG facility west of the TPFF site. During the PCA, 101 soil borings were drilled and three vertical extent monitoring wells were installed. Soil samples were collected from soil borings and analyzed for volatile organic compounds (VOCs) by organic vapor analyzer (OVA) analysis. Groundwater samples were collected from monitoring wells (MWs) installed during previous investigations and from MWs and specific soil borings completed during the PCA.

From January 1996 to April 1996, HLA conducted a contamination assessment (CA) at the TPFF and USCG sites to collect data required to complete a contamination assessment report (CAR) for Florida Department of Environmental Protection (FDEP) approval and to obtain site-specific data to evaluate potential remedial technologies. During the CA, soil samples were collected from 139 additional soil borings and 103 additional MWs were installed and sampled. Soil samples were analyzed for VOCs by OVA analysis and, in some areas, for the Waste Oil Group parameters. Groundwater samples were analyzed for either the Kerosene Analytical Group (KAG) or Waste Oil Group parameters. Sediment and surface water samples were collected and analyzed for the KAG parameters.

In April of 1999, at FDEP's direction, additional samples were collected from surface soil locations in order to complete the site risk assessment. Samples were collected from 41 locations and analyzed for benzene, toluene, ethylbenzene, xylenes (BTEX), MTBE, PAHs, TRPH and metals. The surface soil sampling results indicated the presence of elevated concentrations of arsenic. The arsenic is presumed to be present due to past pesticide application practices.

1.1 **PURPOSE**. The purpose of this Remedial Action Plan (RAP) is to recommend a plan to address petroleum and arsenic contamination at the TPFF. The RAP presented herein is designed for implementation at the TPFF site. Risk-based reasoning has been used to establish human health and ecological risk factors for the guidance of remedial efforts for the arsenic and petroleum-related contamination in the soil and groundwater in accordance with the requirements of Chapter 62-770, Florida Administrative Code (FAC).

1.2 **SCOPE**. This RAP presents the rationale for the remedial actions recommended for implementation at the TPFF. This RAP will include recommendations for a plan to accomplish the following tasks:

- reduce petroleum contaminant source(s) using multiphase extraction, passive product removal, and source area excavation;
- excavate all areas of arsenic contaminated surface soil which exceed the site-specific background concentration of 6.9 mg/kg; and
- natural attenuation monitoring of potential groundwater contaminant pathways so that appropriate measures can be taken if contamination threatens human or ecological receptors.

CHAPTER 2.0

2.0 BACKGROUND

2.1 SITE DESCRIPTION. NAS Key West is located approximately 150 miles southwest of Miami in Monroe County, Florida (Figure 2-1). NAS Key West, a complex located in several areas of the Lower Florida Keys, encompasses approximately 5,000 acres. The majority of the facility's operations and activities are concentrated on Boca Chica Key and Thomas Key. The mission of NAS Key West is to maintain and operate facilities and provide services and materials to support operations of aviation activities and units designated by the Chief of Naval Operations.

The TPFF and USCG sites are located along the northern shore of Key West, south of Fleming Key Cut. The TPFF and the USCG facilities are bordered on the north by Fleming Key Cut, on the west by Man of War Harbor, on the east by Mustin Street, and on the south by Whiting Avenue. Piers D-1, D-2, and D-3, located at the USCG facility, serve as fuel depots for ships.

The TPFF is the location of several ASTs, as well as associated piping and various pumphouses used to transport fuel from the ASTs. The site entrance is located along Trumbo Road near Building D-19. Building D-19 is used as an office and storage facility by site personnel. Buildings D-3A and D-22 through D-26 are pumphouses, which are now used or were formerly used to transport fuel from the site. The TPFF is surrounded by an 8-foot-high chain-link fence. A concrete seawall extends along the northern perimeter of the site. The seawall is approximately 1-foot thick and extends to a depth of approximately 15 to 20 feet below land surface (bls).

The area within the fuel farm has been leased by the Navy to several contractors for the supply and transportation of fuel. During the CA, contractors using the tanks within the fuel farm included Avantra and the Key West Pipeline Company. The northeastern portion of the fuel farm contained six ASTs in a bermed area that was leased by the Key West Pipeline Company. The southern and western portion of the fuel farm, operated by Avantra, contained several cut and cover storage tanks that have been removed. The only remaining tanks within the fuel farm area at this time are three large ASTs operating in the area leased by the Key West Pipeline Company.

The land currently occupied by the USCG facility was previously occupied by NAS Key West. The property was leased by the Navy to the USCG in 1983. The facility primarily consists of two concrete piers (D-2 and D-3) and various buildings used to house operational and support services (maintenance shops, administration offices, living quarters, etc.). Pier D-1, located west of Trumbo Road and adjacent to the USCG property, is currently owned and operated by NAS Key West. Ships docking at Pier D-2 off-load fuel for storage at the TPFF. Fuel dispensers on Piers D-2 and D-3 are used to support USCG operations.

Several aboveground and underground fuel pipelines are located at the site (see Figures 2-2 and 2-3). Diesel fuel marine (DFM) and JP-5 pipelines are used to transport fuel to the fuel farm from Pier D-2 at the USCG facility. Several unused fuel pipelines are present at the TPFF site. An abandoned DFM pipeline extends from pumphouse D-26 near DFM Tank D-4 to another abandoned DFM pipeline located along the west fenceline of the site. An abandoned underground Bunker C oil pipeline reportedly existed along the western fenceline of the TPFF parallel to the abandoned DFM pipeline (see Figure 2-3).

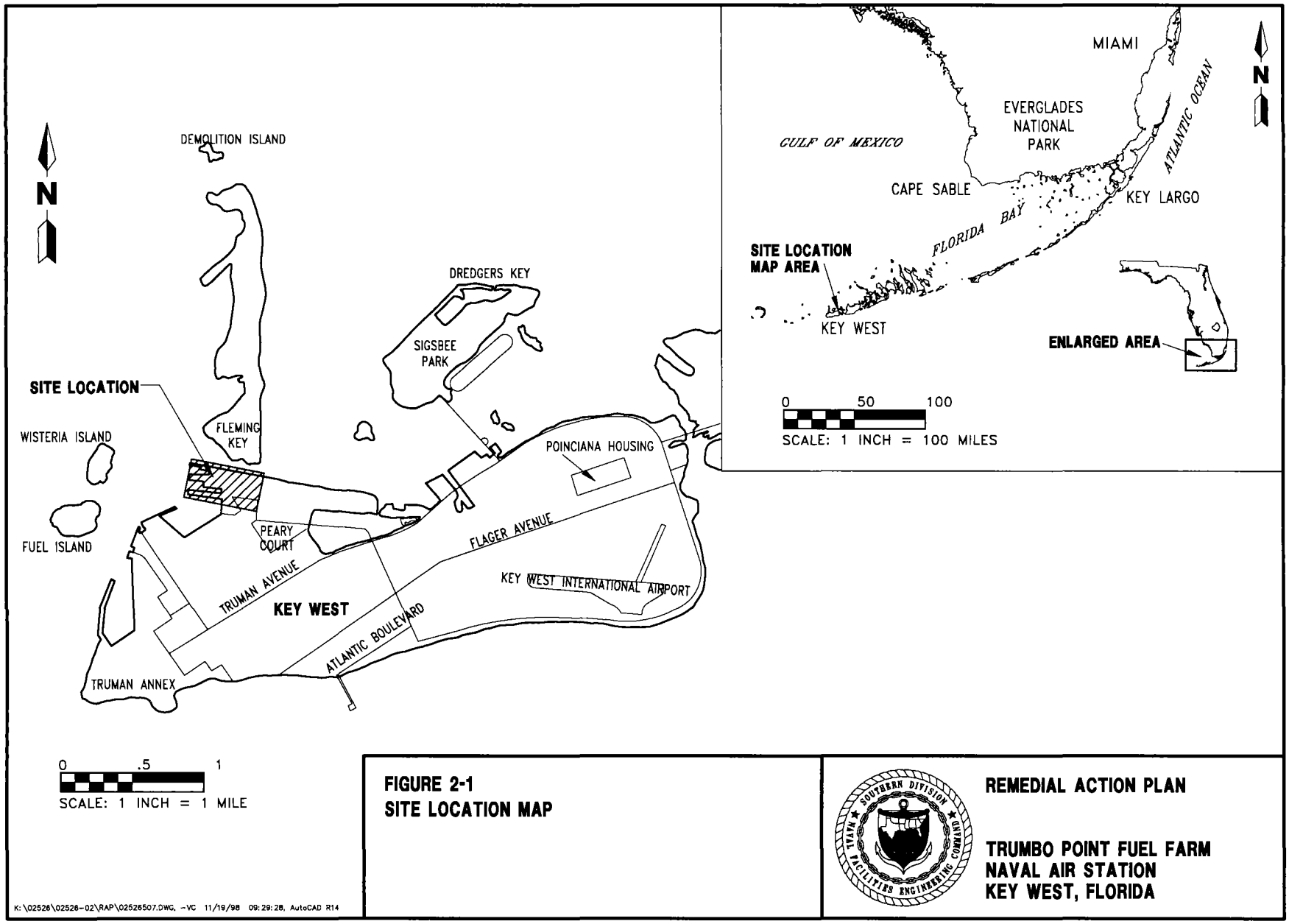

FIGURE 2-1
SITE LOCATION MAP

REMEDIAL ACTION PLAN

TRUMBO POINT FUEL FARM
NAVAL AIR STATION
KEY WEST, FLORIDA

Figure 2-2 Site Plan Map

Figure 2-3 Site Utility Plan Map

Three abandoned underground pipelines are located under the USCG facility access road south of the tennis court. One pipeline was used to transport DFM and a second transported Bunker C oil. The third pipeline is described as a 4-inch sump. The pipelines continue west along the access road, then turn north near Building 103 toward the slip north of Pier D-2. Additional fuel pipelines were abandoned when fuel storage tanks south and west of the bermed area were removed.

An oily wastewater pipeline and a pump station are located on Pier D-1. The oily wastewater pipeline continues from the pump station to an oil-water separator located northwest of Building B-48 (see Figure 2-2). The pump station and oil-water separator are no longer in use. An oily wastewater pipeline and pump station located on the north side of Pier D-3 have never been used.

In addition to the various fuel pipelines, active and inactive, a large number of active buried utilities (electric, communications, water, and sewer), and abandoned utilities are present on the site (see Figure 2-3).

2.2 SITE HISTORY AND CURRENT SITE ACTIVITIES AND CONDITIONS. NAS Key West was first commissioned in 1917 and located on land leased from the Florida East Coast Railroad Company at Trumbo Point. Trumbo Point Annex was constructed in 1918 using dredged materials for use as a seaplane training and blimp facility. At the end of World War I, what is presently NAS Key West was decommissioned. With the outbreak of World War II, NAS Key West was recommissioned and expanded. Beginning in 1942, fuel has been brought into Trumbo Point by tanker and stored at the tank farm. Trumbo Point has been used for storage and distribution of fuels to both the Truman Annex and Boca Chica field. Fuels formerly stored at the fuel farm include Number 6 fuel oil, Bunker C oil, diesel fuel, JP-4, and JP-5. From 1973 to the late 1970s, one tank, D-21, was used for the storage of hazardous wastes that may have included waste oils, hydraulic fluids, solvents, pesticides, and polychlorinated biphenyls.

Until 1984, the TPFF consisted of 28 active fuel storage tanks. The removal of fuel storage tanks began after 1984. By 1988, only 15 tanks remained at the TPFF with 11 that were actively used. Presently within the TPFF, only three ASTs operated by the Key West Pipeline Company are being actively used. All cut and cover tanks have been removed.

Assessment activities for the site have included work by Geraghty & Miller in 1985 and by HLA in 1993, 1996, 1998, and 1999. Remedial activities at the site have included a pilot study by IT Corporation for the collection of free-phase product adjacent to former fuel Tank D-4 in 1990. The action by IT Corporation included the installation of a trench in the area of D-4 to recover free product and excavate excessively contaminated soil. Some of the observations from this activity indicated the following with regard to remediation at the site:

- A groundwater/product recovery system is not a feasible remediation alternative. Low hydraulic conductivity limits the formation of a capture zone, groundwater recovery, and transport of free product.

- The presence of free product indicated by measurements in monitoring wells near Tank D-4 does not correspond with observed accumulations of fuel in excavations or below surface structures in the same area.

Other remedial efforts performed by Bechtel in 1996 included the installation of another trench and recovery sump in the area of former storage Tanks D-2 and D-4. This effort did not result in significant product recovery either.

2.3 CAR SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS.

2.3.1 CAR Summary Based on the findings of the CA and subsequent field investigations and laboratory analytical results, the following is a summary of existing conditions at the site.

Aquifer Characteristics and Hydrogeologic Parameters Summary.

- The sediments encountered during drilling operations are generally composed of silty clay, oolitic lime mud, and oolitic limestone.
- Groundwater beneath the site was encountered at depths of approximately 4 to 6 feet bls and is classified as G-III.
- The direction of groundwater flow in the surficial zone has consistently been radially away from the TPFF and toward the northwest on the piers.
- The average hydraulic gradient in the shallow zone at the site ranges from 8×10^{-4} to 1×10^{-2} feet per foot (ft/ft).
- The average hydraulic gradient in the deep zone at the site ranges from 2.5×10^{-4} to 1×10^{-3} ft/ft.
- The hydraulic conductivity in the shallow zone at the site is 2.88×10^{-2} feet per day (ft/d).
- The hydraulic conductivity in the deep zone at the site is 1.63 ft/d.
- The shallow zone pore water velocity ranges from 5.12×10^{-5} to 6.4×10^{-4} feet per day (ft/day).
- The deep zone pore water velocity ranges from 2.04×10^{-3} to 8.15×10^{-3} ft/day.

Subsurface Soil CA Summary.

- Five areas of excessively contaminated soil, as defined by non-risk based cleanup standards, were identified by OVA headspace analyses. The largest areal extent of soil contamination is located immediately north of the JP-5 tanks. Other areas of excessively contaminated soil included Pier D-2 in the vicinity of Building 105, the area around the basketball court and softball field, the west end of Pier D-1, and the east end of Pier D-1 (see Figure 2-4). Excessively contaminated soil was detected mostly between the 4 and 6 feet bls interval.
- Four areas of excessively contaminated soil, as defined by non-risk based cleanup standards were identified by laboratory analysis: the former Tank D-5 area, the area around tank D-21, the area of the oil

Figure 2-4 Volatile Organic Compounds in Subsurface Soil

water separator, and the area of the oily wastewater pump station on Pier D-1.

Additional Surface Soil Investigation Summary.

- Fourteen locations out of 36 non-background locations sampled had concentrations of one or more analytes above industrial soil cleanup target levels as defined in Chapter 62-730, FAC. This excessive contamination was due to high arsenic and PAH concentrations. The contamination is found scattered across former AST areas, although one very high (440 mg/kg) arsenic sample is associated with a pesticide-mixing building.

- When compared against a site-specific background screening level of 6.9 mg/kg, 13 locations out of 36 non-background locations sampled had concentrations of arsenic in surface soil above background. Figure 2-5 shows arsenic in surface soil above background.

Groundwater CA Summary.

- Two areas of total volatile organic aromatics (VOA) contamination in groundwater were identified during the CA. One large area is in the northeast part of the fuel farm in the vicinity of the JP-5 tanks. The highest total VOA concentrations in this area were observed in MW-4 (1,193 micrograms per liter [$\mu g/\ell$]) and MW-60 (670 $\mu g/\ell$). The second smaller area is on the north side of Pier D-1 in the vicinity of the oily wastewater lines. Total VOA concentrations observed in MW-15 were 87.2 $\mu g/\ell$ (see Figure 2-6).

- The benzene contamination plume overlaps the area of total VOA contamination and is generally in the same location. The area of benzene contamination includes the former AVGAS AST area occupied by tanks D-15 through D-18 and the associated pipelines (see Figure 2-6). The highest benzene concentrations were in the groundwater samples collected from MW-4 (990 $\mu g/\ell$) and MW-60 (620 $\mu g/\ell$). This area of benzene contamination exceed the risk-based corrective action (RBCA) standard of 70 $\mu g/\ell$.

- Total naphthalenes concentrations in the samples collected from monitoring wells MW-15, MW-50, and MW-55 were 174 $\mu g/\ell$, 196 $\mu g/\ell$, and 1,750 $\mu g/\ell$, respectively. MW-15 is located on the north side of Pier D-1, MW-50 is located north of Building D-19, and MW-55 is located north of the Key West Pipeline Company JP-5 Tank No. 1 (see Figure 2-6).

- Two small areas of total recoverable petroleum hydrocarbons (TRPH) contamination in groundwater were identified. These areas are associated with samples collected from monitoring wells KWM-01 (15.7 milligrams per liter [mg/ℓ]) and MW-86 (5.1 mg/ℓ).

- Lead concentrations in all monitoring well samples did not exceed 50 $\mu g/\ell$.

Figure 2-5 Arsenic in Surface Soil Above Background

11 x 17

Figure 2-6 Benzene, Total Volatile Organic Aromatics, and Total Naphthalenes Concentrations in Groundwater

- Free-floating petroleum product was observed in 18 site monitoring wells during the CA.

- No potable water sources were identified within a 0.25-mile radius of the site. Water is supplied via aqueduct from the mainland.

2.3.2 CAR Conclusions Based on the findings of the CA and site conditions, the following can be concluded.

- Excessive subsurface soil contamination in the area of the former AVGAS ASTs and associated piping is apparently related to leaks or releases from the ASTs and the fuel lines in the northern area of the TPFF. Overall, soil contamination is limited to a 1- to 2-foot interval immediately above the water table.

- Excessive arsenic in surface soil contamination is limited to three small regions now former tanks D-1, D-2, and D-3; and one large region (>1 acre) now former tank D-5. Arsenic in surface soil may be associated with former pesticide use.

- The areal extent of groundwater contamination is associated with the areas of excessively contaminated soil.

- The vertical extent of groundwater petroleum contamination appears to extend to greater than 30 feet of the surficial aquifer. Laboratory results reported that contaminant concentrations in the groundwater sample collected from vertical extent well MW-74D (30 feet bls) are 38 $\mu g/\ell$ of benzene, 53.7 $\mu g/\ell$ of total VOA, and 19.2 $\mu g/\ell$ of total naphthalenes. MW-74D was resampled in July 1996 and analyzed for U.S. Environmental Protection Agency (USEPA) Method 602 only. Reported concentrations are 57 $\mu g/\ell$ of benzene and 66.6 $\mu g/\ell$ of total VOA.

- The source of groundwater contamination is apparently due to previous releases from the associated AVGAS fuel pipelines in the vicinity of the ASTs, releases from pipeline junctions, a release from the oily wastewater line, and a release from the oily wastewater pump station.

- There are no potable water wells within a 0.25-mile radius of the site and drinking water is obtained via aqueduct from the mainland. The risk to human health caused by groundwater contamination is extremely low.

- There is no evidence to indicate that groundwater contaminants are migrating off the facility. Contamination is moving toward Fleming Key Cut, but does not appear to be a threat to surface water. For this reason, groundwater contamination at the site appears to be a low risk to area fish and wildlife.

2.3.3 CAR Recommendations Based on the findings, conclusions, and interpretations of the CA, HLA recommends the development of a RAP. The primary contamination includes excessively contaminated soil, and benzene, total VOAs, naphthalenes, and TRPH in groundwater. Free-product recovery efforts initiated at the site should be continued. An RAP will be developed to address the requirements of Chapter 62-770, FAC.

CHAPTER 3.0

3.0 REMEDIAL ALTERNATIVE SELECTION

The site possesses diverse characteristics that significantly affect potential exposure scenarios and the feasibility of potential remedial actions. Land use at the site ranges from park and recreation areas to port facilities for off-loading oil tankers. Groundwater flow conditions range from grass-covered aquifer zones with no subsurface obstructions to paved areas contained on three sides by steel sheetpile bulkheads. Furthermore, the site includes 21 distinct contaminant plumes that are separated not only by physical location, but also by contaminant characteristics. The conditions at this site are not those found at most petroleum-contaminated sites. Site activities, site ownership, ecological setting, and groundwater conditions are such that risk-based alternative cleanup target levels should be considered. For these reasons, and to simplify the evaluation of remedial alternatives, the site has been subdivided into land-use areas.

3.1 SITE PARTITIONING During the initial remedial evaluation of the TPFF area and each of the three piers adjacent to the fuel farm, it was identified that the site-specific characteristics, types of materials identified for remedial efforts, and the nature and varied activities of the site warranted a further breakdown of the site into action areas to address the site-specific remedial action needs. The separation of the site into five land-use areas is an attempt to focus the remedial efforts on the specific needs of each area. Due to the size of the facility at Trumbo Point, widely varying conditions exist across the site. The two primary variables on the site include the activities taking place at different parts of the site and the natural and/or man-made physical conditions of the site. Figure 3-1 shows the five land-use areas

3.1.1 Site Activities The 46-acre facility contains various activities performed by three separate groups. Operations on the facility include a commercial fuel supply contractor Key West Pipeline Company, the Navy Acoustics Warfare Center (NAWC) on Pier D1, and the USCG Station and USCG operations on Piers D2 and D3.

Piers D1 and D3 are presently separated for use by both the USCG and the Navy. The southern half of Pier D1 is enclosed and operated by the NAWC. The northern half of Pier D1 is leased to the USCG. The southern half of the pier D3 is enclosed and operated by the USCG. The northern half of Pier D3 along the Fleming Key Cut belongs to the Navy and does not have any specific use at this time. Both Pier D1 and the northern half of Pier D3 are scheduled to be transferred to the USCG within the next two years. A central area adjacent to Piers D2 and D3 is designated for the housing of USCG personnel and operation of the pier facility.

The fuel farm also has a split use. The bermed AST area is presently operated by the Key West Pipeline Company. The southern area of the fuel farm, formerly operated by Avantra, contained five cut-and-cover tanks during the CA, all of which have since been removed.

3.1.2 Physical Site Characteristics Groundwater beneath the site was encountered at depths of approximately 4 to 6 feet bls and is classified as G-III, non-potable water use. While the site has relatively homogenous geological

Figure 3-1 Land Use Areas

11 x 17

conditions, the man-made features on the site distinctly divide the site. All three piers are paved with asphalt or concrete with the exception of a small grassy area along the parking lot on Pier D2 and an oval shaped grassy area at the end of Pier D2. The USCG housing area adjacent to Piers D2 and D3 consist of a grassy area with several buildings, a basketball court, a baseball field, and a tennis court. One two-lane driveway extends north and south through the center of the housing area and then along the north and west of the housing area. The fuel farm consists of a large grassy area in the southern portion of the fuel farm and several bermed areas around the Key West Pipeline ASTs in the northern portion of the fuel farm.

Piers D2 and D3 are of similar construction, and have been extended twice in the past by placing a new perimeter of interlocking steel sheet piling outside the existing bulkheads and placing backfill in the interim space. Both piers have concrete bulkhead covers that extend to a depth of 3 feet below mean low water. Pier D1 has not been extended and has the original 1912 structure of wooden piles with a concrete cover to a depth of approximately 3 feet below mean low water. The expanses between the Pier D1 and D2 and between D2 and D3 are supported through interlocking steel sheet piling; however, the expanse of sheetpile between D2 and D3 does not have a concrete bulkhead. The areas north of the USCG housing area and the fuel farm are contained with an interlocking steel sheetpile wall with a concrete cover to a depth of 3 feet below mean low water that has been extended over the existing wooden pile structure. The areas to the east and south of the fuel farm area do not have any man-made subsurface walls.

3.1.3 **Site Land-use Areas** Given the site activities and site characteristics, the site can be broken down into the following five areas.

3.1.3.1 **Pier D1** This land-use area is similar to Piers D2 and D3 in that the surface is paved and activities are of a light industrial nature. However, at Pier D1 the waterfront has the original 1912 structure of wooden piles faced with concrete to 3 feet below mean low water. Three product contaminated regions are found in this area. One of these has no monitoring well; the easternmost of these is the only region that has evidence of mobile product.

3.1.3.2 **Piers D2 and D3** Piers D2 and D3 have unique features that allow them to be treated as a combined land-use area. A majority of the activities on these piers are activities related to the USCG. The structure of these piers is similar in design and condition. Activities on Piers D2 and D3 are of a light industrial nature.

3.1.3.3 **USCG Station** The USCG Station has unique features that allow it to be treated as a separate land-use area. The functions carried out in the station area are housing USCG personnel and administrative functions. The conditions at the USCG Station differ from the adjacent pier areas because the station does not face the water, includes large unpaved areas, and has few subsurface utilities and structures.

3.1.3.4 **Key West Pipeline Company Tank Area (ASTs)** The Key West Pipeline Company tank area is separated from the remainder of the fuel farm by earthen containment berms. This area is presently being operated by a commercial contractor and will continue to be operated under this contractor for the foreseeable future. The north boundary of the site is contained along the

Fleming Key Cut by an interlocking steel sheetpile bulkhead with a concrete cap to approximately 3 feet below mean low water.

3.1.3.5 **Navy Tank Area** The Navy tank area differs from the Key West Pipeline Company area in that no ASTs remain in the Navy tank area, and the Navy tank area does not face the waterfront. The expected future use for this area following the tank removal is expected to include varied industrial activities.

3.1.4 **Basis for Alternative Cleanup Target Levels** Contaminant concentrations corresponding to certain hazard indices or cancer risks (combined into one representative concentration) will be calculated for each of the five land-use areas. These will be compared to contaminant concentration data to identify low-risk subareas, which do not require remedial action. Concentrations will also be calculated that correspond to an upper limit of risk beyond which action will be required. Areas corresponding to these concentrations will be identified. Any remaining areas will be dealt with on a case-by-case basis. Various remedial alternatives will then be considered for each area or subarea.

3.2 **CHEMICALS OF CONCERN**. Petroleum contamination at the site appears to be the result of leaks and spills from the former ASTs, USTs, and associated piping. Arsenic contamination at the site appears to be the result of former application practices. Based on the available data, the Chapter 62-770, FAC, Gasoline and Kerosene Analytical Groups of contaminants, and arsenic, are potential chemicals of concern for soil and groundwater remedial efforts. These include the following:

- benzene, ethylbenzene, toluene, total xylenes, and methyl tert-butyl ether (MTBE);
- naphthalene and the 15 method-listed polynuclear aromatic hydrocarbons (PAHs);
- TRPH;
- 1,2-dichloroethane and other priority pollutant volatile organic halocarbons (for groundwater and surface water only);
- 1,2-dibromoethane (for groundwater and surface water only);
- total lead (for groundwater and surface water only), and
- arsenic (for surface soil only)

MTBE and TRPH were detected at concentrations below action levels as prescribed by Chapter 62-770, FAC; therefore, MTBE and TRPH are not considered to be site chemicals of concern.

3.3 **SUMMARY OF HUMAN HEALTH AND ECOLOGICAL RISK EVALUATION**. A risk evaluation was completed to characterize the human health and ecological risks associated with potential exposures to site-related contaminants in environmental media at the site. A summary is presented here. The complete risk evaluation is presented in Appendix A.

3.3.1 Summary of Human Health Risk Evaluation The purpose of the human health risk evaluation is to determine if contamination at the NAS Key West TPFF sites could pose a potential health risk to individuals under current and/or foreseeable future site conditions in the absence of remediation. The risk evaluation was conducted in accordance with FDEP Petroleum Contamination Site Cleanup Criteria (Chapter 62-770, FAC). Other risk guidance from appropriate USEPA sources included: Risk *Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A)* (USEPA, 1989a), *Guidance for Data Usability in Risk Assessment (Part A), Final* (USEPA, 1992a), Region IV Risk Assessment Guidance (USEPA, 1995a).

Based on geography and land use, the site has been divided into five areas. These areas are Pier D-1, Piers D-2 and D-3, the USCG Station, the Navy Fuel Tanks, and the Key West Pipeline Tanks area. The five areas were evaluated separately in this analysis.

Pier D-1 Risk Summary. The entire site is covered with concrete and no surface soil is present. For current and future land use, excavation worker exposures to subsurface soil and a worker washing his hands with groundwater were evaluated. For all exposure scenarios, both cancer and noncancer risk estimates are below USEPA levels of concern

Piers D-2 and D-3 Risk Summary. The entire site is covered with concrete except for a small area at the end of Pier D-2 and no natural surface soil is present. For current and future land use a worker washing his hands with groundwater was evaluated. For this exposure scenario, both cancer and noncancer risk estimates are below USEPA levels of concern.

The USCG Station Risk Summary. The site is partially covered with concrete with open areas consisting of athletic fields and landscaped areas. The material used to develop these areas was brought in for that purpose. For current and future land use a worker washing his hands with groundwater was evaluated. For this exposure scenario, both cancer and noncancer risk estimates are below USEPA levels of concern.

Navy Tank Farm Risk Summary. The Navy Tank Farm site is an area of bare ground and debris located between the USCG Station and the Key West Pipeline Fuel Tanks. In the past, above ground fuel tanks were located on this site. The tanks have been removed, but some minor rubble and debris currently remains. The surface of the area can best be described as crushed marl rock with an average particle diameter of 3 mm. Some paved and unpaved roads are also present at the site. For current and future land use, excavation worker exposures to subsurface soil and a worker washing his hands with groundwater were evaluated. For all exposure scenarios, both cancer and noncancer risk estimates are below USEPA levels of concern.

The cancer risk for the part-time "snow-bird" resident and occupational worker surface soil exposure were identical. The 1x10-6 RGO for arsenic in surface soil is 3.3 mg/kg. This RGO level is much less than the site-specific background. Therefore the recommended RGO for arsenic in surface soil is the background value of 6.9 mg/kg.

Key West Pipeline Tanks Area Risk Summary. The Key West Pipeline Tanks area is the site of above ground fuel tanks, located north of the Navy Tank Farm. The

tanks are surrounded with crushed marl berms. The surface of the area can best be described as crushed marl rock with an average particle diameter of 3 mm. Some unpaved roads are also present at the site. For current and future land use, excavation worker exposures to subsurface soil and a worker washing his hands with groundwater were evaluated. For all exposure scenarios, both cancer and noncancer risk estimates are below USEPA levels of concern.

An RGO for benzene was calculated for groundwater at the Key West Pipeline Tanks area. The 1x10-6 RGO value for benzene is 70.75 $\mu g/\ell$.

3.3.2 Summary of Ecological Risk Evaluation The ecological risk evaluation evaluates potential adverse effects to ecological receptors associated with exposure to petroleum products from TPFF, NAS Key West. The ecological evaluation follows current guidance materials including the following:

- *Risk Assessment Guidance for Superfund Environmental Evaluation Manual* (USEPA, 1989)
- *Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference* (USEPA, 1989)
- *Framework for Ecological Risk Assessment* (USEPA, 1992)
- *Supplemental Guidance to RAGS: Region 4 Bulletins on Ecological Risk Assessment* (USEPA, 1995)
- *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (USEPA, 1997)
- *Guidelines for Ecological Risk Assessment* (USEPA, 1998)
- Standard Guidelines for Risk-Based Corrective Action Applied at Petroleum Release Sites, American Society for Testing and Materials (ASTM, 1997)

All potential routes of exposure are considered in the ecological risk evaluation. The evaluation identified those chemical pathways representing the greatest potential risks to native receptors likely to be present at the site. Migration of contaminants from the site into surface water or sediment adjacent to TPFF represented the pathway with the highest probability to adversely affect receptors. Surface water, sediment, and fish tissue samples were collected for the ecological risk evaluation.

Analytes detected in the surface water were below the state and federal regulatory levels and should not present a risk to marine receptors. Sediment samples contained twelve PAHs, lead, and TRPH. While most of the PAHs exceeded Florida sediment TEL values, only four exceeded the USEPA sediment screening criteria and no PAHs exceeded the PEL.

Lead was detected in all sediment samples at concentrations greater than the state and federal sediment screening criteria. Lead concentrations ranged from 30.4 to 732 mg/kg with a mean of 159. Excluding the highest concentration of 732 mg/kg, the average concentration for the remaining samples is 44 mg/kg, which is

less than the PEL concentration for lead of 112 mg/kg. This suggests a lead hot spot.

Twenty-three fish were collected and analyzed for petroleum related chemicals. No contaminants were detected in fish tissues; therefore, it is assumed that contaminants in surface water and sediment are not present at concentrations that will present a significant risk to top predators.

In summary, because the land use is industrial and the petroleum releases were mostly underground, it is unlikely that terrestrial wildlife will be adversely effected. There is a slight increase in the potential risks to ecological receptors as a result of exposure to PAHs in sediments. However, the PAHs are characteristic of urban areas. Based on the lead concentrations found in sediment samples at TPFF, adverse ecological effects could occur. Additional sampling for lead around sediment location 01D00801 may be warranted.

3.3.3 Total Risk Analysis The risk evaluation at NAS Key West TPFF demonstrates that, under reasonable exposure assumptions, no unacceptable human health or ecological risks are present at the site. Additional investigation of lead-contaminated sediments at sample location 01D00801 is recommended, but should be performed independent of this RAP. The groundwater at the Key West Pipeline area may need some engineering or land use controls due to benzene in the groundwater. However, there are no complete exposure pathways for either humans or ecological receptors. The area is covered with crushed marl and is unsuitable for residential development in its existing condition. Sheet piles at the piers contain the groundwater and there is no complete pathway for groundwater contamination to impact either the surface water or the sediment. The site poses no unacceptable health risks to either human or ecological receptors.

3.4 CLEANUP TARGET LEVELS. Based on the site specific risk evaluation and current and future land use, cleanup target levels have been developed for the Navy Tank Farm area and the Key West Pipeline area.

For the Navy Tank Farm area the cleanup target level for arsenic in surface soil in is 6.9 mg/kg. This is equivalent to the site-specific arsenic background concentration.

For the excavation and treatment of free product contaminated soil in the Navy Tank Farm area (free product areas FP-16 and FP-17) the cleanup target levels for treated soil will be the industrial values established in Table IV, Chapter 62-770, FAC.

For benzene in groundwater in the Key West Pipeline area the cleanup target level is 70 $\mu g/\ell$. The 1x10-6 RGO for benzene of 70.75 $\mu g/\ell$ and the Florida Surface Water Quality Standard for Class III surface water of 71.28 $\mu g/\ell$ were considered in establishing the cleanup target level for benzene in groundwater.

3.5 EXTENT OF CONTAMINATION. Section 2.3.1 summarized the data and conclusions from the CAR on the extent of contamination. As was noted in that section, sample concentrations were classified as "excessively contaminated" or "contaminated" on the basis of the default Section 62-770, FAC, soil cleanup target levels. With the benefit of the RBCA Standards the contaminated areas can

be reclassified on the same basis as what will be used for determining the remedial action(s).

3.5.1 Groundwater Contamination The application of RBCA Standards reveals that only one area has excessively contaminated groundwater. The region on the east side of the Key West Pipeline Company has benzene levels above the site-specific RBCA standard of 70 $\mu g/\ell$. This groundwater plume is associated with a free-product plume found under the Key West Pipeline Company JP-5 Tank 1 and 2, and is assumed to extend beneath that product plume. Other areas of excessively contaminated groundwater are assumed to exist below the free-product plumes discussed below.

3.5.2 Soil Contamination Soil contamination was delineated by OVA headspace readings taken both on the surface and in the soil subsurface.

3.5.2.1 **Subsurface Soil** Subsurface soil samples were taken for laboratory analysis in the former Tank D-5 area, the Tank D-21 area, the oil-water separator area, and the area of the oil-water pump station on Pier D-1. The site-specific risk assessment determined that contaminants in the subsurface soil do not pose any unacceptable risk.

3.5.2.2 **Surface Soil** Surface soil sampling was completed in April of 1999. Analytical results show arsenic concentrations above the site background screening concentration of 6.9 mg/kg.

3.5.3 Free Product Areas of product contamination were delineated during the 1993 PCA and the 1996 CA by

- OVA readings during advancement of soil borings and installation of monitoring wells;
- direct observation of soil samples taken during advancement of soil borings and installation of monitoring wells; or
- product measurements by bailer or product-water interface probe in completed monitoring wells.

Figure 3-2 shows areas of product-contaminated soil overlain on the five land-use areas defined in Section 3.1. For the purposes of this RAP, product areas FP-3, FP-4, and FP-8 are considered part of the USCG Station land-use area, whereas area FP-18 is considered part of the Piers D2 and D3 land-use area. This was done so that the product areas in question would be grouped in the more stringently examined land-use area of the two land-use areas the product areas overlap. Not all areas of product contamination show evidence of mobile product. The product-contaminated areas are labeled FP-1 through FP-21. The product-contaminated areas are grouped by land-use area in Table 3-1 and in the discussion that follows. In Table 3-1 the volume of contaminated soil was determined by multiplying the area of each product-contaminated region by the product-layer thickness. The product-layer thickness was itself determined as the difference between the depth to topmost contamination and the depth of lowest groundwater noted in the product-contaminated region, with 1 foot added to the

Figure 3-2 Product Contaminated Soil Areas

11 x 17

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Table 3-1
Characteristics of Product - Contaminated Areas

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West, Florida

Product Area ID	Area (ft^2)	Volume Contaminant Soil (yd^3)	Estimate Mobile Product Volume (gallon)	Maximum Contaminant Layer Thickness (ft)	Product Description	Surface Condition	Monitoring Well in Product Area?
Piers D2 and D3							
FP-1	1,080	40	0	1	Red-brown medium-high viscosity	Paved	No
FP-2	758	84	6	3	Dark red-brown, medium-high viscosity	Paved	No
FP-6	3,662	678	41	5	Black, high viscosity	Paved	Yes
FP-9	4,913	182	2	1	Dark red, high viscosity	Paved	Yes
FP-10	3,821	283	561	2	Black red-brown, degraded	Paved	Yes
FP-11	503	19	4	1	Brown-black, medium-high viscosity	Paved	No
FP-12	370	41	0	3	Red-brown, medium viscosity	Paved	No
FP-18	3,837	400	5,747		Yellowish-gray, degraded	Partially Paved	No
Coast Guard Station							
FP-3	22,333	2,948	15,095	4	Black, dark red-brown, high viscosity	Partially Paved	Yes
FP-4	5,225	774	2	2	No data	Partially Paved	Yes
FP-7	9,502	1,408	3	4	Dark red-brown to black, medium viscosity, degraded	Partially Paved	Yes
FP-8	3,867	430	1	3	Red-brown, medium to high viscosity	Partially Paved	No
FP-13	1,877	209	1	3	Dark brown to black, high viscosity, degraded	Part under Flammable Storage	Yes
FP-14	1,352	250	0	5	Dark red-brown to black, high viscosity, degraded	Unpaved	No

See notes at end of table.

Table 3-1 (Continued)
Characteristics of Product - Contaminated Areas

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West, Florida

Product Area ID	Area (ft^2)	Volume Contaminant Soil (yd^3)	Estimate Mobile Product Volume (gallon)	Maximum Contaminant Layer Thickness (ft)	Product Description	Surface Condition	Monitoring Well in Product Area?
Pier D1							
FP-19	3,218	358	1	3	Brown, degraded	Paved	Yes
FP-20	848	157	0	5	Grayish brown, opaque, very degraded	Paved	No
FP-21	20,309	3,196	212	5	Dark red to dark gray, low to medium viscosity, degraded	Paved	Yes
Key West Pipeline Tanks							
FP-5	205,963	8,320	28,499	6	Pale yellow to golden, low viscosity	Unpaved	Yes
Navy Tank Area							
FP-15	4,116	357	31	3	Brown to grayish brown, opaque, degraded	Unpaved	Yes
FP-16	67,873	5,086	79,496	2	Varied	Unpaved	Yes
FP-17	22,701	3,365	931	4	Brown to blue-black opaque, medium to high viscosity	Unpaved	Yes

Notes: ID = identification.
ft^2 = square feet.
yd^3 = cubic yard.

product thickness as a factor of safety. The mobile product volume was estimated by:

- averaging over time product-thickness levels noted in individual soil borings and monitoring wells (with the monitoring well data corrected to give an in-soil value),

- determining product-thickness areas within the product-contaminated regions corresponding to each monitoring well or soil boring (occasionally grouping together soil borings and/or monitoring wells that have similar time-averaged thickness values), and

- multiplying each product-thickness by each product-thickness area, summing the results, and multiplying that sum by the porosity value given in the CAR (0.45) (ABB-ES, 1996).

Piers D2 and D3. This land-use area is characterized by paved surfaces, a waterfront bulkhead consisting of interlocking sheet piling covered by concrete to 3 feet below mean low water, and activities of a light industrial nature. Product-contaminated regions in this land-use area include FP-1, FP-2, FP-6, FP-9, FP-10, FP-11, FP-12, and FP-18. Regions FP-1 and FP-12 show no evidence of mobile product; however, no monitoring wells have been installed in these regions. Region FP-18 also has no monitoring wells, but evidence of product was found in soil borings in the region. Region FP-9, which encompasses two monitoring wells, has never shown product in the monitoring wells. Evidence of petroleum contamination was found during the advancement of soil borings, but the mobility of this product has never been demonstrated. The remaining regions, FP-2, FP-6, FP-10, and FP-11, all present indications of mobile product, from product accumulation in either monitoring wells or in groundwater samples taken from boreholes. Regions FP-2 and FP-11 do not have monitoring wells.

USCG Station. This land-use area is characterized by grassy surface cover interspersed with partially paved areas and with buildings, without waterfront areas. The land-use area is occupied by USCG administrative offices and personnel quarters. It includes product-contaminated regions FP-3, FP-4, FP-7, FP-8, FP-13, and FP-14. Regions FP-4, FP-7, and FP-13 had product visible during soil boring advancement, but no mobile product evident in subsequently installed monitoring wells. Regions FP-8 and FP-14 only showed evidence of residual product during soil boring advancement, but lack monitoring wells. FP-3 showed evidence of mobile product in both soil borings and monitoring wells.

Pier D1. This land-use area is similar to Piers D2 and D3 in that the surface is paved and activities are of a light industrial nature. However, at Pier D1, the waterfront has the original 1912 structure of wooden piles covered with concrete to 3 feet below mean low water. Product contaminated regions in this land-use area include FP-19, FP-20, and FP-21. Region FP-20 includes no monitoring wells; Region FP-21 is the only region that has evidence of mobile product.

Key West Pipeline Company Tanks. This land-use area is separated by a berm from the rest of the site, and has little paved surface area. Activities in this area include operation of three large ASTs by the Key West Pipeline Company. The north side of the area faces Fleming Key Cut, and is faced by a bulkhead similar in construction to the waterfront bulkhead on Piers D2 and D3. The only product-

contaminated region in the land-use area is FP-5. FP-5 covers a large area, includes several monitoring wells, and shows evidence of mobile product.

Navy Tank Area. This land-use area includes few paved surface areas, but several buildings. Future uses are expected to be of a varied industrial nature. The land-use area does not face any waterfront. Product-contaminated regions in this area are FP-15, FP-16, and FP-17. FP-15, FP-16, and FP-17 all have mobile product and monitoring wells. Because FP-16 and FP-17 are accessible, the Navy has agreed to use excavation to remove free product in these areas.

3.5.4 Sediment Sediment sample D008 shows contamination levels for lead and PAHs elevated far above risk-based standards. Although the contamination could be associated with product contamination on Pier D2, it is also quite possible that the contamination resulted from fueling activities in the dock areas, from the lead-based paint used on ships in the dock areas, or that the contamination is associated with sediment transported from another location by an undersea current. In any case, further investigation or action regarding this sample is beyond the scope of this document. It is recommended that the matter be pursued further as a separate action.

3.6 SITE-SPECIFIC LIMITATIONS TO ALTERNATIVES. Site-specific limitations often exist that can affect remedial alternative selection. At the TPFF site, several factors that should be considered in the design process are the low permeability of the soil at and below the water table, the shallow water table, the surface cover composed of hard, sandy limestone fill on the site, and the groundwater containment already afforded by the pier seawalls. Furthermore, access to the site is limited. Subsurface features such as storm water sewers, electric lines, telephone lines, and service lines are found at the site. These subsurface features should be located through the Base Public Works Department prior to any excavation, drilling, or trenching activities at the site.

3.7 REMEDIAL STRATEGY. The remedial option or options chosen for NAS Key West TPFF should, as much as is possible:

- eliminate the potential for exposure to groundwater contaminated above human-health and ecological risk-based alternative groundwater cleanup standards;
- prevent any contamination of surface water to a level above human-health and ecological risk-based alternative cleanup standards for surface water;
- eliminate the potential for future exposure to groundwater or surface-water contamination posed by the product-contaminated areas; and
- eliminate the potential for exposure to contaminated surface soil.

There are 21 product-contaminated regions, which are found in a wide variety of settings. Therefore, more than one remedial option may be implemented for the product-contaminated regions. To simplify matters, the product-contaminated regions will be grouped by land-use area as discussed above or otherwise grouped where appropriate.

3.8 ALTERNATIVES CONSIDERED. Because cleanup technologies applicable to sites contaminated with petroleum substances are continually being improved and developed, it is important to develop remedial action alternatives using the most effective technologies available.

Appendix B provides a detailed discussion of the alternatives that were evaluated for this RAP.

3.9 ALTERNATIVE SELECTED. The following are brief explanations of the selected remedies:

1. **Soil Washing**. In areas that are accessible, free product and contaminated subsurface soil will be excavated and treated onsite using soil washing.

2. **Excavation**. To prevent exposure to arsenic in surface soil, areas that exceed the background value for arsenic will be excavated. Excavated material will be disposed of offsite in a permitted facility.

3. **Free-Product Recovery**. In areas that are not accessible to excavation, free product will be recovered actively using multiphase extraction vacuum trucks and passively using in-well passive product skimmers.

4. **Natural Attenuation with Contingency**. Groundwater will be monitored for natural attenuation. If dissolved phase contaminants reach point of compliance wells located in the easternmost portion of the site, the existing seawall will be extended.

5. **Land Use Controls**. Land-use controls will be established to manage exposure through institutional controls.

CHAPTER 4.0

4.0 RECOMMENDED REMEDIAL ACTION

The recommended remedial action for the TPFF site at NAS Key West consists of soil excavation and treatment, product recovery using multiphase extraction and passive in-well skimmers, monitored natural attenuation, and land-use controls. These actions will cost effectively minimize environmental risks while maintaining and enhancing favorable site conditions.

4.1 *EX SITU* SOIL WASHING. One part of the recommended remedial action for the TPFF site consists of source abatement through excavation of product-saturated soils in two accessible areas of known free-product contamination, FP-16 and FP-17. The areas of excavation are shown on Figure 4-1. The excavation areas represent areas where the most contaminant mass can be removed economically. The methodology used to determine the excavation areas is presented in Appendix C.

Excavation and on-site treatment through the use of soil washing is recommended. Excavation shall be to a depth of 7 feet bls. The soil from 0 to 4 feet bls is considered clean and does not require treatment. The total volume of soil to be excavated is 9,300 cubic yards (approximately 14,000 tons) with approximately 4,000 cubic yards (6,000 tons) of soil requiring treatment. Soil volume calculations are presented in Appendix C, Engineering Calculations. The excavation will include the evacuation and capping or removal of any abandoned fuel distribution lines encountered. Existing buried electrical lines and aboveground transformers must be relocated before excavation begins.

4.1.1 Pretreatment Sampling Based on the volume of contaminated soil expected, 11 composite pretreatment samples must be analyzed for VOAs, TRPHs, and naphthalenes in accordance with Chapter 62-775.410, FAC. Each composite soil sample must be collected from at least four locations in the contaminated area and may be taken while performing the excavation.

4.1.2 Excavation Excavation shall be conducted using standard earth-moving equipment. All operators will be certified by the Occupational Safety and Health Administration. OVA headspace analyses will be performed at set intervals during the excavation to monitor soil contaminant levels; however, visual inspection and knowledge of the apparent extent of free-product will be used to delineate the area to be removed and treated. Excavation to a depth approximately 1 foot below the mean low groundwater table is necessary to implement free-product removal. Excavated soil should be loaded directly into trucks to facilitate immediate site removal and delivery to the treatment area and to prevent spreading of the contaminated soil at the site. If free product is encountered in ponded water within the excavation, it shall be removed with absorbent pads.

4.1.3 Soil Washing Excavated soil will be treated using the Ion Collider Process (ICP). The ICP is an innovative technology used to treat petroleum contaminated soil. A detailed description of this technology is provided in Appendix D. This technology was successfully pilot tested at the Flying Club Site on Boca Chica in 1998. Figure 4-2 shows the process flow diagram for this technology. Excavated soils are run through a series of conveyors and sprayed with a mixture of ionized water and potassium permanganate ($KMNO_4$). Treated soil is stockpiled and tested after a 48-hour waiting period. Treated soil is then

Figure 4-1 Subsurface Soil Excavation Areas

11 x 17

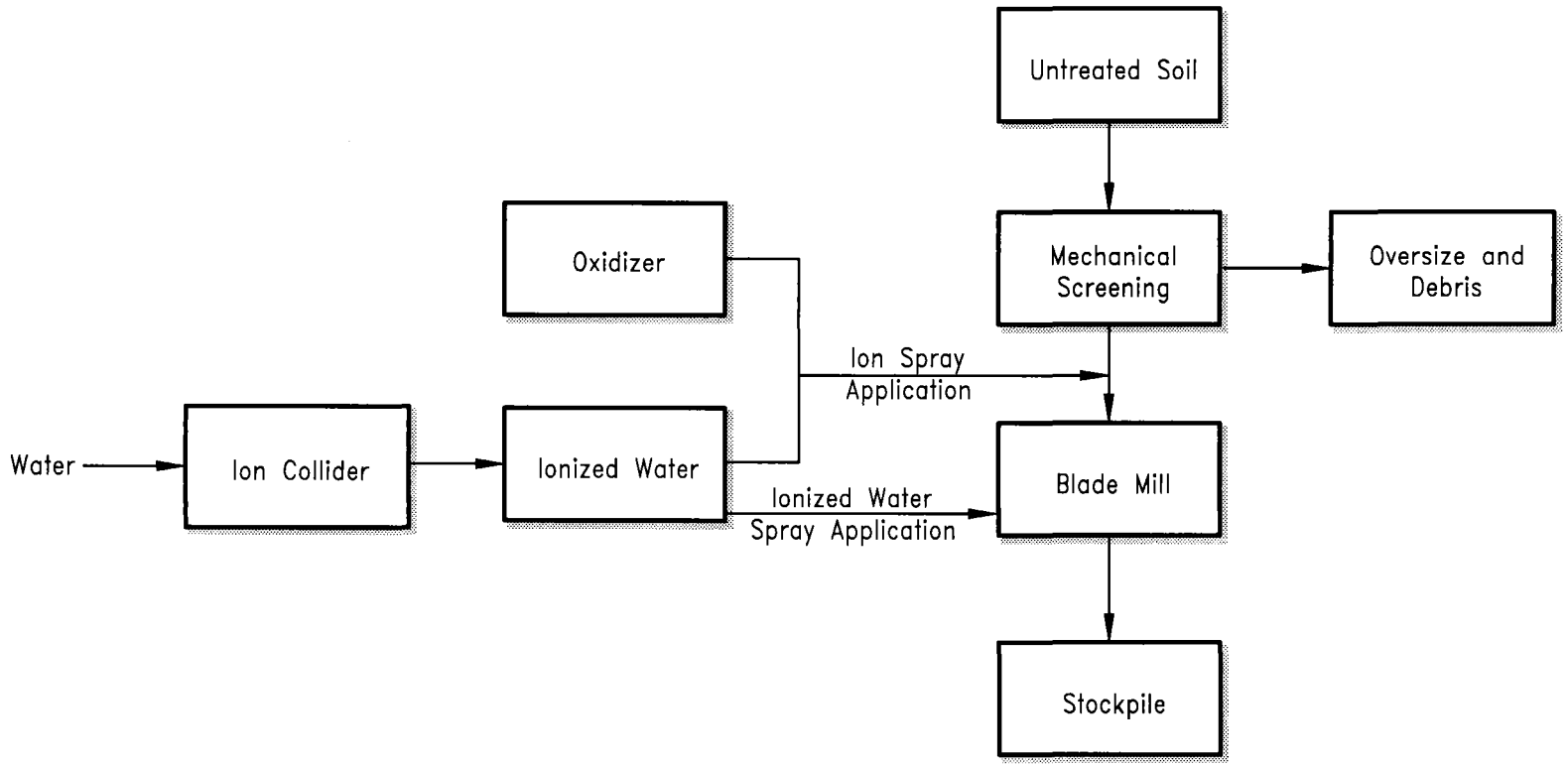

FIGURE 4-2
SOIL TREATMENT PROCESS FLOW DIAGRAM

REMEDIAL ACTION PLAN

TRUMBO POINT FUEL FARM
NAVAL AIR STATION KEY WEST
KEY WEST, FLORIDA

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returned to the excavation, compacted to 85 percent Modified Proctor, and the site reseeded. Signed and sealed as-built drawings shall be provided upon project completion.

4.1.4 Confirmatory Sampling Following treatment composite soil samples shall be collected from each stockpile at the rate of one sample per 400 tons. Confirmatory samples shall be analyzed for total VOAs (USEPA Method 8020), TRPH (FL-PRO), and PAHs (USEPA Method 8270). Soil that meets the direct exposure industrial values listed in Chapter 62-770, FAC, shall be considered clean and suitable for backfill.

4.2 EXCAVATION. Arsenic in surface soil was found above the site-specific background concentration of 6.9 mg/kg at five areas within TPFF (Figure 4-3). Three of the areas are within the Key West Pipeline land use area and two of the areas are within the Navy Fuel Tanks land use area. Sample number 255 had the highest concentration, 440 mg/kg. The two other areas located in the Key West Pipeline land use area, samples 256 and 259, had concentrations above background of 7.1 and 7.7 mg/kg respectively.

In the Navy Fuel Tanks land use area there are two areas with arsenic above background. All five areas shall be excavated to a depth of 2 feet in order to remove arsenic contaminated surface soil. The estimated amount of soil to be excavated is 6,800 cy or 8,500 tons. Volume calculations are included in Appendix C. For each of the three areas in the Key West Pipeline land use area a 10 feet by 10 feet excavation area was assumed. Excavated areas shall be backfilled with clean fill and compacted to 85 percent standard proctor as determined by, ASTM D-698 latest revision.

4.2.1 Confirmatory Sampling The existing excavation limits are based on a limited number of surface soil samples. It is recommended that additional surface soil samples be collected and analyzed for arsenic prior to excavation activities. The purpose of additional sampling will be further define the areas above background. It is anticipated that additional sampling will decrease the area requiring excavation. Since the purpose of excavation is to prevent exposure to arsenic in surface soil post excavation sampling is not required.

4.2.2 Disposal Excavated soil shall be manifested, transported, and disposed in a permitted disposal facility. Contaminated soil shall be handled in accordance with Federal, State, and local regulations. Detailed delivery tickets prepared, signed, and dated by an agent of the disposal facility, certifying the type and amount of materials delivered to the facility, shall be provided to the Navy by the construction contractor.

4.3 MULTIPHASE EXTRACTION. Multiphase extraction is proposed as a source abatement technology for product-contaminated areas FP-3, FP-5, FP-16, and FP-18. Assuming each well used for multiphase extraction has a radius of influence of 50 feet, 2, 6, 2, and 1 additional wells would have to be added in product-contaminated areas FP-3, FP-5, FP-16, and FP-18, respectively. Table 4-1 lists

Figure 4-3 Surface Soil Cap Layout

11 x 17

Figure 4-4 Existing and New Monitoring/Recovery Wells

11 x 17

Table 4-1
Multiphase Free Product Recovery

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West, Florida

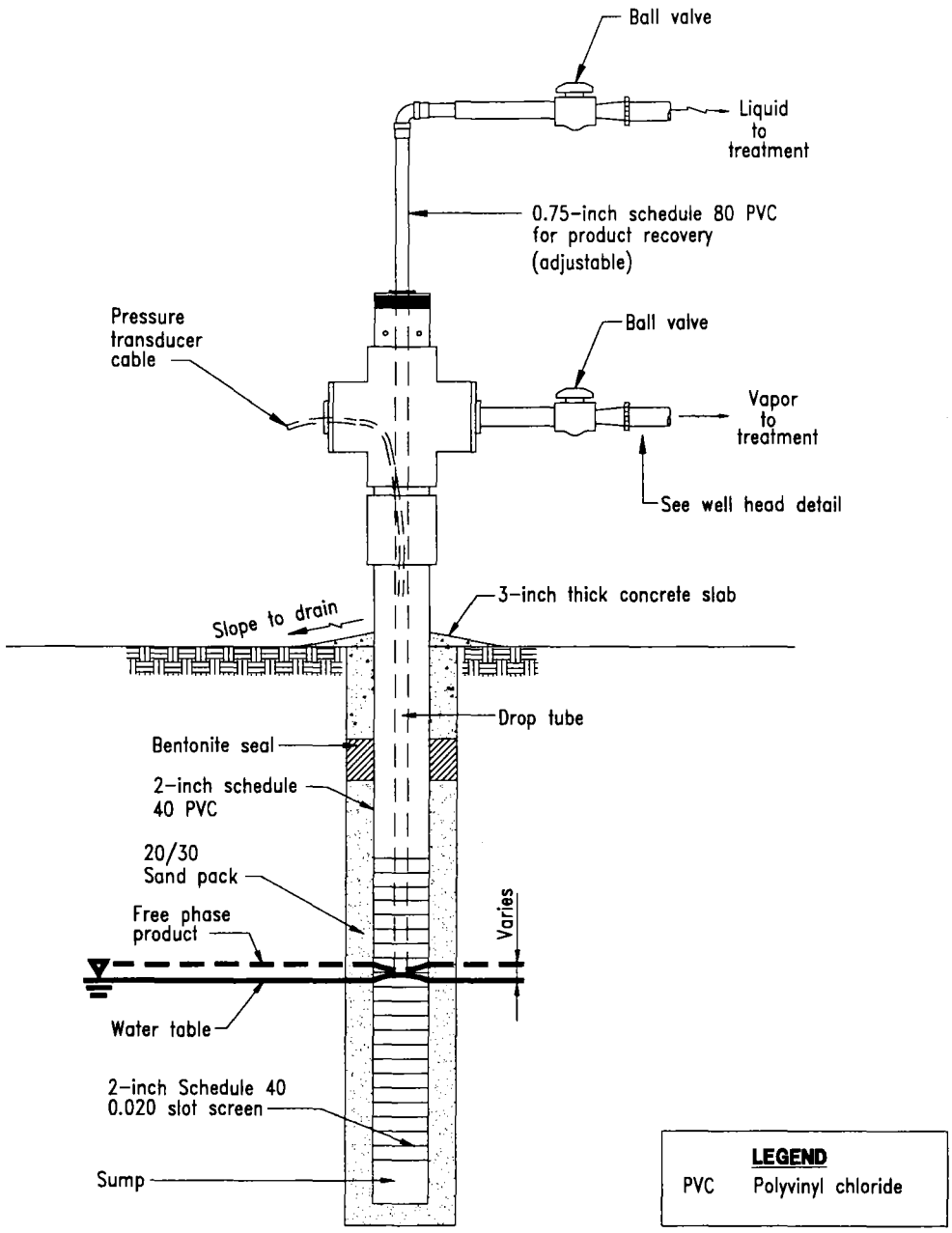
Product Contaminated Area	Estimated Mobile Product Volume (gallons)	Number of Monitoring/-Recovery Wells	Monitoring/Recovery Well Identification	Estimated Time to Cleanup (years)
FP-3	15,095	4	MW-65 FP-3-01 FP-3-02 FP-3-03	1.4
FP-5	28,499	14	MW-62 KMW-21 MMW-20 MW-55 KMW-22 MW-JP-1 MW-JP-3 KMW-07 FP-5-01 FP-5-02 FP-5-03 FP-5-04 FP-5-05 FP-5-06	2.6
FP-16	33,129	4	KMW-23 MW-31 FP-16-01, FP-16-02	3.0
FP-18	5,747	1	FP-18-01	0.5

Note: Wells with free product (FP) label are new. All others are existing.

the wells to be used and shows the estimated time cleanup. Figure 4-4 shows the locations of the proposed additional wells. These wells would also function to confirm the condition of the product-contaminated areas before remediation began, and allow monitoring of the remediation process.

Figure 4-5 shows a schematic of the multiphase extraction system. Mobile product and groundwater are extracted, using a drop tube with its tip located near or at the product-groundwater interface. The top of the well casing is sealed, so that a strong vacuum develops in the well. Mobile petroleum product is drawn to the extraction point primarily by the airflow in the vadose zone, and by the gradient in the product itself. Product and/or groundwater is drawn upward into the drop tube, depressing the product layer and causing product flow towards the well. Simultaneously, the vadose zone is remediated through the airflow induced therein.

The vacuum truck consists of a vacuum pump, total fluids collection tank, and a vapor containment and treatment unit. Generally vacuum trucks are equipped with a vacuum pump that is capable of producing a range of air flow rates (1,000 to 3,000 cubic feet per minute) and vacuum (up to 27 inches of mercury) to facilitate the selective extraction of free-phase petroleum products and groundwater from the extraction well. Vacuum levels are determined in the field during the initial events of multiphase extraction. The maximum allowable vacuum



VACUUM ENHANCED EXTRACTION WELL DETAIL

NOT TO SCALE

FIGURE 4-5
VACUUM ENHANCED EXTRACTION WELL DETAIL

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REMEDIAL ACTION PLAN

TRUMBO POINT FUEL FARM
NAVAL AIR STATION
KEY WEST, FLORIDA

at the extraction well is limited by the structural stability of the extraction well construction materials. For a typical extraction well made of schedule 40, 2-inch diameter polyvinyl chloride (PVC), with a 0.1-inch slotted screen, the maximum allowable vacuum is 24 inches of mercury. Vacuum trucks may be equipped with vapor containment and treatment equipment. Both activated carbon and thermal oxidizer treatment units are available. The vacuum pump itself is usually a liquid ring pump. The liquid ring pump, which is also known as a true vacuum pump, consists of the aluminum impeller that spins at a very low speed (700 revolutions per minute) inside an aluminum housing. The liquid ring is developed inside the pump housing and becomes the housing wall. The liquid used inside the pump is generally water. As the product vapor enters the liquid ring pump, it is compressed on the water layer over the housing wall. The discharge air and vapor, including a portion of the pump's liquid supply, are then released for further processing. These principle design characteristics of liquid ring pumps minimize the risk of a spark occurring in the pump.

The liquid collected during multiphase extraction is a mixture of product and groundwater. The proper handling and disposal of this liquid is the responsibility of the vacuum truck subcontractor. During the initial stage of multiphase extraction remediation activities, it is anticipated that vacuum truck event frequency would be great enough to warrant on-site storage of collected liquids in a tanker semitrailer.

The overall performance of multiphase extraction will be evaluated based on the data obtained for the parameters listed below.

- Initial and final thicknesses of free product in source area and perimeter area monitoring wells;
- Composition of fluids collected at the end of the extraction event.

Additional data will be gathered during each multiphase extraction event, including

- vapor flow rates from the extraction wells,
- vapor concentrations during application of multiphase extraction, and
- vacuum readings at the well heads from the source area and perimeter area wells.

Figure 4-6 shows the decision-making process to be followed in applying multiphase extraction to product-contaminated areas FP-3, FP-5, FP-16, and FP-18. The rules in the figure are summarized below.

- Initially, multiphase extraction will be applied weekly.
- Data parameters will be gathered at each multiphase extraction event.
- If product thickness in an extraction well drops to below 0.1 foot one week after an event (immediately before the following multiphase extraction event), the extraction well will be switched to a monthly event schedule.

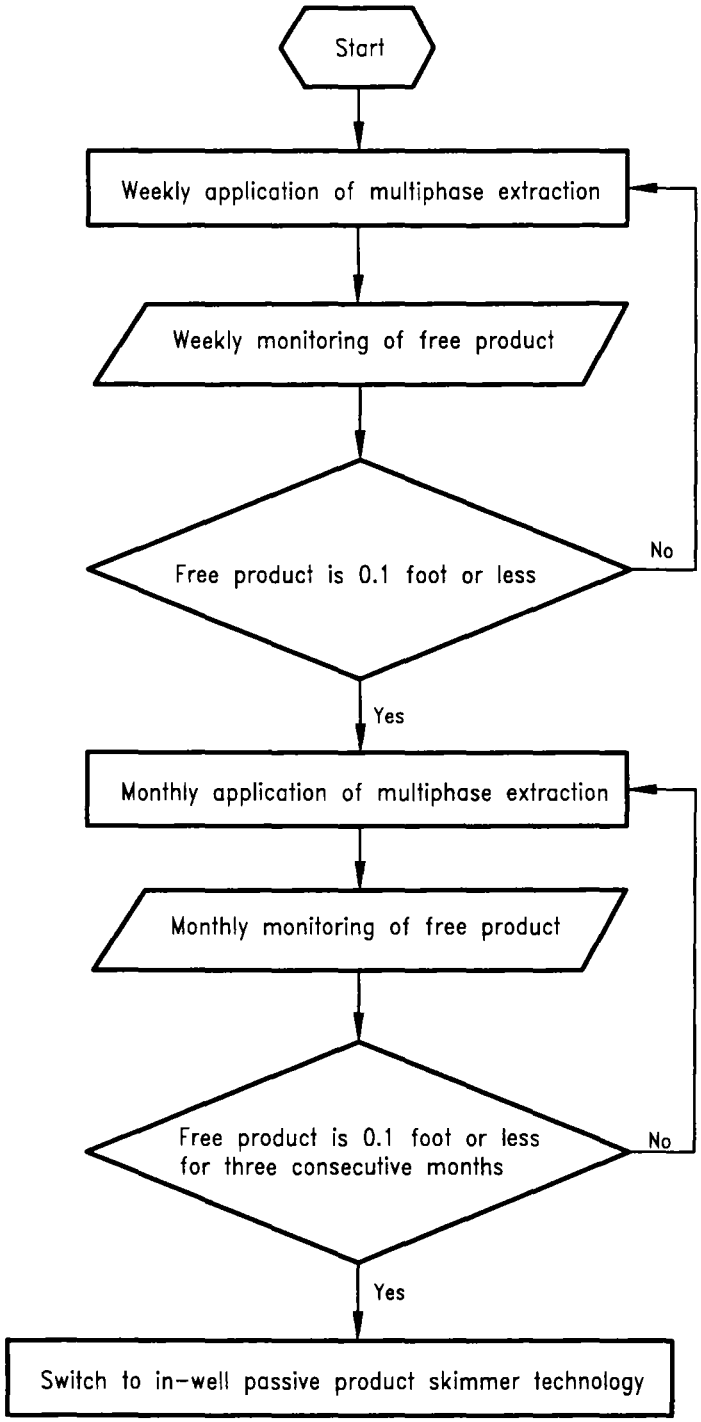

FIGURE 4-6
MULTIPHASE EXTRACTION DECISION TREE

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REMEDIAL ACTION PLAN

TRUMBO POINT FUEL FARM
NAVAL AIR STATION
KEY WEST, FLORIDA

- If product thickness is less than 0.1 foot in an extraction well for three consecutive months of monitoring, the well (and by implication the surrounding product-contaminated area) will be removed from the multiphase extraction schedule and subjected to remediation with the in-well passive product skimmer technology, as detailed in Section 4.4.

It is anticipated that the mobile product recovery program using multiphase extraction will last up to approximately 0.5 years for product-contaminated area FP-18, and up to approximately 1.4 years for product-contaminated areas FP-3, approximately 2.6 years for FP-5, and 3.0 years for FP-16.

4.4 IN-WELL PASSIVE FREE PRODUCT REMOVAL. Product-contaminated areas FP-2, FP-6, FP-10, FP-11, FP-15, FP-17, and FP-21 will be remediated through passive in-well product skimmers, in combination with the containment presently afforded by the relatively impermeable soil and the pier and seawall bulkheads. Product areas FP-3, FP-5, FP-16, and FP-18 will also be subject to this remediation alternative, upon completion of the multiphase extraction remediation alternative (see Section 4.3). This section will focus on the in-well passive selective product skimmers, as the above-mentioned containment is in place and completely passive.

Passive selective product skimmers are available for 2-inch and 4-inch wells, and are designed to remove product down to an in-well thickness of less than 0.01 inches. Detailed information on passive skimmers is presented in Appendix D. Models for areas where groundwater elevations fluctuate with the tides are available. The skimmer typically uses a floating intake with an outer debris screen surrounding an oileophilic/hydrophobic inner screen. Product enters the intake and moves freely through the oileophilic/hydrophobic inner screen to a collection container, while groundwater trying to enter the unit is repelled. The units will be retrieved from the recovery well on a regular basis, the collected product measured, and the collection container emptied into a drum for disposal.

Figure 4-7 shows the decision-making process proposed for the remediation of the product-contaminated areas using passive product skimmers in schematic form. The rules are summarized below.

- A product-contaminated area is a candidate for passive skimmer product recovery if it has recovery wells showing product thicknesses between 0 and 0.1 feet.

- Passive selective product skimmers like those described above will be installed in recovery wells meeting the above criterion. The product skimmers will be checked, volume of product captured recorded, and collected product emptied from the skimmer on a daily basis.

- If the product skimmer collection container is less than 25 percent full when checked for three consecutive days, the recovery well will be demoted to a weekly visit schedule.

- If the product skimmer collection container is less than 25 percent full when checked for three consecutive weeks, the recovery well will be demoted to a monthly visit schedule.

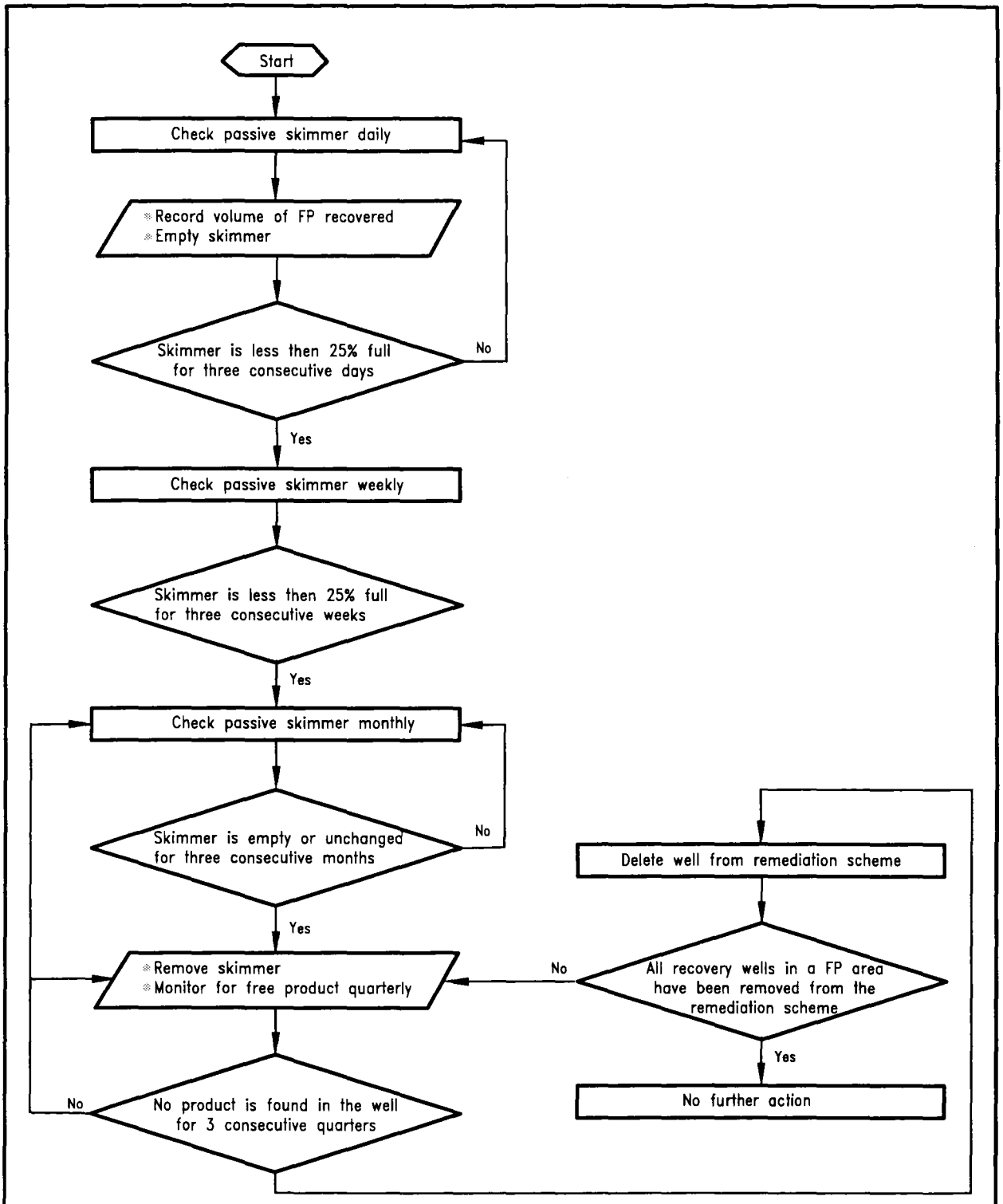

FIGURE 4-7
PASSIVE FREE PRODUCT RECOVERY DECISION TREE

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REMEDIAL ACTION PLAN

TRUMBO POINT FUEL FARM
NAVAL AIR STATION
KEY WEST, FLORIDA

- If the product skimmer collection container is empty or unchanged for three consecutive months, the product skimmer will be removed and the well subjected to quarterly monitoring of product levels.

- If no product is found in the well for the three quarters following the removal of the product skimmer, the recovery well will be removed from the remediation scheme.

- If all the recovery wells in a (formerly) product-contaminated area have been removed from the remediation scheme, a no further action designation will be requested for the (formerly) product-contaminated area.

Product skimmers will be lowered to a depth allowing immediate product recovery at current groundwater elevations, but adjusted so that the movement range of the product intake corresponds as closely as possible to historic groundwater elevation range. Collected product will be drummed and disposed of in the NAS Key West Trumbo Point oil-water separators, under supervision of appropriate base personnel, and following all applicable Federal and State statutes and regulations.

Table 4-2 shows the estimated time to cleanup for product-contaminated areas FP-2, FP-6, FP-10, FP-11, FP-15, FP-17, and FP-21, based on estimated mobile product volumes, a 25.5-ounce product collection container in each product skimmer, and assuming a weekly skimmer maintenance schedule and all recovery wells in each area undergo recovery operations for the same time period. It is to be stressed that this table shows a conservative time-to-cleanup scenario. Six new product recovery wells are necessary for delineation. A maximum 100-foot spacing between wells in product-contaminated areas is recommended. Recovery rates should be monitored and more recovery wells installed in product areas if necessary to reduce time-to-cleanup. Table 4-2 lists the new and existing recovery wells to be used for passive free product recovery. Figure 4-4 shows the location of the wells.

Table 4-2
Passive Free Product Recovery

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key

Product Contaminated Area Identification	Estimated Mobile Product Volume (gallons)	Number of Monitoring/ Recovery Wells	Time to Cleanup (years)	Monitoring Well Identification
FP-2	6	1	0.32	FP-02-01
FP-6	41	1	2.0	MW-43
FP-10	561	2	13	MW-88, MW-89
FP-11	4	1	0.20	FP-11-01
FP-15	31	2	0.72	MW-24, KMW-01
FP-17	6	2	0.15	FP-17-01, MW-9-12
FP-21	212	4	2.6	FP-21-01, MW-103, MW-41, MW-42

Note: Wells with FP label are new, all others are existing.

4.5 MONITORED NATURAL ATTENUATION. To monitor decreases in dissolved phase contaminant concentrations and to verify that the plume is shrinking and not expanding a groundwater monitoring program for natural attenuation shall be initiated, in accordance with Chapter 62-770.690, FAC. The monitoring program will focus on the dissolved plume associated with FP-5 on the east end of the site. The monitoring program is designed to evaluate the progress and effectiveness of natural attenuation to reduce contaminants and retard their migration. In the event that data collected under this long-term monitoring plan indicate that intrinsic remediation is not occurring or is insufficient to protect human health and the environment or that contaminant reduction rates indicate more costly monitoring than anticipated, a contingency plan has been developed to augment or replace the intrinsic remediation alternative.

This remedy will have the following contingency. If the monitoring program indicates that the plume is migrating offsite and into Fleming Key Cut surface water then a barrier will be constructed. The barrier will be an extension of the existing sea wall along Fleming Key Cut. The barrier will increase the travel time necessary for the plume to migrate thereby allowing sufficient time for plume degradation by natural attenuation prior to any possible discharge to surface water.

Natural attenuation data was collected in April 1999 from the FP-5 plume. Groundwater from five monitoring wells was sampled and analyzed for natural attenuation parameters. Figure 4-8 shows the results of these analyses. The data indicate that anaerobic conditions exist, redox conditions are optimum for natural attenuation (-200 to -350 mv), and the primary microbial process is sulfate reduction. The elevated concentrations of methane suggest that anaerobic biodegradation is occurring through methanogenesis. The primary microbial process may be transitioning from sulfate reduction to methanogenesis.

4.5.1 Monitoring Well Locations Monitoring wells to be used for groundwater monitoring are already in place within, and downgradient of, the groundwater plume. Groundwater flow direction at the site was interpreted on July 30, 1996, and in general, is radially outward from the center of the site (see CAR Figure 5-8). Table 4-3 lists the monitoring wells to be used for natural attenuation sampling. Monitoring wells are shown on Figure 4-8.

Table 4-3
Natural Attenuation Monitoring Wells

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West, Florida

Area	Monitoring Well Identification	Location	Purpose
FP-5	MW-4	Plume Interior	COC analyses
	MW-60	Plume Interior	COC analyses
	MW-8	Cross Gradient	Background
	MW-5	Cross Gradient	Background
	MW-9	Down Gradient	Point of compliance
	MW-11	Down Gradient	Point of compliance

Notes: COC = chemicals of concern.

Figure 4-8 Natural Attenuation Data, April 1999

4.5.2 **Groundwater Sampling** Groundwater sampling will be conducted quarterly for the first year and annually for four additional years, if necessary, to verify that the contaminant mass and mobility are being effectively reduced by natural attenuation. Water-level measurements will be collected during each sampling event. Groundwater samples will be collected during each sampling event from the designated source area and downgradient well and analyzed for the COCs in groundwater using the test methods shown in Table 4-4. Natural attenuation parameters listed in Table 4-4 will be collected from the source wells and hydraulically downgradient monitoring wells and background monitoring wells and analyzed during each sampling event to establish trends and supporting evidence that natural attenuation is occurring.

If two consecutive sampling events show that the concentration of benzene is below the site-specific risk-based cleanup goal of 70 $\mu g/\ell$, natural attenuation monitoring may be considered complete. A Site Rehabilitation Completion Report shall be completed and submitted to the FDEP for review (Chapter 62-770.690 (8), FAC). On the other hand, if the data collected at any time during the monitoring period indicate plume migration or a risk to human health, the sampling frequency will be adjusted accordingly and/or the contingency plan will be further developed, approved by FDEP, and implemented.

4.5.3 **Reporting** Within 60 days of each groundwater sampling event, a report will be prepared and submitted to SOUTHNAVFACENGCOM and FDEP, in accordance with Chapter 62-770.690 (7)(e), FAC. The report will include the laboratory report of sample analytical results, the chain of custody, a summary table and site map of the analytical results, water table elevation information (including a summary table and flow map), and recommendations for future actions.

4.6 **LAND-USE CONTROLS**. The MOA between the USEPA, the FDEP and the U.S. Department of the Navy, NAS, Key West, Florida, dated August 31, 1998, will be the basis for implementing all necessary LUCs. Because this plan incorporates the use of risk-based cleanup criteria as a basis for remedial action, future LUCs are necessary to ensure the reliability of land-use assumptions. The MOA ensures that such controls will be maintained for as long as necessary to keep the chosen remedy fully protective of human health and the environment.

An individual LUC Implementation Plan (LUCIP) for this site will be added to Appendix C of the MOA. The LUCIP will identify both the LUC objective as well as the particular LUCs that will be used to achieve that objective. It will also specify the actions necessary to implement and maintain the specific LUCs required for the site.

Information necessary for preparation of the LUCIP is as follows:

Objective. The objective of the LUCs at the TPFF site is to manage exposure through institutional controls.

Land-Use Controls. The withdrawal and/or use of groundwater from the shallow aquifer beneath the site will not be allowed. This will eliminate potential human health and ecological risks associated with exposures to contaminated groundwater by eliminating the only viable exposure pathway.

Table 4-4
Groundwater Monitoring Parameters

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West, Florida

Analysis	Method/ Reference[2]	Data Use	Sample Volume, Sample Container, Sample Preservation	Field or Fixed-Base Laboratory
Chemical(s) of Concern				
Volatile Organic Compounds (VOCs)	602	Method of analysis that includes benzene (COC for groundwater)	Collect water samples in a 40 mℓ VOC vial; cool to 4°C; add hydrochloric acid to pH 2.	Fixed
Natural Attenuation Parameters[1]				
Temperature	170.1, Direct reading thermometer	Well development; biological processes are temperature dependent	Conduct *in situ*	Field
Oxygen	Dissolved oxygen meter or HACH kit	The oxygen concentration is a data input to most biological models; concentrations less than 1 mg/ℓ generally indicate an anaerobic pathway	Collect 300 ml of water in biochemical demand bottles; analyze immediately; alternately measure dissolved oxygen *in situ*	Field
pH	150.1, Direct reading meter	Biological processes are pH sensitive	Collect 100 to 250 mℓ of water in a glass or plastic container; analyze immediately	Field
Conductivity	120.1, Direct reading meter	General water quality parameter used to verify that site samples are obtained from the same groundwater system	Collect 100 to 250 mℓ of water in a glass or plastic container; analyze immediately	Field
Alkalinity	310.1, Manual titrimetric	General water quality parameter used to verify that site samples are obtained from the same groundwater system and to measure the buffering capacity of groundwater	Collect 250 mℓ of water in a glass or plastic container; analyze within 6 hours	Field
Ferrous (Fe^{+2})	HACH DR 850	May indicate an anaerobic degradation process due to depletion of oxygen, nitrate, and manganese	Collect 100 mℓ of water in a glass container and follow kit instructions	Field

See notes at end of table

Table 4-4 (Continued)
Groundwater Monitoring Parameters

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West, Florida

Analysis	Method/ Reference[2]	Data Use	Sample Volume, Sample Container, Sample Preservation	Field or Fixed-Base Laboratory
Nitrate (NO_3^{-1})	HACH DR 850	Substrate for microbial respiration if oxygen is depleted	Collect up to 40 mℓ of water in a glass or plastic container and follow kit instructions	Field
Sulfate (SO_4^{-2})	HACH DR 850	Substrate for anaerobic microbial respiration	Collect up to 40 mℓ of water in a glass container and follow kit instructions	Field
Redox potential	Standard Methods A2580 B	The redox potential of groundwater provides information on environmental conditions and is used to interpret the nature and state of chemical compounds and biological conditions; the redox potential may range from 200 mV to less than -400 mV	Collect 100 to 250 mℓ of water in a glass container, filling container from bottom; analyze immediately	Field
Carbon dioxide	HACH[3] CO_2 titrimetric kit	Elevated levels of free carbon dioxide dissolved in groundwater above background concentrations could indicate an aerobic mechanism for bacterial degradation	Collect 100 mℓ of water in a glass container; analyze immediately	Field
Methane, ethane, ethene	RSK 175	The presence of methane indicates biological degradation via an anaerobic pathway utilizing CO_2 as the electron acceptor	Collect water samples in 40 mℓ VOC vials with butyl gray/Teflon®-lined caps; cool to 4°C	Fixed

[1] Groundwater analytical protocol adapted from Table 2.1 in the *Technical Protocol for Implementing the Intrinsic Remediation with Long-Term Monitoring Option for Natural Attenuation of Dissolved-Phase Fuel Contamination in Ground Water* (Wiedemeier, Todd H., 1995).
[2] Method refers to U.S. Environmental Protection Agency test methods.
[3] HACH refers to the HACH Company catalog.

Notes: COC = chemicals of concern.
mℓ = milliliter.
°C = degrees Celsius.
mg/ℓ = milligrams per liter.
mV = millivolts.
GC/FID = gas chromatograph per flame ionization detector.
TCD = thermal conductivity defecter.

Land use at the site will be nonresidential; however, use of the Navy Tanks Areas for temporary RV camping is acceptable.

The potential to encounter contaminated soil or groundwater during any invasive construction activity must be recorded and adequately communicated to anyone initiating any such activities so that appropriate health and safety precautions can be implemented. Any contaminated soil excavated as part of the construction should be disposed of as petroleum-contaminated soil and not returned to the excavation unless properly treated.

Implementation. The required LUCs will be incorporated into the Base Master Plan.

4.7 RECOVERY WELL INSTALLATION. A total of 15 new recovery wells are required (11 for multiphase extraction and 4 for passive free product recovery). All wells will be screened in the shallow aquifer approximately 5 to 15 feet bls. Monitoring well installation and well development will comply with Southern Division, Naval Facilities Engineering Command *Guidelines for Groundwater Monitoring Well Installation* and with USEPA's *Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells*, EPA/600/4-89/034, April 1989. In addition, recovery well installation will comply with the Chapter 62-532, FAC. Figure 4-9 shows a typical shallow monitoring well construction detail.

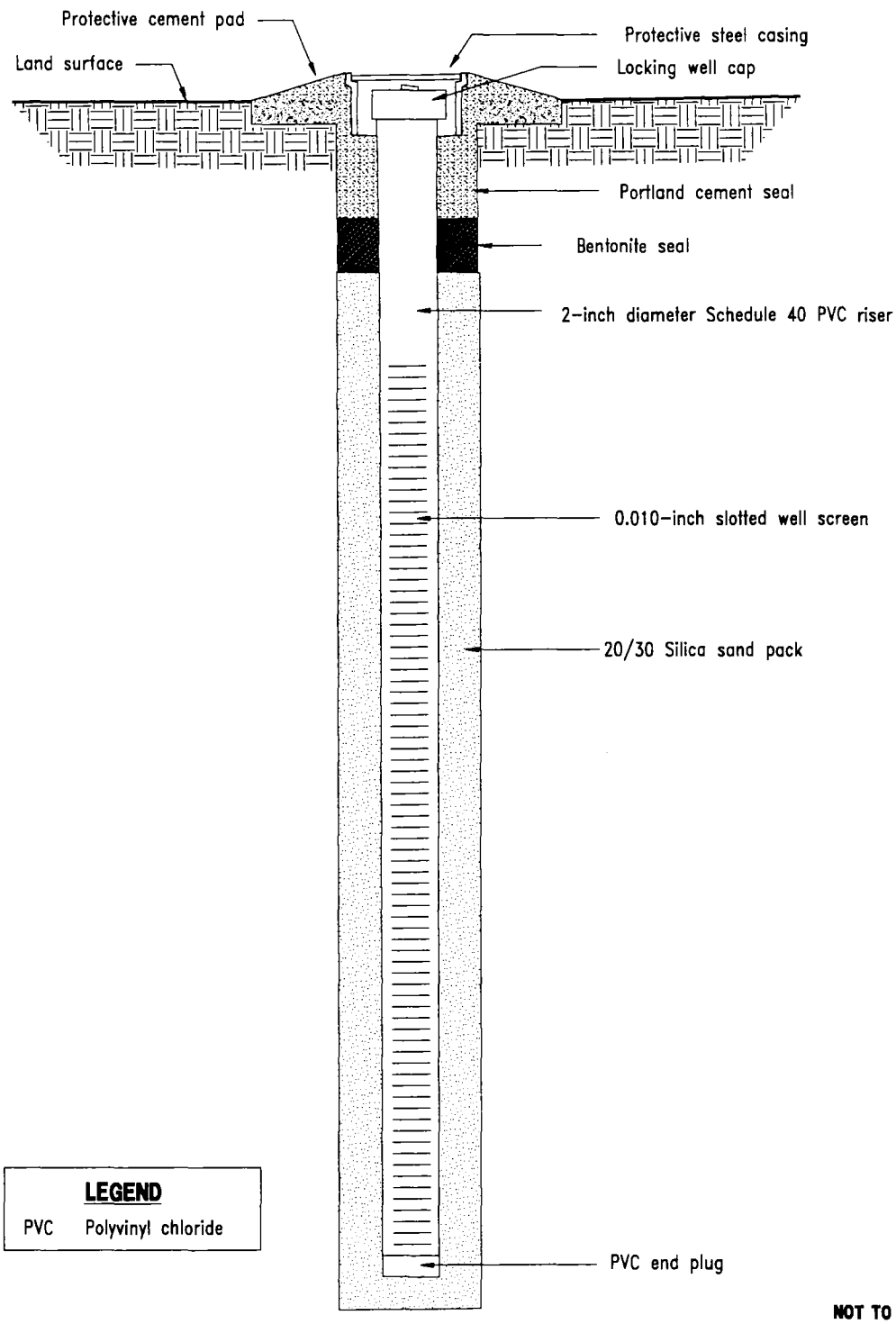

FIGURE 4-9
TYPICAL SHALLOW MONITORING WELL CONSTRUCTION DETAIL

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REMEDIAL ACTION PLAN

TRUMBO ACTION PLAN
NAVAL AIR STATION
KEY WEST, FLORIDA

CHAPTER 5.0

5.0 COST ESTIMATE

The engineering cost estimate for implementing this RAP is contained in Appendix H only in those report copies that require it. This was done to facilitate Navy procurement requirements. The cost estimate was generated using Remedial Action Cost Engineering and Requirements System (RACER) 99.

CHAPTER 6.0

6.0 SCHEDULE

Source removal and free-product recovery actions described in this RAP can begin following FDEP RAP approval. It is estimated that approximately 2 weeks would be necessary for site mobilization and site staging for free-product recovery and monitoring well installations. Preparation of any permit applications should begin immediately upon notice to proceed from the Navy. The location of all underground utilities should also be determined and marked during this time period.

Well permits from the South Florida Water Management District for the abandonment and installation of shallow monitoring wells will be required. This permitting process is expected to take approximately 1 week.

Mobilization and well installation for 15 shallow monitoring wells is expected to be completed within 1 week following mobilization.

Following notice to proceed, including 1 month of procurement, approximately 4 months should be budgeted for implementation of remedial activities at the TPFF site. Active removal of free product will be ongoing until recovery rates indicate it is no longer economically feasible.

Completion of Site Rehabilitation. Upon completion of remedial actions described in this plan at this site, or subsites based on contaminant plumes, land use, or other logical groupings, a Site Rehabilitation Completion Report will be submitted to FDEP for approval in accordance with Chapter 62-770.750 paragraphs (7) through (9), FAC. Upon issuance of a Site Rehabilitation Completion Order for subsites, remedial actions for those subsites will be considered complete.

CHAPTER 7.0

7.0 DOCUMENTATION

A site closure report will be provided following the completion of remedial actions at each plume area. The report should provide at a minimum the following:

- description of actions completed;
- log of field and analytical sampling locations and laboratory analytical results;
- a map of the remediated area, including locations of utilities and obstructions or other features relevant to remedial activities;
- manifests and documentation of treatment and disposal;
- posttreatment analytical results for any soil which required treatment;
- soil compaction confirmation; and
- volume and disposition of water removed during remedial actions.

CHAPTER 8.0

8.0 PROFESSIONAL REVIEW CERTIFICATION

This RAP was prepared using standard engineering practices and designs. The plan for remediating this site is based on information presented in the October 1996 Contamination Assessment Report, the most recent surface soil and groundwater data collected in April 1999, and engineering detailed in the text and appended to this report. If conditions are determined to be different than those described, the undersigned professional engineer should be notified to evaluate the effects of any additional information on the design described in this report.

This RAP was developed for the TPFF site, NAS Key West, Key West, Florida, and should not be construed to apply to any other site.

This certification does not include the risk evaluation presented in Appendix A.

Robert C. Lunardini, Jr.
Florida P.E. No.: 46657
Expires February 28, 2001

REFERENCES

REFERENCES

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APPENDIX A

APPENDIX A

RISK EVALUATION

HUMAN HEALTH AND ECOLOGICAL RISK EVALUATION. This chapter summarizes the technical approach used to conduct the risk evaluation at NAS Key West Trumbo Point Fuel Farm. The purpose of the risk evaluation is to characterize the human health and ecological risks associated with potential exposures to site-related contaminants in environmental media at the site. Based on geography and land use, the site has been divided into five areas. These areas are: Pier D-1, Piers D-2 and D-3, the USCG Station, the Navy Fuel Tanks, and the Key West Pipeline Tanks area. The five areas were evaluated separately in this analysis.

Organization. Subsection A.1 describes the overall technical approach and methods for the human health evaluation. Subsection A.2 presents the evaluation for Pier D-1; Subsection A.3 presents the evaluation for Piers D-2 and D-3; Subsection A.4 presents the evaluation for the USCG Station; Subsection A.5 presents the evaluation for the Navy Fuel Tanks area; and Subsection A.6 is the evaluation for the Key West Pipeline Tanks area. Subsection A.7 provides the uncertainty analysis for the human risk evaluation.

The ecological risk evaluation is arranged in a slightly different manner, beginning with Subsection A.8 which describes the basic ecological methodology. Subsection A.9 contains the Site Characterization followed by Problem Formulation in Subsection A.10, Hazard Assessment and Selection of Ecological Chemicals of Potential Concern (ECPCs) in Subsection A.11, Exposure Assessment in Subsection A.12, Ecological Effects Assessment in Subsection A.13, Risk Characterization in Subsection A.14; and an ecological uncertainty analysis in Subsection A.15. The ecological risk evaluation also contains an model of a Future Reasonable Worst Case Scenario in Subsection A.16. Finally, Subsection A.17 provides a Summary of Ecological Risk .

Subsection A.18 provides a total risk evaluation for the combined human and ecological risks.

A.1 Technical Approach The purpose of the human health risk evaluation is to determine if contamination at the NAS Key West TPFF sites could pose a potential health risk to individuals under current and/or foreseeable future site conditions in the absence of remediation. The risk evaluation was conducted in accordance with FDEP Petroleum Contamination Site Cleanup Criteria (Chapter 62-770, FAC). Other risk guidance from appropriate USEPA sources included: *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A)* (USEPA, 1989a), *Guidance for Data Useability in Risk Assessment (Part A), Final* (USEPA, 1992a), Region IV Risk Assessment Guidance (USEPA, 1995a-1995e).

Consistent with Chapter 62-770, FAC, the risk evaluation contains five components: data evaluation, identification of Chemicals of Potential Concern (COPCs), an exposure assessment of present and potential future human receptors, a toxicity assessment of the chemicals detected at the sites, and a risk characterization (USEPA, 1989a). Collectively, these components are used to identify the site-related contaminants and estimate potential exposures and risks.

Site Description. The purpose of this section is to present a brief description of the five areas that comprise the NAS Key West TPFF site. Information regarding base location, purpose, and historic activities, in addition to detailed descriptions of the areas evaluated in this risk evaluation are presented elsewhere in the CAR (ABB Environmental Services, Inc. [ABB-ES, 1996]).

The TPFF site has been divided into five areas based on geography and organization occupying the area. The five areas include:

- Pier D-1,
- Piers D2 and D-3,
- the USCG Station,
- the Navy Fuel Tanks area, and
- the Key West Pipeline Tanks area.

Data Evaluation. The purpose of this subsection is to evaluate the analytical database for the site and organize it in a manner suitable for use in the quantitative risk evaluations. The data from the site were evaluated independently to determine (1) which detected contaminants are believed to be site related and (2) which data are of sufficient quality for use in quantitative risk evaluations. The individual steps involved in this process are briefly discussed in the following paragraphs.

Data Sort. Data from the previous contamination assessment were compiled and sorted by environmental medium (i.e., soil, groundwater, surface water, sediment, and air). Data collected from different sampling events were combined. All chemicals detected in at least one sample in each medium were identified. For this evaluation, subsurface soil is considered to be greater than 1 to 10 feet bls (USEPA, 1995a).

Analytical Methods. The data used in this evaluation were the result of analyses conducted under the *Petroleum Analytical Methodologies* quality assurance and quality control (QA/QC) procedures. The analytical data were further evaluated for usability in the quantitative risk evaluation by evaluating quantitation limits, evaluating qualified and coded data, comparing concentrations detected in samples to concentrations detected in blanks, and evaluating tentatively identified compounds (TICs).

Quantitation Limits. For the data used in this evaluation, the sample quantitation limit (SQL) is the contract-required quantitation limit (CRQL) (for organic analytes), or the contract-required detection limit (CRDL) (for inorganic analytes), adjusted for sample dilution and moisture content. SQLs have been compared to risk-based concentrations (RBCs). Analyte-specific SQLs that are above RBCs are identified in the uncertainty section so that uncertainties in risk estimates for those analytes can be discussed.

Qualified and Coded Data. Both the laboratory and data validators may assign qualifiers to analytical results; the qualifiers assigned by the data validators supersede the laboratory qualifiers. All positive detections (whether they are unqualified or qualified with a "J") have been considered detected concentrations for the risk evaluation. All nondetections (qualified with a "U") have been retained in the evaluation data set as samples without positive detections. If all sample results for a given analyte in a given medium are nondetects, that analyte is not retained as a detected analyte for the purpose of the evaluation. Any sample results with an "R" validation qualifier have been eliminated from the RBCA data set because QC indicates that the result is unusable.

Blanks. Sample concentrations have been compared to concentrations in associated blanks to distinguish artifacts from actual presence of analytes in environmental samples. The comparisons were conducted as part of the data validation process,

which has been previously discussed. Sample results considered artifacts are generally phthalate ester compounds, chloroform, 2-butanone, acetone, and methylene chloride. Although these analytes are identified as artifacts of sampling and/or analysis, they are retained in the data sets evaluated in the risk evaluation.

Data Summary Sets. The ultimate product of these steps is a data set of sufficient quality to be used in quantitative risk evaluations. The data are presented in data summary sets for each media. The data sets provide the identity of all compounds detected in at least one sample from each sampling event, the ratio of the number of samples in which the analyte is detected to the total number of samples (i.e., frequency of detection), SQL ranges, range of detected concentrations, and mean of detected concentrations. The following data sets have been developed for use in the risk evaluation:

- Pier D-1 Subsurface Soil and Groundwater
- Pier D2 and D-3 Groundwater
- the USCG Station Groundwater
- the Navy Fuel Tanks Surface Soil, Subsurface soil and Groundwater
- the Key West Pipeline Tanks Groundwater

Human Health COPC Selection The data contained in the data summary sets described above are used to select COPCs. Those chemicals that are potentially site related and that may pose risks of concern are selected as COPCs. These chemicals are generally selected based on concentration and frequency of detection; comparison of detected concentrations to background; physical, chemical, and toxicological characteristics; and comparison of detected concentrations with appropriate regulatory standards and guidelines.

The following criteria were used to identify COPCs. COPCs at each site were those chemicals that had the characteristics described below.

- The analyte was positively identified in at least one sample in the data set. This includes analytical results that were not validated with a "U", "UJ", or "NJ" qualifier and that were not rejected ("R" qualifier).

- Detected at levels significantly elevated above blank concentrations. Several common laboratory contaminants (acetone, 2-butanone, methylene chloride, chloroform, and six phthalate esters) were excluded if the concentrations were below 10 times the concentrations in associated laboratory blanks. For all other analytes, concentrations that were below five times the concentrations detected in associated blanks were excluded (USEPA, 1989a; 1992a).

- The analyte was detected at concentration above screening levels. The analyte was excluded if the maximum reported concentration was less than the screening value provided in the FDEP Petroleum Contamination Site Cleanup Criteria for an Industrial Worker (Chapter 62-770, FAC). The soil criteria were based on exposure parameters for an industrial exposure scenario and are calculated for a target hazard quotient (HQ) of 1 or a excess lifetime cancer risk (ELCR) of 1×10^{-6}. Groundwater was compared to both the groundwater screening values in the FDEP Petroleum Contamination Site Cleanup Criteria and the USEPA Region III RBCs

values for tap water. The groundwater criteria were based on exposure parameters for an industrial exposure scenario and are calculated for a target HQ of 1 or a ELCR of 1×10^{-6}.

- Transformation products of chemicals were known to be present. No analyte was eliminated from the COPC list if it was a transformed or parent compound of a COPC. In addition, no analyte was eliminated as a COPC if it was known to be closely related or associated with another analyte that was retained as a COPC.

For each of the five sites described above, the analytical data used to select COPCs and conduct the risk evaluation are summarized in data sets. The data sets provide the data summary for each chemical detected, the chemical-specific screening values, the decision on whether or not the chemical was selected as a COPC, and the rationale for not selecting a chemical as a COPC.

Human Health Exposure Assessment The exposure assessment is conducted to estimate the pathways by which humans are potentially exposed, the magnitude of actual and/or potential human exposure, and the frequency and duration of exposure. This process involves the following several steps: (1) characterization of the exposure setting in terms of physical characteristics and the populations that may potentially be exposed to site-related chemicals, (2) identification of potential exposure pathways, and (3) quantification of exposure for each population in terms of the amount of chemical ingested, inhaled, or absorbed through the skin from all exposure pathways. This assessment process is performed for both current and future site conditions.

Exposure Setting In characterizing the exposure setting of the risk evaluation, the physical attributes and demographics of the area near the site are identified. The physical setting is characterized in terms of the following attributes: climate, meteorology, geology, vegetation, soil type, groundwater, and surface water. This information was gathered from previous investigations and additional information collected during the CAR. The information generated from this analysis aids in defining the physical mechanisms that control or influence how people could be exposed at each site and the processes that may control the fate and transport of contaminants.

Demographics for the TPFF site are characterized for (1) the populations working near each site, (2) the activity patterns of workers, and (3) if any exist, the locations of potentially sensitive subgroups. Determining current and foreseeable future land use of the sites and surrounding areas (e.g., commercial and industrial) was key to this activity. Sources for this information included the following: (1) site visits to NAS Key West TPFF, (2) previous investigations, (3) information generated during the CAR, (4) maps and photographs, and (5) interviews with NAS Key West and USCG personnel.

The land in the site vicinity is best characterized as industrial. A large portion of the area and its associated support buildings is completely paved with concrete, and there is a high level of industrial activity. The area is fenced and the only access is via a guarded gate. Except for Pier D-3 and a small portion of the Navy Fuel Tank area, the only persons on the premises are base workers, USCG personnel, and Navy personnel. When no ships are docked at Pier D-3, the Navy currently allows visitors to fish on the pier and a small section

adjacent to the Navy Fuel Tanks area. The USCG has indicated that this practice will end when it assumes control of these areas.

The only possible change to the current condition is that the a portion of the Tank Farm will be used as an overflow trailer parking area for "snow-bird" visitors at NAS Key West. These visitors may be allowed to park their trailers on this site for up to six months. If land use in the vicinity of the site were to change, it is unlikely that the area would convert to residential use due to the pier facilities available.

Exposure Pathways. This step in the exposure assessment identifies all pathways through which people may be exposed to site-related contaminants through current and foreseeable future land use. A complete exposure pathway requires four elements: a source or mechanism of chemical release, a transport or retention medium, a point of potential human contact with the contaminated source, and a route of exposure at the point of contact (USEPA, 1989a).

First, all contamination sources and receiving media (i.e., soil, groundwater, surface water, and air) are identified. Next, relevant fate and transport mechanisms are evaluated to predict possible distant and/or future exposures. Finally, exposure routes (i.e., ingestion, inhalation, and dermal absorption) are identified where people may potentially come in contact with contaminated media. Exposure pathways with all three elements (i.e., a source or mechanism of release, an exposure point, and an exposure route) are considered complete in this evaluation. A conceptual model was developed that presents a summary of the potential exposure pathways by which people could be exposed to contamination detected in the various exposure media.

Quantification of Exposure. Once complete exposure pathways are selected for evaluation, the final step of the exposure assessment is to quantify exposure (i.e., intake) for each pathway. This quantification process involves developing exposure scenarios to estimate the total amount of contaminants that a hypothetical receptor may ingest, absorb through the skin, or inhale from each exposure pathway. These exposure scenarios are based on several variables that can be grouped into chemical-, population-, and assessment-related variables. The ultimate goal of this step, as defined in USEPA guidance, is to identify the combination of these exposure variables or parameters that results in the most intense level of exposure that may "reasonably" be expected to occur under current and future site conditions (USEPA, 1989a; 1995a). This is performed for every complete exposure pathway selected for evaluation. The resulting exposure scenarios are referred to as the reasonable maximum exposure (RME) for each exposure pathway.

Chemical-Related Variable. The chemical-related variable is the exposure point concentration (EPC) that is the representative concentration at the exposure point. The EPCs have been calculated in a manner consistent with USEPA guidance (USEPA, 1989a). The EPCs were, with the exceptions noted below, the lesser of either the 95 percent upper confidence limit (UCL) on the arithmetic mean of the concentrations or the maximum detected concentration of each COPC for each medium in the data set used to evaluate exposure (USEPA, 1995b). The following equation, consistent with USEPA guidance for calculating the UCL on the arithmetic mean for a log normal distribution, was used to calculate all UCLs:

$$UCL = e^{(\bar{x} + 0.5_s 2 + \frac{sH}{\sqrt{n-1}})} \quad (1)$$

where:

UCL = upper confidence limit,
e = constant (base of the natural log, equal to 2.718),
x = mean of transformed data,
s = standard deviation of the transformed data,
H = H-statistic (from table published in Gilbert, 1987), and
n = number of samples.

In calculating the 95 percent UCLs, samples in which the analyte was not detected were assigned a value equal to one-half the reporting limit in the calculation of the arithmetic means. In cases where the maximum detected concentration was less than the UCL, the maximum detected concentration was used as the EPC. UCLs were not calculated for site with less than ten samples collected.

The exception to this approach is in calculating the EPC for groundwater. The average groundwater concentration is selected as the EPC, which is consistent with USEPA guidance and risk assessments for Naval Training Center Orlando and NAS Jacksonville.

Population-Related Variable. Population-related variables describe the characteristics of a hypothetical individual receptor within each potentially exposed population. Hypothetically exposed populations were identified through analysis of exposure setting and exposure pathway information. Population-related variables include contact rates, such as exposure frequencies and ingestion rates, and physical characteristics of human bodies, such as body weights and surface areas. When applicable, contact rates were selected from standard default exposure parameters or dermal exposure assessment guidance (USEPA, 1992d). If site-specific factors indicated that such parameters were not appropriate, alternative parameters were used based on knowledge of human behavior and the relative accessibility of the sites. Parameters describing the physical characteristics of the exposed populations were identified from appropriate USEPA guidance.

Based on current knowledge of the sites, quantification of exposure was based on residential and industrial land use at the TPFF site. These assumptions are based on current industrial land use and potential future residential, industrial, commercial (i.e., construction), and recreational uses of the base and the surrounding area.

Assessment-Related Variable. The assessment-related variable involved in exposure quantification is the averaging time. Averaging time reflects the duration of exposure and depends on the type of effect being evaluated. Exposure intake during a defined interval (e.g., a lifetime) is averaged over the entire period, resulting in an estimate of average daily intake.

There are two types of adverse health effects evaluated in risk evaluations: carcinogenic effects and noncarcinogenic effects. According to USEPA guidance, the averaging time for carcinogenic effects is assumed to be a 70-year lifetime (USEPA, 1989a). The averaging times for noncarcinogenic effects are equivalent to the exposure duration. Based on USEPA guidance, exposure durations for non-

carcinogenic effects can roughly be categorized into one of three periods: (1) chronic exposures of 7 years to a lifetime, (2) subchronic exposures of 2 weeks to 7 years, and (3) acute exposures of less than 2 weeks (USEPA, 1989a). The length of the exposure period depends on the potentially exposed population and the characteristics of exposure. The averaging times applied to receptors are used in the risk calculations. All exposure scenarios evaluated for non-carcinogenic effects at the site are considered chronic or subchronic exposures. Exposure durations and averaging times for exposure scenarios evaluated in this risk evaluation are presented in Tables AA-1 through AA-22 appended to the end of this appendix.

Intake Calculation. The equations used to calculate intake are those presented in USEPA guidance. The general equation for calculating chemical intake is as follows:

$$Intake = \frac{C \times CR \times EF \times ED}{BW \times AT} \qquad (2)$$

where:

Intake	=	average daily intake over the averaging period (milligram per kilogram of body weight per day [mg/kg of BW/day]),
C	=	concentration of the chemical in the exposure medium (mg/kg),
CR	=	contact rate for the medium of concern (milligrams per day [mg/day]),
EF	=	exposure frequency (days per year),
ED	=	exposure duration (year),
BW	=	body weight of the hypothetically exposed individual (kg), and
AT	=	averaging time (for carcinogens, AT = 70 years times 365 days per year; for noncarcinogens, AT = ED times 365 days per year).

Dermal exposure pathways require additional calculations before intake values can be calculated. A brief explanation of the additional calculations required for dermal absorption are provided below.

Dermal Absorption from Water. The permeability constant approach is used to estimate dermal exposures to contaminants detected in water in accordance with the USEPA *Dermal Exposure Assessment: Principles and Applications, Interim Report*, (USEPA, 1992b). These models apply only to absorption from water. For inorganic chemicals, steady-state conditions and the permeability of water constant is assumed for all analytes. For organic compounds, a nonsteady-state model is used. The model employs a dermal permeability constant estimated from the compound's octanol-water partition coefficient.

Dermal Absorption from Soil. Dermal absorption from soil is calculated in accordance with the USEPA *Dermal Exposure Assessment: Principles and Applications*, Interim Report (USEPA, 1992b). Percutaneous absorption of chemicals detected in soil is chemical and matrix dependent. According to USEPA Region IV guidance (USEPA, 1995a), absorption factors for organics and inorganics are 1 percent and 0.1 percent, respectively. Chemical-specific dermal absorption factors for cadmium are provided in USEPA (1992b) and are used in this risk evaluation in lieu of the standard default values provided by USEPA Region IV.

A soil adherence factor of 1 milligram of soil per square centimeter of skin per event is used in the dermal intake equations (USEPA, 1992b; 1995a).

Human Health Toxicity Assessment The purpose of the toxicity assessment is to evaluate the evidence of potential adverse effects that may be associated with exposure to each COPC. With this information, a relationship between the extent of exposure and the likelihood or severity of adverse human health effects is developed. The toxicity assessment is developed in a two-step process: hazard identification and dose-response assessment.

Hazard Identification Hazard identification is the process of determining whether or not exposure to an agent can cause an increase in the incidence of a particular adverse health effect (e.g., lung cancer or birth defects) and whether or not that effect is likely to occur in humans. In this case, hazard is defined as any chemical, substance, or situation at a site that is capable of doing harm to human health. In most cases, the potential toxic effects associated with contaminants detected at hazardous wastes sites have already been identified. Consequently, the objectives of the hazard identification at the TPFF sites were to (1) identify which of the contaminants detected at the sites are potential hazards and (2) summarize their potential toxicity in brief narrative profiles. Those analytes selected as COPCs were deemed to present potential hazards.

Dose-Response Assessment The objective of the dose-response assessment is to quantify the relationship between the intake, or dose, of a COPC and the likelihood that a toxic effect may result from exposure to that COPC. There are two major types of toxic effects evaluated in the risk evaluation: noncarcinogenic and carcinogenic. Following USEPA guidance (USEPA, 1989a), these two effects (noncarcinogenic and carcinogenic) are evaluated separately. As a result of the dose-response assessment, identified dose-response values were used to estimate the incidence of adverse effects as a function of human exposure to a COPC.

There are two types of dose-response values: cancer slope factors (CSFs) for carcinogens and reference doses (RfDs) for noncarcinogens. For many compounds, both types of values have been developed by USEPA because many compounds elicit both carcinogenic and noncarcinogenic (systemic) effects. In addition, because the toxicity and/or carcinogenicity of a compound can depend on the route of exposure (i.e., oral, inhalation, or dermal), unique dose-response values have been developed for the oral, dermal, and inhalation exposure routes.

The CSF is a chemical-specific toxicity value developed by the USEPA Carcinogenic Risk Assessment Verification Endeavor and is based upon the dose of a chemical and the probability of a carcinogenic response. The unit risk, a toxicity value developed by the USEPA, is an estimate of the relationship between the inhaled concentration of a chemical and the probability of a carcinogenic response from the exposure during the lifetime of the individual.

The RfD is an estimate (with uncertainty spanning perhaps an order of magnitude or more) of a daily intake for the human population, including sensitive subpopulations, that is likely to be without appreciable risk of deleterious noncancer effects during a lifetime. Noncarcinogenic risks due to inhalation are estimated by comparing the inhalation concentration to the inhalation correlate of the RfD, the reference concentration.

For several chemicals, separate sets of RfDs have been developed for evaluating chronic and subchronic exposures. When available, chronic RfDs were used for evaluating exposures lasting more than 7 years. For evaluating exposures less than 7 years but more than 2 weeks (excavation worker), subchronic RfDs were used. There are no analogous reference values for evaluating acute exposures, i.e., those lasting less than 2 weeks.

As required by USEPA Region IV guidance (USEPA, 1995a), risks associated with dermal exposures (most commonly for soil and water dermal contact) are evaluated using CSFs and RfDs that are specific to absorbed doses. Most oral dose-response values are based on an administered dose rather than on the absorbed dose (the CSF for trichloroethene (TCE) is a notable exception). Therefore, it is necessary to adjust toxicity values that are based on administered doses so that they can be used for evaluation of absorbed doses. For dermal exposures, the toxicity values are adjusted as follows:

For carcinogenic substances

$$CSF_{adjusted} = \frac{CSF_{oral}}{ABSEFF_{oral}} \quad \textbf{(3)}$$

and for noncarcinogenic substances

$$RfD_{adjusted} = RfD_{oral} \times ABSEFF_{oral} \quad \textbf{(4)}$$

where $ABSEFF_{oral}$ is the absorption efficiency in the study that is the basis of the oral toxicity value.

If there is no information available on oral absorption efficiency, the conservative default values of 80 percent for VOCs, 50 percent for SVOCs, and 20 percent for inorganics are used.

Sources of Dose-Response Values. The primary source of dose-response values for the risk evaluation was the USEPA Integrated Risk Information System (IRIS) (USEPA, 1986), which is an on-line computer database containing health risk and USEPA regulatory information about specific chemicals. Health risk information is included on IRIS only after a comprehensive review of chronic toxicity data is conducted by work groups composed of USEPA scientists. If no information for a given COPC was found in IRIS, the USEPA Health Effects Assessment Summary Tables (HEAST) were used as a source of information. If appropriate dose-response values were not located from either of these two sources, other USEPA sources (including past versions of IRIS and HEAST and the documents produced by the USEPA's National Center for Environmental Assessment [NCEA]) were consulted. If no USEPA dose-response value was identified, surrogate values from structurally similar compounds were assigned after discussions with USEPA Region IV risk assessment professionals.

Carcinogenic Polynuclear Aromatic Hydrocarbons Toxicity Equivalency Factors (TEF). PAHs are a large class of compounds with complex heterocyclic structures. Seven of these compounds are believed to have a similar carcinogenic mechanism

of action. However, only one compound, benzo (a)pyrene, has sufficient dose-response toxicity data for the USEPA to a published a CSF. The USEPA has developed a TEF approach to address relative potency differences for the remaining six compounds. In this approach, benzo (a)pyrene is assigned TEF of 1 and the remaining compounds are assigned a factor relative to this compound. USEPA Region IV has adopted this approach to evaluate the toxicity of these seven compounds.

In this approach, the TEFs are used to modify the concentration of each carcinogenic PAH into the benzo(a)pyrene-equivalent concentration. The CSF for benzo(a)pyrene is then used to evaluated the carcinogenic risk associated with each of the seven compounds. The TEFs are only used in estimating the cancer risk of these compounds and are not used to estimate the noncancer risks. The TEFs for the carcinogenic PAHs are provided in Table A-1. The calculated EPCs for the potentially carcinogenic PAHs have been adjusted with the TEFs on the risk calculation spreadsheets.

Table A-1
Toxicity Equivalency Factors for
Carcinogenic Polynuclear Aromatic Hydrocarbons

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Polynuclear Aromatic Hydrocarbon	Toxicity Equivalency Factor
Benzo(a)pyrene	1
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.01
Chrysene	0.001
Dibenz(a,h)anthracene	1
Indeno(1,2,3-cd)pyrene	0.1

Source: U.S. Environmental Protection Agency (USEPA, 1993b; 1995d).

<u>Human Health Risk Characterization</u> Risk characterization, the next step in the risk evaluation process integrates the exposure and toxicity information to quantitatively evaluate the potential health risks associated with exposure to COPCs at a site. Risk estimates are then interpreted in the uncertainty analysis, and RGOs are presented. Risk calculations are presented in the risk calculation spreadsheets, Tables AA-1 through AA-22.

<u>Carcinogenic Risks</u>. Carcinogenic risks associated with exposure to individual chemicals are estimated by multiplying the exposure pathway-specific chemical intake (e.g., oral, dermal, inhalation) for each carcinogen by its exposure route-specific CSF (e.g, oral CSF, dermal CSF, inhalation CSF). The calculated value is a chemical-specific ELCR and represents an upper bound of the probability of an individual developing cancer over a lifetime as the result of exposure to a chemical. For each exposure pathway, the chemical-specific risks for all carcinogenic compounds are summed to determine the pathway-specific

lifetime cancer risk from exposure to multiple carcinogenic COPCs. The following equations are used to estimate the chemical- and pathway-specific cancer risks:

Chemical-Specific ELCR

$$Risk_i = CDI_i \times CSF_I \quad \textbf{(5)}$$

where:

$Risk_i$	=	unitless probability of an individual developing cancer as the result of exposure to a chemical i,
CDI_i	=	chronic daily intake of chemical i averaged over 70 years and expressed as mg/kg/BW/day, and
CSF_i	=	USEPA CSF for chemical i $(mg/kg/BW/day)^{-1}$.

Pathway-Specific Incremental Lifetime Cancer Risk

$$Risk_T = \Sigma\ Risk_i \quad \textbf{(6)}$$

where:

$Risk_T$	=	unitless probability of an individual developing cancer as the result of multiple chemical exposures and
$Risk_i$	=	unitless cancer risk estimate for the i^{the} chemical

associated with an exposure pathway

The results of the carcinogenic risk assessment are compared with acceptable risks established by the USEPA. The National Oil and Hazardous Substances Contingency Plan (NCP) indicates that the total lifetime cancer risk due to exposure to the COPCs at a site, by each complete exposure pathway, should not exceed a range of 1 in 1,000,000 (1×10^{-6}) to 1 in 10,000 (1×10^{-4}). For reference, the average cancer burden in the United States in 1993 was 1 in 3 for women and 1 in 2 for men (American Cancer Society, 1994).

<u>Noncarcinogenic Risks</u>. Noncarcinogenic risk estimates are calculated by dividing chemical intake for each compound by the appropriate RfD. The result is called the HQ. The HQs for individual compounds within an exposure pathway were summed to obtain the hazard index (HI) for that particular pathway.

The following equations are used to determine the HQs and HIs:

Hazard Quotient

$$HQ_i = \frac{I_i}{RfD_i} \quad \textbf{(7)}$$

where:

HQ_i	=	hazard quotient of chemical i,
I_i	=	intake of chemical i averaged over the exposure period (mg/kg-day), and
RfD_i	=	reference dose for chemical i corresponding to the same exposure duration as the intake (milligrams per kilogram per day [mg/kg-day]).

Hazard Index

$$HI = \Sigma HQ_i \quad \textbf{(8)}$$

where:

HI = potential for noncarcinogenic effects from multiple chemical exposures and

HQ_i = HQ for the $_i$ chemical associated with an exposure pathway.

An HI less than 1 indicates that noncarcinogenic toxic effects are not expected to occur due to COPC exposure. HIs greater than 1 may be indicative of a possible noncarcinogenic toxic effect. As the HI increases, so does the likelihood that adverse effects might be associated with exposure. This determination is necessarily imprecise because the RfD is developed using multiple uncertainty factors to be protective of human health. It is not at all certain, therefore, that exceedance of an RfD would mean that adverse effects would be expected. In addition, although HQs are typically summed regardless of target organ effects, HQs for individual compounds should properly be summed only if their target organs or mechanisms of action are similar. Therefore, the potential for adverse health effects for a mixture having an HI greater than 1 was assessed on a case-by-case basis. As appropriate, separate HIs were calculated for subchronic and chronic exposures. HIs are based on chronic RfDs.

Summary. The risk estimates calculated for each of the TPFF sites are summarized in risk summary data sets. The risks are summarized according to site, receptor, and medium. Within the text for each site, the relative significance of each pathway risk was evaluated in terms of a comparison with acceptable risk levels established by USEPA.

RGOs This section presents potential health-based cleanup goals for media that contribute to a cancer risk estimate above 1 in 1,000,000 or an HI greater than 1 for combined receptor risks for all media evaluated in this analysis. According to the USEPA Region IV guidance (USEPA, 1995a), the potential health-based cleanup goals are intended to provide the Remedial Project Manager with options for the development of various remedial options.

From the risk summary tables, those receptors with estimated ELCRs above 1×10^{-6} or with a total HI greater than 1 for all media to which the receptor is exposed were identified. Only analytes that individually contribute cancer risks greater than 1×10^{-6} or an HQ greater than 0.1 for a particular medium, or are present in a particular medium at concentrations that exceed an appropriate ARAR, are included. COPCs that meet these criteria are termed chemicals of concern (COCs). RGOs were calculated for target cancer risks of 1×10^{-6}, 1×10^{-5}, 1×10^{-4}, and for noncancer risks associated with HQs of 0.1, 1, and 3. These RGOs are presented for informational purposes and should not be considered actual cleanup goals. RGOs were calculated for each COC using the following equation (USEPA, 1995a):

$$EPC_{chemicali_i} / \text{ Calculated } Risk_{chemical_i} = RGO_{chemical_i} / \text{ Target } Risk \quad \textbf{(9)}$$

A.2 RBCA for Pier D-1 The entire site is covered with concrete and no surface soil is present. Sediment samples were collected adjacent to Pier D-1 for the ecological analysis, but these samples were not evaluated in the human risk analysis due to the lack of a complete exposure pathway.

Exposure Assessment The exposure assessment involves several steps: (1) characterization of the exposure setting, (2) identification of potential exposure pathways, and (3) quantification of exposure. Because the conditions at the site are not expected to change in the foreseeable future, the risk analysis is conducted for only one scenario that represents both present and future conditions.

Characterization of Exposure Setting Pier D-1 is a highly industrialized area completely covered with concrete cap with steel and concrete bulkheads leading down to the sea bed. Access to Pier D-1 is limited to Navy and Coast personnel and the pier is completely surrounded with fencing. Access to Pier D-1 is via a guarded gate or controlled docking at the pier. No civilian vessels are allowed to dock a Pier D-1. There are no recreational facilities at Pier D-1.

The only persons at Pier D-1 are either Navy workers or Navy or USCG Personnel. It is unlikely that other Navy or USCG personnel would frequent this area. Visitors would be unable to come into contact with the subsurface soil due to the concrete cap and bulkheads. Land use at Pier D-1 is not anticipated to change in the foreseeable future. Even if conditions at Pier D-1 were to change, it is highly unlikely that this land would be used for residential purposes. This area would likely be retained for continued docking activity. However, potential activities at Pier D-1 may involve removal of portions of the cement cap or bulkhead and excavation of underlying soil (e.g., for additional building construction). Under these conditions, persons engaged in this work could theoretically be exposed to contamination in the subsurface soil.

The groundwater at Pier D-1 is considered low yield/poor quality due to the nearby open ocean. The groundwater is currently not used at Pier D-1 and there are no plans to use this water in the future. However, if conditions at D-1 were to change, it is theoretically possible that the groundwater could be used for non-potable purposes such as washing. The low yield of this groundwater would limit this use to activities such as hand washing. Under these conditions, persons could theoretically be exposed to contamination in the groundwater.

There is some evidence that fishing activity takes place either on Pier D-1 or in the immediate area around Pier D-1. This is another potential human exposure pathway.

Identification of Exposure Pathways. Subsurface soil, groundwater, and fish are the only contaminated media at the Pier D-1 to which receptors could potentially be exposed. From these potential exposure pathways, the following complete exposure pathways were selected for quantitative evaluation: (1) incidental ingestion and dermal contact with subsurface soil and (2) inhalation of fugitive dust generated during excavation activities, (3) incidental ingestion and dermal contact with groundwater during washing, and (4) ingestion of fish containing

contaminants released from Pier D-1. Table A-2 provides a summary of the justification for inclusion or exclusion of potential exposure pathways.

Subsurface Soil Human Health COPCs. A total of 11 subsurface soil samples were collected during monitoring well installation. These sample locations were: SB-124 (2 samples), SB-168, SB-169, SB-170, SB-171, SB172, SB-173, SB-174, SB-175, and SB-176. All samples were only analyzed for the metals arsenic, cadmium, chromium and lead. Analytes were selected as subsurface soil COPCs at Pier D-1 using the methodology described above. The COPC selection table in presented in Table A-3. Only the inorganic arsenic was detected above screening concentrations and was selected as a COPC for subsurface soil at Pier D-1.

Subsurface Soil EPC. The EPC for the COPC identified in subsurface soil at Pier D-1, arsenic, is presented in Table A-4. Also provided is the frequency of detection, the maximum detected concentration, the 95 percent UCL, if calculated, and the EPC.

Quantification of Exposure. Exposures to subsurface soil were quantified for the excavation worker. The exposure parameters, EPCs, and exposure dose calculations are also documented in the risk calculation spreadsheets, presented at the end of this Appendix.

Toxicity Assessment. The purpose of the toxicity assessment is to identify the adverse effects that are associated with exposure to each analyte and to identify the relationship between level of exposure and severity or likelihood of adverse effects. Dose-response values used in this risk evaluation are current as of June 1999 for IRIS and May 1995 for HEAST.

Risk Characterization. Quantitative estimates of both carcinogenic and noncarcinogenic risks were calculated by comparing exposure doses for each COPC to toxicity data. Risks were quantified for each COPC and each complete exposure pathway selected for evaluation in the exposure assessment. A summary of pathway-specific risks is provided in Table A-5.

Excavation Worker The excavation worker cancer risk estimate is 6×10^{-9}. This risk, due to arsenic exposure, is well below the USEPA acceptable cancer risk range of 1×10^{-6} to 1×10^{-4}. The noncancer risk is also below a level of concern, with a calculated HI of 0.01.

Groundwater Human Health COPCs. Fifteen groundwater samples was collected at Pier D-1; however, not all samples were analyzed for all chemicals. Analytes were selected as groundwater COPCs at Pier D-1 using the methodology described above. The COPC selection table in presented in Table A-6. The volatile organic compound tetrachloroethene and the inorganic arsenic were detected above screening concentrations and selected as COPCs for groundwater at Pier D-1.

Groundwater EPC. The EPCs for the COPCs identified in groundwater at Pier D-1, tetrachloroethene, and arsenic, are presented in Table A-7. Also provided is the frequency of detection, the mean concentration, and the EPC.

Quantification of Exposure Exposures to groundwater were quantified for the worker washing his or her hands and forearms with the groundwater. The exposure parameters, EPCs, and exposure dose calculations are also documented in the risk calculation spreadsheets, presented at the end of this Appendix.

Table A-2
Summary of Human Health Potential Exposure Pathways

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Medium of Exposure	Route of Exposure	Potentially Exposed Population	Selected for Evaluation?	Reason for Selection or Exclusion
Current and Future Land Use				
Surface soil (All 5 sites)	Ingestion and Dermal Contact with soil.	Resident (child and adult) Adult or Child Visitor Base worker	No No No	The material at the land surface can best be described as loose or crushed rock. Material sufficiently small to ingest of adhere to skin is sparse or missing altogether. The soil that is present at the site (i.e. at the Coast Guard Station) has been brought in along with the grass sod.
Subsurface soil (Pier D-1 and Navy Tank Farm)	Ingestion and Dermal Contact with soil.; Fugitive Dust Inhalation.	Excavation worker	Yes	Although the land surface would be difficult to excavate, it may be possible, with heavy machinery, to conduct excavation activities.
Groundwater (All 5 sites)	Groundwater Ingestion (drinking water); Inhalation of volatiles while showering.	Resident (child and adult)	No	No humans are currently using the groundwater because it is of poor yield and poor quality.
	Dermal absorption while washing	Base worker	Yes	The groundwater , although of poor quality and yield, could theoretically be used for nonpotable uses, such as washing.
Sediment and surface water (All 5 sites)	Dermal contact and ingestion of sediment and surface water.	Resident (adult and child) Adult or Child Visitor Base worker	No No No	The site is composed of ship piers, docking and ship support facilities, and administrative buildings. The surrounding seawalls and ship activity do not allow for easy surface water or sediment access. In some areas, surface water or sediment exposure is very dangerous due to the rapid current.
Fish Consumption	Ingestion	Coast Guard Resident Adult and Child Visitor Base worker	Yes Yes Yes	Fishing is currently allowed along Pier D-3 and a small portion of the Navy Fuel Farm. Coast Guard residents also fish at the ends of Piers D1 and D-2. Significant fishing activity was also observed under the bridge leading to Fleming Key, at the corner of the Key West Pipeline Tank Area.
Future Land Use				
Surface Soil Navy Tank Farm	Ingestion and Dermal Contact with soil.	Part Time "snow-bird" resident Adult or Adolescent Visitor Base worker Excavation worker	Yes Yes Yes Yes	The material maybe suitable for trailer parking in the future. Adults or adolescents may visit the area. Base workers may come into contact with the surface material. Excavation workers may come into contact with the surface material.

Table A-3
Selection of Human Health Chemicals of Potential Concern for Subsurface Soil Associated with Pier D-1

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Analyte	Frequency of Detection[1]	Reporting Limit Range	Detected Concentration Range[2]	Mean of Detected Concentrations[3]	Florida Petroleum Cleanup Criteria[4]	Analyte HHCPC? (Yes/No)	Reason[5]
Arsenic	8/8	NR	0.36 to 3.9	1.5	3.7	Y	
Cadmium	8/8	NR	0.15 to 0.99	0.43	1,300	N	P
Chromium	8/8	NR	1.7 to 11.8	4.5	430	N	P
Lead	8/8	NR	0.78 to 59.3	18.5	1,000	N	P
Total Recoverable Petroleum Hydrocarbons (TRPH) (mg/kg)							
TRPH	11/11	NR	37.3 to 3,580	655	2,500	N	P

[1] Frequency of detection is the number of samples in which the analyte was detected over the total number of samples analyzed (excluding rejected values).
[2] The value indicated by an asterisk is the average of a sample and its duplicate. For duplicate samples having one nondetect value, one-half of the contract required quantification limit/contract required detection limit is used as a surrogate concentration for the nondetected concentration.
[3] The mean of detected concentrations is the arithmetic mean of all samples in which the analyte was detected. It does not include those samples with "R", "U", or "UJ" validation qualifiers.
[4] Florida Department of Environmental Protection Petroleum Contamination Site Cleanup Criteria (FAC 62-770), 1997. Values are for a direct industrial exposure (Table IV).
[5] Analyte was included or excluded from the risk assessment for the following reasons:
P = the maximum detected concentration did not exceed the Florida Petroleum Contamination Cleanup Criteria for a Direct Industrial Exposure (FAC 62-770).

Notes: The average of a sample and its duplicate is used for all table calculations.
Samples: SB-124, SB-124, SB-168, SB-169, SB-170, SB-171, SB172, SB-173, SB-174, SB-175, SB-176
Duplicate samples:

HHCPC = human health chemicals of potential concern.
mg/kg = milligrams per kilogram.
NR = not reported.
NSV = no screening value.
* = the average of a sample and its duplicate.

Table A-4
Exposure Point Concentrations for Human Health Chemicals of Potential Concern
Pier D-1 Subsurface Soil

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West, Florida

Chemical	Frequency of Detection[1]	Maximum Detected Concentration	95% UCL[2]	Exposure Point Concentration[3]
Inorganic Analytes (mg/kg)				
Arsenic	8/8	3.9	4.3	3.9

[1] Frequency of detection is the number of samples in which the analyte was detected over the number of samples analyzed.
[2] Ninety-five percent UCL calculated on the arithmetic mean of all samples using one-half the contract-required quantitation limit and contract-required detection limit for nondetected concentrations.
[3] Exposure point concentration equals 95 % UCL unless the maximum detected concentration is less than the 95% UCL. If there are three or fewer total samples, the maximum detected concentration is the exposure point concentration.

Notes: % = percent.
UCL = upper confidence limit.
mg/kg = milligrams per kilogram.

Table A-5
Risk Summary for Pier D-1 Subsurface Soil

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Land Use	Exposure Route	ELCR	HI
Present and Future Land Use			
Excavation Worker:			
Subsurface Soil	Incidental Ingestion	$5x10^{-8}$	0.01
	Dermal Contact	$7x10^{-10}$	$5x10^{-9}$
	Inhalation of fugitive dusts	$5x10^{-9}$	ND
	Total:	**$6x10^{-8}$**	**0.01**

Notes: ELCR = excess lifetime cancer risk.
HI = hazard index.
ND = Not calculated because toxicity data were not available to quantitatively evaluate risk.

Table A-6
Selection of Human Health Contaminants of Potential Concern
Unfiltered Groundwater at Pier D-1

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Analyte	Frequency of Detection[1]	Reporting Limit Range	Detected Concentration Range[2]	Mean[3]	Risk-Based Screening Concentration[4]	Florida Petroleum Cleanup Criteria[5]	HHCPC? (Yes/No)	Reason[6]
Volatile Organic Compounds (µg/ℓ)								
1,1-Dichloroethane	2/14	1 to 5	3.2* to 4.4	3.8	800	NSV	N	S
Ethylbenzene	2/14	1 to 5	1.6 to 10.5*	6.1	1,300	300	N	S,P
Tetrachloroethene	1/14	1 to 5	6.1* to 6.1*	6.1	1.1	NSV	Y	
Toluene	2/14	1 to 5	2 to 6.8*	4.4	750	400	N	S,P
Trichloroethene	2/14	1 to 5	1 to 1.1*	1.1	1.6	NSV	N	S,P
Trichlorofluoromethane	1/14	1 to 5	2.2 to 2.2	2.2	1,300	NSV	N	S,P
o-Xylene	1/6	1 to 1	38.5* to 38.5*	38.5	12,000	200	N	S,P
Semivolatile Organic Compounds (µg/ℓ)								
1-Methylnaphthalene	2/6	1 to 1	5.7 to 52*	28.9	1,500[7]	200[7]	N	S
2-Methylnaphthalene	1/6	1 to 1	38* to 38*	38	1,500[7]	200[7]	N	S
Acenaphthylene	1/14	1 to 10	3.15* to 3.15*	3.2	NSV	2,100	N	
Chrysene	1/14	1 to 10	4.4 to 4.4	4.4	9.2	50	N	S
Fluorene	2/14	1 to 10	2.75* to 3.2	3	1,500[7]	2,800	N	S
Naphthalene	2/14	1 to 10	3.7 to 61.5*	32.6	1,500[7]	2,100	N	S
Phenanthrene	1/14	1 to 10	1.05* to 1.05*	1.1	NSV	2,100	N	P
Inorganic Analytes (µg/ℓ)								
Arsenic	9/9	NR	1.1 to 8	2.9	0.045[8]	500	Y	
Chromium	1/9	7 to 7	7.7 to 7.7	7.7	180[9]	1,000	N	S,P
Lead	1/15	1 to 5	1.3 to 1.3	1.3	NSV	150	N	P

See notes at end of table.

Table A-6 (Continued)
Selection of Human Health Contaminants of Potential Concern
Unfiltered Groundwater at Pier D-1

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Analyte	Frequency of Detection[1]	Reporting Limit Range	Detected Concentration Range[2]	Mean[3]	Risk-Based Screening Concentration[4]	Florida Petroleum Cleanup Criteria[5]	HHCPC? (Yes/No)	Reason[6]
Total Recoverable Petroleum Hydrocarbons (mg/kg)								
TRPH	2/14	0.5 to 1	1.3* to 2.3	1.8	NSV	50	N	P

[1] Frequency of detection is the number of samples in which the analyte was detected divided by the total number of samples analyzed (excluding rejected values).
[2] Value indicated by asterisk is the average of a sample and its duplicate. For nondetect values, one-half the contract-required quantitation limit/contract-required detection limit is used as a surrogate.
[3] The mean of detected concentrations is the arithmetic mean of all samples in which the analyte was detected; it does not include those samples with a "R", "U" , or "UJ" validation qualifier for that analyte.
[4] U.S. Environmental Protection Agency (USEPA) Region III Risk Based Concentration (RBC) for tap water per January 1993 guidance (Selecting Exposure Routes and Chemicals of Concern by Risk-Based Screening, EPA/903/R-93-001) was used for screening. Actual values are taken from the Region III RBC dated 31 January 1997, and are based on a Cancer Risk of 1×10^{-6} or an adjusted Hazard Quotient of 0.1.
[5] Florida Department of Environmental Protection Petroleum Contamination Site Cleanup Criteria (Chapter 62-770, Florida Administrative Code [FAC]), 1997. Values are for Poor Yield/Poor Quality Groundwater (Table VIII).
[6] Analytes were included or excluded from the risk assessment for the following reasons:
S = the maximum detected concentration did not exceed the screening concentration
P = the maximum detected concentration did not exceed the Florida Petroleum Contamination Cleanup Criteria for Poor Yield/Poor Quality Groundwater (FAC 62-770).
C = the analyte is a member of a chemical class which contains other HHCPCs (i.e., carcinogenic polynuclear aromatic hydrocarbons).
R = no risk based screening value is available, therefore, the analyte was retained as a HHCPC.
[7] This value is based on pyrene as a conservative surrogate.
[8] The value is based on arsenic as a carcinogen.
[9] The value is based on hexavalent chromium form.

Notes: The average of a sample and its duplicate is used for all table calculations.
Sample locations include: MW-13, MW-14, MW-15, MW-16, MW-17, MW-18, MW-42, MW-99, MW-101, MW-103, MW-104, MW-105, MW-106D, MW-107
Duplicate samples include:

HHCPC = human health chemicals of potential concern.
$\mu g/\ell$ = micrograms per liter.
NSV = no screening value.

Table A-7
Exposure Point Concentrations for Human Health Chemicals of Potential Concern
Pier D-1 Groundwater

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Chemical	Frequency of Detection	Mean Concentration	Exposure Point Concentration
Volatile Organic Compounds (μg/ℓ)			
Tetrachloroethene	1/14	6.1	6.1
Inorganic Analytes (μg/ℓ)			
Arsenic	9/9	2.9	2.9

[1] Frequency of detection is the number of samples in which the analyte was detected over the number of samples analyzed.

Note: μg/ℓ = micrograms per liter.

Toxicity Assessment The purpose of the toxicity assessment is to identify the adverse effects that are associated with exposure to each analyte and to identify the relationship between level of exposure and severity or likelihood of adverse effects. Dose-response values used in this risk evaluation are current as of June 1999 for IRIS and May 1995 for HEAST.

Risk Characterization Quantitative estimates of both carcinogenic and noncarcinogenic risks were calculated by comparing exposure doses for each COPC to toxicity data. Risks were quantified for each COPC and each complete exposure pathway selected for evaluation in the exposure assessment. A summary of pathway-specific risks is provided in Table A-8.

Table A-8
Risk Summary for Pier D-1 Groundwater

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Land Use	Exposure Route	ELCR	HI
Present and Future Land Use			
Occupational Worker			
Groundwater (Non-Potable)	Incidental Ingestion	4×10^{-7}	0.002
	Dermal Contact	2×10^{-7}	0.001
	Total:	**6×10^{-7}**	**0.003**

Notes: ELCR = excess lifetime cancer risk.
HI = hazard index.

Worker Washing with Groundwater. The cancer risk of the worker using the groundwater to wash his hands and forearms is estimated at 6×10^{-7}. This risk is well below the USEPA acceptable cancer risk range of 1×10^{-6} to 1×10^{-4}. The noncancer risk is also well below a level of concern, with a calculated HI of 0.003.

Pier D-1 Fish Consumption. A total of 23 fish were collected in the Pier D-1 waters. No contaminants were detected in the fish tissue. Therefore, no risks were calculated for this exposure pathway.

Pier D-1 Risk Summary. A summary of total risks for each receptor, by each pathway and medium, is presented in Table A-9. For current and future land use, excavation worker exposures to subsurface soil and a worker washing his hands with groundwater were evaluated. For all exposure scenarios, both cancer and noncancer risk estimates are below USEPA levels of concern.

Table A-9
Total Risk Summary for Pier D-1 Groundwater

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Land Use	Exposure Route	ELCR	HI
Present and Future Land Use			
Excavation Worker:			
Subsurface Soil	Incidental Ingestion, Dermal Contact and Particulate Inhalation	**6×10^{-8}**	**0.01**
Occupational Worker			
Groundwater (Non-Potable)	Incidental Ingestion and Dermal Contact	**6×10^{-7}**	**0.003**

Notes: ELCR = excess lifetime cancer risk.
HI = hazard index.

RGOs Based on the human risk calculation presented above, no RGOs were calculated for either subsurface soil or groundwater at Pier D-1.

A.3 Risk Evaluation for Piers D-2 and D-3 The entire site is covered with concrete except for a small area at the end of Pier D-2 and no natural surface soil is present. Sediment samples were collected at Piers D-2 and D-3 for the ecological analysis, but these samples were not evaluated in the human risk analysis due to the lack of a complete exposure pathway.

Exposure Assessment The exposure assessment involves several steps: (1) characterization of the exposure setting, (2) identification of potential exposure pathways, and (3) quantification of exposure. Because the conditions at Piers D-2 and D-3 are not expected to change in the foreseeable future, the risk analysis is conducted for only once scenario that represents both present and future conditions.

Characterization of Exposure Setting Piers D-2 and D-3 are a highly industrialized area, nearly completely covered with a concrete cap with steel and

concrete bulkheads leading down to the sea bed. Access to Piers D-2 and D-3 is limited to Navy and Coast Guard personnel and the area is completely surrounded with fencing. Access to Piers D-2 and D-3 is via a gate or controlled docking at the pier. No civilian vessels are allowed to dock at Piers D-2 and D-3. There are no recreational facilities at Piers D-2 and D-3.

The only persons at Piers D-2 and D-3 are either Navy or USCG personnel working at the piers. It is unlikely that other Navy or USCG personnel would frequent this area. Visitors are sometimes allowed to fish from a portion of Pier D-3. Visitors would be unable to come into contact with the subsurface soil due to the concrete cap and bulkheads. Land use at Piers D-2 and D-3 is not anticipated to change in the foreseeable future. Even if conditions at Piers D-2 and D-3 were to change, it is highly unlikely that this land would be used for residential purposes. This area would likely be retained for continued docking activity. However, potential activities at Piers D-2 and D-3 may involve removal of portions of the cement cap or bulkhead and excavation of underlying soil (e.g., for additional building construction). Under these conditions, persons engaged in this work could theoretically be exposed to contamination in the subsurface soil.

The groundwater at Piers D-2 and D-3 is considered low yield/poor quality due to the nearby open ocean. The groundwater is currently not used at Piers D-2 and D-3 and there are no plans to use this water in the future. However, if conditions at Piers D-2 and D-3 were to change, it is theoretically possible that the groundwater could be used for non-potable purposes such as washing. The low yield of this groundwater would limit this use to activities such as hand washing. Under these conditions, persons could theoretically be exposed to contamination in the groundwater.

The Navy currently allows fishing activity on and in the immediate area around Pier D-3. This is another potential human exposure pathway.

Identification of Exposure Pathways. Subsurface soil, groundwater, and fish are the only contaminated media at Piers D-2 and D-3 to which receptors could potentially be exposed. From these potential exposure pathways, the following complete exposure pathways were selected for quantitative evaluation: (1) incidental ingestion and dermal contact with subsurface soil and (2) inhalation of fugitive dust generated during excavation activities, (3) incidental ingestion and dermal contact with groundwater during washing, (4) ingestion of fish containing contaminants released from Piers D-2 and D-3. Table A-2 provides a summary of the justification for inclusion or exclusion of potential exposure pathways.

Subsurface Soil Human Health COPCs. No subsurface soil samples were collected at either Pier D-2 or D-3. While this does represent a data gap, it is unlikely to represent a significant one since exposure to subsurface soil would be unlikely due to the concrete cap and bulkheads.

Groundwater Human Health COPCs. A total of 27 groundwater samples were collected at Piers D-2 and D-3. Analytes were selected as groundwater COPCs at Piers D-2 and D-3 using the methodology described above. The COPC selection table in presented in Table A-10. The volatile organic compounds bromodichloromethane, dibromochloromethane, and bromoform were detected above screening concentrations and selected as COPCs for groundwater at Piers D-2 and D-3.

Table A-10
Selection of Human Health Contaminants of Potential Concern
Unfiltered Groundwater at Piers D-2 and D-3

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Analyte	Frequency of Detection[1]	Reporting Limit Range	Detected Concentration Range[2]	Mean[3]	Risk-Based Screening Concentration[4]	Florida Petroleum Cleanup Criteria[5]	HHCPC? (Yes/No)	Reason[6]
Volatile Organic Compounds (µg/ℓ)								
1,1-Dichloroethane	1/27	1 to 1	1.1 to 1.1	1.1	800	NSV	N	S
Benzene	1/27	1 to 1	1 to 1	1	0.36	10	N	P
Bromodichloromethane	1/27	1 to 1	1.1 to 1.1	1.1	0.17	NSV	Y	
Bromoform	1/27	1 to 1	6.5 to 6.5	6.5	2.3	NSV	Y	
Dibromochloromethane	1/27	1 to 1	3.6 to 3.6	3.6	0.13	NSV	Y	
Toluene	1/27	1 to 1	2.4 to 2.4	2.4	750	400	N	S,P
Trichloroethene	1/27	1 to 1	1 to 1	1	1.6	NSV	N	S
Trichlorofluoromethane	1/27	1 to 1	2.1 to 2.1	2.1	1,300	NSV	N	S
Semivolatile Organic Compounds (µg/ℓ)								
1-Methylnaphthalene	4/27	1 to 1	1.1 to 5	3	1,500[7]	200[7]	N	S,P
2-Methylnaphthalene	3/27	1 to 1	1.3 to 3.9	2.2	1,500	200[7]	N	S,P
Acenaphthene	3/27	1 to 1	1.1 to 1.5	1.4	2,200	200	N	S,P
Acenaphthylene	3/27	1 to 1	1.9 to 16	6.7	NSV	2,100	N	S,P
Fluorene	3/27	1 to 1	1.2 to 1.8	1.4	1,500[8]	2,800	N	S,P
Naphthalene	1/27	1 to 1	1.8 to 1.8	1.8	1,500[8]	2,800	N	S,P
Phenanthrene	2/27	1 to 1	1.5 to 2.6	2.1	NSV	2,100	N	P
Pyrene	1/27	1 to 1	1.1 to 1.1	1.1	1,100	2,100	N	S,P
o-Xylene	1/27	1 to 1	1 to 1	1	12,000	200	N	S,P

See notes at end of table.

Table A-10 (Continued)
Selection of Human Health Contaminants of Potential Concern
Unfiltered Groundwater at Piers D-2 and D-3

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Analyte	Frequency of Detection[1]	Reporting Limit Range	Detected Concentration Range[2]	Mean[3]	Risk-Based Screening Concentration[4]	Florida Petroleum Cleanup Criteria[5]	HHCPC? (Yes/No)	Reason[6]
Inorganic Analytes (μg/ℓ)								
Lead	1/27	1 to 5	1.2 to 1.2	1.2	NSV	150	N	P

[1] Frequency of detection is the number of samples in which the analyte was detected divided by the total number of samples analyzed (excluding rejected values).
[2] Value indicated by asterisk is the average of a sample and its duplicate. For nondetect values, 1/2 the CRQL/CRDL is used as a surrogate.
[3] The mean of detected concentrations is the arithmetic mean of all samples in which the analyte was detected; it does not include those samples with a "R", "U", or "UJ" validation qualifier for that analyte.
[4] U.S. Environmental Protection Agency (USEPA) Region III Risk Based Concentration (RBC) for tap water per January 1993 guidance (Selecting Exposure Routes and Chemicals of Concern by Risk-Based Screening, EPA/903/R-93-001) was used for screening. Actual values are taken from the Region III RBC dated 31 January 1995, and are based on a Cancer Risk of 1×10^{-6} or an adjusted Hazard Quotient of 0.1.
[5] Florida Department of Environmental Protection Petroleum Contamination Site Cleanup Criteria (Chapter 62-770, Florida Administrative Code [FAC]), 1997. Values are for Poor Yield/Poor Quality Groundwater (Table VIII).
[6] Analytes were included or excluded from the risk assessment for the following reasons:
S = the maximum detected concentration did not exceed the screening concentration
P = the maximum detected concentration did not exceed the Florida Petroleum Contamination Cleanup Criteria for Poor Yield/Poor Quality Groundwater (FAC 62-770).
C = the analyte is a member of a chemical class which contains other HHCPCs (i.e., carcinogenic polynuclear aromatic hydrocarbons [PAHs]).
R = no risk based screening value is available, therefore, the analyte was retained as a HHCPC.
[7] This value is based on naphthalene as a conservative surrogate.
[8] This value is based on pyrene as a conservative surrogate.
[9] The value is based on arsenic as a carcinogen.

Notes: The average of a sample and its duplicate is used for all table calculations.
Sample locations include: MW-19, MW-20, MW-21, MW-34, MW-35, MW-36, MW-37, MW-38, W-44, MW-46, MW-48D, MW-53, MW-58, MW-63, MW-67D, MW-71D, MW-79, MW-80, MW-81, MW-82, MW-84, MW-88, MW-89, MW-94, MW-95, MW-CG-1, MW-102.
Duplicate samples include:

HHCPC = human health chemicals of potential concern.
μg/ℓ = micrograms per liter.
NSV = no screening value.

Groundwater EPC. The EPC for the COPCs identified in groundwater at Piers D-2 and D-3 are presented in Table A-11. Also provided is the frequency of detection, the mean concentration, and the EPC.

Quantification of Exposure Exposures to groundwater were quantified for the worker washing his hands and forearms with the groundwater. The exposure parameters, EPCs, and exposure dose calculations are also documented in the risk calculation spreadsheets, presented in at the end of this Appendix.

Toxicity Assessment The purpose of the toxicity assessment is to identify the adverse effects that are associated with exposure to each analyte and to identify the relationship between level of exposure and severity or likelihood of adverse effects. Dose-response values used in this risk evaluation are current as of June 1999 for IRIS and May 1995 for HEAST.

Risk Characterization Quantitative estimates of both carcinogenic and noncarcinogenic risks were calculated by comparing exposure doses for each COPC to toxicity data. Risks were quantified for each COPC and each complete exposure pathway selected for evaluation in the exposure assessment. A summary of pathway-specific risks is provided in Table A-12.

Worker Washing with Groundwater.. The cancer risk of the worker using the groundwater to wash his hands and forearms is estimated at 1×10^{-7}. This risk is well below the USEPA acceptable cancer risk range of 1×10^{-6} to 1×10^{-4}. The noncancer risk is also well below a level of concern, with a calculated HI of 0.0005.

Piers D-2 and D-3 Fish Consumption. A total of 23 fish were collected in the Piers D-2 and D-3 waters. No contaminants were detected in the fish tissue. Therefore, no risks were calculated for this exposure pathway.

Piers D-2 and D-3 Risk Summary. A summary of total risks for each receptor, by each pathway and medium, is presented in Table A-12. For current and future land use a worker washing his hands with groundwater was evaluated. For this exposure scenario, both cancer and noncancer risk estimates are below USEPA levels of concern.

A.4 Risk Evaluation for USCG Station The site is partially covered with concrete with open areas consisting of athletic fields and landscaped areas. The material used to develop these areas was brought in for that purpose.

Exposure Assessment The exposure assessment involves several steps: (1) characterization of the exposure setting, (2) identification of potential exposure pathways, and (3) quantification of exposure. Because the conditions at this portion of the site are not expected to change in the foreseeable future, the risk analysis is conducted for only one scenario that represents both present and future conditions.

Characterization of Exposure Setting The USCG Station is a mixed landuse area which includes building, parking areas, and athletic fields. There is a USCG Barracks at the station, which houses unmarried USCG personnel. Access to the USCG Station is via a gate or controlled docking at the adjacent piers. There are recreational facilities at the USCG Station; however, all surface material was brought in with the sod material and trees. These areas were established

Table A-11
Exposure Point Concentrations for Human Health Chemicals of Potential Concern
Piers D-2 and D-3 Groundwater

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Chemical	Frequency of Detection[1]	Mean Concentration	Exposure Point Concentration
Volatile Organic Compounds ($\mu g/\ell$)			
Bromodichloromethane	1/27	1.1	1.1
Bromoform	1/27	6.5	6.5
Dibromochloromethane	1/27	3.6	3.6

[1] Frequency of detection is the number of samples in which the analyte was detected over the number of samples analyzed.

Note: $\mu g/\ell$ = micrograms per liter.

Table A-12
Risk Summary for Pier D-2 and D-3 Groundwater

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Land Use	Exposure Route	ELCR	HI
Present and Future Land Use			
Occupational Worker			
Groundwater (Non-Potable)	Incidental Ingestion	4×10^{-8}	0.0001
	Dermal Contact	1×10^{-7}	0.0003
	Total:	1×10^{-7}	**0.0005**

Notes: ELCR = excess lifetime cancer risk.
HI = hazard index.

after the previous land uses had ceased. Potential contaminant sources presently existing are limited to underground piping.

The only persons at the USCG Station are either civilian workers or USCG Personnel. Visitors normally would be unable to come into contact with the subsurface soil. Land use at the USCG Station is not anticipated to change in the foreseeable future. Even if conditions at the USCG Station were to change, it is highly unlikely that this land would be used for residential purposes. However, potential activities at the USCG Station may involve excavation of soil (e.g., for additional building construction). Under these conditions, persons engaged in this work could theoretically be exposed to contamination in the subsurface soil.

The groundwater at the USCG Station is considered low yield/poor quality due to the nearby open ocean and low soil permeability. The groundwater is currently not used at the USCG Station and there are no plans to use this water in the future. However, if conditions at the USCG Station were to change, it is theoretically possible that the groundwater could be used for non-potable purposes such as washing. The low yield of this groundwater would limit this use to activities such as hand washing. Under these conditions, persons could theoretically be exposed to contamination in the groundwater.

Identification of Exposure Pathways. Subsurface soil and groundwater are the only contaminated media at the USCG Station to which receptors could potentially be exposed. From these potential exposure pathways, the following complete exposure pathways were selected for quantitative evaluation: (1) incidental ingestion and dermal contact with subsurface soil and (2) inhalation of fugitive dust generated during excavation activities, and (3) incidental ingestion and dermal contact with groundwater during washing. Table A-2 provides a summary of the justification for inclusion or exclusion of potential exposure pathways.

Subsurface Soil Human Health COPCs. No subsurface soil samples were collected at the USCG Station. While this does represent a data gap, it is unlikely to represent a significant one since exposure to subsurface soil would be unlikely due to the ongoing land use and the presence of nonsite related surface soil and paved areas.

Groundwater Human Health COPCs. A total of 17 groundwater samples were collected at the USCG Station. Analytes were selected as groundwater COPCs at the USCG Station using the methodology described above. The COPC selection table in presented in Table A-13. Only the inorganic arsenic was detected above screening concentrations and selected as a COPC for groundwater at the USCG Station.

Groundwater EPC. The EPC for the COPCs identified in groundwater at the USCG Station os presented in Table A-14. Also provided is the frequency of detection, the mean concentration, and the EPC.

Quantification of Exposure Exposures to groundwater were quantified for the worker washing his hands and forearms with the groundwater. The exposure parameters, EPCs, and exposure dose calculations are also documented in the risk calculation spreadsheets, presented at the end of this appendix.

Toxicity Assessment The purpose of the toxicity assessment is to identify the adverse effects that are associated with exposure to each analyte and to identify

Table A-13
Selection of Human Health Contaminants of Potential Concern
Groundwater at Coast Guard Station

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Analyte	Frequency of Detection[1]	Reporting Limit Range	Detected Concentration Range[2]	Mean[3]	Risk-Base Screening Concentration[4]	Florida Petroleum Cleanup Criteria[5]	HHCPC? (Yes/No)	Reason[6]
Volatile Organic Compounds (µg/ℓ)								
1,1-Dichloroethane	1/17	1 to 1	3 to 3	3	800	NSV	N	S
Ethylbenzene	1/17	1 to 1	1.3* to 1.3*	1.3	1,300	700	N	S,P
o-Xylene	1/17	1 to 1	1.3* to 1.3*	1.3	12,000	200	N	S,P
Semivolatile Organic Compounds (µg/ℓ)								
1-Methylnaphthalene	2/17	1 to 1	1.9 to 4.3	3.1	1,500[7]	200[7]	N	S
2-Methylnaphthalene	4/17	1 to 1	1.9 to 14	6.5	1,500	200[7]	N	S
Acenaphthene	3/17	1 to 1	1.4* to 9.6	4.2	2,200	200	N	S
Acenaphthylene	5/17	1 to 1	1.1 to 17	5.5	1,500[8]	2,100	N	S
Anthracene	1/17	1 to 1	3 to 3	3	11,000	21,000	N	S
Fluoranthene	1/17	1 to 1	1.3 to 1.3	1.3	1,500[8]	2,800	N	S
Fluorene	3/17	1 to 1	1.5 to 6.3	3.1	1500[8]	2,800	N	S
Naphthalene	2/17	1 to 1	1.3 to 4.8	3.1	1,500[8]	200	N	S
Phenanthrene	2/17	1 to 1	1.5 to 2	1.8	1,500[8]	2,100	N	S
Pyrene	1/17	1 to 1	2.3 to 2.3	2.3	1,100	2,100	N	S
Inorganic Analytes (µg/ℓ)								
Arsenic	1/1	NR	4 to 4	4	0.042[9]	500	Y	
Lead	2/17	1 to 2	1.4 to 3.6	2.5	NSV	150	N	S,P

See notes at end of table.

Table A-13 (Continued)
Selection of Human Health Contaminants of Potential Concern
Groundwater at Coast Guard Station

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Analyte	Frequency of Detection[1]	Reporting Limit Range	Detected Concentration Range[2]	Mean[3]	Risk-Base Screening Concentration[4]	Florida Petroleum Cleanup Criteria[5]	HHCPC? (Yes/No)	Reason[6]
Total Recoverable Petroleum Hydrocarbons (TRPH) (mg/ℓ)								
TRPH	31/7	1 to 1	1.2 to 5.1	3.1	NSV	50	N	P

[1] Frequency of detection is the number of samples in which the analyte was detected divided by the total number of samples analyzed (excluding rejected values).
[2] Value indicated by asterisk is the average of a sample and its duplicate. For nondetect values, 1/2 the CRQL/CRDL is used as a surrogate.
[3] The mean of detected concentrations is the arithmetic mean of all samples in which the analyte was detected; it does not include those samples with a "R", "U" , or "UJ" validation qualifier for that analyte.
[4] U.S. Environmental Protection Agency (USEPA) Region III Risk Based Concentration (RBC) for tap water per January 1993 guidance (Selecting Exposure Routes and Chemicals of Concern by Risk-Based Screening, EPA/903/R-93-001) was used for screening. Actual values are taken from the Region III RBC dated 31 January 1995, and are based on a Cancer Risk of 1×10^{-6} or an adjusted Hazard Quotient of 0.1.
[5] Florida Department of Environmental Protection Petroleum Contamination Site Cleanup Criteria (Chapter 62-770, Florida Administrative Code [FAC]), 1997. Values are for Poor Yield/Poor Quality Groundwater (Table VIII).
[6] Analytes were included or excluded from the risk assessment for the following reasons:
S = the maximum detected concentration did not exceed the screening concentration
P = the maximum detected concentration did not exceed the Florida Petroleum Contamination Cleanup Criteria for Poor Yield/Poor Quality Groundwater (Chapter 62-770, Florida Administrative Code [FAC]).
C = the analyte is a member of a chemical class which contains other HHCPCs (i.e., carcinogenic polynuclear aromatic hydrocarbons [PAHs]).
R = no risk based screening value is available, therefore, the analyte was retained as a HHCPC.
[7] This value is based on naphthalene as a conservative surrogate.
[8] This value is based on pyrene as a conservative surrogate.
[9] The value is based on arsenic as a carcinogen.

Notes: The average of a sample and its duplicate is used for all table calculations.
Sample locations include: MW-64, MW-66, MW-68, MW-69, MW-70, MW-72, MW-83, MW-86, MW-90, MW-91, MW-92D, MW-93, MW-96, MW-97, MW-98, MW-CG-2, MW-100
Duplicate samples include:

HHCPC = human health chemicals of potential concern.
μg/ℓ = micrograms per liter.
NSV = no screening value.
* = the average of a sample and its duplicate.
mg/ℓ = milligrams per liter.

the relationship between level of exposure and severity or likelihood of adverse effects Dose-response values used in this risk evaluation are current as of June 1999 for IRIS and May 1995 for HEAST.

Table A-14
Exposure Point Concentrations for Human Health Chemicals of Potential Concern
Coast Guard Station Groundwater

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Chemical	Frequency of Detection[1]	Mean Concentration	Exposure Point Concentration
Inorganic Analytes (μg/ℓ)			
Arsenic	1/1	4	4

[1] Frequency of detection is the number of samples in which the analyte was detected over the number of samples analyzed.

Note: μg/ℓ = micrograms per liter.

Risk Characterization Quantitative estimates of both carcinogenic and noncarcinogenic risks were calculated by comparing exposure doses for each COPC to toxicity data. Risks were quantified for each COPC and each complete exposure pathway selected for evaluation in the exposure assessment. A summary of pathway-specific risks is provided in Table A-15.

Table A-15
Risk Summary for Coast Guard Station Groundwater

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Land Use	Exposure Route	ELCR	HI
Present and Future Land Use			
Occupational Worker			
Groundwater (Non-Potable)	Incidental Ingestion	5×10^{-7}	0.0003
	Dermal Contact	2×10^{-8}	0.0001
	Total:	**6×10^{-7}**	**0.0005**

Notes: ELCR = excess lifetime cancer risk.
HI = hazard index.

Worker Washing with Groundwater. The cancer risk of the worker using the groundwater to wash his hands and forearms is estimated at is 6×10^{-7}. This risk is well below the USEPA acceptable cancer risk range of 1×10^{-6} to 1×10^{-4}. The noncancer risk is also well below a level of concern, with a calculated HI of 0.0005.

The USCG Station Risk Summary. A summary of total risks for each receptor, by each pathway and medium, is presented in Table A-15. For current and future land use a worker washing his hands with groundwater was evaluated. For this exposure scenario, both cancer and noncancer risk estimates are below USEPA levels of concern.

A.5 Risk Evaluation for the Navy Fuel Tanks Area The Navy Fuel Tank site is an area of bare ground and debris located between the USCG Station and the Key West Pipeline Fuel Tanks. In the past, Navy above ground fuel tanks were located on this site. The tanks have been removed, but some minor rubble and debris currently remains. The surface of the area can best be described as crushed marl rock with an average particle diameter of 3 mm. Some paved and unpaved roads are also present at the site. No surface soil is present at the site.

Exposure Assessment The exposure assessment involves several steps: (1) characterization of the exposure setting, (2) identification of potential exposure pathways, and (3) quantification of exposure. Because the general conditions at the Navy Fuel Tanks area are not expected to change in the foreseeable future, the risk analysis is conducted for only once scenario that represents both present and future conditions.

Characterization of Exposure Setting The Navy Fuel Tanks Area is the former location of numerous cut-and-cover tanks which is now completely covered with crushed concrete paving or crushed marl rock. Access to the Navy Fuel Tanks Area is limited to Navy and Coast Guard personnel and it is completely surrounded with fencing. Access is via a guarded gate. There are no recreational facilities at the site.

Currently the only persons at the Navy Fuel Tanks Area are either Navy workers or Navy personnel. It is unlikely that other Navy or USCG personnel would frequent this area. Visitors would be unable to come into contact with the subsurface soil due to the nature of the surface material land use at the Navy Fuel Tanks area is not clearly defined at this time. It is highly unlikely that this land would be used for residential purposes.

Recent data indicates, however, it is possible that the area could be used for overflow trailer parking during the winter months. This potential site use could allow part-time residents in this area. Additional activities at the site may involve excavation of soil (e.g., for additional building construction). Under these conditions, persons engaged in this work could theoretically be exposed to contamination in the subsurface soil.

The groundwater at the Navy Fuel Tanks area is considered low yield/poor quality due to the nearby open ocean and the low permeability of the fill material. The groundwater is currently not used at the Navy Fuel Tanks area and there are no plans to use this water in the future. However, if conditions were to change, it is theoretically possible that the groundwater could be used for non-potable purposes such as washing. The low yield of this groundwater would limit this use to activities such as hand washing. Under these conditions, persons could theoretically be exposed to contamination in the groundwater.

Identification of Exposure Pathways Surface soil, subsurface soil, and groundwater are the contaminated media at the Navy Fuel Tanks area to which receptors could potentially be exposed. From these potential exposure pathways,

the following complete exposure pathways were selected for quantitative evaluation: (1) incidental ingestion and dermal contact with subsurface soil, (2) inhalation of fugitive dust generated during excavation activities, and (3) incidental ingestion and dermal contact with groundwater during washing. Table A-2 provides a summary of the justification for inclusion or exclusion of potential exposure pathways.

Surface Soil Human Health COPCs. A total of 35 surface soil samples, and four duplicates, were collected from the site and analyzed for various analytical parameters. Fourteen samples were analyzed for Volatile Organic Compounds. Thirty-five samples were analyzed for Semivolatile Organic Compounds. Thirty-three samples were analyzed for arsenic and fourteen samples were analyzed for barium, cadmium, chromium, and lead. Another fourteen samples were analyzed for TRPH. Analytes were selected as surface soil COPCs at the Navy Fuel Tanks area using the methodology described above. The COPC selection table in presented in Table A-16. Arsenic and TRPH were detected above screening concentrations and were selected as COPCs for surface soil at the Navy Fuel Tanks area.

Surface Soil EPC The EPCs for the COPC identified in surface soil at the Navy Fuel Tanks areas, arsenic and TRPH, are presented in Table A-17. Also provided are the frequency of detection, the maximum detected concentration, the 95 percent UCL and the EPC. One sample contained arsenic at 440 μg/kg. the area around this sample is being remediated separately. Therefore, this sample is not included in the risk assessment.

Risk Characterization Quantitative estimates of both carcinogenic and noncarcinogenic risks were calculated by comparing exposure doses for each COPC to toxicity data. Risks were quantified for each COPC and each complete exposure pathway selected for evaluation in the exposure assessment. A summary of pathway-specific risks is provided in Table A-18.

Part-Time "Snow-Bird" Resident The part-time resident cancer risk estimate is 4×10^{-6}. This risk, due to arsenic exposure, is well within the lower end of the USEPA acceptable cancer risk range of 1×10^{-6} to 1×10^{-4}. The noncancer risk is below a level of concern, with a calculated HI of 0.03.

Adult Tresspasser. The adult tresspasser cancer risk estimate is 1×10^{-6}. This risk, due to arsenic exposure, is at the lower end of the USEPA acceptable cancer risk range of 1×10^{-6} to 1×10^{-4}. The noncancer risk is below a level of concern, with a calculated HI of 0.01.

Adolescent Tresspasser. The adolescent tresspasser cancer risk estimate is 2×10^{-6}. This risk, due to arsenic exposure, is below the USEPA acceptable cancer risk range of 1×10^{-6} to 1×10^{-4}. The noncancer risk is below a level of concern, with a calculated HI of 0.01.

Occupational Worker. The occupational worker cancer risk estimate is 4×10^{-6}. This risk, due to arsenic exposure, is well within the lower end of the USEPA acceptable cancer risk range of 1×10^{-6} to 1×10^{-4}. The noncancer risk is also below a level of concern, with a calculated HI of 0.02.

Site Worker. The site worker cancer risk estimate is 4×10^{-7}. This risk, due to arsenic exposure, is below the USEPA acceptable cancer risk range of 1×10^{-6}

Table A-16
Selection of Human Health Chemicals of Potential Concern
Navy Tank Farm Surface Soil

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Analyte	Frequency of Detection[1]	Reporting Limit Range	Detected Concentration Range (*)[2]	Average of Detected Concentrations[3]	Background Screening Concentration[4]	Screening Value[5]	Chemical of Concern
Volatile Organic Compounds (µg/kg)							
Methylene chloride	3/14	6 - 10	4.65* - 10	7.1	NA	850,000	No
Semivolatile Organic Compounds (µg/kg)							
Benzo(a)Anthracene	7/35	170 - 2,800	250 - 990	610	NA	5,100	No
Benzo(a)Pyrene	6/35	170 - 2,800	142.5* - 980	609	NA	500	Yes
Benzo(b)Fluoranthene	7/35	170 - 2,800	147.5* - 940	574	NA	5,000	No
Benzo(g,h,i)Perylene	4/35	170 - 2,800	200 - 940	565	NA	450,000,000	No
Benzo(k)Fluoranthene	8/35	170 - 2,800	147.5* - 970	508	NA	52,000	No
Chrysene	9/35	170 - 2,800	180 - 1,100	555	NA	490,000	No
Dibenzo(a,h)anthracene	1/35	170 - 2,800	940	940	NA	500	Yes
Fluoranthene	15/35	170 - 2,800	150* - 6,200	1,066	NA	45,000,000	No
Indeno(1,2,3-cd)pyrene	4/35	170 - 2,800	190 - 940	553	NA	8,600,000	No
Naphthalene	1/35	12 - 2,800	350	350	NA	8,600,000	No
Phenanthrene	7/35	170 - 2,800	215* - 990	510	NA	29, 000,000	No
Pyrene	11/35	170 - 2,800	240 - 6,100	1,236	NA	29, 000,000	No
Pesticides/PCBs (µg/kg)							
Not Analyzed							
Inorganic Analytes (mg/kg)							
Arsenic	33/33	1 - 1.3	1.5 - 46	8.9	6.9	[6] 3.7	Yes
Barium, total	14/14	1 - 1	8 - 30	15.6		87,000	No
Cadmium, total	2/14	1 - 1	0.64 - 0.71	0.67		1,300	No
Chromium	14/14	1 -1	2.5 - 12	4.74			
Lead, total	14/14	5 - 6	16 - 350	68.8		1,000	No

See notes at end of table.

Table A-16 (Continued)
Selection of Human Health Chemicals of Potential Concern
Navy Tank Farm Surface Soil

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Analyte	Frequency of Detection[1]	Reporting Limit Range	Detected Concentration Range (*)[2]	Average of Detected Concentrations[3]	Background Screening Concentration[4]	Screening Value[5]	Chemical of Concern
Total Petroleum Recoverable Hydrocarbons (mg/kg)							
TRPH-Florida PRO	37/39	4,200 - 22,000	7,625* - 1,200,000	140,289		2,500	Yes

[1] Frequency of detection is the number of samples in which the analyte was detected in relation to the total number of samples analyzed (excluding rejected values).
[2] The value indicated by an asterisk is the average of a sample and its duplicate. For duplicate samples having one nondetect value, one-half of the contract required quantification limit/contract required detection limit is used as a surrogate concentration for the sample where nondetect was reported.
[3] The average of detected concentrations is the arithmetic average of all samples in which the analyte was detected. It does not include those samples with "R", "U", or "UJ" validation qualifiers.
[4] The background screening concentration is twice the average of detected concentrations for inorganic analytes in background samples.
[5] The screening concentrations are taken from Table IV of FAC Chapter 62-770,Petroleum Contamination Site Cleanup Criteria, dated 9/23/97. The screening values are based on worker industrial exposure.
[8] The value is based on arsenic as a carcinogen

Notes: The average of a sample and its duplicate is used for all table calculations.

Samples: 01B24001, 01B24101, 01B24201, 01B24301, 01B24401, 01B24501, 01B24601, 01B24701, 01B24801, 01B24901, ,01B25001, 01B25101, 01B25201, 01B25301, 01B25401, 01B25601, 01B25701, 01B25801, 01B25801D,01B25901, 01B26101, 01B26201, 01B26301, 01B26401, 01B26501, 01B26601, 01B26701,01B26801, 01B26901, 01B27001, 01B27101, 01B27201, 01B27301, 01B27401, 01B27501, 01B27601, 01B27701, 01B27801, 01B27901, 01B28001, 01B24001, 01B24101, 01B24201, 01B24301, 01B24401, 01B24501, 01B24601, 01B24701, 01B24801, 01B24901, 01B24901D,01B26101, 01B26201, 01B26301, 01B26401, 01B26501, 01B26601, 01B26701, ,01B26801, 01B26901,
Duplicate samples: 01B24901D, 01B25801D, 01B26101D, 01B26701D.
Background samples: 01B27601, 01B27701, 01B27801, 01B27901, 01B28001.

* = see footnote 2.
μg/kg = micrograms per kilogram.
PCBs = polychlorinated biphenyls.
mg/kg = milligrams per kilogram.
ND = not detected in any background sample.

Table A-17
Exposure Point Concentrations for Human Health Chemicals of Potential Concern, Navy Tank Farm Surface Soil

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Analyte	Frequency of Detection[1]	Maximum Detected Concentration	95% UCL[2]	Exposure Point Concentration[3]
Volatile Organic Compounds (μg/kg)				
No Analytes Detected				
Semivolatile Organic Compounds (μg/kg)				
Benzo(a)Pyrene	6/35	980	433	433
Dibenzo(a,h)anthracene	1/35	940	340	340
Pesticides/PCBs (μg/kg)				
Not Analyzed				
Inorganic Analytes (mg/kg)				
Arsenic	33/33	46	13.3	13.3
Total Petroleum Recoverable Hydrocarbons (mg/kg)				
TRPH-Florida PRO	13/14	450,000	1,056,001	450,000

[1] Frequency of detection is the number of samples in which the analyte was detected in relation to the total number of samples analyzed (excluding rejected values).
[2] The 95th percent upper confidence limit (UCL) is calculated on the log-transformed average of all samples using the formula provided in the USEPA "Supplemental Guidance to RAGS: Calculating the Concentration Term."
[3] The Exposure Point Concentration (EPC) is the lesser of the maximum detected concentration or the 95 percent UCL.

Notes: μg/kg = microgram per kilogram.
PCBs = polychlorinated biphenyls.
mg/kg = milligrams per kilogram.
TRPH = total recoverable petroleum hydrocarbon.

Table A-18
Risk Summary for Navy Tank Farm Surface Soil

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Land Use	Exposure Route	ELCR	HI
Present and Future Land Use			
Part-Time Resident:			
Surface Soil	Incidental ingestion	7×10^{-6}	0.05
	Dermal contact	2×10^{-6}	0.04
	Inhalation of fugitive dusts	2×10^{-10}	ND
	Total	**8×10^{-6}**	**0.09**
Adult Tresspasser:			
Surface Soil	Incidental ingestion	2×10^{-6}	0.01
	Dermal contact	3×10^{-8}	0.01
	Inhalation of fugitive dusts	6×10^{-12}	ND
	Total	**2×10^{-6}**	**0.02**
Adolescent Tresspasser			
Surface Soil	Incidental ingestion	3×10^{-7}	0.04
	Dermal contact	5×10^{-8}	0.01
	Inhalation of fugitive dusts	3×10^{-14}	ND
	Total	**3×10^{-7}**	**0.05**
Occupational Worker:			
Surface Soil	Incidental ingestion	6×10^{-6}	0.03
	Dermal contact	9×10^{-8}	0.02
	Inhalation of fugitive dusts	1×10^{-10}	ND
	Total	**7×10^{-6}**	**0.06**
Site Worker:			
Surface Soil	Incidental ingestion	5×10^{-7}	0.003
	Dermal contact	3×10^{-7}	0.01
	Inhalation of fugitive dusts	2×10^{-13}	ND
	Total	**8×10^{-7}**	**0.01**
Excavation Worker:			
Surface Soil	Incidental ingestion	3×10^{-7}	0.04
	Dermal contact	1×10^{-8}	0.01
	Inhalation of fugitive dusts	1×10^{-14}	ND
	Total	**3×10^{-7}**	**0.05**

Notes: ELCR = excess lifetime cancer risk.
HI = hazard index.
ND = not calculated because toxicity that were not available to quantitatively evaluate risk.

to 1×10^{-4}. The noncancer risk is also below a level of concern, with a calculated HI of 0.002.

Excavation Worker. The excavation worker cancer risk estimate is 6×10^{-8}. This risk, due to arsenic exposure, is well below the USEPA acceptable cancer risk range of 1×10^{-6} to 1×10^{-4}. The noncancer risk is also below a level of concern, with a calculated HI of 0.02.

Subsurface Soil Human Health COPCs A total of 38 subsurface soil samples were collected during monitoring well installation. These sample locations were: SB-138, SB-139, SB-140, SB-142, SB-143, SB-144, SB-145, SB-146, SB-147, SB-148, SB-149, SB-150, SB-151, SB-152, SB-153, SB-154, SB-155, SB-156(1), SB-156(2), SB-156(3), SB-157, SB-157, SB-158, SB-166, SB-177, SB-178, SB-223, SB-224, SB-225, SB-226, SB-227, SB-228, SB-229, SB-230, SB-238,(1), SB-238(2), SB-239(1), SB-239(2). All samples were analyzed for the metals arsenic, cadmium, chromium and lead. Analytes were selected as subsurface soil COPCs at the Navy Fuel Tanks area using the methodology described above. The COPC selection table in presented in Table A-19. Only the inorganic arsenic was detected above screening concentrations and was selected as a COPC for subsurface soil at the Navy Fuel Tanks area.

Subsurface Soil EPC. The EPC for the COPC identified in subsurface soil at the Navy Fuel Tanks areas, arsenic, is presented in Table A-20. Also provided is the frequency of detection, the maximum detected concentration, the 95 percent UCL, if calculated, and the EPC.

Quantification of Exposure Exposures to subsurface soil were quantified for the excavation worker. The exposure parameters, EPCs, and exposure dose calculations are also documented in the risk calculation spreadsheets, presented at the end of this appendix.

Toxicity Assessment The purpose of the toxicity assessment is to identify the adverse effects that are associated with exposure to each analyte and to identify the relationship between level of exposure and severity or likelihood of adverse effects. Dose-response values used in this risk evaluation are current as of June 1999 for IRIS and May 1995 for HEAST.

Risk Characterization Quantitative estimates of both carcinogenic and noncarcinogenic risks were calculated by comparing exposure doses for each COPC to toxicity data. Risks were quantified for each COPC and each complete exposure pathway selected for evaluation in the exposure assessment. A summary of pathway-specific risks is provided in Table A-21.

Excavation Worker. The excavation worker cancer risk estimate is 6×10^{-8}. This risk, due to arsenic exposure, is well below the USEPA acceptable cancer risk range of 1×10^{-6} to 1×10^{-4}. The noncancer risk is also below a level of concern, with a calculated HI of 0.01.

Groundwater Human Health COPCs. A total of 34 groundwater samples were collected at the Navy Fuel Tanks area. Analytes were selected as groundwater COPCs using the methodology described above. The COPC selection table is presented in Table A-22. The volatile organic compound benzene and the inorganic arsenic were selected as COPCs in the groundwater at the Navy Fuel Tank area.

Table A-19
Selection of Human Health Chemicals of Potential Concern
Navy Tank Farm Subsurface Soil

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Analyte	Frequency of Detection[1]	Reporting Limit Range	Detected Concentration Range[2]	Mean of Detected Concentrations[3]	Florida Soil Cleanup Goals[4]	Analyte HHCPC? (Yes/No)	Reason[5]
Semivolatile Organic Compounds (μg/kg)							
2-Methylnaphthalene	1/3	390 to 480	9,000 to 9,000	9,000	8600	N	P
Anthracene	1/3	390 to 480	1,800 to 1,800	1,800	290,000	N	P
Phenanthrene	1/3	460 to 480	230 to 230	230	29,000	N	P
Pyrene	1/3	390 to 480	220 to 220	220	40,000	N	P
Inorganic Analytes (mg/kg)							
Arsenic	29/30	0.5 to 0.5	0.59 to 12.5	4.3	3.7	Y	
Cadmium	19/30	0.11 to 0.5	0.16 to 0.53	0.26	1300	N	P
Chromium	29/30	2.5 to 2.5	2 to 22.9	3.8	430	N	P
Lead	29/30	2.5 to 2.5	1.6 to 323	25.2	1,000	N	P
Total Recoverable Petroleum Hydrocarbons (mg/kg)							
TRPH	27/35	30.8 to 35.8	30.9* to 35.8	4,580	NSV	2,500	N

[1] Frequency of detection is the number of samples in which the analyte was detected over the total number of samples analyzed (excluding rejected values).
[2] The value indicated by an asterisk is the average of a sample and its duplicate. For duplicate samples having one nondetect value, one-half of the contract required quantification limit/contract required detection limit is used as a surrogate concentration for the nondetected concentration.
[3] The mean of detected concentrations is the arithmetic mean of all samples in which the analyte was detected. It does not include those samples with "R", "U", or "UJ" validation qualifiers.
[4] Florida Department of Environmental Protection Petroleum Contamination Site Cleanup Criteria (Chapter 62-770, FAC), 1997. Values are for a direct industrial exposure (Table IV).
[5] Analyte was included or excluded from the risk assessment for the following reasons:
P = the maximum detected concentration did not exceed the Florida Petroleum Contamination Cleanup Criteria for a Direct Industrial Exposure (FAC 62-770).

Notes: HHCPC = human health chemicals of potential concern.
μg/kg = micrograms per kilogram
mg/kg = milligrams per kilogram.
NSV = no screening value.
* = the average of a sample and its duplicate.

Table A-20
Exposure Point Concentrations for Human Health Chemicals of Potential Concern, Navy Tank Farm Subsurface Soil

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Chemical	Frequency of Detection[1]	Mean Concentration	95% UCL[2]	Exposure Point Concentration
Inorganic Analytes (mg/kg)				
Arsenic	29/30	4.3	6.6	4.3

[1] Frequency of detection is the number of samples in which the analyte was detected over the number of samples analyzed.
[2] Ninety-five percent UCL calculated on the arithmetic mean of all samples using one-half the contract-required quantitation limit and contract-required detection limit for nondetected concentrations.
[3] Exposure point concentration equals 95% UCL unless the maximum detected concentration is less than the 95% UCL. If there are ten or fewer total samples, the maximum detected concentration is the exposure point concentration.

Note: % = percent.
UCL = upper confidence limit.
mg/kg = milligrams per kilogram.

Table A-21
Risk Summary for Navy Tank Farm Subsurface Soil

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Land Use	Exposure Route	ELCR	HI
Present and Future Land Use			
Excavation Worker:			
Subsurface Soil	Incidental ingestion	5×10^{-8}	0.01
	Dermal contact	7×10^{-10}	5×10^{-9}
	Inhalation of fugitive dusts	5×10^{-8}	ND
	Total	**6×10^{-8}**	**0.01**

Notes: ELCR = excess lifetime cancer risk.
HI = hazard index.
ND = not calculated because toxicity that was not available to quantitatively evaluate risk.

Table A-22
Selection of Human Health Contaminants of Potential Concern
Groundwater at Navy Tank Farm

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Analyte	Frequency of Detection[1]	Reporting Limit Range	Detected Concentration Range[2]	Mean[3]	Risk-Base Screening Concentration[4]	Florida Petroleum Cleanup Criteria[5]	HHCPC? (Yes/No)	Reason[6]
Volatile Organic Compounds (µg/ℓ)								
1,1-Dichloroethane	1/33	1 to 5	4 to 4	4	800	NSV	N	S
Benzene	3/33	1 to 5	1.1 to 12	4.8	0.36	10	Y	
Ethylbenzene	2/33	1 to 5	2.2 to 3.6	2.9	1,300	300	N	S,G
Toluene	3/33	1 to 5	1 to 1.6	1.3	750	400	N	S
o-Xylene	1/27	1 to 1	1.2 to 1.2	1.2	12,000	200	N	S, G
Semivolatile Organic Compounds (µg/ℓ)								
1-Methylnaphthalene	7/28	1 to 5.5	1.65* to 98	21.3	1,500[7]	200[7]	N	S
2-Methylnaphthalene	7/28	1 to 5.5	1.4 to 91	22.8	1,500	200[7]	N	S
Methyl tert-butyl ether	1/27	1 to 1	3.5 to 3.5	3.5	6,300	350	N	S
Acenaphthene	6/34	1 to 10	1.5 to 6.6	3.1	2,200	200	N	S
Acenaphthylene	8/34	1 to 10	1.1 to 37	7.7	1,500[8]	2,100	N	S
Anthracene	1/34	1 to 10	2.4 to 2.4	2.4	11,000	21,000	N	S
Fluoranthene	2/34	1 to 10	2.2 to 3.3	2.8	1,500[8]	2,800	N	S
Fluorene	7/34	1 to 10	1.2 to 76	13.1	1,500[8]	2,800	N	S
Naphthalene	4/34	0.5 to 10	0.8* to 7.8	3.4	1,500[8]	200	N	S
Phenanthrene	10/34	1 to 10	1.4 to 34.7*	7.1	1,500[8]	2,100	N	S
Inorganic Analytes (µg/ℓ)								
Arsenic	9/9	NR	1.9 to 14.5	6.3	0.045[9]	500	Y	
Cadmium	1/9	1 to 1	1.1 to 1.1	1.1	18	50	N	S, G
Lead	4/36	1 to 5	1.2 to 12	5.9	NSV	150	N	G

See notes at end of table.

Table A-22 (Continued)
Selection of Human Health Contaminants of Potential Concern
Groundwater at Navy Tank Farm

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Analyte	Frequency of Detection[1]	Reporting Limit Range	Detected Concentration Range[2]	Mean[3]	Risk-Base Screening Concentration[4]	Florida Petroleum Cleanup Criteria[5]	HHCPC? (Yes/No)	Reason[6]
Total Recoverable Petroleum Hydrocarbons (TRPH) (mg/ℓ)								
TRPH	2/33	1 to 1	1.9 to 15.7	8.8	NSV	50	N	

[1] Frequency of detection is the number of samples in which the analyte was detected divided by the total number of samples analyzed (excluding rejected values).
[2] Value indicated by asterisk is the average of a sample and its duplicate. For nondetect values, 1/2 the CRQL/CRDL is used as a surrogate.
[3] The mean of detected concentrations is the arithmetic mean of all samples in which the analyte was detected; it does not include those samples with a "R", "U" , or "UJ" validation qualifier for that analyte.
[4] U.S. Environmental Protection Agency (USEPA) Region III Risk Based Concentration (RBC) for tap water per January 1993 guidance (Selecting Exposure Routes and Chemicals of Concern by Risk-Based Screening, EPA/903/R-93-001) was used for screening. Actual values are taken from the Region III RBC dated 31 January 1995, and are based on a Cancer Risk of 1×10^{-6} or an adjusted Hazard Quotient of 0.1.
[5] Florida Department of Environmental Protection Petroleum Contamination Site Cleanup Criteria (FAC 62-770), 1997. Values are for Poor Yield/Poor Quality Groundwater (Table VIII).
[6] Analytes were included or excluded from the risk assessment for the following reasons:
S = the maximum detected concentration did not exceed the screening concentration
P = the maximum detected concentration did not exceed the Florida Petroleum Contamination Cleanup Criteria for Poor Yield/Poor Quality Groundwater (Chapter 62-770, FAC).
C = the analyte is a member of a chemical class which contains other HHCPCs (i.e., carcinogenic polynuclear aromatic hydrocarbons [PAHs]).
R = no risk based screening value is available, therefore, the analyte was retained as a HHCPC.
[7] This value is based on naphthalene as a conservative surrogate.
[8] This value is based on pyrene as a conservative surrogate.
[9] The value is based on arsenic as a carcinogen.

Notes: The average of a sample and its duplicate is used for all table calculations.
Sample locations include: KMW-01, KMW-02, KMW-25, MW-5, MW-6, MW-7,MW-10, MW-12, MW-22, MW-22, MW-23, MW-24, MW-25, MW-26, MW-27, MW-28, MW-29, MW-30, MW-31, MW-33, MW-39, MW-40, MW-45D, MW-47D, MW-49, MW-50, MW-51, MW-52, MW-54, MW-73, MW-76, MW-77D, MW-85D, MW-87D, MW-9-11, MW-9-13
Duplicate samples include:

HHCPC = human health chemicals of potential concern.
μg/ℓ = micrograms per liter.
NSV = no screening value.
* = the average of a sample and its duplicate.
mg/ℓ = milligrams per liter.

Groundwater EPC. The EPC for the COPCs identified in groundwater at Navy Fuel Tanks area is presented in Table A-23. Also provided are the frequency of detection, the mean concentration, and the EPC.

Table A-23
Exposure Point Concentrations for Human Health Chemicals of Potential Concern for Navy Tank Farm Groundwater

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Chemical	Frequency of Detection[1]	Mean Concentration	Exposure Point Concentration
Volatile Organic Compounds (μg/ℓ)			
Benzene	3/33	4.8	4.8
Inorganic Analytes (μg/ℓ)			
Arsenic	9/9	6.3	4

[1] Frequency of detection is the number of samples in which the analyte was detected over the number of samples analyzed.

Note: μg/ℓ = micrograms per liter.

Quantification of Exposure Exposures to groundwater were quantified for the worker washing his hands and forearms with the groundwater. The exposure parameters, EPCs, and exposure dose calculations are also documented in the risk calculation spreadsheets, presented at the end of this appendix.

Toxicity Assessment The purpose of the toxicity assessment is to identify the adverse effects that are associated with exposure to each analyte and to identify the relationship between level of exposure and severity or likelihood of adverse effects. Dose-response values used in this risk evaluation are current as of June 1999 for IRIS and May 1995 for HEAST.

Risk Characterization Quantitative estimates of both carcinogenic and noncarcinogenic risks were calculated by comparing exposure doses for each COPC to toxicity data. Risks were quantified for each COPC and each complete exposure pathway selected for evaluation in the exposure assessment. A summary of pathway-specific risks is provided in Table A-24.

Worker Washing with Groundwater.. The cancer risk of the worker using the groundwater to has his hands and forearms is estimated at is 9×10^{-7}. This risk is below the USEPA acceptable cancer risk range of 1×10^{-6} to 1×10^{-4}. The noncancer risk is also well below a level of concern, with a calculated HI of 0.007.

Navy Tank Farm Risk Summary. A summary of total risks for each receptor, by each pathway and medium, is presented in Table A-25. For current and future land use, excavation worker exposures to subsurface soil and a worker washing his hands with groundwater were evaluated. For all exposure scenarios, both cancer and noncancer risk estimates are below USEPA levels of concern.

Table A-24
Risk Summary for Navy Tank Farm Groundwater

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Land Use	Exposure Route	ELCR	HI
Present and Future Land Use			
Occupational Worker			
Groundwater (Non-Potable)	Incidental Ingestion	9×10^{-7}	0.006
	Dermal Contact	7×10^{-8}	0.001
	Total:	**9×10^{-7}**	**0.007**

Notes: ELCR = excess lifetime cancer risk.
HI = hazard index.

Table A-25
Total Risk Summary for the Navy Tank Fuel Farm

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Land Use	Exposure Route	ELCR	HI
Present and Future Land Use			
Part-Time "Snow-Bird" Resident:			
Surface Soil	Incidental Ingestion, Dermal Contact and Particulate Inhalation	**8×10^{-6}**	**0.09**
Adult Tresspasser:			
Surface Soil	Incidental Ingestion, Dermal Contact and Particulate Inhalation	**2×10^{-6}**	**0.02**
Adolescent Tresspasser:			
Surface Soil	Incidental Ingestion, Dermal Contact and Particulate Inhalation	**3×10^{-7}**	**0.05**
Occupational Worker:			
Surface Soil	Incidental Ingestion, Dermal Contact and Particulate Inhalation	**7×10^{-6}**	**0.06**
Groundwater	Incidental Ingestion and Dermal Contact	**9×10^{-7}**	**.007**
Site Worker:			
Surface Soil	Incidental Ingestion, Dermal Contact and Particulate Inhalation	**8×10^{-7}**	**0.01**
Groundwater (Non-Potable)	Incidental Ingestion and Dermal Contact	**9×10^{-7}**	**0.007**
Excavation Worker:			
Surface Soil	Incidental Ingestion, Dermal Contact and Particulate Inhalation	**3×10^{-7}**	**0.05**
Subsurface Soil	Incidental Ingestion, Dermal Contact and Particulate Inhalation	**6×10^{-8}**	**0.01**

Notes: ELCR = excess lifetime cancer risk.
HI = hazard index.

RGOs The cancer risk for the part-time "snow-bird" resident and occupational worker surface soil exposure were identical. The RGO for arsenic in surface soil is presented in Table A-26. Note that the RGO level for $1x10^{-6}$ is much less than the site-specific background. Therefore the recommended RGO for surface soil is recommended to be the background value of 6.9 mg/kg.

Table A-26
Remedial Goal Options for the Navy Tank Fuel Farm

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Chemical	Frequency of Detection[1]	Background	Exposure Point Concentration	Carcinogenic Risks		
Inorganic Analytes (mg/kg)						
Part-Time "Snow-Bird Resident:				1×10^{-4}	1×10^{-4}	1×10^{-4}
Arsenic	26/28	6.9	13.3	NA	NA	3.3

[1] Frequency of detection is the number of samples in which the analyte was detected over the number of samples analyzed.

Note: mg/kg = milligrams per kilogram.

A.6 Risk Evaluation for Key West Pipeline Tanks Area The Key West Pipeline Tanks area is the site of above ground fuel tanks, located north of the Navy Tank Farm. The tanks are surrounded with crushed marl berms. The surface of the area can best be described as crushed marl rock with an average particle diameter of 3 mm. Some unpaved roads are also present at the site. No surface soil is present at the site.

Exposure Assessment The exposure assessment involves several steps: (1) characterization of the exposure setting, (2) identification of potential exposure pathways, and (3) quantification of exposure. Because the conditions at Key West Pipeline Tanks area are not expected to change in the foreseeable future, the risk analysis is conducted for only one scenario that represents both present and future conditions.

Characterization of Exposure Setting. The Key West Pipeline Tanks area is an industrialized area covered with crushed marl rock. Access to the area is limited to Navy and Key West Pipeline Company personnel via a guarded gate. There are no recreational facilities at the Key West Pipeline Tanks area.

The only persons at the Key West Pipeline Tanks area are either Navy workers or Key West Pipeline Company personnel. It is unlikely that other Navy or USCG personnel would frequent this area. Visitors would be unable to come into contact with the subsurface soil due to the nature of the surface material. Land use at the site is not anticipated to change in the foreseeable future. Even if conditions at the site were to change, it is unlikely that this land would be used for residential purposes. However, potential activities at the Key West Pipeline Tanks area may involve the excavation of underlying soil (e.g., for additional building construction). Under these conditions, persons engaged in this work could theoretically be exposed to contamination in the subsurface soil.

The groundwater at the Key West Pipeline Tanks area is considered low yield/poor quality due to the nearby open ocean. The groundwater is currently not used at the site and there are no plans to use this water in the future. However, if conditions the site were to change, it is theoretically possible that the groundwater could be used for non-potable purposes such as washing. The low yield of this groundwater would limit this use to activities such as hand washing. Under these conditions, persons could theoretically be exposed to contamination in the groundwater.

Identification of Exposure Pathways. Groundwater is the only contaminated media at the Key West Pipeline Tanks area to which receptors could potentially be exposed. The only complete exposure pathway selected was incidental ingestion and dermal contact with groundwater during washing. Table A-2 provides a summary of the justification for inclusion or exclusion of potential exposure pathways.

Groundwater Human Health COPCs. A total of 17 groundwater samples were collected at the Key West Pipeline Tanks area. Analytes were selected as groundwater COPCs at the site using the methodology described above. The COPC selection table in presented in Table A-27. The volatile organic compounds benzene and trichloroethylene and the inorganic arsenic were selected as COPCs in the groundwater at the Key West Pipeline Tanks area.

Groundwater EPC. The EPC for the COPCs identified in groundwater at the Key West Pipeline Tanks area is presented in Table A-28. Also provided are the frequency of detection, the mean concentration, and the EPC.

Quantification of Exposure Exposures to groundwater were quantified for the worker washing his hands and forearms with the groundwater. The exposure parameters, EPCs, and exposure dose calculations are also documented in the risk calculation spreadsheets, presented at the end of this appendix.

Toxicity Assessment The purpose of the toxicity assessment is to identify the adverse effects that are associated with exposure to each analyte and to identify the relationship between level of exposure and severity or likelihood of adverse effects. Dose-response values used in this risk evaluation are current as of June 1999 for IRIS and May 1995 for HEAST.

Risk Characterization Quantitative estimates of both carcinogenic and noncarcinogenic risks were calculated by comparing exposure doses for each COPC to toxicity data. Risks were quantified for each COPC and each complete exposure pathway selected for evaluation in the exposure assessment. A summary of pathway-specific risks is provided in Table A-29.

Worker Washing with Groundwater. The cancer risk of the worker using the groundwater to wash his hands and forearms is estimated at is 4×10^{-6}. This risk is well within the USEPA acceptable cancer risk range of 1×10^{-6} to 1×10^{-4}. The noncancer risk is also well below a level of concern, with a calculated HI of 0.12.

Key West Pipeline Tanks Area Risk Summary. A summary of total risks for each receptor, by each pathway and medium, is presented in Table A-29. For current and future land use a worker washing his hands with groundwater was evaluated. For all exposure scenarios, both cancer and noncancer risk estimates are below USEPA levels of concern.

Table A-27
Selection of Human Health Contaminants of Potential Concern
Groundwater at Key West Pipeline

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Analyte	Frequency of Detection[1]	Reporting Limit Range	Detected Concentration Range[2]	Mean[3]	Risk-Based Screening concentration[4]	Florida Petroleum Cleanup Criteria[5]	HHCPC? (Yes/No)	Reason[6]
Volatile Organic Compounds (µg/ℓ)								
Benzene	6/17	1 to 1	4.3 to 965*	283	0.36	10	Y	
Chlorobenzene	1/17	1 to 1	1.3* to 1.3*	1.3	39	NSV	N	S
Ethylbenzene	6/17	1 to 1	1.4 to 190*	42.6	1,300	300	N	S, P
Toluene	2/17	1 to 1	1.3 to 2.35*	1.8	750	400	N	S, P
Trichloroethene	1/17	1 to 1.5	3.4 to 3.4	3.4	1.6	NSV	Y	
o-Xylene	3/17	1 to 1	2.5* to 2.6	2.5	12,000	200	N	S, P
Semivolatile Organic Compounds (µg/ℓ)								
1-Methylnaphthalene	10/17	1 to 1	1.4 to 970	116	1,500[7]	200[7]	N	S, P
2-Methylnaphthalene	10/17	1 to 1	2.4 to 650	82.9	1,500	200[7]	N	S, P
Acenaphthene	8/17	1 to 1	1.2 to 63	9.9	2,200	200	N	S, P
Acenaphthylene	10/17	1 to 1	1 to 120	15.7	1,500[8]	2,100	N	S, P
Anthracene	4/17	1 to 1	1.4 to 16	5.4	11,000	21,000	N	S, P
Fluorene	7/17	1 to 10	1.4 to 26	8	1,500[8]	2,800	N	S, P
Naphthalene	11/17	1 to 1	1 to 130	15.9	1,500	200	N	S, P
Phenanthrene	7/17	1 to 10	1.4 to 6.1	3.1	1,500[8]	2,100	N	S, P
Inorganic Analyte (mg/ℓ)								
Arsenic	1/1	NR	10.2 to 10.2	10.2	0.045[9]	500	Y	
Lead	2/18	1 to 5	1.4 to 1.5	1.5	NSV	150	N	P

See notes at end of table.

Table A-27 (Continued)
Selection of Human Health Contaminants of Potential Concern
Groundwater at Key West Pipeline

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Analyte	Frequency of Detection[1]	Reporting Limit Range	Detected Concentration Range[2]	Mean[3]	Risk-Based Screening concentration[4]	Florida Petroleum Cleanup Criteria[5]	HHCPC? (Yes/No)	Reason[6]
Total Recoverable Petroleum Hydrocarbons (TRPH) (mg/ℓ)								
TRPH	5/17	1 to 1	1.1 to 157	32.9	NSV	40	N	P

[1] Frequency of detection is the number of samples in which the analyte was detected divided by the total number of samples analyzed (excluding rejected values).
[2] Value indicated by asterisk is the average of a sample and its duplicate. For nondetect values, 1/2 the CRQL/CRDL is used as a surrogate.
[3] The mean of detected concentrations is the arithmetic mean of all samples in which the analyte was detected; it does not include those samples with a "R", "U", or "UJ" validation qualifier for that analyte.
[4] U.S. Environmental Protection Agency (USEPA) Region III Risk Based Concentration (RBC) for tap water per January 1993 guidance (Selecting Exposure Routes and Chemicals of Concern by Risk-Based Screening, EPA/903/R-93-001) was used for screening. Actual values are taken from the Region III RBC dated 31 January 1995, and are based on a Cancer Risk of 1×10^{-6} or an adjusted Hazard Quotient of 0.1.
[5] Florida Department of Environmental Protection Petroleum Contamination Site Cleanup Criteria (FAC 62-770), 1997. Values are for Poor Yield/Poor Quality Groundwater (Table VIII).
[6] Analytes were included or excluded from the risk assessment for the following reasons:
S = the maximum detected concentration did not exceed the screening concentration
P = the maximum detected concentration did not exceed the Florida Petroleum Contamination Cleanup Criteria for Poor Yield/Poor Quality Groundwater (Chapter 62-770, FAC).
C = the analyte is a member of a chemical class which contains other HHCPCs (i.e., carcinogenic polynuclear aromatic hydrocarbons [PAHs]).
R = no risk based screening value is available, therefore, the analyte was retained as a HHCPC.
[7] This value is based on naphthalene as a conservative surrogate.
[8] This value is based on pyrene as a conservative surrogate.
[9] The value is based on arsenic as a carcinogen.

Notes: The average of a sample and its duplicate is used for all table calculations.
Sample locations include: MW-1D, MW-4, MW-8, MW-9, MW-11, KWM-20, KMW-21, MW-55, MW-56, MW-57, MW-59, MW-60, MW-61, MW-74D, MW-75D, MW-78D, MW-JP-1, MW-JP-2
Duplicate samples include:

HHCPC = human health chemicals of potential concern.
μg/ℓ = micrograms per liter.
* = the average of a sample and its duplicate.
NSV = no screening value.
mg/ℓ = milligrams per liter.

Table A-28
Exposure Point Concentrations for Human Health Contaminants of Potential Concern
Key West Pipeline Groundwater

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Chemical	Frequency of Detection[1]	Mean Concentration	Exposure Point Concentration
Volatile Organic Compounds (μg/ℓ)			
Benzene	6/17	283	283
Trichloroethene	1/17	3.4	3.4
Inorganic Analytes (μg/ℓ)			
Arsenic	1/1	10.2	10.2

[1] Frequency of detection is the number of samples in which the analyte was detected over the number of samples analyzed.

Note: μg/ℓ = micrograms per liter.

Table A-29
Exposure Point Concentrations for Human Health Contaminants of Potential Concern
Key West Pipeline Groundwater

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Land Use	Exposure Route	ELCR	HI
Present and Future Land Use			
Occupational Worker			
Groundwater (Nonpotable)	Incidental Ingestion	2×10^{-6}	0.03
	Dermal Contact	2×10^{-6}	0.09
	Total:	**4×10^{-6}**	**0.12**

Notes: ELCR = excess lifetime cancer risk.
HI = hazard index.

RGOs Based on the human risk calculation presented above, the RGO for benzene was calculated for groundwater at the Key West Pipeline Tanks area. The RGO for the Key West Pipeline Tanks area is presented in Table A-30.

Table A-30
Remedial Goal Options for Key West Pipeline Groundwater

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Chemical	Frequency of Detection[1]	Exposure Point Concentration	Carcinogenic Risks		
Volatile Organic Compounds (μg/ℓ)			1×10^{-4}	1×10^{-5}	1×10^{-6}
Benzene	6/17	283	7,075	707.5	70.75

[1] Frequency of detection is the number of samples in which the analyte was detected over the number of samples analyzed.

Note: μg/ℓ = micrograms per liter.

A.7 Human Health Uncertainty Evaluation The interpretation of risk estimates should be performed with the understanding that risk estimates are conservative values resulting from multiple layers of conservative assumptions inherent in the risk assessment process. Quantitative estimates of risk are based on numerous assumptions, most intended to be protective of human health (i.e., conservative). As such, risk estimates are not truly probabilistic estimates of risk, but rather, conditional estimates given a series of conservative assumptions about exposure and toxicity.

In general, sources of uncertainty can be categorized into site-specific factors (e.g., variability in analytical data and exposure assessment) and toxicity and risk characterization assessment factors. Most toxicity- and risk characterization-specific uncertainties apply to all risk evaluations equally in their impact on the calculated risk estimates. Common (not site-specific) sources of uncertainty and their potential effects on the magnitude of estimated risks are discussed here. Table A-31 summarizes some of the sources of uncertainty in this risk evaluation.

Data Collection, Analysis, and Evaluation. A certain amount of uncertainty is associated with the representative nature of the data collected to complete the risk evaluation at each site. Additional uncertainties associated with estimating exposure result from the variance in sampling and analytical techniques. There are three general uncertainties related to data collection, analysis, and evaluation:

- nature and extent of contamination,
- adequate characterization of exposure areas, and
- background inorganic concentrations.

Nature and Extent of Contamination. The nature and extent of contamination is discussed in detail in the CAR. The sampling and analytical program should adequately characterize the types of contaminants present, the physical location of those contaminants, and the concentrations that are present. There is

Table A-31
Potential Sources of Human Health Risk Assessment Uncertainty

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Potential Source	Direction of Effect	Justification
Exposure Assessment		
Likelihood of exposure pathways	Overestimate	Actual exposure may not occur. Current exposures to subsurface soil were not evaluated. However, estimates of future land-use exposures provide conservative estimates of potential, although unlikely, subsurface soil exposures.
Exposure point concentrations	Overestimate or underestimate	Sampling data are assumed to be representative of the site exposures. Although exposure point concentrations likely overestimate the actual exposures that may occur, the highest contaminant of potential concern (COPC) concentrations in a given medium to which a receptor could potentially be exposed may, by chance, not have been sampled.
Exposure assumptions (e.g., frequency and duration)	Overestimate	Parameters selected are conservative estimates of exposure representing a reasonable maximum exposure.
Particulate emission factor	Unknown, probably underestimate	The particulate emission factor used in the excavation worker exposure scenario is a U.S. Environmental Protection Agency default value. This value reflects a relatively low fugitive dust concentration, whereas construction sites are typically associated with high dust generation. Subsurface soil at these potential sources of contamination is not being excavated and, therefore, measured fugitive dust data could not be collected.
Degradation of chemicals not considered	Overestimate	Risk estimates are based on recent chemical concentrations. Concentrations tend to decrease over time as a result of degradation for many organics. The effects of chronic exposure to very low concentrations of many chemicals are not well characterized.
Absorption of soil contaminants through the skin	Overestimate	Dermal absorption of chemicals is a function of the length of actual skin contact. Contact at this site may be insufficient to result in the adsorption assumed.
Toxicity Assessment		
Extrapolation of animal toxicity data to humans	Unknown	Chemicals differ in toxicity among laboratory animals and humans. Animals and humans differ with respect to absorption, metabolism, distribution, and excretion of chemicals. The magnitude and direction of the difference varies with each chemical. Animal studies typically involve high-dose exposures, whereas humans are exposed to low doses in the environment.
Lack of inhalation toxicity values	Underestimate	Inhalation reference doses and cancer slope factors are not available for all COPCs being evaluated for inhalation exposures (fugitive dust). Therefore, risks cannot be quantified and are underestimated.
Use of linearized, multistage model to derive cancer slope factors	Overestimate	Model assumes a nonthreshold, linear response, at low doses of carcinogens. Many compounds induce cancer by nongenotoxic mechanisms. Model results in 95 percent upper confidence limits of cancer potency. Potency is unlikely to be higher and may be as low as zero.

Table A-31 (Continued)
Potential Sources of Human Health Risk Assessment Uncertainty

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Potential Source	Direction of Effect	Justification
Risk Characterization		
Summation of risks among chemicals within exposure pathways	Unknown	Little is known about the toxicity of chemical mixtures. In the absence of evidence to the contrary, additivity of risk is assumed. However, the risk assessment methods employed in this report cannot take into account the potential synergistic or antagonistic effects of multiple chemical exposures.

inherent uncertainty in this assumption because the number of samples is limited. This is especially true for the subsurface soil samples.

Background Inorganic Concentrations. The background data set for arsenic at the Navy Tank Farm demonstrates the uncertainty associated with using a statistical methodology to establish site-specific background concentrations. The background screening concentration for arsenic is set at 2 times the mean of the background data set. The background arsenic concentrations ranged from 1.5 to 7.2 mg/kg with a mean of 3.44 mg/kg. The background screening is 6.9 mg/kg. However, one of the background surface soil samples (01B27901 at 7.2 mg/kg) is above this screening value and arsenic becomes a COPC because of a background sample.

Arsenic was detected in several other samples above the background screening level and this analyte is correctly designated as both a COPC and a COC. However, this example also demonstrates how a statistic, such as 2 times the mean, can overestimate site-related risk by underestimating the actual background concentrations.

Selection of COPCs. Although a USEPA approach is used in selecting COPCs (USEPA, 1989a), there are uncertainties in the general selection process based on the use of a risk-based screening and comparison to inorganic concentrations at reference locations and consideration of subsurface soil as a leaching source to groundwater.

USEPA Region III RBC Table. USEPA Region IV prefers to exclude contaminants that do not contribute significantly to the risk estimates from the risk calculations (USEPA, 1995a). The risk evaluation uses medium-specific RBCs from the Region III RBC Table (USEPA, 1997a) as a risk-based COPC screening for the maximum concentration of each contaminant detected in groundwater. The RBCs are calculated risk-based levels in water (e.g., tap water) and soil (e.g., residential surface soil), based on residential exposure assumptions and an acceptable cancer risk level of 1×10^{-6} and an HQ of 0.1 (USEPA, 1997a).

Further, in several cases, the USEPA Region III RBC table does not provide values for chemicals. For those chemicals where a USEPA Region III RBC does not exist, a chemical in the table that is similar in structure and physical properties to the detected contaminant may be used to provide a risk-based comparison. Based on the similarities in toxicological properties between the compounds and their surrogates, it is reasonable to conclude that the USEPA Region III RBCs are adequately health-protective for the chemicals detected. Generally, the use of surrogates is an approach to help focus effort on those contaminants that are contributing a significant amount of risk (e.g., cancer risk of greater than 1×10^{-6} and an HQ of greater than 0.1). For specific chemicals where surrogates were not available or appropriate, a risk-based screening is not completed during the COPC selection process.

Transformation Products and Associated Compounds of COPCs. In selecting COPCs, transformation products, parent compounds, and chemicals closely associated with analytes selected as COPCs were also selected as COPCs even if the chemical was detected at a concentration less than the available screening concentration. For example, the selection of a single carcinogenic PAH in a particular medium requires that the additional carcinogenic PAHs detected in that medium be retained as COPCs even if the PAH is less than the available risk-based screening level. This is a protective approach that is unlikely to underestimate risks.

Exposure Assessment. There are four major issues that contribute to uncertainties in the exposure assessment of most risk evaluations:

- land use,
- use of the RME,
- determination of the EPC, and
- exposure parameters.

Land Use. This factor has the least uncertainty. Key West Pipeline Tanks area is an industrial area and will remain so for the foreseeable future. The area is unsuitable for a residential setting due to the surface covering. Sieve analysis of the surface material indicates an average diameter of 3 mm. This would eliminate the potential for a surface soil exposure.

RME. The exposure assessments conducted in a risk evaluation can be characterized as RME. As such, the exposure estimates represent a mix of "high end" and average exposure parameter values that result in an exposure estimate that is unlikely to be exceeded in an exposed population. Because some of these parameters are functions of the behavior patterns and personal habits of the exposed populations, no one value can be assumed representative of all possible exposure conditions. Further, uncertainties associated with assigning single exposure parameters to a heterogeneous population, which includes both men and women and the young and the old, (e.g., body weight, surface area, and ingestion rates), are considered significant. However, the risk analysis incorporates assumptions or procedures that result in the estimate of an upper bound of risk. This type of exposure assessment tends to overestimate risks for the large majority of an exposed population. To address the most conservative exposure scenario, the future resident (an RME) is evaluated, but the likelihood of exposure is uncertain.

EPC. For soil, the EPCs used in the risk evaluation are the lesser of 95 percent UCL on the arithmetic mean concentration or the maximum reported concentration. In many cases there are a relatively small number of samples available, and the 95 percent UCL is actually higher than the maximum detected concentration of a contaminant. In such cases, the maximum detected concentration has been used to represent the exposure concentrations. Because the cancer risks and HI calculations theoretically evaluate risks for average concentrations (USEPA, 1992a), the use of the 95 percent UCL or the maximum detected concentration is a conservative estimate of exposure and, therefore, risk.

When evaluating risks for groundwater and nongroundwater media, it is important to qualify interpretations with the following limitations:

- USEPA Region IV guidance specifies that the groundwater EPC be the average of concentrations associated with a groundwater contaminant plume. The use of average concentration results in lower risk estimates than would either the maximum detected concentration or the 95 percent UCL.

- Risks were estimated for workers who are assumed to use groundwater as a non-potable source of hand washing water. This is an exposure pathway that does not occur under current land use; it is evaluated as a highly conservative, hypothetical exposure pathway.

Given these uncertainties, the groundwater risk estimates developed in this uncertainty section should be viewed as upper-bound for the groundwater

Exposure Parameters. The selection of exposure parameters contributes to the uncertainty inherent in a risk estimate. In this analysis, the exposure parameters that had the greatest impact to the risk values were subsurface soil ingestion, dermal exposure to subsurface soil, incidental groundwater ingestion, and dermal absorption from groundwater.

The approach for calculating dermal exposures to subsurface soil and groundwater is described in Section A.1. In calculating dermal exposures to surface water, permeability constants (K_p) are used to estimate the movement of a chemical across the skin surface. Although some K_p values are empirically based, most are estimated based on characteristics such as octanol water partition coefficients and molecular weights. There are uncertainties inherent in these calculations.

The particulate emission factor (PEF) that is used as an exposure parameter to evaluate exposure to particulates generated during disruption of subsurface soil is a USEPA default value. This value was developed to represent particulate emissions generated during wind erosion of soil, but is used in this risk evaluation to represent particulate emissions generated during excavation activities. It is likely that the default PEF underestimates the particulate emission rate that would actually occur if excavation activities were performed. If more soil particles are suspended in air during soil excavation activities, an excavation worker would be exposed to greater concentrations of airborne COPCs. Therefore, risk associated with inhalation exposures for the excavation worker may be underestimated in the risk evaluation. In general, however, use of a PEF representing greater particulate concentrations would only result in marginally greater estimates of risk.

Toxicity Assessment. Toxicity information for many chemicals is very limited, leading to varying degrees of uncertainty associated with calculated toxicity values obtained in IRIS or HEAST. General sources of uncertainty for calculating toxicity factors include extrapolation from animal to human populations, low to high dose extrapolation, short-term to long-term exposures, interspecies sensitivity variation, extrapolation from subchronic to chronic no observed adverse effect level (NOAEL), extrapolation from lowest observed adverse effect level to NOAEL, amount of data supporting the toxicity factors (i.e., inadequate studies), consistency of different studies for the same chemical, and responses of various species to equivalent doses.

Toxicity data for inhalation exposures are especially limited, particularly for noncancer effects. Noncancer inhalation dose-response values for many chemicals are not available. As a result, risks associated with potential inhalation exposures cannot be quantitatively evaluated for these chemicals; therefore, total risks are underestimated. However, inhalation exposures typically contribute substantially lower COPC intakes than do ingestion exposures. With this in mind, it is unlikely that quantitative evaluation of inhalation risks would substantially increase the total risk estimate for a given receptor.

The identification of human carcinogens and noncarcinogens, based on animal data, is a primary source of uncertainty in the use of toxicity values. It is not certain that the identification of carcinogenic activity in an animal species means that carcinogenic activity in humans will occur. In some cases, the

metabolic processes involved in carcinogenic activity in a particular organ in animals may not exist in humans. Available evidence indicates that there are a limited number of substances that are classified as human carcinogens (USEPA Class A).

The use of toxicity measures (e.g., RfDs and CSFs) introduces additional uncertainties. These parameters are generally based on animal studies, many of which are performed at high doses relative to the site-specific exposures that potentially could occur. These data require interpretation and/or extrapolation in the low dose area of the dose-response curve. The CSFs used in the risk assessment generally represent a "high end" estimate. The CSFs are the 95 percent UCL on the actual slope derived from the scientific data therefore, they are likely overestimates of the potency. In addition, the extrapolation of short-term to long-term exposures is also a component in some cases for the carcinogen dose-response values.

Risk Characterization. A mixture of analytes is present in each medium evaluated at NAS Key West TPFF. The USEPA's *Guidelines for the Health Risk Assessment of Chemical Mixtures* (USEPA, 1986) states that if sufficient data are not available on the effects of the chemical mixture of concern, or a reasonably similar mixture, additivity of effects for constituents of the mixture should be assumed. This assumption, according to USEPA, is expected to yield generally neutral risk estimates (i.e., neither conservative nor lenient). More recent guidance from USEPA (USEPA, 1992c) also references the *Guidelines for the Health Risk Assessment of Chemical Mixtures*, but further states that the assumption of additivity assumes independence of action and that if this assumption is incorrect, overestimation or underestimation of the actual multiple substance risk may occur.

In calculating HI values, additivity is assumed, but in some cases the analytes in a mixture have significantly different toxic mechanisms of action and impact different organs, or act antagonistically with each other. In these cases, the overall HI likely overestimates noncancer risks. For other situations, two chemicals may act synergistically through the same or different mechanisms of action to produce an adverse effect that occurs at a lower dose than the RfD for one or both chemicals. In these cases, the assumption of additivity underestimates noncancer risks.

A.8 Ecological Risk Evaluation The ecological risk evaluation evaluates potential adverse effects to ecological receptors associated with exposure to petroleum products from TPFF NAS Key West. The ecological evaluation follows current guidance materials including the following:

- *Risk Assessment Guidance for Superfund Environmental Evaluation Manual* (USEPA, 1989b)
- *Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference* (USEPA, 1989c)
- *Framework for Ecological Risk Assessment* (USEPA, 1992c)
- Supplemental Guidance to RAGS: Region 4 Bulletins on Ecological Risk Assessment (USEPA, 1995b)

- *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (USEPA, 1997c)

- *Guidelines for Ecological Risk Assessment* (USEPA, 1998)

- Standard Guidelines for Risk-Based Corrective Action Applied at Petroleum Release Sites, American Society for Testing and Materials (ASTM, 1997d)

This ecological risk evaluation was conducted to determine if ecological receptors are potentially exposed to contaminants from TPFF at concentrations that could cause adverse ecological effects. The evaluation consists of nine sections:

- Site Characterization (Section A.9) describes current ecological conditions at the site;

- Problem Formulation (Section A.10) establishes the goals and focus of the assessment and identifies major factors to be considered;

- Hazard Assessment and Selection of Ecological Chemicals of Potential Concern (ECPCs) (Section A.11) reviews the analytical data and identifies chemicals present at the sites that may pose ecological risks;

- Exposure Assessment (Section A.12) identifies complete exposure pathways and quantifies the magnitude and frequency of exposure;

- Ecological Effects Assessment (Section A.13) identifies potential adverse effects to ecological receptors associated with the chemicals of concern identified in Section A.11;

- Risk Characterization (Section A.14) integrates exposure and concentration-toxicity response information to derive a likelihood estimate of adverse effects;

- Uncertainty Analysis (Section A.15) identifies assumptions of the ecological risk evaluation process that may influence the risk assessment conclusions;

- Future Reasonable Worst Case Scenario (Section A.16) evaluates potential pathways and identifies a future released scenario based on existing contamination that should represent the upper limits of adverse ecological effects that could occur; and

- Summary of Ecological Risk (Section A.17).

A.9 Site Characterization TPFF investigation area is approximately 40 acres in size and includes a tank farm, three concrete piers and three finger piers, and support buildings and base dormitories. The western and northern sides of the site are bounded by Fleming Key Cut and Key West Bight. The town of Key West and Key West Bight form the southern boundary. The Naval facility extends east of TPFF. Figure 2-1 presents the site location.

For the past century the study area has primarily been engaged in storage, transfer, and shipping activities. The transfer of portions of the facility from the Navy to the USCG will not significantly change the land use classification from light industrial use. As stated earlier, the study area is built on a dredge spoil area.

The risk evaluation divided TPFF into five study areas based on physical similarities and historical use. The five areas used in this report are: Key West Pipeline Tank Area, Navy Fuel Tank Area, USCG Station, Pier D-1, and Piers D-2 and D-3 (see Figure 3-1). The Key West Pipeline Tank Area is approximately 5 acres and located east of Trumbo Road. The Key West Pipeline operates three large aboveground tanks. Each tank is surrounded by a earthen berm that is part of a spill containment system. The berms are kept relatively free of plants.

The Navy tank farm is located east of Trumbo Road and south of the Key West Pipeline tank area and is approximately 14 acres in size. All tanks in the Navy tank farm have been removed. The area has experienced extensive earthmoving activities over the years as tanks have been constructed or removed. Currently the area is an open field with a chain-linked fence surround the combined Key West pipeline and Navy tank farm areas. The Navy tank farm has a sparse vegetative cover consisting of a few herbaceous plants and no trees. Because of the sparse cover, the area is unlikely to provide suitable habitat for most wildlife species.

The USCG Station consists of 8 acres and includes dormitories and operational support buildings, parking lots, maintained grass areas, and a baseball diamond. Because the site is covered with impervious surfaces or maintained areas, it is unlikely that the study area will provide suitable habitat for most wildlife species.

Piers D-1, D-2, and D-3 are located west of the USCG Station. A short description of the Piers D-1, D-2, and D-3 is that they have concrete cover extending from ground level to below surface water. Based on observations by HLA divers, most the piers have concrete covering that extend to the bottom. Only one area, located between Piers D-2 and D-3, consist of steel sheet piles below the surface water and a concrete cap from surface water to ground level. Pipelines (underground and above ground) were used to transfer petroleum products to and from the storage tanks and ships moored at these piers.

Piers D-2 and D-3 are located west of the USCG Station area. Piers D-2 and D-3 covers approximately 8.6 acres and is mostly covered by impervious surfaces. Because of the impervious covering exposure of terrestrial receptors is unlikely.

Pier D-1 is located south of Pier D-2. Pier D-1 consists of a main pier with three finger piers located on the south side. The finger piers are constructed of steel H-posts and are not integrated into Pier D-1 below water level. Pier D-1 and the finger piers consist of approximately 4.3 areas. Pier D-1 is covered with impervious surfaces thus exposure of terrestrial receptors is unlikely.

The TPFF was built on dredge spoil material. A detailed discussion of the geology is presented in the CAR TPFF (ABB-ES, 1996). The lithology is characterized as a mixture of calcareous gravel, sands and clays. The clays act as an aquitard and reduce the migration of water and associated contaminants to lower zones (ABB-ES, 1996). The piers and bulkheads on the southern and western

sides act as barriers to groundwater migrating laterally into the surrounding surface water. The Navy performs periodic inspections of the piers and bulkheads (above and underwater inspections). Piers D-2 and D-3 and the bulkhead on the northern sides are in good condition. Based on the information provided in the Navy pier evaluation document, Pier D-1 may have some structural weakness that could allow contaminants to migrate into adjacent waters (Ocean Engineering and Construction Project Office, 1989). However, HLA divers reported seeing concrete from surface to the bottom. The divers noted a few areas where the concrete had come off exposing steel backing. The divers reported the steel appears to be in good condition suggesting that contaminants are probably not migrating through the bulkhead at this time.

The Pier D1 and Piers D-2 and D-3 are covered by impervious materials; the USCG area is covered with impervious material or maintained areas; and the Key West Pipeline and Navy tank farm areas are very sparsely covered with vegetation. These areas provide habitat for a limited number of native wildlife and plants. Birds represent the most abundant form of terrestrial wildlife that may utilize the study area.

Because there are no open drainageways or retention ponds at TPFF, freshwater aquatic habitats are not present on the site. However, the study area is located adjacent to a marine environment that is part of the National Marine Sanctuary. Because the surface water adjacent to the site could potentially receive site contaminants, the ecological risk evaluation will also evaluate marine surface water and sediments.

TPFF is located at the entrance and forms the northern boundary to the Key West Bight. In addition to the TPFF, there are several potential sources of petroleum releases that could occur in Key West Bight. Potential other petroleum sources in the Key West Bight are Key West Marine with boats and a fueling dock, Key West Utility with several large storage tanks, and storm water runoff from the streets bordering the Key West Bight.

Also, the habitat around the piers at TPFF was visually assessed to identify communities present and to collect fish and sessile invertebrates from the bulkheads. Unfortunately, few sessile invertebrates were present on the bulkhead, consequently, sessile invertebrates were not collected. The Fleming Cut communities are distinctly different from those observed at other locations. Fleming Cut contains greater species diversity and larger populations than the other locations. Fleming Cut is considered in this evaluation to be a different environment than the other locations. The remaining study areas are similar to each other. The HLA divers observed that biodiversity and populations (both sessile and pelagic species) tended to reduced the further up each slip (away from open water) they progressed. This trend was observed around each pier except for Fleming Cut.

The cause of the reduced biodiversity could not be determined without additional sampling. However, based on other studies in similar environments, the following causes have been identified as possible explanations: toxicity as a result of site related chemicals, low dissolved oxygen, high nutrient concentrations in the water, and insufficient flushing of water.

A.10 Problem Formulation The problem formulation is the initial step of the ecological risk evaluation process. Problem formulation consists of identifica-

tion of potential exposure pathways, identification of potential receptors along those pathways, and the selection of assessment and measurement endpoints based on information gathered during the site characterization.

A.10.1 Identification of Exposure Pathways A complete exposure pathway includes a source of contamination, an exposure route, and a receptor. All potential routes of exposure are considered in the risk evaluation and are presented in the contaminant pathway model. The model differentiates between those exposure routes that are quantitatively evaluated and those that are qualitatively discussed. Pathways that cannot be quantitatively evaluated, due to a lack of toxicological information or pathways that are not believed to be a major contributor to ecological risks, are qualitatively discussed and addressed as uncertainties. This limitation is necessary to focus the risk evaluation to those pathways with the highest contaminant exposures or the pathways where exposures are most likely to occur. The general approach used to identify exposure pathways for the different groups of receptors is explained below.

As identified in the contaminant model, the potential sources of contamination are leaks from underground pipelines and tanks. Potentially contaminated media at TPFF are surface and subsurface soil; groundwater as a result of leaching from soil and free product plumes; and surface water and sediments containing site related chemicals.

A.10.2 Identification of Receptors The contaminant pathway model identifies potentially affected media as a result of a hypothetical contaminant migrating from a source. Representative receptors for each media in the pathway model are identified and evaluated qualitatively to determine if the media should be further evaluated in the ERA. Deductive reasoning is used to eliminate media that are unlikely to be major contributors to the overall risk at the site.

Because of the high traffic and operational activities performed at TPFF, the TPFF landuse classification is light industrial. Also, the economical importance of the study area makes it unlikely that future landuse of TPFF will ever retain the natural structure, function, and biodiversity of the original terrestrial ecosystem. Ecological receptors that may potentially utilize the TPFF include terrestrial wildlife (i.e., mammals, birds, reptiles, and adult amphibians), terrestrial plants, and terrestrial invertebrates. Because there are no stormwater retention ponds or ditches in the study area, freshwater aquatic receptors will not be evaluated. The study area is located adjacent to Key West Bight, a marine habitat. Marine aquatic receptors exist adjacent to, but outside, of the study area. Marine receptors will be evaluated.

No state or federally listed rare, threatened, or endangered species or species of concern are known or likely to inhabit TPFF. However, the marine environment, adjacent to the study area, may provide habitat for several species listed as rare, threatened, or endangered.

Exposure pathways are identified for terrestrial receptors (i.e., terrestrial wildlife, terrestrial plants, and soil invertebrates) and marine receptors.

<u>Terrestrial Wildlife</u>. Terrestrial wildlife are potentially exposed to contaminants in surface soil and food items contaminated as a result of ingestion, dermal adsorption, and inhalation of fugitive dust and volatile emissions. The proposed landuse for the study area is industrial. Native

terrestrial species tend to avoid interactions with humans; therefore, exposure of native terrestrial wildlife is limited. Also, because Key West is a developed island, it is unlikely that non-avion species will emigrate from adjacent islands.

Birds are more mobile than other wildlife species and are often seen in the study area. Because the site is an industrial area, with mostly impervious surfaces and maintained areas, the site provides few food sources or nesting habitat areas. In addition most of the birds observed at the site feed on marine wildlife. Therefore, direct exposure to site related chemicals is not expected to represent a significant exposure route.

In summary, exposure to wildlife is limited because: TPFF land use is industrial, most of TPFF is impervious or maintained areas, TPFF provides few food sources or nesting habitat, few nonavian native species are present at the site, and most avion species are marine feeders or are migratory birds that are only present on the island for a short period. A quantitative evaluation of terrestrial wildlife risks will not be performed in the ecological risk evaluation because exposures to native mammalian, reptiles, adult amphibians, and birds are unlikely to result in significant exposure capable of effecting the population of the species.

Terrestrial Plants and Soil Invertebrates. Terrestrial plants and soil invertebrates may be exposed to contamination in surface soil by direct contact with and root uptake (plants) or ingestion (invertebrates) of soil. However, the area is industrial with large portions covered in impervious surfaces, such as, buildings and asphalt parking lots. In addition, the study area is derived from dredged fill material that is composed of gravel, sand, and clay mixture. This mixture is a poor sub-state for most plants and soil invertebrates. To facilitate the growth of non-native plants, landscaped and maintained areas usually have top soil brought in to cover the existing soil.

It is assumed that the TPFF site represents a minimum risk to plants and soil invertebrates because of the poor existing soil condition and the amount of impervious surfaces covering the study area. Therefore, the plant and soil invertebrate exposure will not be quantitatively evaluated.

Marine Receptors. There are no fresh or marine surface waters at the TPFF; however, a marine environment forms the southern, western, and northern boundary of the site. Because site chemicals could hypothetically migrate from the site into surface water and sediment adjacent to the site, the ecological risk evaluation also includes these exposure pathways. Marine receptors may be exposed to contamination in sediments and surface water (marine) by direct contact with or ingestion of sediment and surface water. The ingestion exposure routes include the ingestion of sediment, surface water, and food items containing chemicals accumulated from TPFF.

A.10.3 Identification of Endpoints Assessment and measurement endpoints are used in the ecological risk evaluation to establish study goals. Assessment endpoints represent the ecological component to be protected, whereas the measurement endpoints approximate or provide a measure of the achievement of the assessment endpoint.

Two hypotheses were developed to gauge potential risks associated with exposure to TPFF surface water and sediment. These hypotheses are designed for multiple

species and trophic levels and represent both individual and community dynamics. Hypotheses for the TPFF ecological risk evaluation include:

1. Are ECPC present in surface water and sediment at concentrations sufficiently high as to reduce marine receptors populations?

2. Are bioaccumulating chemicals sufficiently high as to reduce survivability, growth, or reproduction in top predators (i.e., piscivorous)?

In answer to these two hypotheses, the following assessment and measurement endpoints where selected. The selected assessment endpoints are survival and maintenance of receptor populations and communities. The measurement endpoints used to gauge the likelihood of population- and community-level effects for the marine environment adjacent to TPFF are regulatory benchmark values and fish tissue analysis. These benchmark values are state or federal regulatory or guidance concentrations deemed protective of the environment. The assessment endpoint used to measure the bioaccumulating chemicals is the collection and analysis of fish tissues.

A.11 Hazard Assessment and Selection of ECPCs The hazard assessment includes a review of analytical data and selection of ecological chemicals of potential concern (ECPCs). ECPCs represent analytes detected in environmental media (i.e., sediment and surface water) considered in the ecological risk evaluation and could present a potential risk for ecological receptors. ECPCs are selected by comparing the maximum detected analyte concentration against an ecological screening value for that media (i.e., sediment or surface water). The ecological screening values are issued by State or Federal regulatory agencies and are believed to represent concentrations that are protective of the environment.

The sediment ecological screening values are MacDonald threshold effects level (TEL) and USEPA sediment screening values (MacDonald Environmental Science Ltd., 1994 and USEPA, 1995b, respectively). The surface water ecological screening values are Florida Surface Water Quality Standard (Chapter 62-303, FAC) and USEPA Saltwater Surface Water Criteria (USEPA, 1995b). If the maximum detected concentration of an analyte exceeds either state or federal ecological screening value, the analyte is retained as an ECPC for consideration in the ecological risk evaluation.

Tables A-32 and A-33 present summaries of the respective surface water and sediment analytical data for TPFF and include the following information: frequency of detection, range of detection limits, range of detected concentrations, average of detected concentrations, and ecological screening values. For those analytes that are retained as ECPCs, the following information is also provided: average of all concentrations, and two exposure point concentrations (reasonable maximum exposure (RME) and central tendency (CT). A discussion of how EPCs are determined is provided in Paragraph A.12.1.

As shown in Table A-32, eleven surface water samples were collected at TPFF. Nine samples were collected in 1996 and two samples were collected in 1998. The 1996 samples were analyzed for VOCs, SVOCs, lead, and TRPH while the 1998 samples were analyzed for total recoverable petroleum hydrocarbons (TRPH) and a petroleum finger print analysis, USEPA method 8150. Methylene chloride and toluene were the only analytes detected in the surface water samples from TPFF (see Table A-32). Methylene chloride was detected in only one sample (01W00301) at a

Table A-32
Selection of Ecological Contaminants of Potential Concern
Unfiltered Marine Surface Water at Trumbo Point Fuel Farm

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Analyte	Frequency of Detection[1]	Reporting Limit Range	Detected Concentration Range	Mean[2]	Florida Surface Water Quality Standards[3]	USEPA Surface Water Screening Value[4]	ECPC? (Yes/No)[5]
Volatile Organic Compounds (μg/ℓ)							
Methylene chloride	1/11	1 to 1	3.9 to 3.9	3.9	1,580	2,560	No
Toluene	1/11	1 to 1	1 to 1	1	NSC	37	No

[1] Frequency of detection is the number of samples in which the analyte was detected divided by the total number of samples analyzed (excluding rejected values).
[2] The mean of detected concentrations is the arithmetic mean of all samples in which the analyte was detected; it does not include those samples with a "R", "U", or "UJ" validation qualifier for that analyte.
[3] Florida Department of Environmental Protection Groundwater Surface Water Quality Standards (62-302 Florida Administrative Code) for Class III Maine waters (December 1996).
[4] USEPA Region IV "Supplemental Guidance to RAGS: Region 4 Bulletins Ecological Risk Assessment," this table used the chronic screening value for saltwater surface water screening values (USEPA, 1995).
[5]

Notes: The average of a sample and its duplicate is used for all table calculations.
Sample identifiers include: 01W00101, 01W00201, 01W00301, 01W00401, 01W00501, 01W00501, 01W00601, 01W00701, 01W00801, 01W00901, 01W01001, 01W01101, KWW101, KWW301
Duplicate samples include: 01W00201D

μg/ℓ = micrograms per liter.
NSC = no screening value.

Table A-33
Selection of Ecological Chemicals of Potential Concern for Sediment Associated with Trumbo Point Fuel Farm

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Analyte	Frequency of Detection[1]	Reporting Limit Range	Detected Concentration Range (*)[2]	Average of Detected Concentrations[3]	Florida Threshold Effects Level[4]	Region IV Sediment Screening Value[5]	Chemical of Ecological Concern[6]	Average of All Samples[7]	Exposure Point Concentration	
									RME[8]	CT[9]
Semivolatile Organic Compounds (µg/kg)										
Benzo(a)Anthracene	2/8	48 to 2,000	74* to 150	112	46.9	330	Yes	238	150	150
Benzo(a)Pyrene	4/8	25 to 100	91 to 310	173	74.8	330	Yes	109	310	109
Benzo(b)Fluoranthene	8/8	25 to 50	150 to 480	211	88.8	330	Yes	211	480	211
Benzo(g,h,i)Perylene	2/2	25 to 50	130 to 170	150	NSC	[10]655	No			
Benzo(k)Fluoranthene	5/8	25 to 100	43 to 310	139	NSC	[10]655	No			
Chrysene	2/2	25 to 50	63 to 75	69	NSC	[10]655	No			
Dibenzo(a,h)anthracene	5/8	77 to 200	130 to 330	197	108	330	Yes	147	330	147
Fluoranthene	2/2	25 to 50	53 to 70	61.5	6.22	330	Yes	61.5	70	61.5
Indeno(1,2,3-cd)pyrene	6/8	25 to 100	139* to 770	288	113	330	Yes	227	770	227
Naphthalene	5/8	25 to 100	55 to 280	134	NSC	[10]655	No			
Phenanthrene	2/8	48 to 2,000	89* to 150	120	86.7	330	Yes	240	150	150
Pyrene	6/8	25 to 100	120 to 580	290	153	330	Yes	229	580	229
Inorganic Analytes (mg/kg)										
Lead	6/6	NR	30.4 to 732	159	30.2	30.2	Yes	159	732	159

See notes at end of table.

Table A-33 (Continued)
Selection of Ecological Chemicals of Potential Concern for Sediment Associated with Trumbo Point Fuel Farm

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Analyte	Frequency of Detection[1]	Reporting Limit Range	Detected Concentration Range (*)[2]	Average of Detected Concentrations[3]	Florida Threshold Effects Level[4]	Region IV Sediment Screening Value[5]	Chemical of Ecological Concern[6]	Average of All Samples[7]	Exposure Point Concentration	
									RME[8]	CT[9]
Total Recoverable/Petroleum Hydrocarbons (mg/kg)										
TRPH	6/8	0.1	169 to 1,860	533	NSC	NSC	Yes	399	1,860	399

[1] Frequency of detection is the number of samples in which the analyte was detected in relation to the total number of samples analyzed (excluding rejected values).
[2] The value indicated by an asterisk is the average of a sample and its duplicate. For duplicate samples having one nondetect value, one-half of the contract required quantification limit/contract required detection limit is used as a surrogate concentration for the sample where nondetect was reported.
[3] The average of detected concentrations is the arithmetic average of all samples in which the analyte was detected. It does not include those samples with "R", "U", or "UJ" validation qualifiers.
[4] The Florida threshold effects level (TEL) is from "Approach to the Assessment of Sediment Quality in Florida Coastal Waters" (MacDonald, 1994).
[5] The Region IV Sediment Screening Values is from USEPA Region IV Supplemental Guidance to RAGS: Ecological Risk Assessment (USEPA, 1995).
[6] The maximum detected concentration exceeded either the Florida TEL or USEPA Sediment Screening Value and is retained as an ECPC for further evaluation.
[7] The average of all samples assigns a value of one-half of the contract required quantification limit/contract required detection limit as a surrogate concentration for samples where nondetect was reported.
[8] The reasonable maximum exposure (RME) concentration is equal to the maximum detected concentration.
[9] The central tendency (CT) concentration is equal to the maximum detected concentration.
[10] A screening value is not available for this analyte, benzo(a)pyrene is used as a surrogate.
[11] A screening value is not available for this analyte, a value for "high molecular weight PAHs" is used as a surrogate.

Notes: The average of a sample and its duplicate is used for all table calculations.

Samples: D005, D006, D008, D009, D0010, D0011, KWSD101, KWSD301
Duplicate sample: D009D

* = see footnote 2.
RME = reasonable maximum exposure.
CT = central tendency.
TEL = threshold effects level.
USEPA = U.S. Environmental Protection Agency.

concentration of 3.9 $\mu g/\ell$. Toluene was only detected in one sample (01W01101) at a concentration of 1 $\mu g/\ell$.

As shown in Table A-33, eight sediment samples were collected at TPFF. Six samples were collected in 1996 and two samples were collected in 1998. The 1996 samples were analyzed for VOCs, SVOCs, lead, and TRPH while the 1998 samples were analyzed for TRPH. The samples contained twelve polynuclear aromatic type SVOCs [anthracene, Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, pyrene], one inorganic (lead), and TRPH.

A.12 Exposure Assessment The purpose of the ecological exposure assessment is to estimate or measure the amount of an ECPC to which an ecological receptor may be exposed. The following sections briefly describe how contaminant exposures are estimated for marine receptors around TPFF. The contaminant pathway model provides a summary of the potential exposure pathways that exist for each group of receptors.

A.12.1 Calculation of Exposure Point Concentrations The exposure point concentration (EPC) is a representative concentration used for evaluating risks throughout this ecological risk evaluation. Reasonable Maximum Exposure (RME) and Central Tendency (CT) concentrations are derived for each ECPC. Because the sample size for the surface water data set is greater than ten, the RME value is equal to the lesser of the maximum detected concentration and the 95 percent UCL calculated on the log-transformed arithmetic mean (USEPA, 1992c). One-half of the detection limit is used to calculate the 95 percent UCL. Only eight sediment samples were collected, therefore, the sediment RME concentration is equal to the maximum detected concentration.

If potential risks are predicted based on the RME scenario, then the CT exposure scenario is also evaluated. The CT exposure concentration is represented by the arithmetic mean of all samples. One-half of the detection limit is also used as a surrogate value for sample results that are below the detection limit. As shown in Table A-32 no analytes exceeded the surface water screening value. Therefore, risks related to surface water at TPFF will not be calculated. Table A-33 presents the RME and CT exposure point concentrations for selected ECPCs in sediments.

A.12.2 Marine Receptors Marine vertebrates and invertebrates may be exposed to ECPCs via direct contact with and direct and indirect ingestion of ECPCs detected in TPFF sediment and surface water. The benchmark values used are protective of organisms living in the water and sediment at the screening concentrations.

A.12.3 Fish Analysis Twenty-three fish were collected and their tissues (filet)analyzed for petroleum related chemicals. Fish from different trophic levels and feeding guilds were collected for analysis. Tissues were analyzed for TRPH (Florida Pro) and fingerprint analysis (USEPA method 8150).

A.13 Ecological Effects Assessment The ecological effect assessment presents the measurement endpoints used to evaluate potential adverse impacts to the assessment endpoints (i.e., the maintenance of receptor populations). The methods used for identifying and characterizing ecological effects for ECPCs in each media are described in the following subsections.

The assessment endpoints selected for marine receptors adjacent to TPFF are the reduction in abundance of marine invertebrates and fish. Site-specific toxicity data for marine invertebrates and fish at these areas are not available; therefore, state and federal guidance and standards were used to evaluate surface water and sediment concentrations. These guidance and standards are believed to be protective of the environment and therefore safe for marine receptors.

MacDonald developed the sediment quality assessment guidelines (SQAG) for Florida. The SQAG included two values: threshold effects level (TEL) and probable effects level (PEL). No adverse biological effects are anticipated for contaminant concentrations below the TEL. The PEL defines the lower limit of the range of contaminant concentrations that are usually associated with adverse biological effects (MacDonald, 1994). The SQAG uses the TEL and PEL as the lower and upper range where biological effects would start to occur.

A.14 Risk Characterization This section presents the risk characterization for ecological receptors exposed to surface water and sediment adjacent TPFF. Potential risks associated with exposures to ECPCs in surface water and sediment at or adjacent to TPFF are discussed separately

A.14.1 Surface Water Only two analytes, methylene chloride and toluene, were detected in surface water. Toluene and methylene chloride are both common laboratory contaminates. Both analytes were detected only once and at concentrations below their regulatory standard. Because the regulatory standards are believed to be protective of marine receptors, it is unlikely that the chemicals detected in surface water will adversely affect marine receptors.

A.14.2 Sediment The analytes detected in sediment included twelve PAHs, lead, and TRPH. Thirteen analytes exceeded Florida TEL screening concentration. However, only four analytes (benzo(a)pyrene, fluoranthene, pyrene, and lead)exceeded both Florida and Regional IV sediment screening concentration and lead is the only analyte that exceeded the PEL value.

Sediment analysis detected a total of 12 PAHs. PAHs are major constituents of petroleum and its derivatives, with oil spills and refinery effluents being major sources of PAH contamination to estuarine and marine environments (MacDonald et al., 1992). "Substances detected most frequently in coastal sediments include acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, chrysene, fluoranthene, phenanthrene, and pyrene. In general, elevated levels of sediment-associated PAHs in Florida are found in the vicinity of urban areas." (MacDonald Environmental Sciences, 1994). TPFF is in an urban area with many potential sources of petroleum, the PAHs found at TPFF are typical of urban petroleum spills, and the concentration detected are within the SQAG range typical of urban areas.

TRPH analysis was also performed on the sediment samples collected at TPFF. TRPH analysis is a composite value representing a variety of natural and anthropogenic sources. No background or screening value for TRPH are available. There is no ecological screening value for TRPH in sediment.

Lead was also detected in six out of six sediment samples at concentrations greater than the state and federal sediment screening criteria. Lead concentrations ranged from 30.4 to 732 mg/kg with a mean of 159. Excluding the highest concentration of 732 mg/kg, the average concentration for the remaining samples

is 44 mg/kg. The Florida PEL value for lead is 112. Only one sample, 01D00801 exceeded the PEL screening concentration. This suggests there is a lead "hot spot" at this one location. The lead concentrations detected in sediments at TPFF may pose an ecological risk to marine receptors.

Because no petroleum related chemicals were identified in the fish tissues, surface water and sediment concentrations are not being incorporated into the food chain at rates that are likely to adversely affect fish.

In summary, the surface water is unlikely to represent a risk to ecological receptors. Sediment samples collected from TPFF contain PAHs and lead. The PAH detected analytes are similar to those typically found in marine water located near urban areas. The PAH concentrations are between the TEL and PEL indicating a potential for some ecological effects. Lead was detected above the TEL in all samples and above the PEL in one sample. Additional investigation may be needed to evaluate the risks lead poses to marine receptors.

A.15 Uncertainty Analysis The objective of the uncertainty analysis is to discuss the assumptions of the ecological risk evaluation process that may influence the results and conclusions. Specific uncertainties associated with exposure to surface soil at TPFF include the following:

Risks to mammalian, amphibians, reptiles, and avian species were not evaluated. Exposure to these terrestrial receptors is limited because of the small size of the site, its land use as industrial, limited number of natural nonavian species on the island, transient nature of migratory birds and the marine diet of most birds found at the site. As a result, potential risks to terrestrial species were not evaluated.

Sediment and surface water were compared to federal and state regulatory or guidance values. These values are assumed to be protective of all marine species.

It was assumed that future site conditions will be similar to present conditions. Changes in land use or a catastrophic change in the bulkhead may result in higher site related chemical concentrations in the surface water or sediment.

It was assumed that the chemical analyses included all site-related chemicals that may affect receptor populations at TPFF.

A.16 Future Reasonable Worst-Case Scenario The future reasonably worst case scenario identifies the exposure pathway that could reasonably occur and, if it did occur would represent the greatest risks to environmental receptors. Therefore, the reasonable worst-case scenario represents an upper exposure limit to which the environment is likely to be affected by a release from the site at some future date.

The worst-case scenario uses marine receptors exposed to a catastrophic release from the site of subsoil and groundwater. The most likely sources is from a petroleum free-product plume located adjacent to the marine environment. Figure 3-2 shows the free product areas identified at TPFF. Product Area 21 (FP-21) was selected for evaluation because it has been identified as one of the largest free product plumes at TPFF, it has one of the thickest free-product levels, and is located next to surface water.

Sediment. FP-21 is at the base of Pier D-1 and is covered with asphalt and bounded vertically by a concrete seawall. To mobilize subsurface soils requires the breakdown of these barriers. Deterioration of the seawall would allow subsurface material to move into the adjacent surface water. However, because of the economical value of this property, a deterioration of the seawall is unlikely.

Surface water. The worst case scenario is a conservative model that assumes that all the contamination in a free product area is moved to the surface water. FP 21, located at the base of Pier D-1, covers a large area and has a relatively thick free product layer. It is estimated that 205 gallons of potentially mobile product are present at FP-21. Two hundred and five gallons is enough to warrant an immediate action by the USCG and enough to have ecological effects. However, a sudden release of 205 gallons would have a significant initial effect but a minimum long-term effect. A slow release may have a long-term adverse effect; however, the biodiversity in the area is already reduced due to urbanization. Compared to current adverse effects in the area, a slow release would only add a minimum additional stress the system.

In summary, after evaluating the different pathways, a reasonable worst case scenario would be if free product were to migrate into adjacent surface water. One of the largest product plumes (FP-21) located adjacent to surface water was selected. The plume contains approximately 205 gallons of petroleum products. Long-term adverse effects are unlikely to result from a 205-gallon release.

A.17 Summary of Ecological Risk for TPFF All potential routes of exposure are considered in the ecological risk evaluation. The evaluation identified those chemical pathways representing the greatest potential risks to native receptors likely to be present at the site. Migration of contaminants from the site into surface water or sediment adjacent to TPFF represented the pathway with the highest probability to adversely affect receptors. Surface water, sediment, and fish tissue samples were collected for the ecological risk evaluation.

Analytes detected in the surface water were below the state and federal regulatory levels and should not present a risk to marine receptors. Sediment samples contained twelve PAHs, lead, and TRPH. While most of the PAHs exceeded Florida sediment TEL values, only four exceeded the USEPA sediment screening criteria and no PAHs exceeded the PEL.

Lead was detected in all sediment samples at concentrations greater than the state and federal sediment screening criteria. Lead concentrations ranged from 30.4 to 732 mg/kg with a mean of 159. Excluding the highest concentration of 732 mg/kg, the average concentration for the remaining samples is 44 mg/kg, which is less than the PEL concentration for lead of 112 mg/kg. This suggests a lead hot spot.

Twenty-three fish were collected and analyzed for petroleum related chemicals. No contaminants were detected in fish tissues; therefore, it is assumed that contaminants in surface water and sediment are not present at concentrations that will present a significant risk to top predators.

In summary, because the land use is industrial and the petroleum releases were mostly underground, it is unlikely that terrestrial wildlife will be adversely effected. There is a slight increase in the potential risks to ecological

receptors as a result of exposure to PAHs in sediments. However, the PAHs are characteristic of urban areas. Based on the lead concentrations found in sediment samples at TPFF, adverse ecological effects could occur. Additional sampling for lead around sediment location 01D00801 may be warranted.

A.18 Total Risk Analysis. The risk evaluation at NAS Key West TPFF demonstrates that, under reasonable exposure assumptions, no unacceptable human health or ecological risks are present at the site. Additional investigation of lead-contaminated sediments at sample location 01D00801 is recommended, but should be performed independent of this RAP. The groundwater at the Key West Pipeline area may need some engineering or land use controls due to benzene in the groundwater. However, there are no complete exposure pathways for either humans or ecological receptors. The area is covered with crushed marl and is unsuitable for residential development in its existing condition. The groundwater is contained by sheet piles at the piers and there is no complete pathway for groundwater contamination to impact either the surface water or the sediment.

Table A-34 provides a complete risk summary for the NAS Key West TPFF. It clearly shows that the site poses no health risks to either human or ecological receptors.

Table A-34
Total Risk Summary Trumbo Fuel Farm

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Site Name	Land Use	Exposure Route	ELCR	HI
		Human Receptors		
Pier D-1	Present and Future Land Use			
	Excavation Worker:			
	Subsurface Soil	Incidental Ingestion	$5x10^{-8}$	0.01
		Dermal Contact	$7x10^{-10}$	$5x10^{-9}$
		Inhalation of fugitive dusts	5×10^{-9}	ND
		Total:	**$6x10^{-8}$**	**0.01**
	Occupational Worker			
	Groundwater (Non-Potable)	Incidental Ingestion	4×10^{-7}	0.002
		Dermal Contact	2×10^{-7}	0.001
		Total:	**6×10^{-7}**	**0.003**
Piers D-2 and D-3	Occupational Worker			
	Groundwater (Non-Potable)	Incidental Ingestion	4×10^{-8}	0.0001
		Dermal Contact	1×10^{-7}	0.0003
		Total:	**1×10^{-7}**	**0.0005**
Coast Guard Station	Occupational Worker			
	Groundwater (Non-Potable)	Incidental Ingestion	5×10^{-7}	0.0003
		Dermal Contact	2×10^{-8}	0.0001
		Total:	**6×10^{-7}**	**0.0005**
Navy Tank Farm	Part-Time "snow-bird" Resident			
	Surface Soil	Incidental Ingestion	4×10^{-6}	0.03
		Dermal Contact	2×10^{-7}	ND
		Inhalation of fugitive dusts	3×10^{-12}	ND
		Total:	**4×10^{-6}**	**0.03**
	Adult Tresspasser			
	Surface Soil	Incidental Ingestion	1×10^{-6}	0.01
		Dermal Contact	3×10^{-8}	ND
		Inhalation of fugitive dusts	6×10^{-14}	ND
		Total:	**1×10^{-6}**	**0.01**
	Adolescent Tresspasser			
	Surface Soil	Incidental Ingestion	2×10^{-6}	0.01
		Dermal Contact	5×10^{-8}	ND
		Inhalation of fugitive dusts	3×10^{-14}	ND
		Total:	**2×10^{-6}**	**0.01**
	Occupational Worker			
	Surface Soil	Incidental Ingestion	4×10^{-6}	0.02
		Dermal Contact	9×10^{-8}	0.001
		Inhalation of fugitive dusts	5×10^{-8}	ND
		Total:	**4×10^{-6}**	**0.02**

See notes at end of table.

Table A-34 (Continued)
Total Risk Summary Trumbo Fuel Farm

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Site Name	Land Use	Exposure Route	ELCR	HI
		Human Receptors--continued		
	Excavation Worker			
	Surface Soil	Incidental Ingestion	2×10^{-7}	0.02
		Dermal Contact	1×10^{-9}	4×10^{-4}
		Inhalation of fugitive dusts	1×10^{-14}	ND
		Total:	$\mathbf{6 \times 10^{-8}}$	**0.02**
	Excavation Worker:			
	Subsurface Soil	Incidental Ingestion	$5x10^{-8}$	0.01
		Dermal Contact	$7x10^{-10}$	$5x10^{-9}$
		Inhalation of fugitive dusts	$5x10^{-9}$	ND
		Total:	6×10^{-8}	**0.01**
	Occupational Worker			
	Surface Soil	Incidental Ingestion	3×10^{-7}	0.002
		Dermal Contact	2×10^{-8}	3×10^{-4}
		Inhalation of fugitive dusts	2×10^{-13}	ND
		Total:	$\mathbf{4 \times 10^{-7}}$	**0.002**
	Occupational Worker			
	Groundwater (Non-Potable)	Incidental Ingestion	9×10^{-7}	0.006
		Dermal Contact	7×10^{-8}	0.001
		Total:	$\mathbf{9 \times 10^{-7}}$	**0.007**
Key West Pipeline	Occupational Worker			
	Groundwater (Non-Potable)	Incidental Ingestion	2×10^{-6}	0.03
		Dermal Contact	2×10^{-6}	0.09
		Total:	$\mathbf{4 \times 10^{-6}}$	**0.12**
		Ecological Receptors		
All Sites	Sediments:	In general, elevated levels of sediment-associated PAHs in Florida are found in the vicinity of urban areas. Lead in one sediment sample may be ecological risk to marine receptors.		
	Surface Water	All chemicals detected below all their regulatory standards		

Notes: ELCR = excess lifetime cancer risk.
HI = hazard index.
ND = not calculated because toxicity data were not available to quantitatively evaluate risk.

TABLE AA1

DIRECT CONTACT WITH AND INCIDENTAL INGESTION OF SUBSURFACE SOIL
EXCAVATION WORKER
TRUMBO FUEL FARM
NAS KEY WEST
Pier D-1 Subsurface Soil

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SOIL	CS	chemical-specific	chemical-specific	
INGESTION RATE	IR	480	mg/day	USEPA, 1995
FRACTION INGESTED	FI	100%	unitless	Assumption
ADHERENCE FACTOR	AF	1	mg/cm²-event	USEPA, 1995
ABSORPTION FRACTION	ABS	chemical-specific	unitless	USEPA, 1995
SURFACE AREA EXPOSED	SA	5,750	cm²	USEPA, 1992
DOSE ABSORBED PER EVENT	DA_{event}	chemical-specific	mg/cm²-event	USEPA, 1992
CONVERSION FACTOR	CF	1.00E-09	kg/ug	Organic conversion
CONVERSION FACTOR	CF	1.00E-06	kg/mg	Inorganic conversion
BODY WEIGHT	BW	70	kg	USEPA, 1991
EXPOSURE FREQUENCY	EF	30	days/year [1]	Assumption
EXPOSURE DURATION	ED	1	years	USEPA, 1991
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	1	years	USEPA, 1991

[1] Units for exposure frequency are events/year in the calculation of the dermally absorbed dose.
USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors"; OSWER Directive 9285.6-03.
USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B; January 1992
USEPA, 1995. Supplemental Guidance to RAGS : Region IV, Human Health Risk Assessment Bulletin No. 3

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR $(mg/kg\text{-}day)^{-1}$

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$INTAKE_{-INGESTION} = \frac{CS \times IR \times FI \times CF \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

$$INTAKE_{-DERMAL} = \frac{DAevent \times SA \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

Where:

DA_{event} = CS x AF x ABS x CF

Note: For noncarcinogenic effects, AT = ED

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL CSF $(mg/kg\text{-}day)^{-1}$	CANCER RISK INGESTION	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	DERMAL CSF [2] $(mg/kg\text{-}day)^{-1}$	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	I	3.9	mg/kg	3.1E-08	1.5	4.7E-08	0.001	3.8E-10	1.79	6.7E-10	4.8E-08
SUMMARY CANCER RISK						5E-08				7E-10	5E-08

[1] USEPA Region IV guidance specifies absorption factors of 1% for organics and 0.1% for inorganics (November 1995).
[2] Calculated from oral CSFs.
NE = not evaluated.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	DERMAL RfD [2] (mg/kg-day)	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	I	3.9	mg/kg	2.2E-06	0.0003	7.3E-03	0.001	2.6E-08	0.000294	9.0E-05	7.4E-03
SUMMARY HAZARD INDEX						0.01				9.0E-05	0.01

[1] USEPA Region IV guidance specifies absorption factors of 1% for organics and 0.1% for inorganics (November 1995).
[2] Calculated from oral RfDs.
ND = no data available.

1/22

TABLE AA2

INHALATION OF PARTICULATES - SUBSURFACE SOIL
EXCAVATION WORKER
TRUMBO FUEL FARM
NAS KEY WEST
Pier D-1 Subsurface Soil

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
SOIL CONCENTRATION	C	chemical-specific	chemical-specific	
PART. EMISSION FACTOR	PEF	12000000	m^3/kg	
CONCENTRATION AIR	CA	chemical-specific	mg/m^3	
INHALATION RATE	IR	2.5	m^3/hour	USEPA, 1995
BODY WEIGHT	BW	70	kg	USEPA, 1991
EXPOSURE TIME	ET	8	hours/day	Assumption
EXPOSURE FREQUENCY	EF	30	days/year	Assumption
EXPOSURE DURATION	ED	1	years	Assumption
CONVERSION FACTOR	CF	0.001	mg/ug	Organics only
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	1	years	USEPA, 1991

[1] PEF has been derived in the PEF Appendix to this report.
USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance:
Standard Default Exposure Factors; OSWER Directive 9285.6-03.
USEPA, 1995. Supplemental Guidance to RAGS : Region IV, Human Health Risk Assessment Bulletin No. 3.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x INHALATION CANCER SLOPE FACTOR (mg/kg-day)$^{-1}$

'HAZARD QUOTIENT = INTAKE (mg/kg-day) / INHALATION REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE} = \frac{\text{CA x IR x ET x EF x ED}}{\text{BW x AT x 365 days/yr}}$$

Where:

CA = C x CF x (1/PEF)

Note: For noncarcinogens, AT = ED.

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	AIR CONCENTRATION (mg/m^3)	INTAKE (mg/kg-day)	INHALATION CSF (mg/kg-day)^-1	CANCER RISK
Arsenic	I	3.9	mg/kg	3.25E-07	1.1E-10	50	**5.5E-09**
					SUMMARY CANCER RISK		**5E-09**

NE = not evaluated.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	AIR CONCENTRATION (mg/m^3)	INTAKE (mg/kg-day)	INHALATION RfD (mg/kg-day)	HAZARD QUOTIENT
Arsenic	I	3.9	mg/kg	3.25E-07	7.6E-09	ND	
					SUMMARY HAZARD INDEX		**0E+00**

ND = no data available.

TABLE AA3

INCIDENTAL INGESTION OF AND DIRECT CONTACT WITH NON-POTABLE GROUNDWATER
OCCUPATIONAL WORKER
TRUMBO POINT FUEL FARM
NAS KEY WEST
PIER D-1

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical-specific	ug/liter	
INGESTION RATE [1]	IR	0.026	liters/day	USEPA, 1995
SURFACE AREA [2]	SA	3,120	cm2	USEPA, 1989
EVENT FREQUENCY	EV	1	events/day	Assumption
BODY WEIGHT	BW	70	kg	USEPA, 1991
DOSE ABSORBED PER EVENT	DAevent	chemical-specific	mg/cm2-event	Calculated
EXPOSURE TIME	ET	0.33	hours/day	Assumption
EXPOSURE FREQUENCY	EF	250	days/year	Assumption
EXPOSURE DURATION	ED	25	years	Assumption
DIFFUSION DEPTH PER EVENT	PCevent	chemical-specific	cm/event	Calculated per USEPA, 1992 [3]
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	25	years	USEPA, 1995
CONVERSION FACTOR	CF1	0.001	mg/ug	
CONVERSION FACTOR	CF2	0.001	liter/cm3	

[1] Ingestion Rate = 0.026 l/day = 10 ml/hour x 2.6 hours/day x 0.001 l/ml
[2] Surface area assumes hands and arms are exposed.
[3] PCevent is calculated in Table AA4
USEPA, 1989. Exposure Factors Handbook; EPA/600/8-89/043; May 1989.
USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters."
USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B.
USEPA, 1995. Supplemental Guidance to RAGS: Region 4 Bulletins, Bulletin No. 3, November 1995.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times EF \times ED \times CF1}{BW \times AT \times 365\ days/yr}$$

$$\text{INTAKE-DERMAL} = \frac{DAevent \times EV \times EF \times ED \times SA}{AT \times BW \times 365\ days/yr}$$

Where:
DAevent = PCevent x CW x CF1 x CF2

Note: For noncarcinogenic effects, AT = ED.

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	WATER CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	PCEVENT[2] (cm/event)	INTAKE DERMAL (mg/kg-day)	DERMAL CSF [1, 3] (mg/kg-day)^-1	CANCER RISK DERMAL	TOTAL CANCER RISK
Tetrachloroethene	ORGANIC	6.1	ug/L	5.5E-07	0.052	2.9E-08	4.80E-02	3.2E-06	0.052	1.7E-07	**1.9E-07**
Arsenic	INORGANIC	2.9	ug/L	2.6E-07	1.5	4.0E-07	0.00033	1.0E-08	1.53	1.6E-08	**4.1E-07**
			ug/L								
					SUMMARY CANCER RISK	**4E-07**				**2E-07**	**6E-07**

[1] Relative potency factors were applied to the CSFs of carcinogenic PAHs. Relative potency factors are derived in "Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons," USEPA, 1993.
[2] This chemical-specific value is calculated in Appendix ?
[3] Calculated from oral CSFs.
ND = no data available.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	WATER CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	PCEVENT[1] (cm/event)	INTAKE DERMAL (mg/kg-day)	DERMAL RfD [2] (mg/kg-day)^-1	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Tetrachloroethene	ORGANIC	6.1	ug/L	1.6E-06	0.052	3.0E-05	0.048	8.9E-06	0.01	8.9E-04	**9.2E-04**
Arsenic	INORGANIC	2.9	ug/L	7.4E-07	0.0003	2.5E-03	0.00033	2.9E-08	0.000294	9.9E-05	**2.6E-03**
			ug/L								
			ug/L								
					SUMMARY HAZARD INDEX	**2E-03**				**1E-03**	**3E-03**

[1] This chemical-specific value is calculated in Appendix ?
[2] Calculated from oral RfDs.
ND = no data available.

3/22

TABLE AA4
PC_{event} Calculations for Direct Contact with Groundwater

All Receptors
TRUMBO POINT FUEL FARM
NAS KEY WEST

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
Diffusion depth per event	PC_{event}	chemical specific	cm/event	
Permeability Constant	PC	chemical specific	cm/hr	USEPA, 1992
Duration of a Single Event	t_{event}	0.33	hr	USEPA,1989
Thickness of Stratum Corneum	L_{sc}	10	μm	USEPA, 1992
Octanol-water partition coefficient/104	B	chemical specific	dimensionless	USEPA, 1992
Pi	π	3.14	dimensionless	USEPA, 1992
Lag time	τ	chemical specific	hr	USEPA, 1992
Time to Reach Steady State	t*	chemical specific	hr	USEPA, 1992
Stratum Corneum Diffusion Coefficient	D_{sc}	chemical specific	cm^2/hr	USEPA, 1992

EQUATIONS

INORGANICS

$$PC_{event} = PC \times t_{event}$$

ORGANICS

$$PC_{event} = 2PC \times (6\tau \times t_{event}/\pi)0.5$$

Where $t_{event} < t^*$

and: $$PC_{event} = PC \times ((t_{event}/(1+B)) + 2\tau \times ((1+3B)/(1+B))$$

Where $t_{event} > t^*$

Note: $\tau = L_{sc}^2/6D_{sc}$

REFERENCES

USEPA,1989. Risk Assessment Guidance for Superfund, Volume I, Part A, EPA/540/1-89/002, December 1989. This value is receptor-specific and set at 0.33 hours for this assessment.

USEPA, 1992. Dermal Exposure Assessment: Principles and Applications.

The term τ is not calculated here. Values are provided in USEPA, 1992.

COMPOUND	INORGANIC OR ORGANIC? I/O	PC (cm/hr)	τ (hr)	t* (hr)	B (unitless)	PCevent (cm/event)
Benzene	O	2.1E-02	3.3E-01	6.3E-01	1.3E-02	1.92E-02
Tetrachloroethene	O	4.8E-02	3.3E-01	4.3E+00	2.5E-01	4.38E-02
1,2-Dichloroethene	O	1.0E-02	3.3E-01	8.2E-01	7.2E-03	9.12E-03
Trichloroethene	O	1.6E-02	3.3E-01	1.3E+00	2.6E-02	1.46E-02
Bromodichloromethane	O	5.8E-02	3.3E-01	2.1E+00	1.2E-02	5.29E-02
Bromoform	O	2.6E-02	3.3E-01	7.3E+00	2.3E-02	2.37E-02
Dibromochloromethane	O	1.6E-02	3.3E-01	2.1E+00	1.2E-02	1.46E-02
Arsenic	I	1.0E-03	3.3E-01	NA	NA	3.30E-04

NA = Not applicable. For inorganic analytes, this term is not used to calculate PC_{event}.

REFERENCES:

Unless otherwise noted, values are taken from USEPA, 1992. Dermal Exposure Assessment:Principles and Applications,EPA/600/8-91/011B

TABLE AA5

INCIDENTAL INGESTION OF AND DIRECT CONTACT WITH NON-POTABLE GROUNDWATER
OCCUPATIONAL WORKER
TRUMBO POINT FUEL FARM
NAS KEY WEST
PIERS D-2 AND D-3

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical-specific	ug/liter	
INGESTION RATE [1]	IR	0.026	liters/day	USEPA, 1995
SURFACE AREA [2]	SA	3,120	cm2	USEPA, 1989
EVENT FREQUENCY	EV	1	events/day	Assumption
BODY WEIGHT	BW	70	kg	USEPA, 1991
DOSE ABSORBED PER EVENT	DAevent	chemical-specific	mg/cm2-event	Calculated
EXPOSURE TIME	ET	0.33	hours/day	Assumption
EXPOSURE FREQUENCY	EF	250	days/year	Assumption
EXPOSURE DURATION	ED	25	years	Assumption
DIFFUSION DEPTH PER EVENT	PCevent	chemical-specific	cm/event	Calculated per USEPA, 1992 [3]
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	25	years	USEPA, 1995
CONVERSION FACTOR	CF1	0.001	mg/ug	
CONVERSION FACTOR	CF2	0.001	liter/cm3	

[1] Ingestion Rate = 0.026 l/day = 10 ml/hour x 2.6 hours/day x 0.001 l/ml
[2] Surface area assumes hands and arms are exposed.
[3] PCevent is calculated in Table AA4
USEPA, 1989. Exposure Factors Handbook; EPA/600/8-89/043; May 1989.
USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters."
USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B.
USEPA, 1995. Supplemental Guidance to RAGS: Region 4 Bulletins, Bulletin No. 3, November 1995.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times EF \times ED \times CF1}{BW \times AT \times 365\ \text{days/yr}}$$

$$\text{INTAKE-DERMAL} = \frac{DAevent \times EV \times EF \times ED \times SA}{AT \times BW \times 365\ \text{days/yr}}$$

Where:
DAevent = PCevent x CW x CF1 x CF2

Note: For noncarcinogenic effects, AT = ED.

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	WATER CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	PCEVENT[2] (cm/event)	INTAKE DERMAL (mg/kg-day)	DERMAL CSF [1, 3] (mg/kg-day)^-1	CANCER RISK DERMAL	TOTAL CANCER RISK
Bromodichloromethane	ORGANIC	1.1	ug/L	1.0E-07	0.062	6.2E-09	5.29E-02	6.3E-07	0.062	3.9E-08	**5E-08**
Bromoform	ORGANIC	6.5	ug/L	5.9E-07	0.0079	4.7E-09	2.37E-02	1.7E-06	0.0079	1.3E-08	**2E-08**
Dibromochloromethane	ORGANIC	3.6	ug/L	3.3E-07	0.084	2.7E-08	1.46E-02	5.7E-07	0.084	4.8E-08	**8E-08**
			ug/L								
					SUMMARY CANCER RISK	**4E-08**				**1E-07**	**1E-07**

[1] Relative potency factors were applied to the CSFs of carcinogenic PAHs. Relative potency factors are derived in "Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons," USEPA, 1993.
[2] This chemical-specific value is calculated in Appendix ?
[3] Calculated from oral CSFs.
ND = no data available.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	WATER CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	PCEVENT[1] (cm/event)	INTAKE DERMAL (mg/kg-day)	DERMAL RfD [2] (mg/kg-day)^-1	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Bromodichloromethane	ORGANIC	1.1	ug/L	2.8E-07	0.02	1.4E-05	5.29E-02	1.8E-06	0.02	8.9E-05	**1.0E-04**
Bromoform	ORGANIC	6.5	ug/L	1.7E-06	**0.02**	8.3E-05	2.37E-02	4.7E-06	**0.02**	2.4E-04	**3.2E-04**
Dibromochloromethane	ORGANIC	3.6	ug/L	9.2E-07	**0.02**	4.6E-05	1.46E-02	1.6E-06			**4.6E-05**
			ug/L								
					SUMMARY HAZARD INDEX	**1E-04**				**3E-04**	**5E-04**

[1] This chemical-specific value is calculated in Appendix ?
[2] Calculated from oral RfDs.
ND = no data available.

TABLE AA6

INCIDENTAL INGESTION OF AND DIRECT CONTACT WITH NON-POTABLE GROUNDWATER
OCCUPATIONAL WORKER
TRUMBO POINT FUEL FARM
NAS KEY WEST
COAST GUARD STATION

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical-specific	ug/liter	
INGESTION RATE [1]	IR	0.026	liters/day	USEPA, 1995
SURFACE AREA [2]	SA	3,120	cm2	USEPA, 1989
EVENT FREQUENCY	EV	1	events/day	Assumption
BODY WEIGHT	BW	70	kg	USEPA, 1991
DOSE ABSORBED PER EVENT	DAevent	chemical-specific	mg/cm2-event	Calculated
EXPOSURE TIME	ET	0.33	hours/day	Assumption
EXPOSURE FREQUENCY	EF	250	days/year	Assumption
EXPOSURE DURATION	ED	25	years	Assumption
DIFFUSION DEPTH PER EVENT	PCevent	chemical-specific	cm/event	Calculated per USEPA, 1992 [3]
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	25	years	USEPA, 1995
CONVERSION FACTOR	CF1	0.001	mg/ug	
CONVERSION FACTOR	CF2	0.001	liter/cm3	

[1] Ingestion Rate = 0.026 l/day = 10 ml/hour x 2.6 hours/day x 0.001 l/ml
[2] Surface area assumes hands and arms are exposed.
[3] PCevent is calculated in Table AA4
USEPA, 1989. Exposure Factors Handbook; EPA/600/8-89/043; May 1989.
USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters."
USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B.
USEPA, 1995. Supplemental Guidance to RAGS. Region 4 Bulletins, Bulletin No. 3, November 1995.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times EF \times ED \times CF1}{BW \times AT \times 365\ \text{days/yr}}$$

$$\text{INTAKE-DERMAL} = \frac{DAevent \times EV \times EF \times ED \times SA}{AT \times BW \times 365\ \text{days/yr}}$$

Where:
DAevent = PCevent x CW x CF1 x CF2

Note: For noncarcinogenic effects, AT = ED.

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	WATER CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	PCEVENT[2] (cm/event)	INTAKE DERMAL (mg/kg-day)	DERMAL CSF [1, 3] (mg/kg-day)^-1	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	INORGANIC	4	ug/L	3.6E-07	1.5	5.5E-07	0.00033	1.4E-08	1.53	2.2E-08	**6E-07**
					SUMMARY CANCER RISK	**5E-07**				**2E-08**	**6E-07**

[1] Relative potency factors were applied to the CSFs of carcinogenic PAHs. Relative potency factors are derived in "Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons," USEPA, 1993
[2] This chemical-specific value is calculated in Appendix ?
[3] Calculated from oral CSFs.
ND = no data available.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	WATER CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	PCEVENT[1] (cm/event)	INTAKE DERMAL (mg/kg-day)	DERMAL RfD [2] (mg/kg-day)^-1	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	INORGANIC	4	ug/L	1.0E-06	0.003	3.4E-04	3.30E-04	4.0E-08	0.000294	1.4E-04	**4.8E-04**
					SUMMARY HAZARD INDEX	**3E-04**				**1E-04**	**5E-04**

[1] This chemical-specific value is calculated in Appendix ?
[2] Calculated from oral RfDs.
ND = no data available.

TABLE A.A7

DIRECT CONTACT WITH AND INCIDENTAL INGESTION OF SURFACE SOIL
ADULT "Snow-Bird" RESIDENT
NAS Key West Trumbo Point Fuel Farm
Navy Tank Farm
EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SOIL	CS	chemical-specific	chemical-specific	
INGESTION RATE	IR	100	mg/day	USEPA, 1995
FRACTION INGESTED	FI	100%	unitless	USEPA, 1995
ADHERENCE FACTOR	AF	1	mg/cm^2-event	USEPA, 1995
ABSORPTION FRACTION	ABS_d	chemical-specific	unitless	USEPA, 1992b
SURFACE AREA EXPOSED	SA	5,750	cm^2	USEPA, 1992a
DOSE ABSORBED PER EVENT	DA_{event}	chemical-specific	mg/cm^2-event	USEPA, 1992a
CONVERSION FACTOR	CF	1.00E-09	kg/ug	Organic conversion
CONVERSION FACTOR	CF	1.00E-06	kg/mg	Inorganic conversion
BODY WEIGHT	BW	70	kg	USEPA, 1991
EXPOSURE FREQUENCY	EF	183	days/year [1]	Assumption
EXPOSURE DURATION	ED	20	years	USEPA, 1995
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	20	years	USEPA, 1995

[1] Units for exposure frequency are events/year in the calculation of the dermally absorbed dose.
USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors"; OSWER Directive 9285.6-03.
USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B; January 1992.
USEPA, 1995. Supplemental Guidance to RAGS : Region IV, Human Health Risk Assessment Bulletin No. 3

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR $(mg/kg\text{-}day)^{-1}$

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$INTAKE\text{-}_{INGESTION} = \frac{CS \times IR \times FI \times CF \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

$$INTAKE\text{-}_{DERMAL} = \frac{DA_{event} \times SA \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

Where:

$$DA_{event} = CS \times AF \times ABS_d \times CF$$

Note: For noncarcinogenic effects, AT = ED.

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL CSF [1] $(mg/kg\text{-}day)^{-1}$	CANCER RISK INGESTION	DERMAL ABS [2]	INTAKE DERMAL (mg/kg-day)	DERMAL CSF [3] $(mg/kg\text{-}day)^{-1}$	CANCER RISK DERMAL	TOTAL CANCER RISK
Benzo(a)pyrene	O	433	ug/kg	8.9E-08	7.3	6.5E-07	0.01	5.1E-08	8	4.1E-07	1.1E-06
Dibenz(a,h)anthracene	O	340	ug/kg	7.0E-08	7.3	5.1E-07	0.01	4.0E-08	8	3.2E-07	8.3E-07
Arsenic	I	13.3	mg/kg	2.7E-06	1.5	4.1E-06	0.001	1.6E-07	1.5	2.3E-07	4.3E-06
SUMMARY CANCER RISK						7E-06				2E-06	8E-06

[1]Relative potency factors were applied to the CSFs for carcinogenic PAHs. Relative potency factors are derived in "Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons," USEPA, 1993.
[2] USEPA Region IV guidance specifies absorption factors of 1% for organics and 0.1% for inorganics (November 1995).
[3] Calculated from oral CSFs.
ND = no data available.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	DERMAL RfD [2] (mg/kg-day)	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Benzo(a)pyrene	O	433	ug/kg	3.1E-07	ND		0.01	1.8E-07	ND		
Dibenz(a,h)anthracene	O	340	ug/kg	2.4E-07	ND		0.01	1.4E-07	ND		
Arsenic	I	13.3	mg/kg	9.5E-06	0.0003	3.2E-02	0.001	5.5E-07	0.00029	1.9E-03	3.4E-02
Florida TRPH	O	450000	ug/kg	3.2E-04	ND		0.01	1.9E-04	ND		
SUMMARY HAZARD INDEX						0.05				0.04	0.09

[1] USEPA Region IV guidance specifies absorption factors of 1% for organics and 0.1% for inorganics (November, 1995).
[2] Calculated from oral RfDs.

TABLE A.A8

INHALATION OF PARTICULATES - SURFACE SOIL
ADULT "Snow-Bird" RESIDENT
NAS Key West Trumbo Point Fuel Farm
Navy Tank Farm

13-Aug-99

June 1999

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
SOIL CONCENTRATION	C	chemical-specific	chemical-specific	
PART. EMISSION FACTOR	PEF	1.24E+09	m^3/kg	default [1]
CONCENTRATION AIR	CA	chemical-specific	mg/m^3	
INHALATION RATE	IR	0.833	m^3/hour	USEPA, 1995
BODY WEIGHT	BW	70	kg	USEPA, 1991
EXPOSURE TIME	ET	24	hours/day	Assumption
EXPOSURE FREQUENCY	EF	350	days/year	USEPA, 1995
EXPOSURE DURATION	ED	24	years	USEPA, 1995
CONVERSION FACTOR	CF	0.001	mg/ug	Organics only
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	24	years	USEPA, 1995

[1] PEF has been derived in the PEF Appendix to this report.
USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors"; OSWER Directive 9285.6-03.
USEPA, 1995. Supplemental Guidance to RAGS : Region IV, Human Health Risk Assessment Bulletin No. 3.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x INHALATION CANCER SLOPE FACTOR $(mg/kg\text{-}day)^{-1}$

HAZARD QUOTIENT = INTAKE (mg/kg-day) / INHALATION REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE} = \frac{CA \times IR \times ET \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

Where:

CA = C x CF x (1/PEF)

Note:

For noncarcinogenic effects: AT = ED

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	AIR CONCENTRATION (mg/m^3)	INTAKE (mg/kg-day)	INHALATION CSF (mg/kg-day)-1	CANCER RISK
Arsenic	I	13.6	mg/kg	1.10E-08	1.0E-09	0.003	**3.1E-12**
Benzo(a)pyrene		433	ug/kg	3.49E-10	3.3E-11	3.1	**1.0E-10**
Dibenz(a,h)anthracene		340	ug/kg	2.74E-10	2.6E-11	3.1	**8.0E-11**
				SUMMARY CANCER RISK			**2E-10**

ND = no data available.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	AIR CONCENTRATION (mg/m^3)	INTAKE (mg/kg-day)	INHALATION RfD (mg/kg-day)	HAZARD QUOTIENT
Arsenic	I	9.7	mg/kg	7.82E-09	2.1E-09	ND	
TRPH (Florida Pro)	O	450000	mg/kg				
				SUMMARY HAZARD INDEX			**0E+00**

TABLE AA9

DIRECT CONTACT WITH AND INCIDENTAL INGESTION OF SURFACE SOIL
ADULT TRESPASSER
NAS Key West Trumbo Point Fuel Farm
Navy Tank Farm

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SOIL	CS	chemical-specific	chemical-specific	
INGESTION RATE	IR	100	mg/day	USEPA, 1991
FRACTION INGESTED	FI	100%	unitless	USEPA, 1995
ADHERENCE FACTOR	AF	1	mg/cm²-event	USEPA, 1992
ABSORPTION FRACTION	ABS_d	chemical specific	unitless	USEPA, 1995
SURFACE AREA EXPOSED	SA	5,750	cm²	USEPA, 1992
DOSE ABSORBED PER EVENT	DAevent	chemical specific	mg/cm²-event	USEPA, 1992
CONVERSION FACTOR	CF	1.00E-06	kg/mg	inorganics
	CF	1.00E-09	kg/ug	organics
BODY WEIGHT	BW	70	kg	USEPA, 1991
EXPOSURE FREQUENCY	EF	45	days/year [1]	Assumption
EXPOSURE DURATION	ED	20	years	Assumption
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	20	years	Assumption

[1] Units for exposure frequency are events/year in the calculation of the dermally absorbed dose.
USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors"; OSWER Directive 9285.6-03.
USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B; 1/92.
USEPA, 1995. Supplemental Guidance to RAGS : Region IV, Human Health Risk Assessment Bulletin No. 3.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR $(mg/kg\text{-}day)^{-1}$

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$INTAKE\text{-}_{INGESTION} = \frac{CS \times IR \times FI \times CF \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

$$INTAKE\text{-}_{DERMAL} = \frac{DAevent \times SA \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

Where:

$_{DAevent} = AF \times ABS_d \times CF$

Note: For noncarcinogenic effects: AT = ED

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL CSF $(mg/kg\text{-}day)^{-1}$	CANCER RISK INGESTION	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	DERMAL CSF [2] $(mg/kg\text{-}day)^{-1}$	CANCER RISK DERMAL	TOTAL CANCER RISK
Benzo(a)pyrene	O	433	ug/kg	2.2E-08	7.3	1.6E-07	0.01	1.3E-08	8	1.0E-07	2.6E-07
Dibenz(a,h)anthracene	O	340	ug/kg	1.7E-08	7.3	1.2E-07	0.01	9.8E-09	8	7.9E-08	2.0E-07
Arsenic	I	13.3	mg/kg	6.7E-07	1.5	1.0E-06	0.001	3.8E-08	1.5	5.8E-08	1.1E-06
				SUMMARY CANCER RISK		2E-06				4E-07	2E-06

[1] USEPA Region IV guidance specifies absorption factors of 1% for organics and 0.1% for inorganics (November 1995).
[2] Calculated from oral CSFs.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	DERMAL RfD [2] (mg/kg-day)	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Benzo(a)pyrene	O	433	ug/kg	7.6E-08	ND		0.01	4.4E-08	ND		
Dibenz(a,h)anthracene	O	340	ug/kg	6.0E-08	ND		0.01	3.4E-08	ND		
Arsenic	I	13.3	mg/kg	2.3E-06	0.0003	7.8E-03	0.001	1.3E-07	0.00029	4.6E-04	8.3E-03
Florida TRPH	O	450000	ug/kg	7.9E-05	ND		0.01	4.6E-05	ND		
				SUMMARY HAZARD INDEX		0.01				0.01	0.02

[1] USEPA Region IV guidance specifies absorption factors of 1% for organics and 0.1% for inorganics (November 1995).
[2] Calculated from oral RfDs.
[3] Pyrene RfD used as a surrogate for Phenanthrene.
ND = no data available. Note: all chemicals with ND were assessed as a carcinogen with the exception of lead.

9/22

TABLE A.A10

INHALATION OF PARTICULATES - SURFACE SOIL
ADULT TRESPASSER
NAS Key West Trumbo Point Fuel Farm
Navy Tank Farm

13-Aug-99

June 1999

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
SOIL CONCENTRATION	C	chemical-specific	chemical-specific	
PART. EMISSION FACTOR	PEF	1.24E+09	m^3/kg	default [1]
CONCENTRATION AIR	CA	chemical-specific	mg/m^3	
INHALATION RATE	IR	0.833	m^3/hour	USEPA, 1995
BODY WEIGHT	BW	70	kg	USEPA, 1991
EXPOSURE TIME	ET	4	hours/day	Assumption
EXPOSURE FREQUENCY	EF	45	days/year	Assumption
EXPOSURE DURATION	ED	20	years	Assumption
CONVERSION FACTOR	CF	0.001	mg/ug	Organics only
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	20	years	USEPA, 1991

[1] PEF has been derived in the PEF Appendix to this report.
USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors"; OSWER Directive 9285.6-03.
USEPA, 1995. Supplemental Guidance to RAGS : Region IV, Human Health Risk Assessment Bulletin No. 3.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x INHALATION CANCER SLOPE FACTOR $(mg/kg\text{-}day)^{-1}$

HAZARD QUOTIENT = INTAKE (mg/kg-day) / INHALATION REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE} = \frac{CA \times IR \times ET \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

Where:

CA = C x CF x (1/PEF)

Note: For noncarcinogenic effects, AT = ED

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	AIR CONCENTRATION (mg/m^3)	INTAKE (mg/kg-day)	INHALATION CSF $(mg/kg\text{-}day)^{-1}$	CANCER RISK
Arsenic	I	13.6	mg/kg	1.10E-08	1.8E-11	0.003	5.5E-14
Benzo(a)pyrene	O	433	ug/kg	3.49E-10	5.9E-13	3.1	1.8E-12
Dibenz(a,h)anthracene		340	ug/kg	2.74E-10	4.6E-13	3.1	1.4E-12
						SUMMARY CANCER RISK	6E-14

NE = not evaluated.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	AIR CONCENTRATION (mg/m^3)	INTAKE (mg/kg-day)	INHALATION RfD (mg/kg-day)	HAZARD QUOTIENT
Arsenic	I	9.7	mg/kg	7.82E-09	4.6E-11	ND	
TRPH (Florida Pro)	O	450000	mg/kg	3.63E-07	2.1E-09	ND	
						SUMMARY HAZARD INDEX	ND

ND = no data available.

TABLE AA11

DIRECT CONTACT WITH AND INCIDENTAL INGESTION OF SURFACE SOIL
ADOLESCENT TRESPASSER
NAS Key West Trumbo Point Fuel Farm
Navy Tank Farm

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SOIL	CS	chemical-specific	chemical-specific	
INGESTION RATE	IR	480	mg/day	USEPA, 1995
FRACTION INGESTED	FI	100%	unitless	Assumption
ADHERENCE FACTOR	AF	1	mg/cm²-event	USEPA, 1992
ABSORPTION FRACTION	ABS	chemical-specific	unitless	Assumption
SURFACE AREA EXPOSED	SA	5,750	cm²	USEPA, 1992
DOSE ABSORBED PER EVENT	DA_{event}	chemical-specific	mg/cm²-event	USEPA, 1992
CONVERSION FACTOR	CF	1.00E-09	kg/ug	Organic conversion
CONVERSION FACTOR	CF	1.00E-06	kg/mg	Inorganic conversion
BODY WEIGHT	BW	70	kg	USEPA, 1991
EXPOSURE FREQUENCY	EF	30	days/year [1]	Assumption
EXPOSURE DURATION	ED	1	years	USEPA, 1991
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	1	years	USEPA, 1991

[1] Units for exposure frequency are events/year in the calculation of the dermally absorbed dose.
USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors": OSWER Directive 9285.6-03.
USEPA, 1992. Dermal Exposure Assessment: Principles and Applications: EPA/600/8-91/011B; 1/92.
USEPA, 1995. Supplemental Guidance to RAGS : Region IV, Human Health Risk Assessment Bulletin No. 3.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR $(mg/kg\text{-}day)^{-1}$

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$INTAKE_{-INGESTION} = \frac{CS \times IR \times FI \times CF \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

$$INTAKE_{-DERMAL} = \frac{DAevent \times SA \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

Where:

DA_{event} = CS x AF x ABS x CF

Note: For noncarcinogenic effects, AT = ED

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL CSF $(mg/kg\text{-}day)^{-1}$	CANCER RISK INGESTION	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	DERMAL CSF [2] $(mg/kg\text{-}day)^{-1}$	CANCER RISK DERMAL	TOTAL CANCER RISK
Benzo(a)pyrene	O	433	ug/kg	3.5E-09	7.3	2.5E-08	0.01	4.2E-10	8	3.3E-09	2.9E-08
Dibenz(a,h)anthracene	O	340	ug/kg	2.7E-09	7.3	2.0E-08	0.01	3.3E-10	8	2.6E-09	2.3E-08
Arsenic	I	13.3	mg/kg	1.1E-07	1.5	1.6E-07	0.001	1.3E-09	1.5	1.9E-09	1.6E-07
			SUMMARY CANCER RISK			**3E-07**				**1E-08**	**3E-07**

[1] USEPA Region IV guidance specifies absorption factors of 1% for organics and 0.1% for inorganics (November 1995).
[2] Calculated from oral CSFs.
NE = not evaluated.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL RfD [1] (mg/kg-day)	HAZARD QUOTIENT INGESTION	DERMAL ABS [2]	INTAKE DERMAL (mg/kg-day)	DERMAL RfD [3] (mg/kg-day)	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Benzo(a)pyrene	O	433	ug/kg	2.4E-07	ND		0.01	2.9E-08	ND		
Dibenz(a,h)anthracene	O	340	ug/kg	1.9E-07	ND		0.01	2.3E-08	ND		
Arsenic	I	13.3	mg/kg	7.5E-06	0.0003	2.5E-02	0.001	9.0E-08	0.00029	3.1E-04	2.5E-02
Florida TRPH	O	450000	ug/kg	2.5E-04	ND		0.01	3.0E-05	ND		
			SUMMARY HAZARD INDEX			**0.04**				**0.01**	**0.05**

[1] Subchronic Rfd values were used for the excavation worker due to short exposure scenario for all chemicals except aluminum, where a subchronic value is not available and therefore the chronic value was used.
[2] USEPA Region IV guidance specifies absorption factors of 1% for organics and 0.1% for inorganics (February 10, 1992).
[3] Calculated from oral RfDs.
[4] Pyrene RfD used as a surrogate for Phenanthrene.
ND = no data available. Note: all chemicals with ND were assessed as a carcinogen with the exception of lead.

11/22

TABLE A.A12

INHALATION OF PARTICULATES - SURFACE SOIL
ADOLESCENT TRESPASSER
NAS Key West Trumbo Point Fuel Farm
Navy Tank Farm

13-Aug-99

June 1999

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
SOIL CONCENTRATION	C	chemical specific	chemical specific	
PART. EMISSION FACTOR	PEF	1.24E +09	m^3/kg	default [1]
CONCENTRATION AIR	CA	chemical-specific	mg/m^3	
INHALATION RATE	IR	0.625	m^3/hour	USEPA, 1995
BODY WEIGHT	BW	45	kg	USEPA, 1995
EXPOSURE TIME	ET	4	hours/day	Assumption
EXPOSURE FREQUENCY	EF	45	days/year	Assumption
EXPOSURE DURATION	ED	10	years	USEPA, 1995
CONVERSION FACTOR	CF	0.001	mg/ug	Organics only
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	10	years	USEPA, 1995

[1] PEF has been derived in the PEF Appendix to this report.
USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors": OSWER Directive 9285.6-03.
USEPA 1995. Supplemental Guidance to RAGS, Region 4 Bulletins, Bulletin No. 3, November 1995.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x INHALATION CANCER SLOPE FACTOR $(mg/kg\text{-}day)^{-1}$

HAZARD QUOTIENT = INTAKE (mg/kg-day) / INHALATION REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE} = \frac{CA \times IR \times ET \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

Where:

CA = C x CF x (1/PEF)

Note: For noncarcinogenic effects: AT = ED

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	AIR CONCENTRATION (mg/m³)	INTAKE (mg/kg-day)	INHALATION CSF $(mg/kg\text{-}day)^{-1}$	CANCER RISK
Arsenic	I	13.6	mg/kg	1.10E-08	1.1E-11	0.003	3.2E-14
Benzo(a)pyrene	0	433	ug/kg	3.49E-10	3.4E-13	3.1	1.1E-12
Dibenz(a,h)anthracene	0	340	ug/kg	2.74E-10	2.7E-13	3.1	8.3E-13
						SUMMARY CANCER RISK	3E-14

NE = not evaluated.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	AIR CONCENTRATION (mg/m³)	INTAKE (mg/kg-day)	INHALATION RfD (mg/kg-day)	HAZARD QUOTIENT
Arsenic	I	9.7	mg/kg	7.82E-09	5.4E-11	ND	ND
#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!	#REF!
TRPH (Florida Pro)	O	450000	mg/kg	3.63E-07	2.5E-09	ND	ND
						SUMMARY HAZARD INDEX	ND

ND = no data available.

TABLE AA13

DIRECT CONTACT WITH AND INCIDENTAL INGESTION OF SURFACE SOIL
OCCUPATIONAL WORKER
NAS Key West Trumbo Point Fuel Farm
Navy Tank Farm
EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SOIL	CS	chemical-specific	chemical-specific	
INGESTION RATE	IR	50	mg/day	USEPA, 1995
FRACTION INGESTED	FI	100%	unitless	Assumption
ADHERENCE FACTOR	AF	1	mg/cm²-event	USEPA, 1992
ABSORPTION FRACTION	ABS	chemical specific	unitless	Assumption
SURFACE AREA EXPOSED	SA	2,300	cm²	USEPA, 1992
DOSE ABSORBED PER EVENT	DA_{event}	chemical-specific	mg/cm²-event	USEPA, 1992
CONVERSION FACTOR	CF	1.00E-09	kg/ug	Organic conversion
CONVERSION FACTOR	CF	1.00E-06	kg/mg	Inorganic conversion
BODY WEIGHT	BW	70	kg	USEPA, 1991
EXPOSURE FREQUENCY	EF	250	days/year [1]	USEPA, 1995
EXPOSURE DURATION	ED	25	years	USEPA, 1995
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	25	years	USEPA, 1995

[1] Units for exposure frequency are events/year in the calculation of the dermally absorbed dose.
USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors"; OSWER Directive 9285.6-03.
USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B; 1/92.
USEPA, 1995. Supplemental Guidance to RAGS : Region IV, Human Health Risk Assessment Bulletin No. 3.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR $(mg/kg\text{-}day)^{-1}$

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$INTAKE_{-INGESTION} = \frac{CS \times IR \times FI \times CF \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

$$INTAKE_{-DERMAL} = \frac{DA_{event} \times SA \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

Where:

$$DA_{event} = CS \times AF \times ABS \times CF$$

Note: For noncarcinogenic effects, AT = ED

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL CSF $(mg/kg\text{-}day)^{-1}$	CANCER RISK INGESTION	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	DERMAL CSF [2] $(mg/kg\text{-}day)^{-1}$	CANCER RISK DERMAL	TOTAL CANCER RISK
Benzo(a)pyrene	O	433	ug/kg	7.6E-08	7.3	5.5E-07	0.01	3.5E-08	8	2.8E-07	8.3E-07
Dibenz(a,h)anthracene	O	340	ug/kg	5.9E-08	7.3	4.3E-07	0.01	2.7E-08	8	2.2E-07	6.5E-07
Arsenic	I	13.3	mg/kg	2.3E-06	1.5	3.5E-06	0.001	1.1E-07	1.5	1.6E-07	3.6E-06
SUMMARY CANCER RISK						6E-06				1E-06	7E-06

[1] USEPA Region IV guidance specifies absorption factors of 1% for organics and 0.1% for inorganics (November 1995).
[2] Calculated from oral CSFs.
NE = not evaluated.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	DERMAL RfD [2] (mg/kg-day)	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Benzo(a)anthracene	O	3400	ug/kg	1.7E-06	ND		0.01	7.7E-07	ND		
Benzo(a)pyrene	O	433	ug/kg	2.1E-07	ND		0.01	9.7E-08	ND		
Dibenz(a,h)anthracene	O	340	ug/kg	1.7E-07	ND		0.01	7.7E-08	ND		
Arsenic	I	13.3	mg/kg	6.5E-06	0.0003	2.2E-02	0.001	3.0E-07	0.00029	1.0E-03	2.3E-02
Florida TRPH	O	450000	ug/kg	2.2E-04	ND		0.01	1.0E-04	ND		
SUMMARY HAZARD INDEX						0.03				0.02	0.06

[1] USEPA Region IV guidance specifies absorption factors of 1% for organics and 0.1% for inorganics (November 1995).
[2] Calculated from oral RfDs.

TABLE A.A14

INHALATION OF PARTICULATES - SURFACE SOIL
OCCUPATIONAL WORKER
NAS Key West Trumbo Point Fuel Farm
Navy Tank Farm

13-Aug-99

June 1999

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
SOIL CONCENTRATION	C	chemical-specific	chemical-specific	
PART. EMISSION FACTOR	PEF	1.24E+09	m^3/kg	default [1]
CONCENTRATION AIR	CA	chemical-specific	mg/m^3	
INHALATION RATE	IR	2.5	m^3/hour	USEPA, 1995
BODY WEIGHT	BW	70	kg	USEPA, 1991
EXPOSURE TIME	ET	8	hours/day	Assumption
EXPOSURE FREQUENCY	EF	250	days/year	Assumption
EXPOSURE DURATION	ED	25	years	USEPA, 1995
CONVERSION FACTOR	CF	0.001	mg/ug	Organics only
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	25	years	USEPA, 1995

[1] PEF has been derived in the PEF Appendix to this report.
USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors"; OSWER Directive 9285.6-03.
USEPA, 1995. Supplemental Guidance to RAGS: Region 4 Bulletins, Bulletin No. 3, November 1995.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x INHALATION CANCER SLOPE FACTOR (mg/kg-day)$^{-1}$

HAZARD QUOTIENT = INTAKE (mg/kg-day) / INHALATION REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE} = \frac{\text{CA x IR x ET x EF x ED}}{\text{BW x AT x 365 days/yr}}$$

Where:

CA = C x CF x (1/PEF)

Note: For noncarcinogenic effects, AT = ED.

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	AIR CONCENTRATION (mg/m^3)	INTAKE (mg/kg-day)	INHALATION CSF (mg/kg-day)^-1	CANCER RISK
Arsenic	I	13.6	mg/kg	1.10E-08	7.7E-10	0.003	2.3E-12
Benzo(a)pyrene	O	433	ug/kg	3.49E-10	2.4E-11	3.1	7.6E-11
Dibenz(a,h)anthracene	O	340	ug/kg	2.74E-10	1.9E-11	3.1	5.9E-11
SUMMARY CANCER RISK							1E-10

NE = not evaluated.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	AIR CONCENTRATION (mg/m^3)	INTAKE (mg/kg-day)	INHALATION RfD (mg/kg-day)	HAZARD QUOTIENT
Arsenic	I	9.7	mg/kg	7.82E-09	1.5E-09	ND	
TRPH (Florida Pro)	O	450000	mg/kg	3.63E-07	7.1E-08	ND	
SUMMARY HAZARD INDEX							#REF!

ND = no data available.

TABLE AA15

DIRECT CONTACT WITH AND INCIDENTAL INGESTION OF SURFACE SOIL
SITE MAINTENANCE WORKER
NAS Key West Trumbo Point Fuel Farm

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SOIL	CS	chemical-specific	chemical-specific	
INGESTION RATE	IR	50	mg/day	USEPA, 1992
FRACTION INGESTED	FI	100%	unitless	Assumption
ADHERENCE FACTOR	AF	1	mg/cm²-event	USEPA, 1992
ABSORPTION FRACTION	ABS	chemical-specific	unitless	Assumption
SURFACE AREA EXPOSED	SA	5,750	cm²	USEPA, 1992
DOSE ABSORBED PER EVENT	DA_{event}	chemical specific	mg/cm² event	USEPA, 1992
CONVERSION FACTOR	CF	1.00E-09	kg/ug	Organic conversion
CONVERSION FACTOR	CF	1.00E-06	kg/mg	Inorganic conversion
BODY WEIGHT	BW	70	kg	USEPA, 1991
EXPOSURE FREQUENCY	EF	24	days/year [1]	Assumption
EXPOSURE DURATION	ED	25	years	USEPA, 1995
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	25	years	USEPA, 1995

[1] Units for exposure frequency are events/year in the calculation of the dermally absorbed dose.
USEPA, 1991. Human Health Evaluation Manual. Supplemental Guidance: "Standard Default Exposure Factors"; OSWER Directive 9285.6-03.
USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B; 1/92.
USEPA, 1995. Supplemental Guidance to RAGS : Region IV, Human Health Risk Assessment Bulletin No. 3.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR $(mg/kg\text{-}day)^{-1}$

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$INTAKE_{-INGESTION} = \frac{CS \times IR \times FI \times CF \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

$$INTAKE_{-DERMAL} = \frac{DA_{event} \times SA \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

Where:

$$DA_{event} = CS \times AF \times ABS \times CF$$

Note: For noncarcinogenic effects, AT = ED

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL CSF $(mg/kg\text{-}day)^{-1}$	CANCER RISK INGESTION	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	DERMAL CSF [2] $(mg/kg\text{-}day)^{-1}$	CANCER RISK DERMAL	TOTAL CANCER RISK
Benzo(a)pyrene	O	**433**	ug/kg	7.3E-09	**7.3**	5.3E-08	0.01	8.4E-09	**8**	6.7E-08	1.2E-07
Dibenz(a,h)anthracene	O	**340**	ug/kg	5.7E-09	**7.3**	4.2E-08	0.01	6.6E-09	**8**	5.2E-08	9.4E-08
Arsenic	I	**13.3**	mg/kg	2.2E-07	**1.5**	3.3E-07	0.001	2.6E-08	**1.5**	3.8E-08	3.7E-07
				SUMMARY CANCER RISK		**5E-07**				**3E-07**	**8E-07**

[1] USEPA Region IV guidance specifies absorption factors of 1% for organics and 0.1% for inorganics (November 1995).
[2] Calculated from oral CSFs.
NE = not evaluated.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	DERMAL RfD [2] (mg/kg-day)	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Benzo(a)pyrene	O	**433**	ug/kg	2.0E-08	**ND**		0.01	2.3E-08	**ND**		
Dibenz(a,h)anthracene	O	**340**	ug/kg	1.6E-08	**ND**		0.01	1.8E-08	**ND**		
Arsenic	I	**13.3**	mg/kg	6.2E-07	**0.0003**	2.1E-03	0.001	7.2E-08	**0.00029**	2.5E-04	2.3E-03
Florida TRPH	O	**450000**	ug/kg	2.1E-05	**ND**		0.01	2.4E-05	**ND**		
				SUMMARY HAZARD INDEX		**0.003**				**0.01**	**0.01**

[1] USEPA Region IV guidance specifies absorption factors of 1% for organics and 0.1% for inorganics (November 1995).
[2] Calculated from oral RfDs.

TABLE A.A16

INHALATION OF PARTICULATES - SURFACE SOIL
SITE MAINTENANCE WORKER
NAS Key West Trumbo Point Fuel Farm
Navy Tank Farm

13-Aug-99

June 1999

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
SOIL CONCENTRATION	C	chemical-specific	chemical-specific	
PART. EMISSION FACTOR	PEF	1.24E+09	m^3/kg	default [1]
CONCENTRATION AIR	CA	chemical-specific	mg/m^3	
INHALATION RATE	IR	2.5	m^3/hour	USEPA, 1995
BODY WEIGHT	BW	70	kg	USEPA, 1991
EXPOSURE TIME	ET	8	hours/day	Assumption
EXPOSURE FREQUENCY	EF	24	days/year	Assumption
EXPOSURE DURATION	ED	25	years	USEPA, 1995
CONVERSION FACTOR	CF	0.001	mg/ug	Organics only
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	25	years	USEPA, 1995

[1] PEF has been derived in the PEF Appendix to this report.
USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance:
"Standard Default Exposure Factors"; OSWER Directive 9285.6-03.
USEPA, 1995. Supplemental Guidance to RAGS: Region 4 Bulletins, Bulletin No. 3, November 1995.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x INHALATION CANCER SLOPE FACTOR (mg/kg-day)$^{-1}$

HAZARD QUOTIENT = INTAKE (mg/kg-day) / INHALATION REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE} = \frac{\text{CA x IR x ET x EF x ED}}{\text{BW x AT x 365 days/yr}}$$

Where:

CA = C x CF x (1/PEF)

Note: For noncarcinogenic effects, AT = ED

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC	SOIL CONCENTRATION	UNITS	AIR CONCENTRATION	INTAKE (mg/kg-day)	INHALATION CSF	CANCER RISK
Arsenic	I	13.6	mg/kg	1.10E-08	7.4E-11	0.003	2.2E-13
Benzo(a)pyrene	0	433	ug/kg	3.49E-10	2.3E-12	3.1	7.3E-12
Dibenz(a,h)anthracene	0	340	ug/kg	2.74E-10	1.8E-12	3.1	5.7E-12
					SUMMARY CANCER RISK		2E-13

NE = not evaluated.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	AIR CONCENTRATION (mg/m^3)	INTAKE (mg/kg-day)	INHALATION RfD (mg/kg-day)	HAZARD QUOTIENT
Arsenic	I	9.7	mg/kg	7.82E-09	1.5E-10	ND	ND
TRPH (Florida Pro)	O	450000	mg/kg	3.63E-07	6.8E-09	ND	ND
					SUMMARY HAZARD INDEX		ND

ND = no data available.

TABLE AA17

DIRECT CONTACT WITH AND INCIDENTAL INGESTION OF SURFACE SOIL
EXCAVATION WORKER
NAS Key West Trumbo Point Fuel Farm
Navy Tank Farm

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SOIL	CS	chemical-specific	chemical-specific	
INGESTION RATE	IR	480	mg/day	USEPA, 1995
FRACTION INGESTED	FI	100%	unitless	Assumption
ADHERENCE FACTOR	AF	1	mg/cm^2-event	USEPA, 1992
ABSORPTION FRACTION	ABS	chemical-specific	unitless	Assumption
SURFACE AREA EXPOSED	SA	5,750	cm^2	USEPA, 1992
DOSE ABSORBED PER EVENT	DA_{event}	chemical-specific	mg/cm^2-event	USEPA, 1992
CONVERSION FACTOR	CF	1.00E-09	kg/ug	Organic conversion
CONVERSION FACTOR	CF	1.00E-06	kg/mg	Inorganic conversion
BODY WEIGHT	BW	70	kg	USEPA, 1991
EXPOSURE FREQUENCY	EF	30	days/year [1]	Assumption
EXPOSURE DURATION	ED	1	years	USEPA, 1991
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	1	years	USEPA, 1991

[1] Units for exposure frequency are events/year in the calculation of the dermally absorbed dose.
USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors"; OSWER Directive 9285.6-03.
USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B; 1/92.
USEPA, 1995. Supplemental Guidance to RAGS : Region IV, Human Health Risk Assessment Bulletin No. 3.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR $(mg/kg\text{-}day)^{-1}$

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$INTAKE\text{-}_{INGESTION} = \frac{CS \times IR \times FI \times CF \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

$$INTAKE\text{-}_{DERMAL} = \frac{DAevent \times SA \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

Where:

DA_{event} = CS x AF x ABS x CF

Note: For noncarcinogenic effects, AT = ED

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL CSF $(mg/kg\text{-}day)^{-1}$	CANCER RISK INGESTION	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	DERMAL CSF [2] $(mg/kg\text{-}day)^{-1}$	CANCER RISK DERMAL	TOTAL CANCER RISK
Benzo(a)pyrene	O	433	ug/kg	3.5E-09	7.3	2.5E-08	0.01	4.2E-10	8	3.3E-09	2.9E-08
Dibenz(a,h)anthracene	O	340	ug/kg	2.7E-09	7.3	2.0E-08	0.01	3.3E-10	8	2.6E-09	2.3E-08
Arsenic	I	13.3	mg/kg	1.1E-07	1.5	1.6E-07	0.001	1.3E-09	1.5	1.9E-09	1.6E-07
SUMMARY CANCER RISK						3E-07				1E-08	3E-07

[1] USEPA Region IV guidance specifies absorption factors of 1% for organics and 0.1% for inorganics (November 1995).
[2] Calculated from oral CSFs.
NE = not evaluated.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL RfD [1] (mg/kg-day)	HAZARD QUOTIENT INGESTION	DERMAL ABS [2]	INTAKE DERMAL (mg/kg-day)	DERMAL RfD [3] (mg/kg-day)	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Benzo(a)pyrene	O	433	ug/kg	2.4E-07	ND		0.01	2.9E-08	ND		
Dibenz(a,h)anthracene	O	340	ug/kg	1.9E-07	ND		0.01	2.3E-08	ND		
Arsenic	I	13.3	mg/kg	7.5E-06	0.0003	2.5E-02	0.001	9.0E-08	0.00029	3.1E-04	2.5E-02
Florida TRPH	O	450000	ug/kg	2.5E-04	ND		0.01	3.0E-05	ND		
SUMMARY HAZARD INDEX						0.04				0.01	0.05

[1] Subchronic RfD values were used for the excavation worker due to short exposure scenario for all chemicals except aluminum, where a subchronic value is not available and therefore the chronic value was used.
[2] USEPA Region IV guidance specifies absorption factors of 1% for organics and 0.1% for inorganics (February 10, 1992).
[3] Calculated from oral RfDs.
[4] Pyrene RfD used as a surrogate for Phenanthrene.
ND = no data available. Note: all chemicals with ND were assessed as a carcinogen with the exception of lead.

TABLE A.A18

INHALATION OF PARTICULATES - SURFACE SOIL
EXCAVATION WORKER
NAS Key West Trumbo Point Fuel Farm
Navy Tank Farm

13-Aug-99

June 1999

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
SOIL CONCENTRATION	C	chemical-specific	chemical-specific	
PART. EMISSION FACTOR	PEF	1.24E+09	m^3/kg	default [1]
CONCENTRATION AIR	CA	chemical-specific	mg/m^3	
INHALATION RATE	IR	2.5	m^3/hour	USEPA, 1995
BODY WEIGHT	BW	70	kg	USEPA, 1991
EXPOSURE TIME	ET	8	hours/day	Assumption
EXPOSURE FREQUENCY	EF	30	days/year	Assumption
EXPOSURE DURATION	ED	1	years	Assumption
CONVERSION FACTOR	CF	0.001	mg/ug	Organics only
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	1	years	USEPA, 1991

[1] PEF has been derived in the PEF Appendix to this report.
USEPA. 1991. Human Health Evaluation Manual, Supplemental Guidance:
Standard Default Exposure Factors; OSWER Directive 9285.6-03.
USEPA, 1995. Supplemental Guidance to RAGS : Region IV, Human Health Risk Assessment Bulletin No. 3.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x INHALATION CANCER SLOPE FACTOR (mg/kg-day)$^{-1}$

HAZARD QUOTIENT = INTAKE (mg/kg-day) / INHALATION REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE} = \frac{\text{CA x IR x ET x EF x ED}}{\text{BW x AT x 365 days/yr}}$$

Where:

CA = C x CF x (1/PEF)

Note: For noncarcinogens, AT = ED.

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	AIR CONCENTRATION (mg/m^3)	INTAKE (mg/kg-day)	INHALATION CSF (mg/kg-day)^-1	CANCER RISK
Arsenic	I	13.6	mg/kg	1.10E-08	3.7E-12	0.003	**1.1E-14**
Benzo(a)pyrene	O	433	ug/kg	3.49E-10	1.2E-13	3.1	**3.6E-13**
Dibenz(a,h)anthracene	O	340	ug/kg	2.74E-10	9.2E-14	3.1	**2.9E-13**
						SUMMARY CANCER RISK	**1E-14**

NE = not evaluated.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	AIR CONCENTRATION (mg/m^3)	INTAKE (mg/kg-day)	INHALATION RfD (mg/kg-day)	HAZARD QUOTIENT
Arsenic	I	9.7	mg/kg	7.82E-09	1.8E-10	ND	**ND**
TRPH (Florida Pro)	O	450000	mg/kg	3.63E-07	8.5E-09	ND	**ND**
						SUMMARY HAZARD INDEX	**ND**

ND = no data available.

TABLE AA19

DIRECT CONTACT WITH AND INCIDENTAL INGESTION OF SUBSURFACE SOIL
EXCAVATION WORKER
TRUMBO FUEL FARM RBCA
NAS KEY WEST
NAVY TANK FARM

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SOIL	CS	chemical-specific	chemical-specific	
INGESTION RATE	IR	480	mg/day	USEPA, 1995
FRACTION INGESTED	FI	100%	unitless	Assumption
ADHERENCE FACTOR	AF	1	mg/cm²-event	USEPA, 1995
ABSORPTION FRACTION	ABS	chemical-specific	unitless	USEPA, 1995
SURFACE AREA EXPOSED	SA	5,750	cm²	USEPA, 1992
DOSE ABSORBED PER EVENT	DA_{event}	chemical-specific	mg/cm²-event	USEPA, 1992
CONVERSION FACTOR	CF	1.00E-09	kg/ug	Organic conversion
CONVERSION FACTOR	CF	1.00E-06	kg/mg	Inorganic conversion
BODY WEIGHT	BW	70	kg	USEPA, 1991
EXPOSURE FREQUENCY	EF	30	days/year [1]	Assumption
EXPOSURE DURATION	ED	1	years	USEPA, 1991
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	1	years	USEPA, 1991

[1] Units for exposure frequency are events/year in the calculation of the dermally absorbed dose.
USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors"; OSWER Directive 9285.6-03.
USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B; January 1992.
USEPA, 1995. Supplemental Guidance to RAGS : Region IV, Human Health Risk Assessment Bulletin No. 3.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR $(mg/kg\text{-}day)^{-1}$

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$INTAKE_{-INGESTION} = \frac{CS \times IR \times FI \times CF \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

$$INTAKE_{-DERMAL} = \frac{DAevent \times SA \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

Where:

$$DA_{event} = CS \times AF \times ABS \times CF$$

Note: For noncarcinogenic effects, AT = ED

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL CSF $(mg/kg\text{-}day)^{-1}$	CANCER RISK INGESTION	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	DERMAL CSF [2] $(mg/kg\text{-}day)^{-1}$	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	I	4	mg/kg	3.2E-08	1.5	4.8E-08	0.001	3.9E-10	1.79	6.9E-10	4.9E-08
SUMMARY CANCER RISK						5E-08				7E-10	5E-08

[1] USEPA Region IV guidance specifies absorption factors of 1% for organics and 0.1% for inorganics (November 1995).
[2] Calculated from oral CSFs.
NE = not evaluated.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	DERMAL RfD [2] (mg/kg-day)	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	I	4	mg/kg	2.3E-06	0.0003	7.5E-03	0.001	2.7E-08	0.000294	9.2E-05	7.6E-03
SUMMARY HAZARD INDEX						0.01				9.2E-05	0.01

[1] USEPA Region IV guidance specifies absorption factors of 1% for organics and 0.1% for inorganics (November 1995).
[2] Calculated from oral RfDs.
ND = no data available.

19/22

TABLE AA20

INHALATION OF PARTICULATES - SUBSURFACE SOIL
EXCAVATION WORKER
TRUMBO FUEL FARM RBCA
NAS KEY WEST
NAVY TANK FARM

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
SOIL CONCENTRATION	C	chemical-specific	chemical-specific	
PART. EMISSION FACTOR	PEF	12000000	m^3/kg	
CONCENTRATION AIR	CA	chemical-specific	mg/m^3	
INHALATION RATE	IR	2.5	$m^3/hour$	USEPA, 1995
BODY WEIGHT	BW	70	kg	USEPA, 1991
EXPOSURE TIME	ET	8	hours/day	Assumption
EXPOSURE FREQUENCY	EF	30	days/year	Assumption
EXPOSURE DURATION	ED	1	years	Assumption
CONVERSION FACTOR	CF	0.001	mg/ug	Organics only
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	1	years	USEPA, 1991

[1] PEF has been derived in the PEF Appendix to this report.
USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors; OSWER Directive 9285.6-03.
USEPA, 1995. Supplemental Guidance to RAGS : Region IV, Human Health Risk Assessment Bulletin No. 3.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x INHALATION CANCER SLOPE FACTOR $(mg/kg\text{-}day)^{-1}$

[1]HAZARD QUOTIENT = INTAKE (mg/kg-day) / INHALATION REFERENCE DOSE (mg/kg-day)

$$INTAKE = \frac{CA \times IR \times ET \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

Where:

CA = C x CF x (1/PEF)

Note: For noncarcinogens, AT = ED.

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	AIR CONCENTRATION (mg/m^3)	INTAKE (mg/kg-day)	INHALATION CSF (mg/kg-day)^-1	CANCER RISK
Arsenic	I	4	mg/kg	3.33E-07	1.1E-10	50	5.6E-09
					SUMMARY CANCER RISK		6E-09

NE = not evaluated.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	AIR CONCENTRATION (mg/m^3)	INTAKE (mg/kg-day)	INHALATION RfD (mg/kg-day)	HAZARD QUOTIENT
Arsenic	I	4	mg/kg	3.33E-07	7.8E-09	ND	
					SUMMARY HAZARD INDEX		0E+00

ND = no data available.

TABLE AA21

INCIDENTAL INGESTION OF AND DIRECT CONTACT WITH NON-POTABLE GROUNDWATER
OCCUPATIONAL WORKER
TRUMBO POINT FUEL FARM
NAS KEY WEST
NAVY TANK FARM

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical-specific	ug/liter	
INGESTION RATE [1]	IR	0.026	liters/day	USEPA, 1995
SURFACE AREA [2]	SA	3,120	cm2	USEPA 1989
EVENT FREQUENCY	EV	1	events/day	Assumption
BODY WEIGHT	BW	70	kg	USEPA, 1991
DOSE ABSORBED PER EVENT	DAevent	chemical-specific	mg/cm2-event	Calculated
EXPOSURE TIME	ET	0.33	hours/day	Assumption
EXPOSURE FREQUENCY	EF	250	days/year	Assumption
EXPOSURE DURATION	ED	25	years	Assumption
DIFFUSION DEPTH PER EVENT	PCevent	chemical-specific	cm/event	Calculated per USEPA, 1992 [3]
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	25	years	USEPA, 1995
CONVERSION FACTOR	CF1	0.001	mg/ug	
CONVERSION FACTOR	CF2	0.001	liter/cm3	

[1] Ingestion Rate = 0.026 l/day = 10 ml/hour x 2.6 hours/day x 0.001 l/ml
[2] Surface area assumes hands and arms are exposed
[3] PCevent is calculated in Table AA4
USEPA, 1989. Exposure Factors Handbook; EPA/600/8-89/043; May 1989.
USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters."
USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B.
USEPA, 1995. Supplemental Guidance to RAGS: Region 4 Bulletins, Bulletin No. 3, November 1995.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times EF \times ED \times CF1}{BW \times AT \times 365\ days/yr}$$

$$\text{INTAKE-DERMAL} = \frac{DAevent \times EV \times EF \times ED \times SA}{AT \times BW \times 365\ days/yr}$$

Where:
DAevent = PCevent x CW x CF1 x CF2

Note: For noncarcinogenic effects, AT = ED.

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	WATER CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	PCEVENT[2] (cm/event)	INTAKE DERMAL (mg/kg-day)	DERMAL CSF [1, 3] (mg/kg-day)^-1	CANCER RISK DERMAL	TOTAL CANCER RISK
Benzene	ORGANIC	4.8	ug/L	4.4E-07	0.029	1.3E-08	2.10E-02	1.1E-06	0.029	3.2E-08	**4.5E-08**
Arsenic	INORGANIC	6.3	ug/L	5.7E-07	1.5	8.6E-07	0.00033	2.3E-08	1.53	3.5E-08	**8.9E-07**
					SUMMARY CANCER RISK	**9E-07**				**7E-08**	**9E-07**

[1] Relative potency factors were applied to the CSFs of carcinogenic PAHs. Relative potency factors are derived in "Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons," USEPA, 1993.
[3] Calculated from oral CSFs.
ND = no data available.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	WATER CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	PCEVENT[1] (cm/event)	INTAKE DERMAL (mg/kg-day)	DERMAL RfD [2] (mg/kg-day)^-1	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Tetrachloroethene	ORGANIC	4.8	ug/L	1.2E-06	0.003	4.1E-04	2.10E-02	3.1E-06	0.003	1.0E-03	**1.4E-03**
Arsenic	INORGANIC	6.3	ug/L	1.6E-06	0.0003	5.3E-03	0.00033	6.3E-08	0.000294	2.2E-04	**5.6E-03**
					SUMMARY HAZARD INDEX	**6E-03**				**1E-03**	**7E-03**

[1] This chemical-specific value is calculated in Appendix ?
[2] Calculated from oral RfDs.
ND = no data available.

TABLE AA22

INCIDENTAL INGESTION OF AND DIRECT CONTACT WITH NON-POTABLE GROUNDWATER
OCCUPATIONAL WORKER
TRUMBO POINT FUEL FARM
NAS KEY WEST
KEY WEST PIPELINE

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical-specific	ug/liter	
INGESTION RATE [1]	IR	0.026	liters/day	USEPA, 1995
SURFACE AREA [2]	SA	3,120	cm2	USEPA, 1989
EVENT FREQUENCY	EV	1	events/day	Assumption
BODY WEIGHT	BW	70	kg	USEPA, 1991
DOSE ABSORBED PER EVENT	DAevent	chemical-specific	mg/cm2-event	Calculated
EXPOSURE TIME	ET	0.33	hours/day	Assumption
EXPOSURE FREQUENCY	EF	250	days/year	Assumption
EXPOSURE DURATION	ED	25	years	Assumption
DIFFUSION DEPTH PER EVENT	PCevent	chemical-specific	cm/event	Calculated per USEPA, 1992 [3]
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	25	years	USEPA, 1995
CONVERSION FACTOR	CF1	0.001	mg/ug	
CONVERSION FACTOR	CF2	0.001	liter/cm3	

[1] Ingestion Rate = 0.026 l/day = 10 ml/hour x 2.6 hours/day x 0.001 l/ml
[2] Surface area assumes hands and arms are exposed.
[3] PCevent is calculated in Table AA4
USEPA, 1989. Exposure Factors Handbook; EPA/600/8-89/043; May 1989.
USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters."
USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B.
USEPA, 1995. Supplemental Guidance to RAGS: Region 4 Bulletins, Bulletin No. 3, November 1995.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

INTAKE-INGESTION = $\frac{CW \times IR \times EF \times ED \times CF1}{BW \times AT \times 365 \text{ days/yr}}$

INTAKE-DERMAL = $\frac{DAevent \times EV \times EF \times ED \times SA}{AT \times BW \times 365 \text{ days/yr}}$

Where:
DAevent = PCevent x CW x CF1 x CF2

Note: For noncarcinogenic effects, AT = ED.

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	WATER CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	PCEVENT[2] (cm/event)	INTAKE DERMAL (mg/kg-day)	DERMAL CSF [1, 3] (mg/kg-day)^-1	CANCER RISK DERMAL	TOTAL CANCER RISK
Benzene	ORGANIC	283	ug/L	2.6E-05	0.029	7.5E-07	2.10E-02	6.5E-05	0.029	1.9E-06	**2.6E-06**
Trichloroethene	ORGANIC	3.4	ug/L	3.1E-07	0.011	3.4E-09	0.016	5.9E-07	0.011	6.5E-09	**9.9E-09**
Arsenic	INORGANIC	**10.2**	ug/L	9.3E-07	1.5	1.4E-06	0.00033	3.7E-08	1.53	5.6E-08	**1.4E-06**
					SUMMARY CANCER RISK	**2E-06**				**2E-06**	**4E-06**

[1] Relative potency factors were applied to the CSFs of carcinogenic PAHs. Relative potency factors are derived in "Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons," USEPA, 1993.
[3] Calculated from oral CSFs.
ND = no data available.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	WATER CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	PCEVENT[1] (cm/event)	INTAKE DERMAL (mg/kg-day)	DERMAL RfD [2] (mg/kg-day)^-1	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Benzene	ORGANIC	283	ug/L	7.2E-05	0.003	2.4E-02	2.10E-02	1.8E-04	0.003	6.0E-02	**8.4E-02**
Trichloroethene	ORGANIC	3.4	ug/L	8.6E-07	**0.006**	1.4E-04	0.016	1.7E-06	**0.006**	2.8E-04	**4.2E-04**
Arsenic	INORGANIC	**10.2**	ug/L	2.6E-06	**0.0003**	8.6E-03	**0.00033**	1.0E-07	**0.000294**	3.5E-04	**9.0E-03**
					SUMMARY HAZARD INDEX	**3E-02**				**6E-02**	**9E-02**

[1] This chemical-specific value is calculated in Appendix ?
[2] Calculated from oral RfDs.
ND = no data available.

APPENDIX B

APPENDIX B

REMEDIAL ALTERNATIVES CONSIDERED

DISCUSSION OF ALTERNATIVES. After defining the chemicals of concern, the applicable cleanup standards, the extent of contamination and developing a remedial strategy, it is necessary to identify and screen technologies that may be applicable to mitigating the contamination at the site. Because each site is unique and cleanup technologies applicable to sites contaminated with petroleum substances are continually being improved and developed, it is important to develop remedial action alternatives using the most effective technologies available. Table B-1 shows a variety of remedial alternatives for potential use at the Trumbo Point Fuel Farm (TPFF), along with advantages and disadvantages for each alternative. Also included is a column showing the results of the initial screening process. The table groups the remedial alternatives by media, i.e., into a group for the remediation of groundwater, a group for the remediation of product zones, and a group for the remediation of surface soil.

B.1 Technologies for Groundwater Remediation Technologies for groundwater remediation include both *ex situ* and *in situ* technologies. Proper groundwater remediation technologies will address both potential exposure to the contaminated groundwater itself and the potential for groundwater to contaminate surface waters.

***Ex Situ* Treatment** This alternative consists of capturing and collecting the contaminated groundwater, treating it to reduce its toxicity, and disposing of the treated effluent. The groundwater would be collected through an extraction system. Possible extraction systems include extraction wells, combined vapor-fluid vacuum-enhanced extraction systems, and recovery trenches. Any such extraction system would likely be ineffective in light of the low permeability of the soil in the contaminated zone. For example, assume an extraction well is screened in the geologic unit containing the contamination, namely, the soft, silty to sandy limestone mud generally found from 3 feet bls to 13 feet bls. With groundwater generally found at 5 feet bls, assume a 4-foot drawdown is allowed in the recovery wells, because a drawdown greater than this would simply cause ever-increasing upwelling from the more permeable lower zone generally found at depths greater than 13 feet bls. Using the shallow well type-curve analysis results from the CAR, the radius of influence of each recovery well can be estimated by assuming an 180-day pumping time. This calculation yields a radius of influence of 108 feet. Considering the calculated radius of influence of 108 feet, and the estimated plume area of 131,000 square feet, four ideally situated recovery wells would be needed to treat the groundwater plume. Five recovery wells are needed so that their treatment areas will overlap. Substituting the calculated radius in the steady-state unconfined aquifer well equation along with the assumed drawdown and other data from the CAR yields the flow rate of $Q = 0.0037$ gallons per minute for each well. To pump one pore volume in the contaminated area would take 360 years.

The above calculations show that any *ex situ* groundwater treatment system would likely be ineffective. Although the case of enhanced vapor extraction or recovery trenches was not addressed in the calculations, a pilot study of a groundwater treatment/product recovery system using an infiltration gallery for extraction was conducted by the IT Corporation in 1990 (IT Corp., 1991). The March 1991 report on the pilot project concluded that the groundwater/product recovery system used is not a feasible remediation alternative. Site conditions

Table B-1
Remedial Technologies

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key

Remedial Technology	Advantages	Disadvantages	Decision/ Comments
Groundwater			
Air Sparging	Actively removes contaminants from groundwater; may assist biodegradation.	Low soil permeability prevents movement of contaminated groundwater into treatment well for in-well stripping and also prevents movement of high DO water to aquifer for assisting biodegradation.	Eliminated
Containment	Relatively low cost, simple and proven technology, no maintenance.	Does not itself remove contamination from groundwater.	Retained. May be used in combination with other technologies.
Enhanced Biodegradation	Relatively low cost, can be effective if nutrients and oxygenated groundwater are provided.	Low permeability would greatly limit movement of high nutrient or DO groundwater through aquifer; low microbial counts in groundwater suggest microbial activity may be inhibited.	Eliminated
Land-Use Controls	Low cost, effective if implemented correctly.	Does not itself remove contamination from groundwater. Requires long-life institution to maintain implementation.	Retained
Natural Attenuation	Only cost is for monitoring and periodic evaluation, which will be needed for other groundwater remediation technology in this table.	May not prevent contamination of surface waters from all groundwater plumes.	Retained. Must be used in combination with other technologies.
Pump and Treat/Recovery Trenches/ Vacuum Enhanced Extraction and Treatment	Actively remediates groundwater.	Low permeability makes treatment of groundwater plume unreasonably long; relatively high cost and high maintenance; previous pilot study using recovery trenches yielded negative results.	Eliminated
Phytoremediation	Can actively remove contaminants or act as a groundwater gradient control by intercepting infiltration. Costs less than mechanical groundwater extraction technologies (pump and treat, etc.). May result in additional benefits such as recreational use or property enhancements.	Requires maintenance; probably not sufficient to remediate or contain contaminated groundwater in and of itself.	Retained. Must be used in combination with other technologies.

See notes at end of table.

Table B-1 (Continued)
Remedial Technologies

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key

Remedial Technology	Advantages	Disadvantages	Decision/ Comments
Free Product			
Absorbent Socks/In-Well Product Skimmers	Low cost, simple technology.	Not effective for remediating large quantities of free product. Low soil permeability may hinder performance.	Retained. Not appropriate for large product plumes.
Direct Excavation and Ion Collider Washing of Free-Product Containing Soil	Permanently eliminates all contamination.	Potential for exposure to free product during excavation and transport; very high cost; disruptive of base operations; safety concerns associated with excavation; onsite location need ion-collider soil-washing equipment.	Retained
Direct Excavation and Land Farming /Bio-Piling of Free-Product Containing Soil	Permanently eliminates all contamination.	Potential for exposure to free product during excavation and transport; very high cost; disruptive of base operations; safety concerns associated with excavation; large area needed for land farming/bio-pile location.	Retained
Direct Excavation and Landfilling of Free-Product Containing Soil	Permanently eliminates all contamination.	Potential for exposure to free product during excavation and transport; very high cost; disruptive of base operations; safety concerns associated with excavation.	Retained
Direct Excavation and Thermal Treatment of Free-Product Containing Soil	Permanently eliminates all contamination. Can be accomplished onsite or offsite.	Potential for exposure to free product during excavation and transport; very high cost; disruptive of base operations; safety concerns associated with excavation; onsite treatment would require location for treatment equipment.	Retained
Multiphase Vacuum Enhanced Extraction	Vacuum enhancement helps overcome low permeability of soil. Can be accomplished with existing wells and permanent or mobile equipment. Lower cost than excavation.	Low permeability of soil may hinder performance.	Retained
Recovery trenches sumps		Previous product recovery systems shown to be ineffective; high cost and maintenance needs.	Eliminated

Note: DO = dissolved oxygen.

at the TPFF dictate that an *ex situ* groundwater treatment system would function mainly as a capture and containment system, preventing migration of the groundwater plume, not as a remediation system. Because containment of the groundwater plume can be accomplished much more easily, cheaply, and reliably by passive methods, active *ex situ* groundwater treatment is rejected as a remediation method for groundwater at the TPFF.

***In Situ* Treatment.** *In situ* treatment technologies for groundwater at the TPFF site include air sparging, containment, enhanced biodegradation, LUCs, natural attenuation, and phytoremediation. As noted in Table B-1, air sparging has been eliminated as a possible treatment technology, because the low permeability of the site soil would largely preclude movement of sparged water from the well through to the aquifer. One merely needs to review the flow calculations for an extraction well discussed in the *ex situ* groundwater treatment technologies section above to recognize that the gradient created by an air-sparging system would be much less than the gradient created by an extraction well. Enhanced biodegradation has been eliminated for the similar reason that low soil permeability would limit movement of nutrient or dissolved oxygen enhanced groundwater through the aquifer.

Data on biological activity and the fraction of organic carbon found in the soil indicate that natural attenuation is likely occurring at Naval Air Station (NAS) Key West TPFF. Natural attenuation would not prevent potential exposure to contaminated groundwater if, for example, a water supply well was installed in a contaminated groundwater plume. Furthermore, contaminated groundwater in the northeast portion of the Key West Pipeline Company land-use area has the potential to migrate to a surficial water body (Fleming Key Cut). As a consequence, natural attenuation is not proposed as a remedy in and of itself for groundwater contamination. Natural attenuation can serve an important role as an enhancement or an addition to other remedial technologies chosen. The monitoring requirements or natural attenuation would also be necessary in the implementation of other remedial technologies. Therefore, natural attenuation will be further considered as a possible component of the chosen remedial alternative.

Land-use controls can block the exposure of receptors to contaminated groundwater, as long as a long-lived institution is in place to maintain the implementation of the land-use controls. NAS Key West is precisely such an institution. Precedent for the establishment of long-term land-use controls at U.S. Navy facilities has been established by the Memorandum of Agreement (MOA) entered into by the USEPA, FDEP, and the U.S. Department of the Navy regarding NAS Jacksonville (USEPA, et.al., 1998). This remedial technology will be further considered as a possible component of the chosen remedial alternative.

The groundwater plume in the northeast portion of the site has the potential to contaminate the water in Fleming Key cut. Although natural attenuation is likely occurring in this region, surface water contamination could still possibly occur. A contingency action that could be taken in the event surface water is threatened is groundwater plume containment by extending the existing seawall. Migration of any other groundwater plumes to surface water is blocked by the bulkheads surrounding the piers and the north side of the facility. The travel time for the plume to reach Fleming Key Cut can be adjusted within a range, depending on the length of the containment wall. The increased plume travel time would allow natural attenuation to work more thoroughly. This remedial technology is

effective, requires no maintenance, is inexpensive, and is protective of surface waters. For these reasons, containment will be further considered as a possible contingency component of the chosen remedial alternative. Long-term monitoring is required with this remedial technology in order to verify that plume travel times are indeed slow enough for it to be effective.

Insufficient evidence exists to recommend phytoremediation as an active remediation technology, because there is not enough evidence that plant species would draw water from the contaminated water zone. For the same reason, it is unproven that plants would be able to intercept groundwater flow and thus contain contaminated groundwater. Phytoremediation could be used in a constructed wetland. A constructed wetland area could intercept groundwater flow, with phytoremediation used in the wetland to remediate recharging groundwater before it is discharged into a surficial water body. A pilot study would have to be implemented to ensure the effectiveness of this technology. Care would have to be taken to use only native species appropriate to the conditions of the wetland. This remedial option would require a considerable land area for the constructed wetland. The constructed wetland would require maintenance and protection from disruption by storm water runoff or high tides and/or storm surges from the sea. The constructed wetland could offer additional benefits of recreational and property value enhancement. Due to the need for a pilot study, the uncertainty in finding appropriate species that would thrive in what would be close to an intertidal environment, and the land that would have to be permanently set aside (given natural groundwater movement rates) for this remedial technology, this remedial technology is not chosen for further consideration as a possible component of the remedial alternative. Note that this remedial technology may be implemented despite the above reasons as an augmentation to other remedial technologies, and particularly for recreational and property value enhancement.

<u>B.2 Technologies for Product-Contamination Remediation</u> As noted in the remedial strategy (Section 3.8), any product-contamination remediation should have as its goal the prevention of potential future exposure to groundwater or surface water contamination posed by the product-contaminated areas. Analogous to the groundwater-remediation technologies, product-contamination remediation technologies can be broadly divided into *in situ* and *ex situ* categories. Accordingly, the technologies are grouped by these categories in the discussion which follows.

***Ex Situ* Treatment.** All *ex situ* product-contamination treatment technologies obviously involve excavation. All such treatment technologies thus share the various disadvantages accompanying excavation of product-contaminated soil. Given the depths of product contamination noted during the site investigations and the need to excavate below the contamination watertable interface, all excavations would require protection against cave-ins, be it shoring, trench boxes, or gently sloping excavation sides. An exposure risk exists not found with *in situ* technologies because *ex situ* methods involve excavating and thus openly exposing product. Similarly, a product-exposure risk is presented when transporting product. Once the soil is excavated, a variety of treatment options are available. These include soil washing with water treated by an ion-collider system, landfarming/biopiles, disposal in a landfill, thermal desorption, and incineration. Furthermore, the treatment options may be on site or off site. All soil treatment methods are presumed to be equally effective in that the contamination is 100 percent removed, so the basis for choosing a soil treatment method devolves to the factors of convenience, safety, and cost. Landfarming/-

biopiles as a treatment technology would tie up NAS Key West TPFF property for a lengthy period of time. This option is thus eliminated because less disruptive and similarly expensive remediation technologies are available. On-site incineration is rejected since on site thermal desorption accomplishes the same result while using less fuel, resulting the lower costs and lower carbon dioxide emissions.

The remaining *ex situ* treatment technologies include on site thermal desorption, on-site soil washing with ion-collider treated water, off-site incineration, off-site landfilling, and off-site thermal treatment. For comparison and calculations purposes, it will be assumed the area FP-16 will be excavated and contaminated soil treated. This assumption is made for the following reasons: (1) over 100,000 gallons of mobile free product are estimated to remain in this area; (2) FP-16 has very few obstructions that would have to be removed in an excavation effort; and (3) the Navy Tanks land-use area is the land-use area most likely to see land-use changes. Assuming that FP-16 will be the only product-contaminated areas subject to *ex situ* treatment, costs for the above-listed treatment technologies can be calculated.

Table B-2 lists the technologies and the calculated cost for remediating FP-16. As the table shows, on-site soil washing is the least expensive treatment. Besides cost, on-site soil washing is advantageous because soil is not transported offsite, which reduces the exposure risk to the public. For these reasons, on-site soil washing is retained for possible use, while other *ex situ* remedial technologies are eliminated. As with other remedial technologies, its use is restricted to appropriate product-contaminated areas, i.e., those with large quantities of mobile product in an easily accessible area. The backup for the costs provided in Table B-2 are presented in the FP-16 tables at the end of this appendix.

Table B-2
Cost Comparison of *Ex Situ* Product Contaminated Treatment Technologies

Remedial Action Plan
Trumbo Point Fuel Farm
Naval Air Station Key West
Trumbo Point Annex, Key West

Remediation Technology	Calculated Cost for Remediating FP-16
Excavation and landfilling	$882,000
Excavation and offsite incineration	$896,000
Excavation and offsite thermal treatment	$854,000
Excavation and onsite soil washing	$662,000
Excavation and onsite thermal treatment	$747,000

***In Situ* Treatment** *In situ* remediation technologies include recovery trenches and sumps, in-well product-absorbent socks or passive product skimmers, multiphase extraction, containment, and long-term monitoring. Recovery trenches and sumps are eliminated in light of the extremely low permeability of the site soil and the previous disappointing results of the pilot study by the IT Corporation (IT

Corporation, 1991). Containment and long-term monitoring are appropriate for product-contaminated regions where no mobile product has been observed. If a product region is stabilized or immobilized by containment, the risk to surface water is eliminated. Similarly, groundwater is protected if both the product and the groundwater can be shown to be stable and immobile. Long-term monitoring is typically specified with any containment design to verify the effectiveness of the design. This combination of remediation technologies is retained.

In-well product-absorbent socks or passive product skimmers require ongoing operations and maintenance efforts in order to change out the in-well units. The in-well unit, be it a sock or a passive product skimmer, cannot physically contain much product. For this reason, the amount of product removed by this method is small compared to other remediation methods. Cost, convenience, and lack of disruption to facility activities favor this method. It is retained, but only where the amount of mobile product is estimated to be small enough that the method can work in a reasonable amount of time. In practical terms, the product-contaminated areas with less than 0.1 foot of product calculated to be in formation in the most contaminated part of the product-contaminated zone are the product-contaminated areas that meet this criterion.

Multiphase extraction, conversely, is suitable where product thicknesses are greater than 0.1 foot. The method offers convenience and generally costs less than *ex situ* methods. Furthermore, the method has a relative advantage in more impermeable formations, due to the air flow induced in the vadose zone. Multi-phase extraction can be accomplished either by installing a permanent system on site, or by visiting the site with vacuum extraction trucks. The cost-effectiveness of each method depends on the size and estimated time-to-cleanup of the site in question. The two types of multiphase extraction are retained, subject to cost analyses to determine the appropriateness of each method in comparison with each other and with other remediation technologies.

B.3 TECHNOLOGIES FOR SURFACE SOIL REMEDIATION. Just as remedial technologies for groundwater and product-contaminated subsurface soil can be divided into *in situ* and *ex situ* groupings, remedial technologies for contaminated surface soils can be divided into *in situ* and *ex situ* groupings. Whatever remedial technology is chosen, the overall remedy must prevent exposure of human and ecological receptors to excessively contaminated surface soil, as stated in the Remedial Strategy (Section 3.8). As noted in the surface soil risk assessment, the primary risk posed by surface soil is risk to humans, not ecological risk. In particular, the risk to humans in a residential exposure scenario poses the most substantial risk, and thus this scenario will shape the chosen remedy.

***Ex Situ* Treatment**. These alternatives include excavation, disposal, and backfill with clean soil; excavation, soil stabilization, and backfill.

Excavation, disposal, and backfill with clean soil is an older and proven technology for eliminating the risk posed by contaminated surface soil. This alternative does not destroy contamination; it merely moves it to another location. However, no chemical or physical process can destroy arsenic contamination. Arsenic can only be moved from one location or media to another. A disadvantage of this alternative is the transport costs involved. Given the remote location of NAS Key West, transport costs for large amounts of soil become prohibitive, especially when that cost includes both transport of contaminated soil from Key West to a mainland-located landfill, and transport of clean soil

from a mainland source to Key West. In light of the high transport cost associated with this alternative, the fact that this alternative merely moves the contamination from one location to another, and the existence of remedial alternatives that do not involve soil transport, this remedial alternative is not recommended.

Excavation, soil stabilization, and backfill allow contaminated soil to be treated onsite. Risk reduction is accomplished by transforming the contaminated soil to a form less likely to lead to human or ecological receptor exposure. At the Trumbo Point Fuel Farm, the primary exposure pathway and receptor driving risk concerns is soil ingestion in a residential risk scenario. Soil stabilization in this situation would likely involve mixing the soil with concrete, to form an impervious, hard material. Two factors argue against this alternative. First, the soil at the Trumbo Point Fuel Farm is already extremely hard and impervious. Some of the most recent surface soil samples had to be collected with a pickaxe due to soil hardness. In regard to imperviousness, a permeability of 1.8×10^{-6} cm/s was measured from a representative soil sample. Thus, the additional advantage gained by mixing the soil with concrete would be small to negligible. Therefore, this technology is not recommended.

***In Situ* Treatment**. *In situ* treatment alternatives considered include capping, using asphalt or concrete. Both would eliminate exposure. Asphalt would be less expensive to install, but would require maintenance and replacement after a few years. Concrete is more expensive to install but requires less maintenance and can last up to 50 years. A concrete cap is retained for further evaluation.

B.4 ALTERNATIVE SELECTION. The remedial action selected at TPFF site takes into account the existing site-specific considerations and conditions. In this section, alternatives will be considered and appropriate selections will be made.

As noted in the remedial strategy, three different risks are posed by contamination at NAS Key West Trumbo Point Fuel Farm: (1) the risk to human health posed by contaminated groundwater, (2) the risk of ecological damage posed by contaminated groundwater or mobile product migrating to surface water, and (3) the potential risk of further contaminating groundwater or surface water posed by the mobile product areas.

Reviewing the remedial strategy in regards to the risk to human health posed by groundwater contamination shows that this risk can be adequately addressed through the imposition of land-use controls. By imposing land-use controls, any direct contact between humans and groundwater would be eliminated. Land-use controls have been used on other naval facilities and are an effective and accepted way of eliminating risk due to potential exposure to contaminants.

The risk posed to surface water by contaminated groundwater will be dealt with by natural attenuation, with a contingency requirements that natural attenuation be augmented with containment if the groundwater plume reaches selected point of compliance wells. The seawall in place around most of the facility, combined with the extremely low permeability of the soil, act to block groundwater flow to surface water in all but two areas. One of these areas is the shore south of Pier D1. Although a product plume exists at the base of Pier D1, no groundwater contamination above acceptable limits has been detected in the this area. The extremely low soil permeability in the region would act to retard any groundwater flow to the surface water. Two groundwater elevation surveys conducted during

the CA on April 16, 1996 and July 29, 1996, reveal a groundwater gradient that indicates groundwater flow towards the west end of the pier, away from the pier base and the potential exposure route. Finally, the remediation alternative for product-contaminated area FP-21 would include long-term monitoring of the stability of the plume. If contaminated groundwater did move towards the exposed shore, it would be detected by this monitoring program.

The other area where groundwater could potentially migrate to and contaminate surface water is in the area past the end of the seawall, east of the bridge to Fleming Key. A groundwater plume with contamination above acceptable levels has been detected in this area. If natural attenuation is a sufficient remedy for this groundwater plume, this will be shown through long-term monitoring. Alternatively, if natural attenuation is insufficient to prevent surface water contamination, then the natural attenuation process will be augmented through plume containment. A containment wall in the soil would force groundwater flow to take a spatially and temporally longer path to the surface water. The containment wall length would be chosen so that the length of time for groundwater flow would allow natural attenuation to reduce the contaminant concentrations to below acceptable limits. The efficaciousness of the containment and natural attenuation would be established through long-term monitoring.

A multipronged remediation alternative is needed for the product-contaminated areas. Figure 3-2 shows the product contaminated areas grouped into three categories: those with no know mobile product; those with no monitoring wells averaging (over time) over 0.1 feet of product; and those with an average of over 0.1 feet of product in a least one monitoring well. The first group includes product-contaminated areas FP-1, FP-4, FP-7, FP-8, FP-9, FP-12, FP-13, FP-14, FP-19, and FP-20; the second group includes product-contaminated areas FP-2, FP-6, FP-10, FP-11, FP-15, FP-17, and FP-21; the third group includes product contaminated areas FP-3, FP-5, FP-16, and FP-18.

For the first group, the chosen remedial alternative is containment and long-term monitoring, utilizing existing containment features. This alternative avoids disrupting facility operations yet is protective of human health and the environment. It is a response proportional to the magnitude of the threat posed by this group of product-contaminated areas. As part of this alternative, additional monitoring wells will be installed as necessary to ensure the completeness of the monitoring program.

The second group, product-contaminated areas averaging less than 0.1 feet of product in all of their wells, benefit from the containment afforded by the existing seawall or pier bulkheads as well as the impermeable soil. However, The mobile product evident in these areas must be addressed, however, again preferably in a way that minimizes disruptions of the facility. For those areas currently under pavement or in areas when excavation would pose disruption, the chosen remedial alternative is containment via existing structures and/or conditions, combined with product recovery using in-well passive product skimmers and long-term monitoring. As with the first group of product areas considered above, additional monitoring wells will be installed, as necessary to ensure the completeness of the monitoring program and to provide more points at which to remove product. Product contaminated areas not currently under pavement and not in areas where excavation would pose a disruption, i.e., FP-17, will be grouped and considered with the third group of product areas discussed below.

For the third group, more aggressive product remediation technologies are needed due to the threat posed by the relatively large amounts of mobile product. Looking at the product areas individually reveals quite a few differences. FP-3 is partially under pavement, and extends up to the bulkhead between Piers D3 and D2. Because the bulkhead includes buried tiebacks, excavation in this area would have to be undertaken with extreme care. Multiphase extraction would avoid this difficulty while offering removal of mobile product in a reasonable amount of time.

An analysis of product-contaminated area FP-18 reveals similarities to FP-3. The area sits partially across Trumbo Road; any excavation here would certainly be disruptive to facility operations. Time to recover all mobile product is estimated to be under two years using vacuum trucks. The area sits far from any surface water body. Again, multiphase extraction is the remedial alternative of choice for this product-contaminated area.

Product-contaminated area FP-5 presents exceptional difficulties to any *ex situ* remediation alternative because the area is partially overlain by the three large ASTs operated by Key West Pipeline Company. Any excavation in this area would have to be undertaken with a very high degree of care and precaution. Quite possibly the storage tanks would have to be shut down while the excavation took place. Furthermore, any contamination underneath the storage tanks would be left in the ground, unless the storage tanks were demolished. For these reasons, *ex situ* remedial alternatives are rejected for FP-5. Multiphase extraction is recommended as the appropriate remedial alternative.

FP-16: EXCAVATION AND LANDFILLING

	Unit Cost		Quantities and Costs
A. Site Preparation and Mobilization			
Pavement Areas (square feet)			0
Pavement Removal ($) @	0.45	/square foot	$0
Product - Contaminated Region Area (square feet)			68662
Perimeter of Product-Contaminated Area (feet)			1000
Engineer/Scientist - Utility Clearance (event) @	5	hours/event	5
Engineer/Scientist - Utility Clearance ($) @	$40	/hour	$200
Front End Loader - Mobilize/Demobilize - 6 hours ($) @	$70	/hour	$840
Track Hoe - Mobilize/Demobilize - 6 hours ($) @	$80	/hour	$480
Vehicle - Rental/fuel ($) @	$70	/day	$4,774
Miscellaneous Tools and Decon Equipment ($) @	$5,000	/each	$5,000
Engineer/Scientist - Mobilize/Setup/Demobilize (hours)			46
Engineer/Scientist - Mobilize/Setup/Demobilize ($) @	$40	/hour	$1,840
Technician - Mobilize/Demobilize (hours)			46
Technician - Mobilize/Demobilize ($) @	$30	/hour	$1,380
Lodging/Food Per Diem for Engineer, Tech, and 3 Ops. ($) @	$189	/day	$64,450
Clear and Grub ($) @	$4,000	/acre	$6,305
Warning/Hazard Signs (One Every 100') ($) @	$15	/each	$150
Fence, 4' High ($) @	$3	/linear foot	$3,000
Rental of Poly Tank for Decon Water ($) @	$120	/week	$1,169
Purchase of Pressure Washer ($) @	$90	/each	$90
Water Trailer Rental for Decon Water ($) @	$400	/week	$3,897
Plastic Sheeting for Decon Area ($) @	$0.023	/square foot	$58
Sand Bags for Decon Pad - 300 ($) @	$5	/each	$1,500
Office Trailer ($) @	$150	/month	$330
Storage Trailer ($) @	$150	/month	$330
Trailer Set-Up, Removal ($) @	$300	/trailer	$600
Port-a-John ($) @	$30	/week	$292
Water Cooler ($) @	$25	/week	$244
Water ($) @	$15	/day	$1,023
Telephone Service ($) @	$500	/month	$1,137
Office Equipment ($) @	$1,000	/month	$2,273
Laborer (2 Men x 5 Day/Man x 8 Hours/Day) ($) @	$25	/hour	$2,000
Electrician (2 Men x 5 Day/Man x 8 Hours/Day) ($) @	$55	/hour	$4,400
Total Hours this Section			51

B. Construct Soil Staging Area with Berm (100' x 100')

3 days @ 10 hours/day

Crushed Stone/Gravel (cubic yards)			97
Crushed Stone/Gravel ($) @	$20.00	/cubic yard	$1,940
Plastic Sheeting (square feet)			25340
Plastic Sheeting ($) @	$0.023	/square feet	$583
Front End Loader (hours)			30
Front End Loader ($) @	$70.00	/hour	$2,100
Engineer/Scientist (hours)			30
Engineer/Scientist ($) @	$40.00	/hour	$1,200
Total Hours this Section			30

C. Construct Clean Soil Staging Area with Berm (100' x 100')

3 days @ 10 hours/day

Crushed Stone/Gravel (cubic yards)			97
Crushed Stone/Gravel ($) @	$20	/cubic yard	$1,940
Plastic Sheeting (square feet)			25340
Plastic Sheeting ($) @	$0.023	/square foot	$583
Front End Loader (hours)			30
Front End Loader ($) @	$70	/hour	$2,100
Engineer/Scientist (hours)			30
Engineer/Scientist ($) @	$40	/hour	$1,200
Total Hours this Section			30

D. Excavate and Stockpile Soil (200 cubic yards/day)

Number of Monitoring Wells to be Abondoned and Disposed			9
Bentonite Plug ($) @	$100	/well	$900
Approval Fee ($)	$1,096	/well	$9,864
Transport ($) @	$420	/load	$420
Disposal Fee ($) @	$30	/ton	$270
Sampling and Analysis of Decon Water	$690	/KAG or GAG suite	$2,070
Product - Contaminated Region Area (square feet)			68662
Excavation Depth (feet bls)			6
Excavation Volume (cubic yards)			15258
Depth of Topmost Contamination (feet bls)			4
Contaminated Soil Volume (cubic yards)			5086
Excavate Soil - Track Hoe (hours)			763

FP-16: EXCAVATION AND LANDFILLING

Excavate Soil - Track Hoe ($) @	$80	/hour	$61,033
Excavate Soil - Two Front Loader (hours)			763
Excavate Soil - Two Front End Loaders ($) @	$70	/hour	$106,808
Technician (hours)			763
Technician ($) @	$30	/hour	$22,887
Engineer/Scientist (hours)			763
Engineer/Scientist ($) @	$40	/hour	$30,516
Total Hours this Section			763
E. Transport			
Transport ($) @	$26	/cubic yard	$131,729
Total Hours this Section			0
F. Treatment Charge			
Tipping Charge ($) @	$34	/cubic yard	$170,892
Total Hours this Section			$0
G. Sampling and Analysis			
Number of Analyses Suites Needed			13
Laboratory Analysis ($) @	$680	/KAG or GAG suite	$8,950
Shipping ($) @	$149	/cooler (2 sample sets)	$980
Total Hours this Section			$0
H. Backfill with Clean Soil and Restore Site (200 cubic yards/day)			
Load, Haul, and Backfill Excavation Area - Dump Truck ($) @	$20	/cubic yard	$102,891
Backfill and Compact Soil Two Front End Loaders (hours)			763
Backfill and Compact Soil Two Front End Loaders ($) @	$70	/hour	$53,404
Remove Tempoarary Fencing ($) @	$3	/linear foot	$3,000
Seed, Fertilize, and Mulch	$1,800	/acre	$2,837
Engineer (hours)			763
Technician (hours)			763
Engineer ($) @	$40	/hour	$30,516
Technician ($) @	$30	/hour	$22,887
Repavement	$2.80	/square foot	$0
Total Hours this Section			763
		Totals:	$882,263
		Total Hours:	1,637

FP-16: EXCAVATION AND OFFSITE INCINERATION

	Unit Cost		Quantities and Costs
A. Site Preparation and Mobilization			
Pavement Areas (square feet)			0
Pavement Removal ($) @	0.45	/square foot	$0
Product - Contaminated Region Area (square feet)			68662
Perimeter of Product-Contaminated Area (feet)			1000
Engineer/Scientist - Utility Clearance (event) @	5	hours/event	5
Engineer/Scientist - Utility Clearance ($) @	$40	/hour	$200
Front End Loader - Mobilize/Demobilize - 6 hours ($) @	$70	/hour	$840
Track Hoe - Mobilize/Demobilize - 6 hours ($) @	$80	/hour	$480
Vehicle - Rental/fuel ($) @	$70	/day	$4,774
Miscellaneous Tools and Decon Equipment ($) @	$5,000	/each	$5,000
Engineer/Scientist - Mobilize/Setup/Demobilize (hours)			46
Engineer/Scientist - Mobilize/Setup/Demobilize ($) @	$40	/hour	$1,840
Technician - Mobilize/Demobilize (hours)			46
Technician - Mobilize/Demobilize ($) @	$30	/hour	$1,380
Lodging/Food Per Diem for Engineer, Tech, and 3 Ops. ($) @	$189	/day	$64,450
Clear and Grub ($) @	$4,000	/acre	$6,305
Warning/Hazard Signs (One Every 100') ($) @	$15	/each	$150
Fence, 4' High ($) @	$3	/linear foot	$3,000
Rental of Poly Tank for Decon Water ($) @	$120	/week	$1,169
Purchase of Pressure Washer ($) @	$90	/each	$90
Water Trailer Rental for Decon Water ($) @	$400	/week	$3,897
Plastic Sheeting for Decon Area ($) @	$0.023	/square foot	$58
Sand Bags for Decon Pad - 300 ($) @	$5	/each	$1,500
Office Trailer ($) @	$150	/month	$330
Storage Trailer ($) @	$150	/month	$330
Trailer Set-Up, Removal ($) @	$300	/trailer	$600
Port-a-John ($) @	$30	/week	$292
Water Cooler ($) @	$25	/week	$244
Water ($) @	$15	/day	$1,023
Telephone Service ($) @	$500	/month	$1,137
Office Equipment ($) @	$1,000	/month	$2,273
Laborer (2 Men x 5 Day/Man x 8 Hours/Day) ($) @	$25	/hour	$2,000
Electrician (2 Men x 5 Day/Man x 8 Hours/Day) ($) @	$55	/hour	$4,400
Total Hours this Section			51

B. Construct Soil Staging Area with Berm (100' x 100')

3 days @ 10 hours/day			
Crushed Stone/Gravel (cubic yards)			97
Crushed Stone/Gravel ($) @	$20.00	/cubic yard	$1,940
Plastic Sheeting (square feet)			25340
Plastic Sheeting ($) @	$0.023	/square feet	$583
Front End Loader (hours)			30
Front End Loader ($) @	$70.00	/hour	$2,100
Engineer/Scientist (hours)			30
Engineer/Scientist ($) @	$40.00	/hour	$1,200
Total Hours this Section			30

C. Construct Clean Soil Staging Area with Berm (100' x 100')

3 days @ 10 hours/day			
Crushed Stone/Gravel (cubic yards)			97
Crushed Stone/Gravel ($) @	$20	/cubic yard	$1,940
Plastic Sheeting (square feet)			25340
Plastic Sheeting ($) @	$0.023	/square foot	$583
Front End Loader (hours)			30
Front End Loader ($) @	$70	/hour	$2,100
Engineer/Scientist (hours)			30
Engineer/Scientist ($) @	$40	/hour	$1,200
Total Hours this Section			30

D. Excavate and Stockpile Soil (200 cubic yards/day)

Number of Monitoring Wells to be Abondoned and Disposed			9
Bentonite Plug ($) @	$100	/well	$900
Approval Fee ($)	$1,096	/well	$9,864
Transport ($) @	$420	/load	$420
Disposal Fee ($) @	$30	/ton	$270
Sampling and Analysis of Decon Water	$690	/KAG or GAG suite	$2,070
Product - Contaminated Region Area (square feet)			68662
Excavation Depth (feet bls)			6
Excavation Volume (cubic yards)			15258
Depth of Topmost Contamination (feet bls)			4
Contaminated Soil Volume (cubic yards)			5086
Excavate Soil - Track Hoe (hours)			763
Excavate Soil - Track Hoe ($) @	$80	/hour	$61,033
Excavate Soil - Two Front Loader (hours)			763

FP-16: EXCAVATION AND OFFSITE INCINERATION

Excavate Soil - Two Front End Loaders ($) @	$70	/hour	$106,808
Technician (hours)			763
Technician ($) @	$30	/hour	$22,887
Engineer/Scientist (hours)			763
Engineer/Scientist ($) @	$40	/hour	$30,516
Total Hours this Section			763
E. Transport			
Transport ($) @	$26	/cubic yard	$131,729
Total Hours this Section			0
F. Treatment Charge			
Incineration Charge ($) @	$36	/cubic yard	$185,133
Total Hours this Section			0
G. Sampling and Analysis			
Number of Analyses Suites Needed			13
Laboratory Analysis ($) @	$680	/KAG or GAG suite	$8,950
Shipping ($) @	$149	/cooler (2 sample sets)	$980
Total Hours this Section			0
H. Backfill with Clean Soil and Restore Site (200 cubic yards/day)			
Load, Haul, and Backfill Excavation Area - Dump Truck ($) @	$20	/cubic yard	$102,891
Backfill and Compact Soil Two Front End Loaders (hours)			763
Backfill and Compact Soil Two Front End Loaders ($) @	$70	/hour	$53,404
Remove Tempoarary Fencing ($) @	$3	/linear foot	$3,000
Seed, Fertilize, and Mulch	$1,800	/acre	$2,837
Engineer (hours)			763
Technician (hours)			763
Engineer ($) @	$40	/hour	$30,516
Technician ($) @	$30	/hour	$22,887
Repavement	$2.80	/square foot	$0
Total Hours this Section			763
		Total Hours:	1,637
		Total:	$896,504

FP-16: EXCAVATION AND OFFSITE THERMAL DESORPTION

	Unit Cost		General Costs for Remedial Option
A. Site Preparation and Mobilization			
Pavement Areas (square feet)			0
Pavement Removal ($) @	0.45	/square foot	$0
Product - Contaminated Region Area (square feet)			68662
Perimeter of Product-Contaminated Area (feet)			1000
Engineer/Scientist - Utility Clearance (event) @	5	hours/event	5
Engineer/Scientist - Utility Clearance ($) @	$40	/hour	$200
Front End Loader - Mobilize/Demobilize - 6 hours ($) @	$70	/hour	$840
Track Hoe - Mobilize/Demobilize - 6 hours ($) @	$80	/hour	$480
Vehicle - Rental/fuel ($) @	$70	/day	$4,774
Miscellaneous Tools and Decon Equipment ($) @	$5,000	/each	$5,000
Engineer/Scientist - Mobilize/Setup/Demobilize (hours)			46
Engineer/Scientist - Mobilize/Setup/Demobilize ($) @	$40	/hour	$1,840
Technician - Mobilize/Demobilize (hours)			46
Technician - Mobilize/Demobilize ($) @	$30	/hour	$1,380
Lodging/Food Per Diem for Engineer, Tech, and 3 Ops. ($) @	$189	/day	$64,450
Clear and Grub ($) @	$4,000	/acre	$6,305
Warning/Hazard Signs (One Every 100') ($) @	$15	/each	$150
Fence, 4' High ($) @	$3	/linear foot	$3,000
Rental of Poly Tank for Decon Water ($) @	$120	/week	$1,169
Purchase of Pressure Washer ($) @	$90	/each	$90
Water Trailer Rental for Decon Water ($) @	$400	/week	$3,897
Plastic Sheeting for Decon Area ($) @	$0.023	/square foot	$58
Sand Bags for Decon Pad - 300 ($) @	$5	/each	$1,500
Office Trailer ($) @	$150	/month	$330
Storage Trailer ($) @	$150	/month	$330
Trailer Set-Up, Removal ($) @	$300	/trailer	$600
Port-a-John ($) @	$30	/week	$292
Water Cooler ($) @	$25	/week	$244
Water ($) @	$15	/day	$1,023
Telephone Service ($) @	$500	/month	$1,137
Office Equipment ($) @	$1,000	/month	$2,273
Laborer (2 Men x 5 Day/Man x 8 Hours/Day) ($) @	$25	/hour	$2,000
Electrician (2 Men x 5 Day/Man x 8 Hours/Day) ($) @	$55	/hour	$4,400
Total Hours this Section			51

B. Construct Soil Staging Area with Berm (100' x 100')

3 days @ 10 hours/day

Crushed Stone/Gravel (cubic yards)			97
Crushed Stone/Gravel ($) @	$20.00	/cubic yard	$1,940
Plastic Sheeting (square feet)			25340
Plastic Sheeting ($) @	$0.023	/square feet	$583
Front End Loader (hours)			30
Front End Loader ($) @	$70.00	/hour	$2,100
Engineer/Scientist (hours)			30
Engineer/Scientist ($) @	$40.00	/hour	$1,200
Total Hours this Section			30

C. Construct Treated Soil Staging Area with Berm (100' x 100')

3 days @ 10 hours/day

Crushed Stone/Gravel (cubic yards)			97
Crushed Stone/Gravel ($) @	$20	/cubic yard	$1,940
Plastic Sheeting (square feet)			25340
Plastic Sheeting ($) @	$0.023	/square foot	$583
Front End Loader (hours)			30
Front End Loader ($) @	$70	/hour	$2,100
Engineer/Scientist (hours)			30
Engineer/Scientist ($) @	$40	/hour	$1,200
Total Hours this Section			30

D. Excavate and Stockpile Soil (200 cubic yards/day)

Number of Monitoring Wells to be Abondoned and Disposed			9
Bentonite Plug ($) @	$100	/well	$900
Approval Fee ($)	$1,096	/well	$9,864
Transport ($) @	$420	/load	$420
Disposal Fee ($) @	$30	/ton	$270
Sampling and Analysis of Decon Water	$690	/KAG or GAG suite	$2,070
Product - Contaminated Region Area (square feet)			68662
Excavation Depth (feet bls)			6
Excavation Volume (cubic yards)			15258
Depth of Topmost Contamination (feet bls)			4
Contaminated Soil Volume (cubic yards)			5086
Excavate Soil - Track Hoe (hours)			763
Excavate Soil - Track Hoe ($) @	$80	/hour	$61,033
Excavate Soil - Two Front Loader (hours)			763
Excavate Soil - Two Front End Loaders ($) @	$70	/hour	$106,808
Technician (hours)			763

Technician ($) @	$30	/hour	$22,887
Engineer/Scientist (hours)			763
Engineer/Scientist ($) @	$40	/hour	$30,516
Total Hours this Section			763
E. Transport			
Transport ($) @	$26	/cubic yard	$131,729
Total Hours this Section			0
F. Treatment Charge			
Thermal Desorption Treatment Charge ($) @	$28	/cubic yard	$142,410
Total Hours this Section			0
G. Sampling and Analysis			
Number of Analyses Suites Needed			13
Laboratory Analysis ($) @	$680	/KAG or GAG suite	$8,950
Shipping ($) @	$149	/cooler (2 sample sets)	$980
Total Hours this Section			0
H. Backfill with Clean Soil and Restore Site (200 cubic yards/day)			
Load, Haul, and Backfill Excavation Area - Dump Truck ($) @	$20	/cubic yard	$102,891
Backfill and Compact Soil Two Front End Loaders (hours)			763
Backfill and Compact Soil Two Front End Loaders ($) @	$70	/hour	$53,404
Remove Tempoarary Fencing ($) @	$3	/linear foot	$3,000
Seed, Fertilize, and Mulch	$1,800	/acre	$2,837
Engineer (hours)			763
Technician (hours)			763
Engineer ($) @	$40	/hour	$30,516
Technician ($) @	$30	/hour	$22,887
Repavement	$2.80	/square foot	$0
Total Hours this Section			763
		Total Hours:	1,637
		Total:	$853,781

FP-16: EXCAVATION AND ONSITE SOIL WASHING

	Unit Cost		Quantities and Costs
A. Site Preparation and Mobilization			
Pavement Areas (square feet)			0
Pavement Removal ($) @	0.45	/square foot	$0
Product - Contaminated Region Area (square feet)			68662
Perimeter of Product-Contaminated Area (feet)			1000
Engineer/Scientist - Utility Clearance (event) @	5	hours/event	5
Engineer/Scientist - Utility Clearance ($) @	$40	/hour	$200
Front End Loader - Mobilize/Demobilize - 6 hours ($) @	$70	/hour	$840
Track Hoe - Mobilize/Demobilize - 6 hours ($) @	$80	/hour	$480
Vehicle - Rental/fuel ($) @	$70	/day	$4,775
Miscellaneous Tools and Decon Equipment ($) @	$5,000	/each	$5,000
Engineer/Scientist - Mobilize/Setup/Demobilize (hours)			46
Engineer/Scientist - Mobilize/Setup/Demobilize ($) @	$40	/hour	$1,840
Technician - Mobilize/Demobilize (hours)			46
Technician - Mobilize/Demobilize ($) @	$30	/hour	$1,380
Lodging/Food Per Diem for Engineer, Tech, and 3 Ops. ($) @	$189	/day	$64,457
Clear and Grub ($) @	$4,000	/acre	$6,305
Warning/Hazard Signs (One Every 100') ($) @	$15	/each	$150
Fence, 4' High ($) @	$3	/linear foot	$3,000
Rental of Poly Tank for Decon Water ($) @	$120	/week	$1,169
Purchase of Pressure Washer ($) @	$90	/each	$90
Water Trailer Rental for Decon Water ($) @	$400	/week	$3,898
Plastic Sheeting for Decon Area ($) @	$0.023	/square foot	$58
Sand Bags for Decon Pad - 300 ($) @	$5	/each	$1,500
Office Trailer ($) @	$150	/month	$330
Storage Trailer ($) @	$150	/month	$330
Trailer Set-Up, Removal ($) @	$300	/trailer	$600
Port-a-John ($) @	$30	/week	$292
Water Cooler ($) @	$25	/week	$244
Water ($) @	$15	/day	$1,023
Telephone Service ($) @	$500	/month	$1,137
Office Equipment ($) @	$1,000	/month	$2,274
Laborer (2 Men x 5 Day/Man x 8 Hours/Day) ($) @	$25	/hour	$2,000
Electrician (2 Men x 5 Day/Man x 8 Hours/Day) ($) @	$55	/hour	$4,400

Total Hours this Section			51

B. Construct Soil Staging Area with Berm (100' x 100')

3 days @ 10 hours/day

Crushed Stone/Gravel (cubic yards)			97
Crushed Stone/Gravel ($) @	$20.00	/cubic yard	$1,940
Plastic Sheeting (square feet)			25340
Plastic Sheeting ($) @	$0.023	/square feet	$583
Front End Loader (hours)			30
Front End Loader ($) @	$70.00	/hour	$2,100
Engineer/Scientist (hours)			30
Engineer/Scientist ($) @	$40.00	/hour	$1,200
Total Hours this Section			30

C. Construct Treated Soil Staging Area with Berm (100' x 100')

3 days @ 10 hours/day

Crushed Stone/Gravel (cubic yards)			97
Crushed Stone/Gravel ($) @	$20	/cubic yard	$1,940
Plastic Sheeting (square feet)			25340
Plastic Sheeting ($) @	$0.023	/square foot	$583
Front End Loader (hours)			30
Front End Loader ($) @	$70	/hour	$2,100
Engineer/Scientist (hours)			30
Engineer/Scientist ($) @	$40	/hour	$1,200
Total Hours this Section			30

D. Excavate and Stockpile Soil (200 cubic yards/day)

Number of Monitoring Wells to be Abondoned and Disposed			9
Bentonite Plug ($) @	$100	/well	$900
Approval Fee ($)	$1,096	/well	$9,864
Transport ($) @	$420	/load	$420
Disposal Fee ($) @	$30	/ton	$270
Sampling and Analysis of Decon Water	$690	/KAG or GAG suite	$2,070
Product - Contaminated Region Area (square feet)			68662
Excavation Depth (feet bls)			6
Excavation Volume (cubic yards)			15258
Depth of Topmost Contamination (feet bls)			4

FP-16: EXCAVATION AND ONSITE SOIL WASHING

Contaminated Soil Volume (cubic yards)			5086
Excavate Soil - Track Hoe (hours)			763
Excavate Soil - Track Hoe ($) @	$80	/hour	$61,033
Excavate Soil - Two Front Loader (hours)			763
Excavate Soil - Two Front End Loaders ($) @	$70	/hour	$106,808
Technician (hours)			763
Technician ($) @	$30	/hour	$22,887
Engineer/Scientist (hours)			763
Engineer/Scientist ($) @	$40	/hour	$30,516
Total Hours this Section			763
E. Treatment Charge			
Soil Washing Charge ($) @	$36	/cubic yard	$185,133
Total Hours this Section			0
F. Sampling and Analysis			
Number of Analyses Suites Needed			13
Laboratory Analysis ($) @	$680	/KAG or GAG suite	$8,950
Shipping ($) @	$149	/cooler (2 sample sets)	$980
Total Hours this Section			0
G. Backfill with Clean Soil and Restore Site (200 cubic yards/day)			
Backfill and Compact Soil Two Front End Loaders (hours)			763
Backfill and Compact Soil Two Front End Loaders ($) @	$70	/hour	$53,404
Remove Tempoarary Fencing ($) @	$3	/linear foot	$3,000
Seed, Fertilize, and Mulch	$1,800	/acre	$2,837
Engineer (hours)			763
Technician (hours)			763
Engineer ($) @	$40	/hour	$30,516
Technician ($) @	$30	/hour	$22,887
Repavement	$2.80	/square foot	$0
Total Hours this Section			763
		Total Hours:	1,637
		Total:	$661,892

12/15

FP-16: EXCAVATION AND ONSITE THERMAL DESORPTION

	Unit Cost		Quantities and Costs
A. Site Preparation and Mobilization			
Pavement Areas (square feet)			0
Pavement Removal ($) @	0.45	/square foot	$0
Product - Contaminated Region Area (square feet)			68662
Perimeter of Product-Contaminated Area (feet)			1000
Engineer/Scientist - Utility Clearance (event) @	5	hours/event	5
Engineer/Scientist - Utility Clearance ($) @	$40	/hour	$200
Front End Loader - Mobilize/Demobilize - 6 hours ($) @	$70	/hour	$840
Track Hoe - Mobilize/Demobilize - 6 hours ($) @	$80	/hour	$480
Vehicle - Rental/fuel ($) @	$70	/day	$4,775
Miscellaneous Tools and Decon Equipment ($) @	$5,000	/each	$5,000
Engineer/Scientist - Mobilize/Setup/Demobilize (hours)			46
Engineer/Scientist - Mobilize/Setup/Demobilize ($) @	$40	/hour	$1,840
Technician - Mobilize/Setup/Demobilize (hours)			46
Technician - Mobilize/Setup/Demobilize ($) @	$30	/hour	$1,380
Lodging/Food Per Diem for Engineer, Tech, and 3 Ops. ($) @	$189	/day	$64,457
Clear and Grub ($) @	$4,000	/acre	$6,305
Warning/Hazard Signs (One Every 100') ($) @	$15	/each	$150
Fence, 4' High ($) @	$3	/linear foot	$3,000
Rental of Poly Tank for Decon Water ($) @	$120	/week	$1,169
Purchase of Pressure Washer ($) @	$90	/each	$90
Water Trailer Rental for Decon Water ($) @	$400	/week	$3,898
Plastic Sheeting for Decon Area ($) @	$0.023	/square foot	$58
Sand Bags for Decon Pad - 300 ($) @	$5	/each	$1,500
Office Trailer ($) @	$150	/month	$330
Storage Trailer ($) @	$150	/month	$330
Trailer Set-Up, Removal ($) @	$300	/trailer	$600
Port-a-John ($) @	$30	/week	$292
Water Cooler ($) @	$25	/week	$244
Water ($) @	$15	/day	$1,023
Telephone Service ($) @	$500	/month	$1,137
Office Equipment ($) @	$1,000	/month	$2,274
Laborer (2 Men x 5 Day/Man x 8 Hours/Day) ($) @	$25	/hour	$2,000
Electrician (2 Men x 5 Day/Man x 8 Hours/Day) ($) @	$55	/hour	$4,400

Total Hours this Section			51

B. Construct Soil Staging Area with Berm (100' x 100')

3 days @ 10 hours/day

Crushed Stone/Gravel (cubic yards)			97
Crushed Stone/Gravel ($) @	$20.00	/cubic yard	$1,940
Plastic Sheeting (square feet)			25340
Plastic Sheeting ($) @	$0.023	/square feet	$583
Front End Loader (hours)			30
Front End Loader ($) @	$70.00	/hour	$2,100
Engineer/Scientist (hours)			30
Engineer/Scientist ($) @	$40.00	/hour	$1,200
Total Hours this Section			30

C. Construct Treated Soil Staging Area with Berm (100' x 100')

3 days @ 10 hours/day

Crushed Stone/Gravel (cubic yards)			97
Crushed Stone/Gravel ($) @	$20	/cubic yard	$1,940
Plastic Sheeting (square feet)			25340
Plastic Sheeting ($) @	$0.023	/square foot	$583
Front End Loader (hours)			30
Front End Loader ($) @	$70	/hour	$2,100
Engineer/Scientist (hours)			30
Engineer/Scientist ($) @	$40	/hour	$1,200
Total Hours this Section			30

D. Excavate and Stockpile Soil (200 cubic yards/day)

Number of Monitoring Wells to be Abondoned and Disposed			9
Bentonite Plug ($) @	$100	/well	$900
Approval Fee ($)	$1,096	/well	$9,864
Transport ($) @	$420	/load	$420
Disposal Fee ($) @	$30	/ton	$270
Sampling and Analysis of Decon Water	$690	/KAG or GAG suite	$2,070
Product - Contaminated Region Area (square feet)			68662
Excavation Depth (feet bls)			6
Excavation Volume (cubic yards)			15258
Depth of Topmost Contamination (feet bls)			4

FP-16: EXCAVATION AND ONSITE THERMAL DESORPTION

Contaminated Soil Volume (cubic yards)			5086
Excavate Soil - Track Hoe (hours)			763
Excavate Soil - Track Hoe ($) @	$80	/hour	$61,033
Excavate Soil - Two Front Loader (hours)			763
Excavate Soil - Two Front End Loaders ($) @	$70	/hour	$106,808
Technician (hours)			763
Technician ($) @	$30	/hour	$22,887
Engineer/Scientist (hours)			763
Engineer/Scientist ($) @	$40	/hour	$30,516
Total Hours this Section			763
E. Treatment Charge			
Thermal Desorption Charge ($) @	$53	/cubic yard	$270,579
Total Hours this Section			0
F. Sampling and Analysis			
Number of Analyses Suites Needed			13
Laboratory Analysis ($) @	$680	/KAG or GAG suite	$8,950
Shipping ($) @	$149	/cooler (2 sample sets)	$980
Total Hours this Section			0
G. Backfill with Clean Soil and Restore Site (200 cubic yards/day)			
Backfill and Compact Soil Two Front End Loaders (hours)			763
Backfill and Compact Soil Two Front End Loaders ($) @	$70	/hour	$53,404
Remove Tempoarary Fencing ($) @	$3	/linear foot	$3,000
Seed, Fertilize, and Mulch	$1,800	/acre	$2,837
Engineer (hours)			763
Technician (hours)			763
Engineer ($) @	$40	/hour	$30,516
Technician ($) @	$30	/hour	$22,887
Repavement	$2.80	/square foot	$0
Total Hours this Section			763
		Total Hours:	1,637
		Total:	$747,338

APPENDIX C

APPENDIX C

DESIGN CALCULATIONS

Checked by: RCL 8/6/99

MOBILE PRODUCT [illegible]

[illegible] soil areas [illegible] Soil may be [illegible] product [illegible] one to [illegible] drops of product or [illegible] Soil may also be [illegible] product [illegible] to high O/M [illegible] in which case no mobile product [illegible] present. [illegible]

In order to [illegible] mate the [illegible] product [illegible] product [illegible] The area [illegible] into subareas, [illegible] is assigned to each subarea. The product layer [illegible] are derived from [illegible] direct measurements of [illegible] during advancement of [illegible] or from product [illegible] in monitoring [illegible] For the [illegible] observed. The [illegible] observed in a monitoring [illegible] to a [illegible] from the [illegible] by the following equation (Kaczmarek, Practical Decision Guidance for Groundwater and Soil [illegible], 1999, [illegible]):

$$t_g = t(1 - S_g) - h_a$$

where

t_g = [illegible] formation thickness [illegible]
t = [illegible]
S_g = [illegible] specific gravity of product
h_a = [illegible] from the top of the water table

Further [illegible] that S_g = 75, and h_a = 0 (the product [illegible] table). Thus,

$$t_g = t(1 - 0.75)$$
$$t_g = 0.25t$$

Therefore, monitoring well product thickness is divided by four to get the [illegible] percent thickness. Monitoring well product thickness is averaged over time. Subarea boundaries generally run halfway between data points, unless such an area cannot work result in an unrealistic [illegible] area of [illegible] with [illegible] points.

MOBILE [illegible] VOLUME [illegible]: EXAMPLE - FP-21

[illegible] the available product observations [illegible] where product was observed in a monitoring well [illegible] listed. However, [illegible] number of observations [illegible] the parameters. For FP-21, free product was observed in two [illegible] boreholes, but the thicknesses observed on these [illegible] were [illegible] different. Since these two [illegible] occurring [illegible] MW-41, the data from MW-41 will be deemed representative and the data from the [illegible] average [illegible].

Averaging the observations in MW-41:

(0.12' + 0.[illegible]' + 0.[illegible]) / 3 = 0.07' ✓

Dividing by four to find the formation thickness:

0.07 / 4 = 0.0175' ⇒ 0.02' ✓

Since the [illegible] MW-41 [illegible] be drawn to [illegible] 50 max radius [illegible] assigned to [illegible]. The area of the resulting polygon is 3053 ft² (see [illegible] drawing).

3053 ft² × 0.02 ft × 0.45 × 7.48 gal/ft³ =

↑ porosity

205.5 gal ⇒ 206 gal. ✓

The [illegible] area of FP-21 does not show [illegible] contours. Thus, [illegible] assumed. From [illegible], the remaining [illegible] is 17,255 ft².

17255 ft² × 0.02 ft × 0.45 × 7.48 gal/ft³ = 5[illegible] gal.

Total [illegible] volume [illegible]

= 712 gal

[illegible]

3/5

Soil Boring ID	FP_ID	Observed Product Thickness
SB-135	FP-01	Residual
MW-19	FP-01	See SB-135
SB-160	FP-02	Sheen
SB-101	FP-03	No data - logbook water-damaged on this page.
SB-162	FP-03	Residual
SB-194	FP-03	Residual
SB-195	FP-03	2'
SB-196	FP-03	Residual
MW-65	FP-03	Trace
MW-67D	FP-03	No product visible and no product noted
SB-193	FP-04	No evidence of product
MW-51	FP-04	Residual
SB-59	FP-05	Residual
SB-62	FP-05	No product visible
SB-63	FP-05	No product visible
SB-68	FP-05	No product visible
MW-JP-1	FP-05	0.57' measured on 4/16/96; 0.82 measured on 3/18/96; no product observed on 7/30/96, 0.45 measured on 2/19/98;
KWM-22	FP-05	1.36' measured on 3/18/96; 2.61' measured on 4/16/96; 0.82' measured on 7/30/96; 0' measured on 2/19/98
KWM-07	FP-05	Approximately 0.13' measured during bail-down test on 2/19/98; 0' measured on 7/30/96
MW-JP-3	FP-05	0.52' measured on 3/18/96; 0.57' measured on 4/16/96, 0.49' measured on 7/30/98, 0' measured on 2/19/98
MW-74D	FP-05	No product visible
KMW-20	FP-05	0.0' measured on 3/18/96; 0.0' measured on 4/16/96; 0.0' measured on 7/3/96; 0.04' measured on 2/19/98
MW-55	FP-05	0.0' measured on 3/18/96; 0.0' measured on 4/16/96; 0.0' measured on 7/30/96; 0.38' measured on 2/19/98
MW-62	FP-05	0.06' measured on 3/18/96; 0.02' measured on 4/16/96; 0.0' measured on 7/30/99
SB-187	FP-06	No product visible
MW-43	FP-06	0.0' measured on 3/19/99; "trace" measured on 4/16/96; 0.03' measured on 7/30/98
SB-191	FP-07	"Free product at 5' bls."
SB-198	FP-07	"Free product at 5' bls."
SB-199	FP-07	"2" layer of black sand, apparently stained by product"
SB-200	FP-07	"2" layer of stained soil at 6""
MW-93	FP-07	No evidence of product
MW-90	FP-07	No evidence of product
MW-91	FP-07	No evidence of product
SB-189	FP-08	No product visible
SB-44	FP-08	Residual
SB-181	FP-09	"Free product at 5' bls" plus free product from 6-8 feet.
MW-102	FP-09	Residual
MW-53	FP-09	Residual
SB-182	FP-10	Residual
SB-203	FP-10	0.08'
MW-88	FP-10	No evidence of product
MW-89	FP-10	No evidence of product
SB-219	FP-11	Sheen
SB-218	FP-12	Residual
MW-94	FP-12	See SB-218
SB-210	FP-13	Residual
SB-213	FP-13	No product odor/none visible
SB-97	FP-13	None visible
MW-83	FP-13	Residual???
MW-92D	FP-13	No product visible
SB-207	FP-14	No product visible
SB-208	FP-14	No product visible
SB-157	FP-15	No product visible
SB-158	FP-15	No product visible
KMW-01	FP-15	0.13' observed on 2/1/96; observed 0.02' product on 4/16/96; 0.0' observed on 7/30/96
SB-12	FP-16	No product visible
SB-13	FP-16	No product visible
SB-237	FP-16	No description
SB-9	FP-16	No product visible
MW-31	FP-16	1.17' observed with bailer; 2.76' observed with interface probe on 3/19/96, 1.52' observed with interface probe on 4/16/96
MW-32	FP-16	5.33' observed on 3/16/96; 5.35' observed on 4/16/96; 2.52' observed on 7/30/96
KMW-04	FP-16	0.21' observed on 7/30/96; half a foot of black product observed on 8/31/93
KMW-24	FP-16	4.46' observed on 4/12/96; 2.27' observed on 4/16/96; 0.36' observed on 6/30/96
MW-9-17	FP-16	0.69' observed on 3/18/96; 0.0' observed on 4/16/96; 0.84' observed on 7/30/96
MW-9-16	FP-16	2.29' observed on 3/18/96; 1.66' observed on 4/16/96; 1.89' observed on 7/30/96; CAR has 2.33' from bailer and 2.16' from interface probe; 3.19' observed on 2/20/98
MW-9-15	FP-16	1.11' observed on 3/18/96; 1.48' observed on 4/16/96; 1.81' observed on 7/30/96; 6.65' observed on 2/20/98; CAR has >3 from bailer and 3.10' from interface probe
MW-87D	FP-16	No product visible
KMW-23	FP-16	1.00' observed on 4/16/96; 0.93' observed on 7/30/96; 2.09' observed on 2/20/98

Soil Boring ID	FP_ID	Observed Product Thickness
SB-139	FP-17	No product visible
SB-140	FP-17	No product visible
SB-141	FP-17	No product visible
SB-142	FP-17	No product visible
SB-144	FP-17	No product visible
SB-145	FP-17	No product visible
SB-146	FP-17	No product visible
SB-21	FP-17	Residual
SB-238	FP-17	No product visible
MW-27	FP-17	0.23' measured on 7/30/96
MW-9-12	FP-17	Free product but no thickness measurements
MW-45D	FP-17	No product visible
SB-166	FP-18	Free product but no thickness measurements
SB-177	FP-18	No product visible
SB-178	FP-18	Free product from approx. 5' bls to at least 6.5' bls
SB-222	FP-18	"...free product at 5' bls"
SB-109	FP-19	Residual - "stained by product" from approx. 4' bls to at least 8' bls
MW-99	FP-19	No product noted
SB-122	FP-20	Residual
SB-102	FP-21	Free product - thickness subject to interpretation
SB-124	FP-21	Residual
SB-167	FP-21	Free product - thickness subject to interpretation
SB-168	FP-21	Residual
SB-172	FP-21	No product visible
SB-173	FP-21	Residual
SB-234	FP-21	No product visible
MW-41	FP-21	0.0' measured on 3/19/96; 0.08' measured on 4/16/96; 0.13' measured on 7/30/96
MW-106D	FP-21	No product visible
MW-103	FP-21	No product visible

NAS Key West RAP
Product Volume Calculations

FP_ID	Area (square feet)	Product Thickness	Estimated Mobile Product Volume (gallons; porosity assumed to be 0.45)		FP-ID	Total Est. Mobile Product Vol. (gal.)
FP-1	1080	0.0001	0		FP-1	0
FP-10	3821	0.0001	1		FP-2	6
FP-10	2078	0.0800	560		FP-3	15095
FP-11	503	0.0025	4		FP-4	2
FP-12	370	0.0001	0		FP-5	28499
FP-13	1877	0.0001	1		FP-6	41
FP-14	1352	0.0001	0		FP-7	3
FP-15	3215	0.0001	1		FP-8	1
FP-15	901	0.0100	30		FP-9	2
FP-16-1	1949	1.1000	7216		FP-10	561
FP-16-2	17955	0.6100	36866		FP-11	4
FP-16-3	24296	0.4000	32712		FP-12	0
FP-16-4	953	0.1300	417		FP-13	1
FP-16-5	7524	0.0900	2279		FP-14	0
FP-16-6	6114	0.0001	2		FP-15	31
FP-16-7	9082	0.0001	3		FP-16	79496
FP-17-1	4580	0.0600	925		FP-17	931
FP-17-2	18121	0.0001	6		FP-18	5747
FP-18	2699	0.0001	1		FP-19	1
FP-18	1138	1.5000	5746		FP-20	0
FP-19	3218	0.0001	1		FP-21	212
FP-2	758	0.0025	6			
FP-20	848	0.0001	0			
FP-21	17256	0.0001	6			
FP-21	3053	0.0200	206			
FP-3	19898	0.0001	7			
FP-3	2241	2.0000	15086			
FP-3	194	0.0025	2			
FP-4	5225	0.0001	2			
FP-5	84131	0.0025	708			
FP-5	34709	0.1100	12851			
FP-5	185	0.0100	6			
FP-5	40385	0.0700	9516			
FP-5	1816	0.3000	1834			
FP-5	44737	0.0238	3584			
FP-6	3662	0.0033	41			
FP-7	9502	0.0001	3			
FP-8	3867	0.0001	1			
FP-9	4913	0.0001	2			

5/49 15

5/5

Excavation vs. Concentration Cost Analysis

Excavation and onsite soil washing has been recommended for two product-contaminated subsurface soil areas at the NAS Key West Trumbo Point Fuel Farm. These two product-contaminated subsurface soil areas are known as FP-16 and FP-17. This analysis is being done to determine if there is an economic breakpoint within the excavation areas. The goal is to remove the most product mass for the least cost.

The calculation of what portions of FP-16 and FP-17 contain the mass of product is based on soil boring data and monitoring well observations. These data are used to calculate a product thickness for a subarea of the product-contaminated soil area. The product thickness is multiplied by the area of the subarea and by the porosity (0.45 as measured during the CAR), giving the volume of product in the subarea. The volume is then multiplied by a typical product density (0.75 times the density of water), giving the product mass.

Soil boring observations are a one-time only observation. The advantage of soil-boring observations is that product layer thickness in the soil is observed directly, typically as a visible layer in a split-spoon sample. Monitoring well observations, in contrast, do not give direct observation of the mobile product layer in the soil. The equation $t_g = t\,(1 - S_g) - h_a$, [where t_g is the product layer thickness in the soil, t is the product layer thickness in the monitoring well, S_g is the product specific gravity, and h_a is the distance from the bottom of the free product to the water table] is used to estimate the product layer thickness in the soil (Kuo, 1999). A value of 0.75 is used for S_g (a typical value for gasoline), and a value of 0 is used for h_a (which is in accord with observed conditions). With these values substituted in, the equation reduces to $t_g = 0.25t$. Monitoring well observations can be averaged over time, giving a more realistic value for the product layer thickness over a range of subsurface conditions. Note that since the product-contaminated subsurface soil areas can be defined in part by elevated OVA readings, it is possible that some monitoring wells and soil borings within a product-contaminated region show no evidence of a product layer. In these areas, a product layer thickness of 0.001 foot is assumed. Table 1 shows the soil boring observations and monitoring well free product thicknesses.

Monitoring well data was averaged and transformed to represent the product layer thickness in the soil, and the product layer thickness at each measuring point (soil boring or monitoring well) was plotted on a map of the product-contaminated soil area (see Figure C-1). The product-contaminated soil area was then divided into subareas. Generally one measuring point was included in each subarea, although if two adjacent measuring points had similar values for the mobile product layer thickness, one subarea encompassing both measuring points with a mobile product layer thickness that is the average of the two measuring points' values was defined. The boundaries of the subareas generally were chosen so that they are halfway between measuring points. An exception to this general rule was made when an isolated measuring point had a relatively high mobile product layer thickness. In this case it was assumed that the subarea associated with the measuring point in question had a boundary no more than approximately 50 feet from the measuring point, rather than strictly halfway between the measuring point and the next measuring point.

With the above information assembled, a product volume and product mass was calculated for each subarea of the product-contaminated area. The percentage of product mass each subarea contributes to the total product mass was then calculated. Likewise the percentage of excavation volume each area contributes to the total excavation was calculated. The excavation volume is the area excavated multiplied by a 7-foot excavation depth. This data is presented in Table 2.

The data show that excavating subareas FP-16-1 and FP-16-2 will remove 55% of the mass by excavating 29% of the volume. At FP-17- excavating FP-17-1 will remove 99% of the mass by excavating 20% of the volume. This is shown graphically on Figures C-2 and C-3.

Kuo, Jeff, Practical Design Calculations for Groundwater and Soil Remediation. Boca Raton: CRC Press, 1999, p. 22.

NAS Key West RAP
Product Mass Calculations Table 1

Soil Boring ID	FP_ID	Observed Product Thickness	Estimated Product Thickness	
SB-12	FP-16	No product visible	None	
SB-13	FP-16	No product visible	None	
SB-237	FP-16	No description	None	
SB-9	FP-16	No product visible	None	
MW-31	FP-16	1.17' observed with bailer; 2.76' observed with interface probe on 3/19/96, 1.52' observed with interface probe on 4/16/96 (3 observations)		0.45
MW-32	FP-16	5.33' observed in well on 3/16/96; 5.35' observed in well on 4/16/96; 2.52' observed in well on 7/30/96 (3 observations)		1.10
KMW-04	FP-16	0.21' observed in well on 7/30/96; half a foot of black product observed on 8/31/93 (2 observations)		0.09
KMW-24	FP-16	4.46' observed in well on 4/12/96; 2.27' observed in well on 4/16/96; 0.36' observed on 6/30/96 (3 observations)		0.59
MW-9-17	FP-16	0.69' observed in well on 3/18/96; 0.84' observed in well on 7/30/96 (3 observations)		0.13
MW-9-16	FP-16	2.29' observed in well on 3/18/96; 1.66' observed in well on 4/16/96; 1.89' observed in well on 7/30/96; 3.19' observed in well on 2/20/98 (4 observations)		0.56
MW-9-15	FP-16	1.11' observed in well on 3/18/96; 1.48' observed in well on 4/16/96; 1.81' observed in well on 7/30/96; 6.65' observed in well on 2/20/98 (4 observations)		0.69
MW-87D	FP-16	No product visible	None	
KMW-23	FP-16	1.00' observed in well on 4/16/96; 0.93' observed in well on 7/30/96; 2.09' observed in well on 2/20/98 (3 observations)		0.34
SB-139	FP-17	No product visible	None	
SB-140	FP-17	No product visible	None	
SB-141	FP-17	No product visible	None	
SB-142	FP-17	No product visible	None	
SB-144	FP-17	No product visible	None	
SB-145	FP-17	No product visible	None	
SB-146	FP-17	No product visible	None	
SB-21	FP-17	Residual	Residual	
SB-238	FP-17	No product visible	None	
MW-27	FP-17	0.23' measured in well on 7/30/96 (1 observation)		0.06
MW-9-12	FP-17	Free product but no thickness measurements	Free product no data	
MW-45D	FP-17	No product visible	None	

Notes on product mass calculations:

For FP-17, the product contaminated area was divided into two subareas, one corresponding to MW-27 and the product layer observed at that well, the other a large area defined by OVA readings where no product layer was observed. For FP-16, the subareas correspond to the following monitoring wells and soilborings:

FP-16-1: MW-32
FP-16-2: KMW-24, MW-9-15, MW-9-16 (values averaged)
FP-16-3: KMW-23, MW-31(values averaged; deep well MW-87D and soil boring SB-237 ignored)
FP-16-4: MW-9-17
FP-16-5: KMW-04
FP-16-6: SB-13
FP-16-7: SB-9

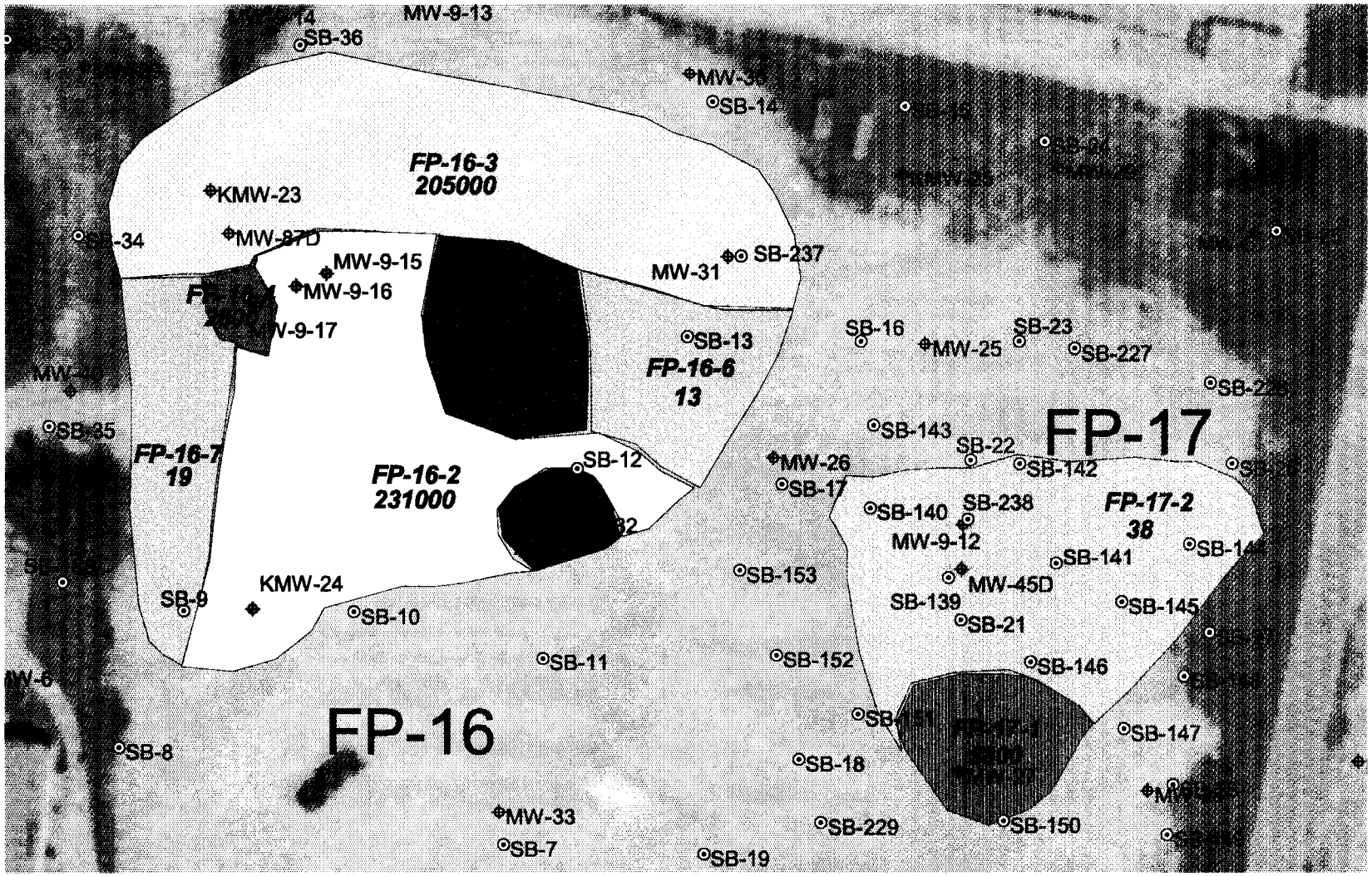


Figure C-1: NAS Key West Trumbo Point Fuel Farm RAP: Product Areas and Subareas

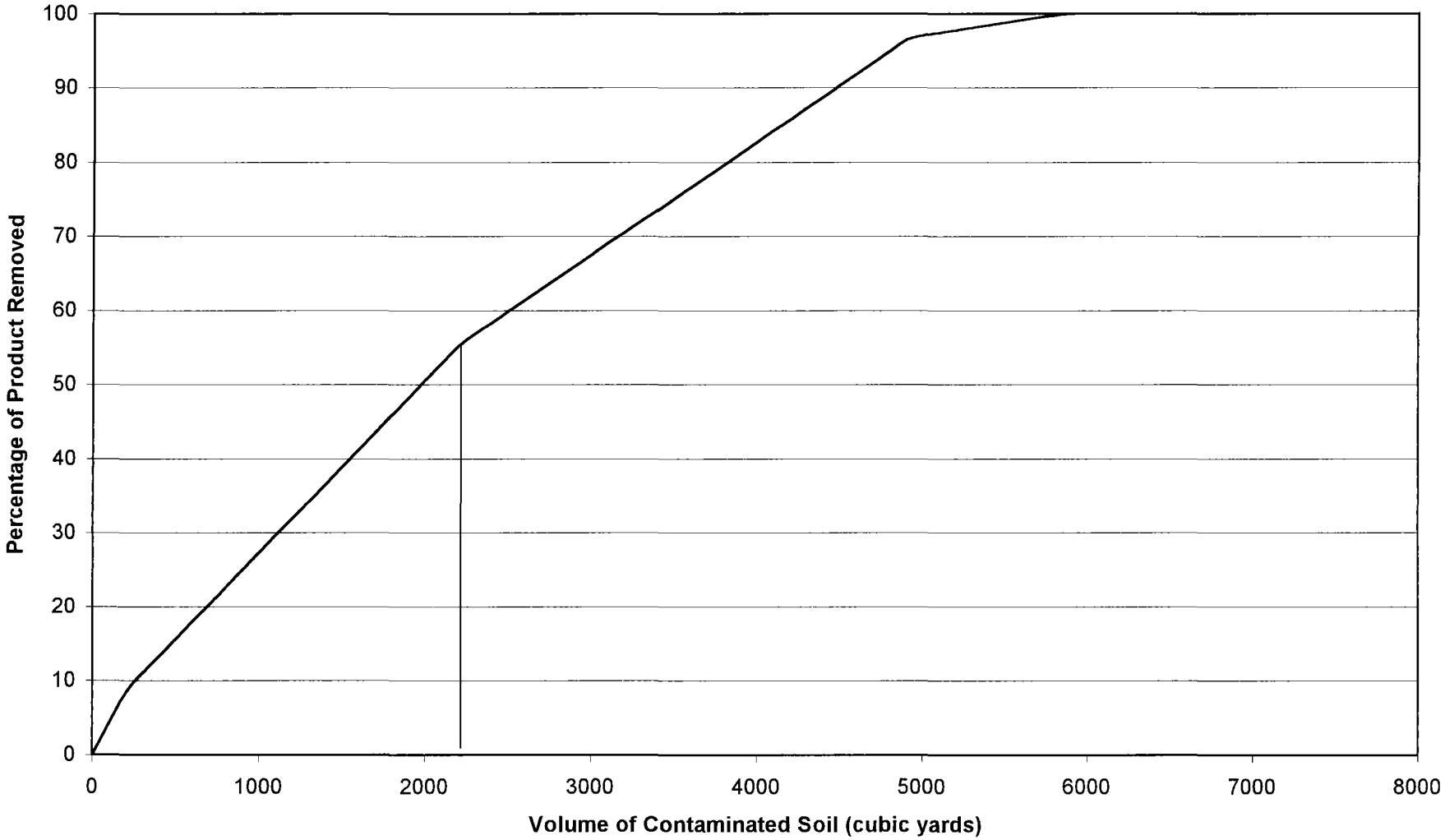
8/4/15

3/6

NAS Key West RAP
Table 2

Subarea ID	Area (square feet)	Product Thickness (ft)	Excavation Volume (cy)	Percent Excavation Volume	Product Mass (pounds)	Percent Mass
FP-16-1	1,949	1.1	227	2.9	45,151	9.1
FP-16-2	17,955	0.61	2095	26.5	230,661	46.4
FP-16-3	24,296	0.4	2835	35.8	204,670	41.1
FP-16-4	953	0.13	111	1.4	2,609	0.5
FP-16-5	7,524	0.09	878	11.1	14,261	2.9
FP-16-6	6,114	0.0001	713	9.0	13	0.0
FP-16-7	9,082	0.0001	1060	13.4	19	0.0
Subtotal	67,873		7,919	100	497,383	100
FP-17-1	4,580	0.06	534	20.2	5,787	99.3
FP-17-2	18,121	0.0001	2,114	79.8	38	0.7
Subtotal	22,701		2,648	100	5,825	100

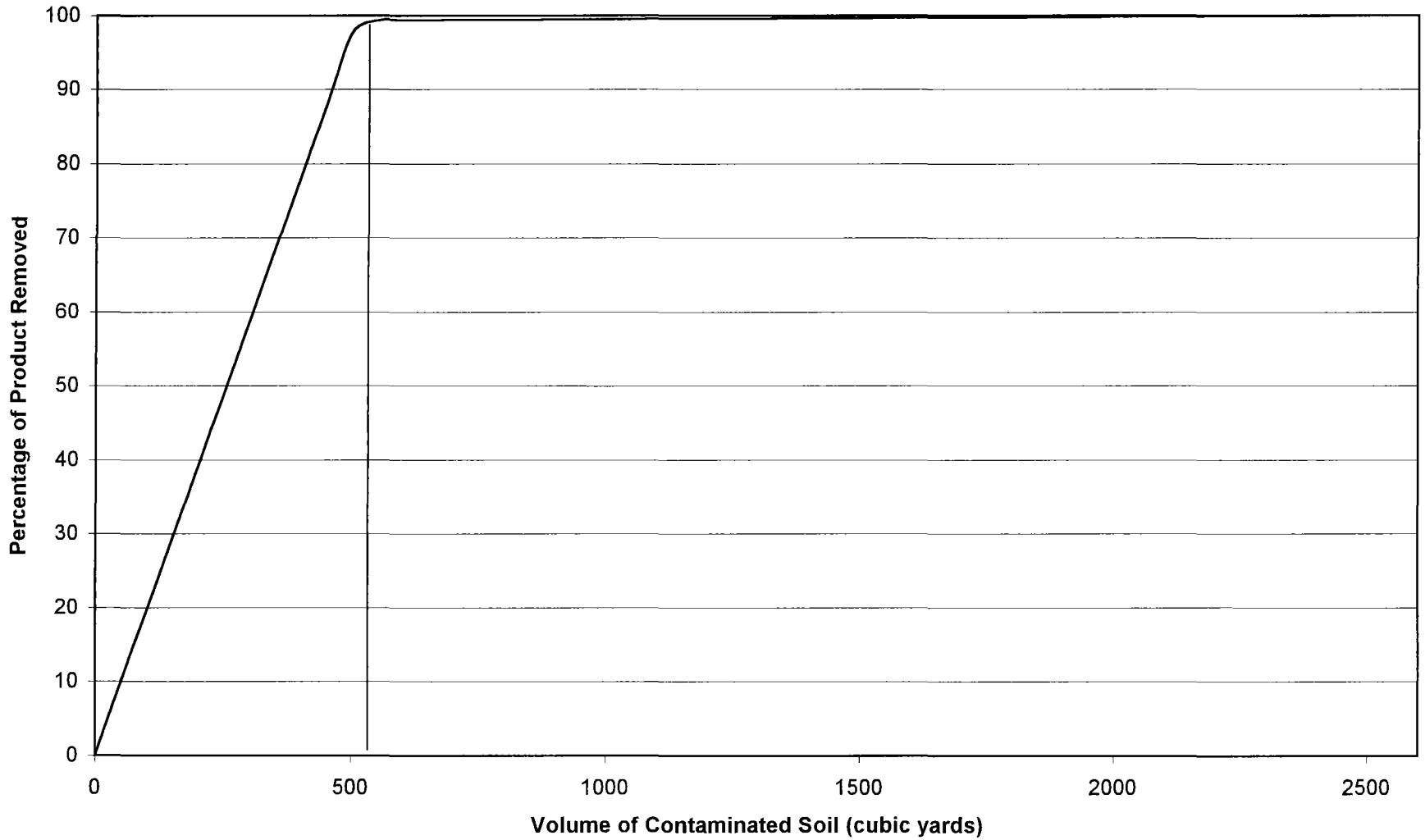
Figure C-2
FP-16: Percentage of Product Removed vs. Excavation Volume



10/49/15

5/6

Figure C-3
FP-17: Percentage of Product Removed vs. Excavation Volume



11/48/15

Calculated by: [illegible] 9/16/99 [illegible]
Checked by: DAR 8/18/99 1/1

NAS [illegible]

[illegible]

As shown on Figure 4-1 there are 2 areas to be excavated.

The soil from 0-4 ft bls is considered clean. The soil from 4-7 ft bls must be excavated and treated. Four feet [illegible] the historic high water table, 7 ft [illegible] the river low water table.

Using Tamaya Digital Planimeter, Planix 7, the scale factor was set to 600 to equate to 1" = 50' (50' [illegible]). The area was measured 3 times and an average taken.

Results: $Area_w$ = 30,[illegible] ft^2 $Area_e$ = 5,057 ft^2

Vol_w = 30,[illegible] × 3' = 92533 cf = 3427 cy ✓

Assume soil [illegible] × [illegible] ✓

= 3427 cy × 1.5 tons/cy ✓

$Mass_w$ = 5140 tons ✓

Vol_e = [illegible] 15[illegible]1 cf = 562 cy ✓

= 562 × 1.5

$Mass_e$ = 843 tons ✓

Total mass to be treated:

Total Vol = 3427 + 562 = 3,989 cy say 4,000 cy ✓

Total Mass = 5140 + 843 = 5,983 tons say 6,000 tons ✓

Volume also excavated:

Total Vol = ([illegible] + [illegible]) × 7ft = 25[illegible] cf = 9308 cy ✓

Total Mass = 9308 × 1.5 = 13,962 tons ✓

12/19/15

Calc by: RCL 12/1/99
Checked by: DAR 12-10-99

NAS Key West RAP

1/1

Excavation Volumes of Arsenic Contaminated Surface Soil

From Fig 2-5 there are 5 areas w/arsenic in surface soil above background concentration of [illegible] mg/kg.

Assume excavation depth 2 feet
Assume area of excavation for 3 areas in Key West Pipeline Area is 10'x10'
Assume density of 1.25 tons/cy
Volume Calcs:

Navy Tanks Area West: 100 x 140 x 2 = 28,000 cf = 1037 cy

Navy Tanks Area East: 140 x 150 x 2 + 340 x 165 x 2 =
42,000 + 112,200 = 154200 cf
= 5711 cy

Key West Pipeline Areas:
(10 x 10 x 2) 3 = 600 cf = 22 cy

Total Vol = 1037 + 5711 + 22 = 6770 cy say 6800 cy

Total Mass = 6800 x 1.25 tons/cy = 8500 tons

CALCULATED BY: DAR 8/3/99

CHECKED BY: RCL 8/9/99 1/2

[illegible]

[illegible] : • [illegible] PRODUCT VOLUME [illegible]

• [illegible]

• [illegible] ER [illegible]

CONTAMINATED SOIL AREA [illegible]

• PRODUCT [illegible] RECOVERED [illegible]

[illegible] OF 51 OZ [illegible]

[illegible]. NOTE [illegible]

APPROXIMATELY [illegible] A [illegible]

[illegible] 25% OF THE TOTAL

[illegible] IN EACH [illegible]

PRODUCT [illegible]

[illegible]

WITH [illegible] 30 [illegible]

[illegible] 0

= 0.297 /DAY ✓

(AVERAGE [illegible]) = [illegible] ✓

PRODUCT CONTAMINATED AREA	EST. [illegible]			= [illegible]
FP-2	6	gal	[illegible]	= 32
[illegible]	41	gal	[illegible]	= 210
[illegible]	560	gal	[illegible]	= 2800
[illegible]	4.2	gal	[illegible]	= 21
[illegible]	30	gal	[illegible]	= 150
[illegible]	20	gal	[illegible]	= 110
~~FP-16 (Subarea 2)~~	~~130~~	~~gal~~	~~[illegible]~~	~~= 650~~
FP-17 (Subarea 2)	6	gal		= 30

PRODUCT CONTAMINATED AREA	# SKIMMER EMPTYINGS EVENTS		# WELLS		TIME TO CLEANUP
FP-2	33	÷		÷ (2 EVENTS/WEEK) X (52 WEEKS)	= 0.32 YR. ✓
[illegible]	210	÷		[illegible]	= 2.0 YR. ✓
[illegible]	2800	÷	[illegible]	[illegible]	= 13 YR. ✓
[illegible]	21	÷	[illegible]	[illegible]	= [illegible] ✓
[illegible]	150	÷	[illegible]	[illegible]	[illegible] ✓
FP-2[illegible]	1100	÷	4		= 2.6 YR ✓
~~FP-16 (Subarea 2)~~	~~650~~	~~÷~~	~~1~~		~~= 6.2~~ ✓
FP-17 (Subarea 2)	30	÷	2		= 0.15 yr ✓

14/15

18/19

Checked by: RCL 8/18/99

[illegible]

[illegible]

[illegible] WILL [illegible]

[illegible] LY CLEANOUT [illegible]

OTHER [illegible]

[illegible]

[illegible] $\frac{1}{2}$ = 0.0[illegible] [illegible] ✓

[illegible] PERIOD [illegible] ✓

PERIOD [illegible]

[illegible]		[illegible]	[illegible]	[illegible] ✓
[illegible]		[illegible]		[illegible] ✓
[illegible]				18 ✓
[illegible]	4	33.~~777~~ 150		~~[illegible]~~ 100 ✓

PERIOD [illegible]

[illegible]		46 [illegible]		[illegible] ✓
				= 2.6 ✓
				= 0.5[illegible] ✓
	-4	~~[illegible]~~ 100		~~[illegible]~~ 3.0 ✓

APPENDIX D

APPENDIX D

VENDOR INFORMATION

FLORIDA

Department of Environmental Protection

Lawton Chiles
Governor

Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, Florida 32399-2400

Virginia B. Wetherell
Secretary

1/12

April 30, 1997

Mr. Nick Knezevich
Nacor of Naples, Incorporated
790 Harbour Drive, Suite 2C
Naples, Florida 34103

Re: Ion Collider Soil Remediation System

Dear Mr. Knezevich:

The Bureau of Petroleum Storage Systems thanks you and your associates for visiting on March 24, 1997 and April 24, 1997 to discuss the ex situ remediation of petroleum contaminated soil by an innovative, chemical oxidation method. The Ion Collider technology, developed by Universal Environmental Technologies, destroys petroleum hydrocarbon contaminants by converting them to carbon dioxide and water. We have reviewed laboratory results for treated soil from a full-scale operation at Opa Locka Airport, handling soil from the Miami International Airport expansion, and note that the method is effective.

As indicated to the department, the process is essentially a five-step, mechanized train of continuously operating equipment items, to which contaminated soil is fed on a continuous basis. The steps are: (1) screening of the feed soil on a trommel for the purpose of removing debris, rocks, and oversize material; (2) spraying the screened soil with a mixture of ionized water and potassium permanganate as it rides a conveyor belt; (3) passing it through a blade mill, where mixing occurs and more ionized water may be added; (4) moving it with an auger and passing it through a series of paddles, in both of which further mixing occurs; and (5) curing in a 400-ton stockpile for approximately 12 hours. To a small degree, any treated soil that is exposed to sunlight during and after stockpiling will benefit from ultraviolet radiation, which is capable of increasing the rate of reaction for oxidation by potassium permanganate.

A device called an Ion Collider converts water to ionized water before it is used in the process. The ionized water has an elevated concentration of hydroxyl radicals, which are effective oxidizing agents. The ionized water has a pH of approximately 8 and contains a small amount of hydrogen peroxide, which is also an oxidizer.

2/12

The bureau has no objection to expanding the application of Ion Collider technology to other sites in Florida, for the remediation of petroleum contaminated soil. The degree of treatment required will vary, depending upon the final disposition of the treated soil. There are two chapters of the Florida Administrative Code (F.A.C.), as well as some guidance documents that are worth mentioning with respect to soil remediation and soil cleanup goals. The current issue of Chapter 62-770, F.A.C., dated September 3, 1996, sets forth cleanup criteria for petroleum contaminated sites. It is presently being revised to include soil cleanup criteria for different situations and should be available this year. Chapter 62-775, F.A.C., dated November 30, 1992, sets forth clean soil criteria for soil thermal treatment facilities but may be helpful as a reference. Additionally, the Department of Environmental Protection has issued a July 5, 1994 memorandum titled "Cleanup Goals for Military Sites in Florida", and a May 1994 document titled "Guidelines for Assessment and Remediation of Petroleum Contaminated Soil". Please note that treated soil which will be used as clean fill may be subject to local requirements that may be more stringent than those set forth by the department.

If you intend to construct a large, high-volume stationary soil treatment plant, to commercially treat soil which has been excavated and hauled from petroleum contaminated sites, then you must obtain a permit for such a facility. If you intend to use smaller-scale equipment for the onsite cleanup of individual petroleum contaminated sites, such as gasoline service stations, then it is only necessary for the remedial action plan for each such site to prescribe the Ion Collider technology. In that case, either a small-scale system will be constructed at the site, or a trailer-mounted or skid-mounted system may be deployed.

While the Department of Environmental Protection does not provide endorsement of specific or brand name remediation products or processes, it does recognize the need to determine their acceptability from an environmental standpoint, with respect to applicable rules and regulations, and the interests of public health, safety, and welfare. Vendor's must then market the products and processes on their own merits regarding performance, cost, and safety in comparison to competing alternatives in the marketplace.

Department acceptance of any particular remediation product or process does not imply it has been deemed applicable for

all cleanup situations, or that it is preferred over others in any particular case. A site specific evaluation of applicability and cost-effectiveness must be considered for any product or process each time a remedial action plan is prepared for a site, regardless of whether conventional or innovative methods will be used. The plan should also include adequate site specific design details.

Preparers of remedial action plan documents for state-funded cleanups may wish to include a copy of this letter in the appendix of plans they submit, and call attention to it in the text of their document. In this way, technical reviewers throughout the state and its contracted local reviewing programs will be informed that you have contacted the Department of Environmental Protection to inquire about the environmental acceptability of this process. To aid those reviewers, the Bureau of Petroleum Storage Systems lists some items below.

a. Concentration of applied potassium permanganate ($KMnO_4$): It has been indicated that 10 pounds of pure $KMnO_4$ is applied to every 800 tons of soil processed. This equates to .000625 percent by weight. This is a very small concentration in comparison to even the most stringent soil criterion available at this time for manganese, which is .57 percent by weight.

b. Oxidation products and fate of the potassium and manganese species: For ionized water alone, which contains an elevated concentration of hydroxyl radicals, the products of petroleum hydrocarbon destruction are carbon dioxide (CO_2) and water (H_2O). For $KMnO_4$, oxidation of petroleum or other organic compounds, the products are likely to include manganese dioxide (MnO_2) and potassium carbonate (K_2CO_3) in addition to CO_2 and H_2O. For the treatment of petroleum contaminated soils where the ambient naturally occurring concentration of total organic carbon (TOC) is already elevated, the amount of ionized water and $KMnO_4$ used during the treatment process may have to be increased, if there is not sufficient oxidant in the application ratio described in item (a) above.

c. Fate of potassium and manganese with respect to final disposition of treated soil: In the interest of protecting the groundwaters of the state, the concentration of $KMnO_4$ added to soil during the

treatment process shall not be so high as to cause a leachability risk with respect to manganese upon final disposition of the treated soil. At this time, there is no leachability concentration established for manganese. Furthermore, and more importantly, the bureau believes that the amount of $KMnO_4$ typically added during the treatment process is so small that leachability is not likely to be a problem. In the unlikely event that groundwater were to be affected by soil treated by this process, the current secondary maximum contaminant level for manganese per Chapter 62-550, F.A.C., drinking water standards is 50 micrograms per liter (or equivalently 50 parts per billion). In regard to potassium, there is neither a primary nor a secondary standard.

d. Moisture content: It has been indicated that the moisture content of the soil immediately after the treatment process ranges from 30 to 40 percent. This may vary, depending upon the nature of the soil at the site. Sandy soils will have a lower moisture content.

e. Runoff: As a matter of good practice, the necessary and appropriate steps shall be taken to ensure that stockpiles of contaminated soil awaiting treatment will not cause a runoff problem. If a site does not already have a paved and bermed area for stockpiling feed soil, then liners and berms, or other means or methods of containment should be installed or employed.

f. Air emissions: Since the degree of contamination will vary from site to site, the need for air emissions control may need to be assessed on a site to site basis. However, the bureau believes that air emissions from this process are not likely to be a problem at most sites. Reasons: (1) petroleum is converted to carbon dioxide and water by the oxidation process, unlike thermal treatment processes which drive off the hydrocarbons as vapors; (2) the surface area of a contaminated stockpile awaiting treatment is small in comparison to its volume, thereby limiting the rate at which vapors may escape; and (3) transfer of soil using earth moving equipment will occur one scoop at a time, which limits the amount of vapors that may be able to escape as periodic surges.

The environmental acceptability of this soil treatment process, as determined by the bureau, is based on the use of potassium permanganate as the oxidant used in combination with ionized water. In the event that an alternate to potassium permanganate will be used in some situations, we request that the subsitution be made clear in a remedial action plan and submitted for approval. Prior to prescribing a substitute, the preparer of the plan should consider the substitute's toxicological aspects, allowable soil concentrations, allowable groundwater concentrations, and the fate of the compound and its constituent chemical species upon addition to the process and release to the environment.

The department reserves the right to revoke its acceptance of this process if the nature or composition of either or any of its principal or proprietary ingredients, or the performance of the process, has been falsely represented. You may contact me at 904/487-3299.

Sincerely,

Rick Ruscito

Rick Ruscito, P.E.
Bureau of Petroleum Storage Systems

cc: Ronald Wilson
R.H. Wilson and Associates Engineers
P.O. Box 915260
Longwood, Florida 32791-5260

Tom Conrardy, FDEP/Tallahassee

other108.doc

Technology Description

The Ion Collider provides the catalyst for a range of applications that include cleaning hydrocarbon contaminated soils and treating industrial aqueous effluents. The Ion Collider is a patented device that permanently effects the molecular structure of liquids and gases, particularly water and hydrocarbons. The Ion collider combines scientific principles into a remarkably effective method of separating imiscible particles from a liquid mixture or emulsion. The following are the four critical design criteria incorporated into the Ion Collider:

A. Mechanical pressure is utilized in place of exothermic heat.

B. Magnetohydrodynamics (MHD) are maximized in the design of the device to direct the induced magnetic field back into the liquid or gas, thus imparting a charge directly into the liquid or gas.

C. The material composition of the device is of specific alloys or combinations thereof, which are known to have catalytic properties and characteristics. This, in conjunction with the MHD, results in a negative charge being imparted into the fluid or gas.

D. The internal configuration of the device is designed to create specific flow regimes which facilitate the capability of the fluids and gases to accept the negative charge.

The Soil Oxidation System utilizes a chemical reduction and oxidation (REDOX) technology that causes the formation of hydroxyl radicals (OH). Hydroxyl radicals are powerful oxidizers that destroy organic compounds by breaking them down into non-regulated, environmentally safe compounds. As ionized water passed through the Ion Collider is applied to contaminated soil, the process achieves rapid inexpensive separation of particles and results in high degrees of purity in residual liquids while producing no waste stream. Employing inexpensive and readily available reagents, the system is easily controlled and is applicable to a wide variety of contaminants. The process will not inhibit biological activity but will actually enhance most ongoing biological processes. In contrast to other oxidizing systems it is equally effective in destroying oil & grease and hydrocarbons.

Advantages

- Highest production available - from 60 tons per hour.
- Low treatment price independent of soil type.
- Needs no custom heavy equipment.
- Patented technology.
- Technology applicable to both small mobile and large semi-mobile installations.
- Results are quick and final.
- Preserves soil matrix and will not kill indigenous microorganisms.

Soil Oxidation System Description

The process will handle all types of hydrocarbon contaminated soils at any level of contamination. The basic equipment consists of the following components: two front end loaders, a model 616 Trommel to aerate and screen the soil, a blade mill for mixing the screened soil with the oxidant and treated water, and a radial stacking conveyor. The system requires a water source, four 1500 gallon plastic tanks, a 55 gallon mixing tank with a lightening mixer, two 1 horsepower pumps and the plumbing and valves needed to distribute the ionized water to the spray head arrays (See Figures 1-3).

The soil to be cleaned is first processed by the Trommel 616 rotary screening apparatus consisting of a hopper that feeds a conveyor which, in turn, moves the soil to an inclined rotating cylindrical screen.

Oversize rocks, trash and debris exit from the end of the drum and are deposited in a stockpile by the tail conveyor.

The screened material exits from under the drum by a side conveyor. As the screened soil appears in the conveyor, it is sprayed by the proprietary oxidizer diluted with water that has been passed through the Ion Collider. This side conveyor deposits the soil into the hopper of a 40 foot conveyor which empties the soil into a blade mill. The soil is then picked up by an auger followed by a series of paddles which thoroughly mix the soil together with the oxidizer and treated water, all the while drawing it up through an inclined sluice to finally deposit the mixed soil in the hopper of a radial stacking conveyor. The soil is finally deposited in one of four 400 ton stockpiles to cure for 12 hours. Normal turn-around time for required testing procedures is 24 to 48 hours.

The illustrations show the semi-permanent installation for the Miami project at Opa Locka Airport. Figure 1 is a flow chart which illustrates the process. Figure 2 shows a plan view of the facility at Opa Locka but modified to accommodate six, four hundred ton piles. Figure 3 shows the side and front elevation of the facility. The foot print that is required for all of the equipment and piles is about 100 feet square, not including traffic areas required to feed the Trommel and to access and remove the treated soil. To minimize material handling, the treated soil is not moved until test results come back and soil can be removed to a clean fill stockpile. The soil that has been treated to date has been contaminated with Jet A and diesel fuel as well as some solvents. All soil has been cleaned to levels below the local clean fill standards.*

*For EPA 8020<100 parts per billion, for EPA 8110 diesel<500 parts per billion, for EPA 8100 solvents<250 parts per million, for EPA 9071 O&G<250 parts per million.

Soil Treatment Process Flow Diagram

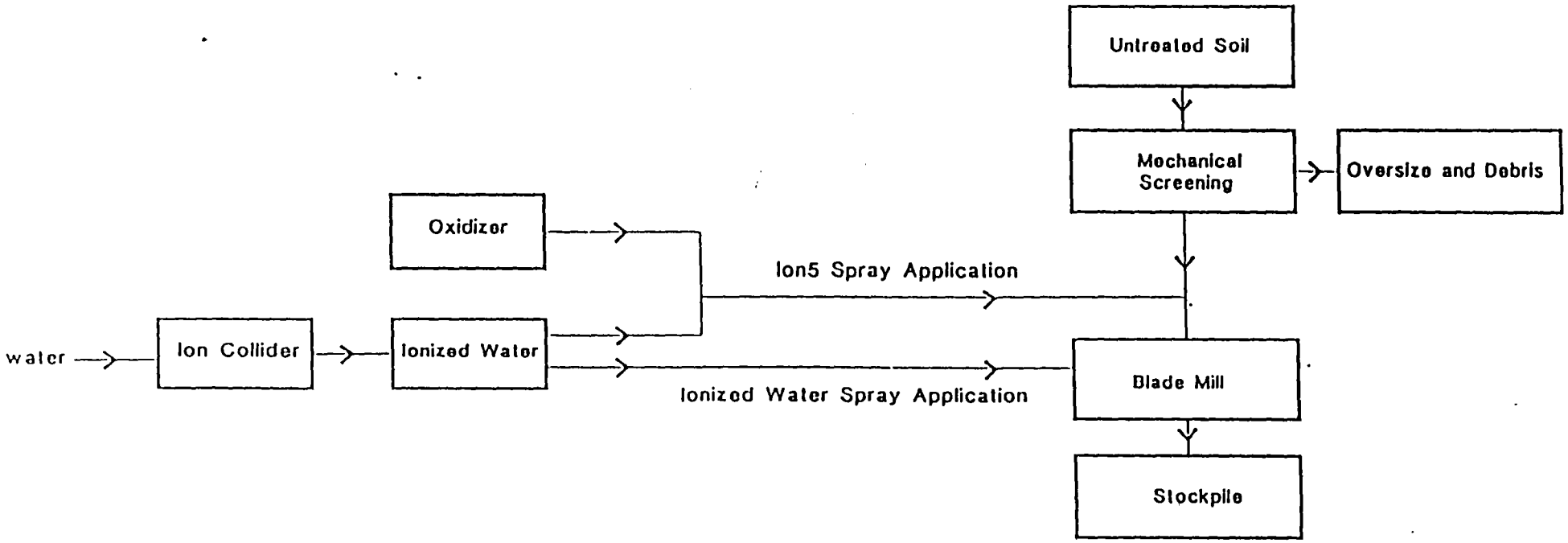


Fig. 1

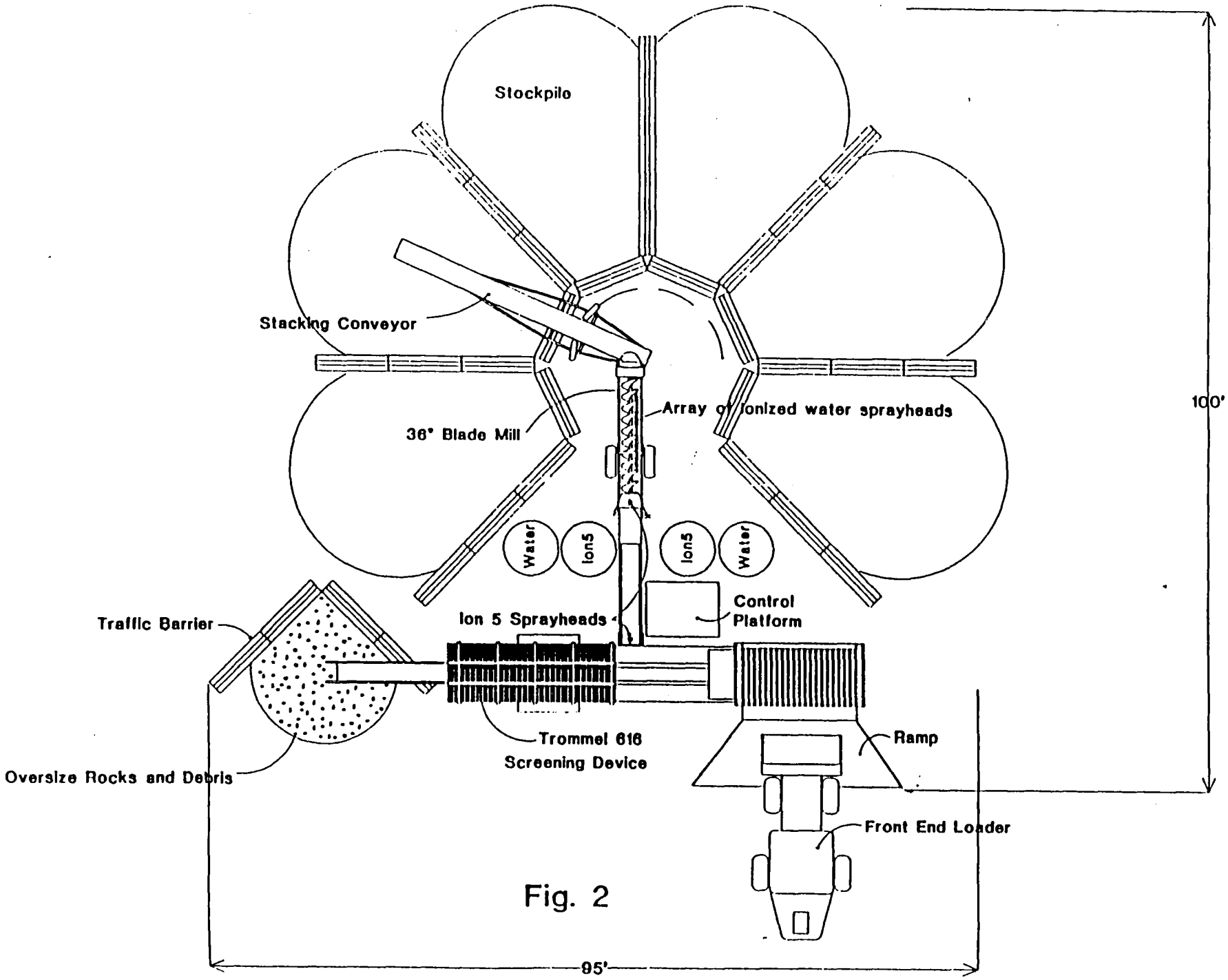
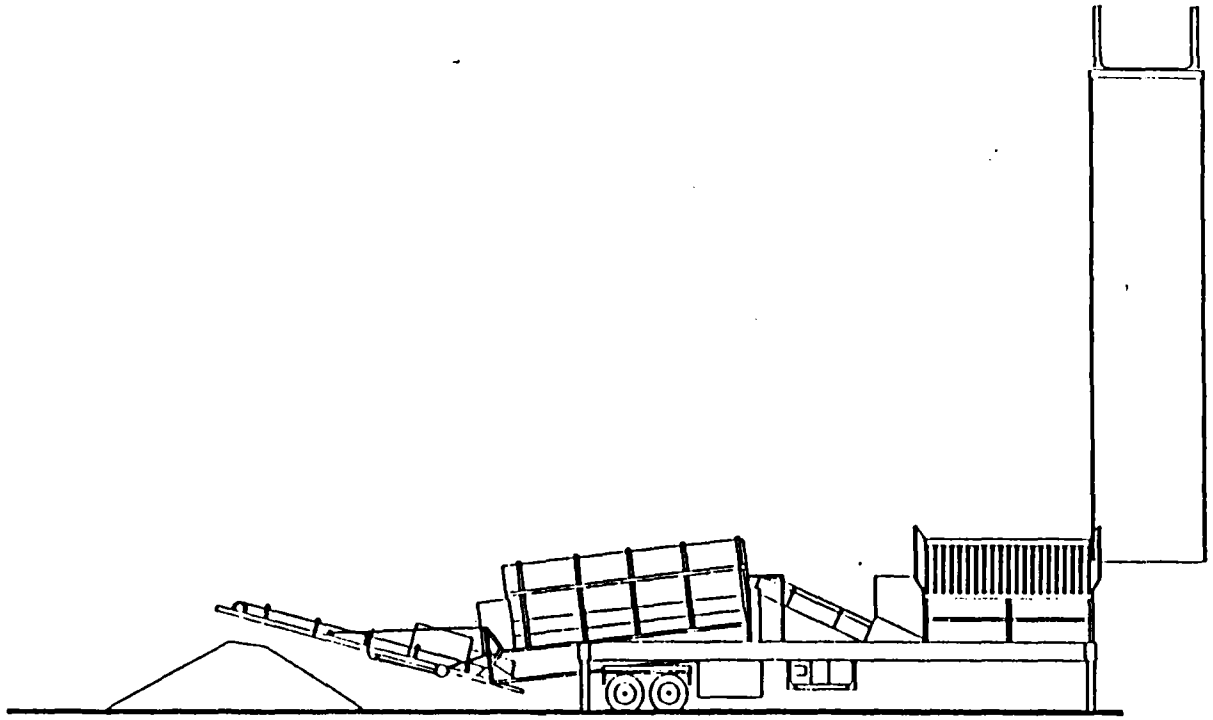
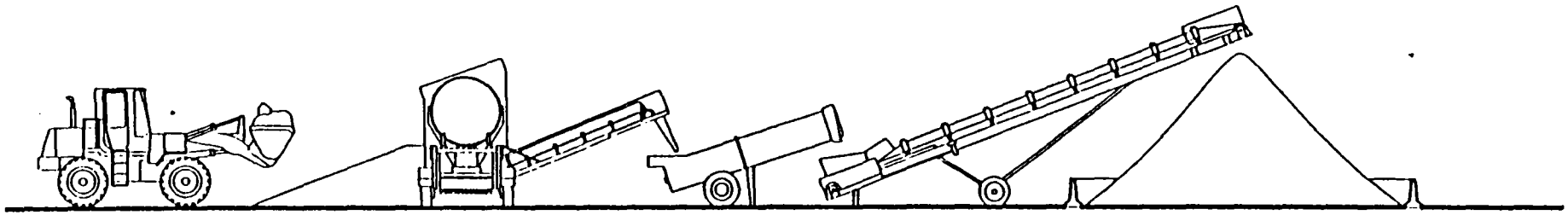

Stockpile
Stacking Conveyor
36" Blade Mill
Array of Ionized water sprayheads
Water
Ion5
Ion5
Water
Control Platform
Ion 5 Sprayheads
Traffic Barrier
Trommel 616 Screening Device
Ramp
Oversize Rocks and Debris
Front End Loader
100'
95'

Fig. 2



Side View

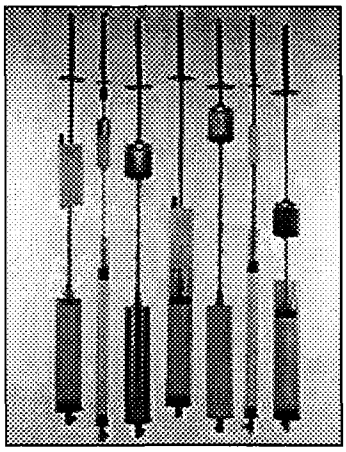


End View

Fig. 3

11/12

OIL SKIMMERS



SOS-P
SPG-P

Applications:

Skimming (LNAPL)

Passive Floating-Intake Skimmers
SOS-P Reduce Product Lense to a sheen
SPG-P High Viscosity Hydrocarbons

OVERVIEW

Unlike any other design, these unique Passive Skimmers can be upgraded to fully automatic, active Product Only Recovery Systems. They are designed to recover free-floating hydrocarbon from any depth down to a sheen (0.01 inches) without the need for any power source. The floating intake head (which in two configurations SOS and SPG) follows water table fluctuations. Passive Skimmers include versions for 2-inch (5cm) and 4-inch (10cm) diameter wells, and Tidal Passive Skimmers with extra long strokes are available for sites with high and low tide considerations.

Passive Skimmers consist of four main items: a Floating Intake Head, Guide Rod & Flexible Tube, a Well Centering Disk, and a Clear Product Canister.

PASSIVE OPERATION

The skimmer is lowered into the well until the midpoint of the skimmer's travel is located at the fluid level in the well. The support rope is tied off holding the skimmer at a specific depth and the skimmer is left in the well to collect floating hydrocarbons.

A floating intake head follows any water table fluctuation. Hydrocarbon first enters the skimmer through the floating intake's outer debris screen and then an inner oil eophilic

12/12

hydrophobic screen, down through a flexible, yellow tube, and into the see-through canister.

To empty the skimmer, it is pulled to the surface and the canister is drained using the valve at its base. The skimmer is returned to the well until next checked at its predetermined maintenance interval.

SKIMMER CAPACITY

- 18-inch canister : 13.0 oz. (0.38 l)
- 36-inch canister : 25.5 oz. (0.75 l)
- 18-inch canister : 47.0 oz. (1.4 l)
- 36-inch canister : 94.0 oz. (2.8 l)

OPERATIONS AND ACCESSORIES

CEE Passive Skimmers have three upgrade options that are simply undertaken in the field. Each requires simple tools and takes less than thirty minutes. Should it be needed, reverse upgrading back to the standard Passive SOS Skimmer is a process that involves the same upgrade steps in reverse order.

CANISTER UPGRADE. CEE Passive Skimmers come in stock canister lengths ranging from 12 - 36 inches with ranging capacities from 8.5 oz. (0.25 L) to 94 oz. (2.8 L) depending on canister diameter. (Other sizes are available dependent on site requirements.) Furthermore, canisters can be removed and replaced as capacity or compatibility demands change.

HAND-PUMP UPGRADE. Most CEE Passive Skimmers, when outfitted with a skimmer-to-surface product tubes, can be serviced without raising the skimmer out of the well. Using a pump at the surface, maintenance personnel can pump product out of the skimmer's product canister and into a portable collection canister at the surface.

FULLY AUTOMATIC PRODUCT RECOVERY UPGRADE. CEE Passive Skimmers can be upgraded to active, fully automatic Product Only Recovery Systems as site needs change. As active systems, product can be recovered at rates over 2000 gpd. Safety and protective features are available such as Tank-Full Shut-Off (TFSO), which turns off the system when the product tank becomes full, and High-Water Shut-Off (HWSO), which turns off the product pump temporarily when water levels rise above the skimmer's effective travel. (Part Number for upgrade is 300031.)

APPENDIX E

APPENDIX E

APRIL 1999 SURFACE SOIL SAMPLING DATA

NAS Key West - April 1999 Surface Soil Sampling

Sample Identifier	01B24001	01B24001RE	01B24101	01B24101RE
Sample Collect Date	4/27/1999	4/27/1999	4/27/1999	4/27/1999
Analyte				
Metals				
Arsenic	5.3 U mg/kg (5.3)	2.1 mg/kg (1.1)	5.9 mg/kg (5.)	5.9 mg/kg (1.1)
Petroleum Hydrocarbons				
Total Petroleum Hydrocarbons (C8-C40)	21000. ug/kg (4200.)	--	24000. ug/kg (4300.)	--
Semivolatile Organic Compounds				
Acenaphthene	170. U ug/kg (170.)	--	180. U ug/kg (180.)	--
Acenaphthylene	170. U ug/kg (170.)	--	180. U ug/kg (180.)	--
Anthracene	170. U ug/kg (170.)	--	180. U ug/kg (180.)	--
Benzo(a)anthracene	170. U ug/kg (170.)	--	180. U ug/kg (180.)	--
Benzo(a)pyrene	170. U ug/kg (170.)	--	180. U ug/kg (180.)	--
Benzo(b)fluoranthene	170. U ug/kg (170.)	--	180. U ug/kg (180.)	--
Benzo(g,h,i)perylene	170. U ug/kg (170.)	--	180. U ug/kg (180.)	--
Benzo(k)fluoranthene	170. U ug/kg (170.)	--	180. U ug/kg (180.)	--
Chrysene	170. U ug/kg (170.)	--	180. ug/kg (180.)	--
Dibenzo(a,h)anthracene	170. U ug/kg (170.)	--	180. U ug/kg (180.)	--
Fluoranthene	170. U ug/kg (170.)	--	310. ug/kg (180.)	--
Fluorene	170. U ug/kg (170.)	--	180. U ug/kg (180.)	--
Indeno(1,2,3-cd)pyrene	170. U ug/kg (170.)	--	180. U ug/kg (180.)	--
Naphthalene	170. U ug/kg (170.)	--	180. U ug/kg (180.)	--
Phenanthrene	170. U ug/kg (170.)	--	180. U ug/kg (180.)	--
Pyrene	170. U ug/kg (170.)	--	250. ug/kg (180.)	--
Volatile Organic Compounds				
Naphthalene	170. U ug/kg (170.)	--	180. U ug/kg (180.)	--

Sample Identifier	01B24201	01B24201RE	01B24301	01B24301RE
Sample Collect Date	4/27/1999	4/27/1999	4/27/1999	4/27/1999
Analyte				
Metals				
Arsenic	5.6 U mg/kg (5.6)	2.7 mg/kg (1.1)	15. mg/kg (5.)	15. mg/kg (1.1)
Petroleum Hydrocarbons				
Total Petroleum Hydrocarbons (C8-C40)	4500. U ug/kg (4500.)	--	72000. ug/kg (4300.)	--
Semivolatile Organic Compounds				
Acenaphthene	190. U ug/kg (190.)	--	880. U ug/kg (880.)	--
Acenaphthylene	190. U ug/kg (190.)	--	880. U ug/kg (880.)	--
Anthracene	190. U ug/kg (190.)	--	880. U ug/kg (880.)	--
Benzo(a)anthracene	190. U ug/kg (190.)	--	880. J ug/kg (880.)	--
Benzo(a)pyrene	190. U ug/kg (190.)	--	880. J ug/kg (880.)	--
Benzo(b)fluoranthene	190. U ug/kg (190.)	--	880. J ug/kg (880.)	--
Benzo(g,h,i)perylene	190. U ug/kg (190.)	--	880. J ug/kg (880.)	--
Benzo(k)fluoranthene	190. U ug/kg (190.)	--	880. J ug/kg (880.)	--
Chrysene	190. U ug/kg (190.)	--	880. J ug/kg (880.)	--
Dibenzo(a,h)anthracene	190. U ug/kg (190.)	--	880. U ug/kg (880.)	--
Fluoranthene	190. U ug/kg (190.)	--	1900. ug/kg (880.)	--
Fluorene	190. U ug/kg (190.)	--	880. U ug/kg (880.)	--
Indeno(1,2,3-cd)pyrene	190. U ug/kg (190.)	--	880. J ug/kg (880.)	--
Naphthalene	190. U ug/kg (190.)	--	880. U ug/kg (880.)	--
Phenanthrene	190. U ug/kg (190.)	--	990. ug/kg (880.)	--
Pyrene	190. U ug/kg (190.)	--	1400. ug/kg (880.)	--
Volatile Organic Compounds				
Naphthalene	190. U ug/kg (190.)	--	880. U ug/kg (880.)	--

Sample Identifier	01B24401	01B24401RE	01B24501	01B24501RE
Sample Collect Date	4/27/1999	4/27/1999	4/27/1999	4/27/1999
Analyte				
Metals				
Arsenic	5.7 U mg/kg (5.7)	3.5 mg/kg (1.1)	14. mg/kg (6.)	14. mg/kg (1.1)
Petroleum Hydrocarbons				
Total Petroleum Hydrocarbons (C8-C40)	28000. ug/kg (4500.)	--	40000. ug/kg (4500.)	--
Semivolatile Organic Compounds				
Acenaphthene	940. U ug/kg (940.)	--	190. U ug/kg (190.)	--
Acenaphthylene	940. U ug/kg (940.)	--	190. U ug/kg (190.)	--
Anthracene	940. U ug/kg (940.)	--	190. U ug/kg (190.)	--
Benzo(a)anthracene	940. J ug/kg (940.)	--	250. ug/kg (190.)	--
Benzo(a)pyrene	980. ug/kg (940.)	--	190. U ug/kg (190.)	--
Benzo(b)fluoranthene	940. J ug/kg (940.)	--	200. ug/kg (190.)	--
Benzo(g,h,i)perylene	940. J ug/kg (940.)	--	190. U ug/kg (190.)	--
Benzo(k)fluoranthene	970. ug/kg (940.)	--	200. ug/kg (190.)	--
Chrysene	940. J ug/kg (940.)	--	290. ug/kg (190.)	--
Dibenzo(a,h)anthracene	940. J ug/kg (940.)	--	190. U ug/kg (190.)	--
Fluoranthene	1500. ug/kg (940.)	--	460. ug/kg (190.)	--
Fluorene	940. U ug/kg (940.)	--	190. U ug/kg (190.)	--
Indeno(1,2,3-cd)pyrene	940. J ug/kg (940.)	--	190. U ug/kg (190.)	--
Naphthalene	940. U ug/kg (940.)	--	190. U ug/kg (190.)	--
Phenanthrene	940. J ug/kg (940.)	--	190. U ug/kg (190.)	--
Pyrene	1500. ug/kg (940.)	--	380. ug/kg (190.)	--
Volatile Organic Compounds				
Naphthalene	940. U ug/kg (940.)	--	190. U ug/kg (190.)	--

Sample Identifier	01B24601	01B24601RE	01B24701	01B24701RE
Sample Collect Date	4/27/1999	4/27/1999	4/27/1999	4/27/1999
Analyte				
Metals				
Arsenic	5.9 mg/kg (5.)	5.9 mg/kg (1.1)	6. mg/kg (5.)	6. mg/kg (1.1)
Petroleum Hydrocarbons				
Total Petroleum Hydrocarbons (C8-C40)	53000. ug/kg (4300.)	--	25000. ug/kg (4300.)	--
Semivolatile Organic Compounds				
Acenaphthene	180. U ug/kg (180.)	--	180. U ug/kg (180.)	--
Acenaphthylene	180. U ug/kg (180.)	--	180. U ug/kg (180.)	--
Anthracene	180. U ug/kg (180.)	--	180. U ug/kg (180.)	--
Benzo(a)anthracene	990. ug/kg (180.)	--	180. U ug/kg (180.)	--
Benzo(a)pyrene	730. ug/kg (180.)	--	180. U ug/kg (180.)	--
Benzo(b)fluoranthene	750. ug/kg (180.)	--	180. U ug/kg (180.)	--
Benzo(g,h,i)perylene	200. ug/kg (180.)	--	180. U ug/kg (180.)	--
Benzo(k)fluoranthene	830. ug/kg (180.)	--	180. U ug/kg (180.)	--
Chrysene	1100. ug/kg (180.)	--	180. U ug/kg (180.)	--
Dibenzo(a,h)anthracene	180. U ug/kg (180.)	--	180. U ug/kg (180.)	--
Fluoranthene	1300. ug/kg (180.)	--	180. U ug/kg (180.)	--
Fluorene	180. U ug/kg (180.)	--	180. U ug/kg (180.)	--
Indeno(1,2,3-cd)pyrene	200. ug/kg (180.)	--	180. U ug/kg (180.)	--
Naphthalene	180. U ug/kg (180.)	--	180. U ug/kg (180.)	--
Phenanthrene	340. ug/kg (180.)	--	180. U ug/kg (180.)	--
Pyrene	1100. ug/kg (180.)	--	180. U ug/kg (180.)	--
Volatile Organic Compounds				
Naphthalene	180. U ug/kg (180.)	--	180. U ug/kg (180.)	--

Sample Identifier	01B24801	01B24801RE	01B24901	01B24901D
Sample Collect Date	4/28/1999	4/27/1999	4/28/1999	4/28/1999
Analyte				
Metals				
Arsenic	8.5 mg/kg (5.)	8.5 mg/kg (1.1)	5.3 U mg/kg (5.3)	5.3 U mg/kg (5.3)
Petroleum Hydrocarbons				
Total Petroleum Hydrocarbons (C8-C40)	25000. ug/kg (4300.)	--	30000. ug/kg (4200.)	4200. U ug/kg (4200.)
Semivolatile Organic Compounds				
Acenaphthene	180. U ug/kg (180.)	--	170. U ug/kg (170.)	170. U ug/kg (170.)
Acenaphthylene	180. U ug/kg (180.)	--	170. U ug/kg (170.)	170. U ug/kg (170.)
Anthracene	180. U ug/kg (180.)	--	170. U ug/kg (170.)	170. U ug/kg (170.)
Benzo(a)anthracene	180. U ug/kg (180.)	--	280. ug/kg (170.)	220. ug/kg (170.)
Benzo(a)pyrene	180. U ug/kg (180.)	--	200. ug/kg (170.)	170. U ug/kg (170.)
Benzo(b)fluoranthene	180. U ug/kg (180.)	--	210. ug/kg (170.)	170. U ug/kg (170.)
Benzo(g,h,i)perylene	180. U ug/kg (180.)	--	170. U ug/kg (170.)	170. U ug/kg (170.)
Benzo(k)fluoranthene	180. ug/kg (180.)	--	210. ug/kg (170.)	170. U ug/kg (170.)
Chrysene	190. ug/kg (180.)	--	280. ug/kg (170.)	230. ug/kg (170.)
Dibenzo(a,h)anthracene	180. U ug/kg (180.)	--	170. U ug/kg (170.)	170. U ug/kg (170.)
Fluoranthene	330. ug/kg (180.)	--	570. ug/kg (170.)	420. ug/kg (170.)
Fluorene	180. U ug/kg (180.)	--	170. U ug/kg (170.)	170. U ug/kg (170.)
Indeno(1,2,3-cd)pyrene	180. U ug/kg (180.)	--	170. U ug/kg (170.)	170. U ug/kg (170.)
Naphthalene	180. U ug/kg (180.)	--	170. U ug/kg (170.)	170. U ug/kg (170.)
Phenanthrene	180. U ug/kg (180.)	--	240. ug/kg (170.)	190. ug/kg (170.)
Pyrene	240. ug/kg (180.)	--	410. ug/kg (170.)	290. ug/kg (170.)
Volatile Organic Compounds				
Naphthalene	180. U ug/kg (180.)	--	170. U ug/kg (170.)	170. U ug/kg (170.)

Sample Identifier	01B24901DRE	01B24901RE	01B25001	01B25001RE
Sample Collect Date	4/27/1999	4/27/1999	4/27/1999	4/27/1999
Analyte				
Metals				
Arsenic	4. mg/kg (1.1)	3.2 mg/kg (1.1)	5.4 U mg/kg (5.4)	4.2 mg/kg (1.1)
Petroleum Hydrocarbons				
Total Petroleum Hydrocarbons (C8-C40)	--	--	41000. ug/kg (4300.)	--
Semivolatile Organic Compounds				
Acenaphthene	--	--	180. U ug/kg (180.)	--
Acenaphthylene	--	--	180. U ug/kg (180.)	--
Anthracene	--	--	180. U ug/kg (180.)	--
Benzo(a)anthracene	--	--	180. U ug/kg (180.)	--
Benzo(a)pyrene	--	--	180. U ug/kg (180.)	--
Benzo(b)fluoranthene	--	--	180. U ug/kg (180.)	--
Benzo(g,h,i)perylene	--	--	180. U ug/kg (180.)	--
Benzo(k)fluoranthene	--	--	180. U ug/kg (180.)	--
Chrysene	--	--	180. U ug/kg (180.)	--
Dibenzo(a,h)anthracene	--	--	180. U ug/kg (180.)	--
Fluoranthene	--	--	180. U ug/kg (180.)	--
Fluorene	--	--	180. U ug/kg (180.)	--
Indeno(1,2,3-cd)pyrene	--	--	180. U ug/kg (180.)	--
Naphthalene	--	--	180. U ug/kg (180.)	--
Phenanthrene	--	--	180. U ug/kg (180.)	--
Pyrene	--	--	180. U ug/kg (180.)	--
Volatile Organic Compounds				
Naphthalene	--	--	180. U ug/kg (180.)	--

Sample Identifier	01B25101	01B25101RE	01B25201	01B25201RE
Sample Collect Date	4/27/1999	4/27/1999	4/27/1999	4/27/1999
Analyte				
Metals				
Arsenic	6.9 mg/kg (6.)	6.9 mg/kg (1.1)	5.4 U mg/kg (5.4)	4.9 mg/kg (1.1)
Petroleum Hydrocarbons				
Total Petroleum Hydrocarbons (C8-C40)	28000. ug/kg (4500.)	--	21000. ug/kg (4300.)	--
Semivolatile Organic Compounds				
Acenaphthene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	--
Acenaphthylene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	--
Anthracene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	--
Benzo(a)anthracene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	--
Benzo(a)pyrene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	--
Benzo(b)fluoranthene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	--
Benzo(g,h,i)perylene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	--
Benzo(k)fluoranthene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	--
Chrysene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	--
Dibenzo(a,h)anthracene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	--
Fluoranthene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	--
Fluorene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	--
Indeno(1,2,3-cd)pyrene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	--
Naphthalene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	--
Phenanthrene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	--
Pyrene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	--
Volatile Organic Compounds				
Naphthalene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	--

Sample Identifier	01B25301	01B25301RE	01B25401	01B25401RE
Sample Collect Date	4/27/1999	4/27/1999	4/27/1999	4/27/1999
Analyte				
Metals				
Arsenic	5.6 U mg/kg (5.6)	4.8 mg/kg (1.1)	18. mg/kg (5.)	18. mg/kg (1.1)
Petroleum Hydrocarbons				
Total Petroleum Hydrocarbons (C8-C40)	4400. U ug/kg (4400.)	--	450000. ug/kg (8600.)	--
Semivolatile Organic Compounds				
Acenaphthene	180. U ug/kg (180.)	--	180. U ug/kg (180.)	--
Acenaphthylene	180. U ug/kg (180.)	--	180. U ug/kg (180.)	--
Anthracene	180. U ug/kg (180.)	--	180. U ug/kg (180.)	--
Benzo(a)anthracene	180. U ug/kg (180.)	--	180. U ug/kg (180.)	--
Benzo(a)pyrene	180. U ug/kg (180.)	--	180. U ug/kg (180.)	--
Benzo(b)fluoranthene	180. U ug/kg (180.)	--	180. U ug/kg (180.)	--
Benzo(g,h,i)perylene	180. U ug/kg (180.)	--	180. U ug/kg (180.)	--
Benzo(k)fluoranthene	180. U ug/kg (180.)	--	180. U ug/kg (180.)	--
Chrysene	180. U ug/kg (180.)	--	180. U ug/kg (180.)	--
Dibenzo(a,h)anthracene	180. U ug/kg (180.)	--	180. U ug/kg (180.)	--
Fluoranthene	180. U ug/kg (180.)	--	180. U ug/kg (180.)	--
Fluorene	180. U ug/kg (180.)	--	180. U ug/kg (180.)	--
Indeno(1,2,3-cd)pyrene	180. U ug/kg (180.)	--	180. U ug/kg (180.)	--
Naphthalene	180. U ug/kg (180.)	--	180. U ug/kg (180.)	--
Phenanthrene	180. U ug/kg (180.)	--	180. U ug/kg (180.)	--
Pyrene	180. U ug/kg (180.)	--	180. U ug/kg (180.)	--
Volatile Organic Compounds				
Naphthalene	180. U ug/kg (180.)	--	180. U ug/kg (180.)	--

Sample Identifier	01B25501	01B25501RE	01B25601	01B25601RE
Sample Collect Date	4/27/1999	4/27/1999	4/27/1999	4/27/1999
Analyte				
Metals				
Arsenic	440. mg/kg (5.)	440. mg/kg (1.1)	7.1 mg/kg (6.)	7.1 mg/kg (1.1)
Petroleum Hydrocarbons				
Total Petroleum Hydrocarbons (C8-C40)	230000. ug/kg (4300.)	--	44000. ug/kg (4400.)	--
Semivolatile Organic Compounds				
Acenaphthene	180. U ug/kg (180.)	--	180. U ug/kg (180.)	--
Acenaphthylene	180. U ug/kg (180.)	--	180. U ug/kg (180.)	--
Anthracene	460. ug/kg (180.)	--	180. U ug/kg (180.)	--
Benzo(a)anthracene	2200. ug/kg (180.)	--	180. U ug/kg (180.)	--
Benzo(a)pyrene	1800. ug/kg (180.)	--	180. U ug/kg (180.)	--
Benzo(b)fluoranthene	1900. ug/kg (180.)	--	180. U ug/kg (180.)	--
Benzo(g,h,i)perylene	910. ug/kg (180.)	--	180. U ug/kg (180.)	--
Benzo(k)fluoranthene	1600. ug/kg (180.)	--	180. U ug/kg (180.)	--
Chrysene	2300. ug/kg (180.)	--	180. U ug/kg (180.)	--
Dibenzo(a,h)anthracene	180. U ug/kg (180.)	--	180. U ug/kg (180.)	--
Fluoranthene	5000. ug/kg (180.)	--	180. U ug/kg (180.)	--
Fluorene	190. ug/kg (180.)	--	180. U ug/kg (180.)	--
Indeno(1,2,3-cd)pyrene	950. ug/kg (180.)	--	180. U ug/kg (180.)	--
Naphthalene	180. U ug/kg (180.)	--	180. U ug/kg (180.)	--
Phenanthrene	2700. ug/kg (180.)	--	180. U ug/kg (180.)	--
Pyrene	3600. ug/kg (180.)	--	180. U ug/kg (180.)	--
Volatile Organic Compounds				
Naphthalene	180. U ug/kg (180.)	--	180. U ug/kg (180.)	--

Sample Identifier	01B25701	01B25701RE	01B25801	01B25801D
Sample Collect Date	4/27/1999	4/27/1999	4/27/1999	4/27/1999
Analyte				
Metals				
Arsenic	5.6 U mg/kg (5.6)	3.4 mg/kg (1.1)	5.4 U mg/kg (5.4)	5.5 U mg/kg (5.5)
Petroleum Hydrocarbons				
Total Petroleum Hydrocarbons (C8-C40)	220000. ug/kg (4500.)	--	230000. ug/kg (4300.)	250000. ug/kg (4400.)
Semivolatile Organic Compounds				
Acenaphthene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	180. U ug/kg (180.)
Acenaphthylene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	180. U ug/kg (180.)
Anthracene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	180. U ug/kg (180.)
Benzo(a)anthracene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	180. U ug/kg (180.)
Benzo(a)pyrene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	180. U ug/kg (180.)
Benzo(b)fluoranthene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	180. U ug/kg (180.)
Benzo(g,h,i)perylene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	180. U ug/kg (180.)
Benzo(k)fluoranthene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	180. U ug/kg (180.)
Chrysene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	180. U ug/kg (180.)
Dibenzo(a,h)anthracene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	180. U ug/kg (180.)
Fluoranthene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	210. ug/kg (180.)
Fluorene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	180. U ug/kg (180.)
Indeno(1,2,3-cd)pyrene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	180. U ug/kg (180.)
Naphthalene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	180. U ug/kg (180.)
Phenanthrene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	180. U ug/kg (180.)
Pyrene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	180. U ug/kg (180.)
Volatile Organic Compounds				
Naphthalene	190. U ug/kg (190.)	--	180. U ug/kg (180.)	180. U ug/kg (180.)

Sample Identifier	01B25801DRE	01B25801RE	01B25901	01B25901RE
Sample Collect Date	4/27/1999	4/27/1999	4/27/1999	4/27/1999
Analyte				
Metals				
Arsenic	3.1 mg/kg (1.1)	3. mg/kg (1.1)	7.7 mg/kg (5.)	7.7 mg/kg (1.1)
Petroleum Hydrocarbons				
Total Petroleum Hydrocarbons (C8-C40)	--	--	28000. ug/kg (4300.)	--
Semivolatile Organic Compounds				
Acenaphthene	--	--	180. U ug/kg (180.)	--
Acenaphthylene	--	--	180. U ug/kg (180.)	--
Anthracene	--	--	180. U ug/kg (180.)	--
Benzo(a)anthracene	--	--	180. U ug/kg (180.)	--
Benzo(a)pyrene	--	--	180. U ug/kg (180.)	--
Benzo(b)fluoranthene	--	--	180. U ug/kg (180.)	--
Benzo(g,h,i)perylene	--	--	180. U ug/kg (180.)	--
Benzo(k)fluoranthene	--	--	180. U ug/kg (180.)	--
Chrysene	--	--	180. U ug/kg (180.)	--
Dibenzo(a,h)anthracene	--	--	180. U ug/kg (180.)	--
Fluoranthene	--	--	180. U ug/kg (180.)	--
Fluorene	--	--	180. U ug/kg (180.)	--
Indeno(1,2,3-cd)pyrene	--	--	180. U ug/kg (180.)	--
Naphthalene	--	--	180. U ug/kg (180.)	--
Phenanthrene	--	--	180. U ug/kg (180.)	--
Pyrene	--	--	180. U ug/kg (180.)	--
Volatile Organic Compounds				
Naphthalene	--	--	180. U ug/kg (180.)	--

Sample Identifier	01B26101	01B26101D	01B26101DRE	01B26101RE
Sample Collect Date	4/28/1999	4/28/1999	4/27/1999	4/27/1999
Analyte				
Metals				
Arsenic	--	--	3.6 mg/kg (1.1)	3.8 mg/kg (1.2)
Barium	12. mg/kg (1.)	9.8 mg/kg (1.)	--	--
Cadmium	0.6 U mg/kg (0.6)	0.56 U mg/kg (0.56)	--	--
Chromium	3.2 mg/kg (1.)	2.9 mg/kg (1.)	--	--
Lead	24. mg/kg (6.)	22. mg/kg (6.)	--	--
Mercury	0.3 U mg/kg (0.3)	0.28 U mg/kg (0.28)	--	--
Selenium	6. U mg/kg (6.)	5.6 U mg/kg (5.6)	--	--
Silver	2.4 U mg/kg (2.4)	2.2 U mg/kg (2.2)	--	--
Petroleum Hydrocarbons				
Total Petroleum Hydrocarbons (C8-C40)	200000. ug/kg (4800.)	200000. ug/kg (4400.)	--	--
Semivolatile Organic Compounds				
1,2,4-Trichlorobenzene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
1,2-Dichlorobenzene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
1,3-Dichlorobenzene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
1,4-Dichlorobenzene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
Acenaphthene	200. U ug/kg (200.)	370. U ug/kg (370.)	--	--
Acenaphthylene	200. U ug/kg (200.)	370. U ug/kg (370.)	--	--
Anthracene	200. U ug/kg (200.)	370. U ug/kg (370.)	--	--
Benzo(a)anthracene	200. U ug/kg (200.)	830. UJ ug/kg (830.)	--	--
Benzo(a)pyrene	200. U ug/kg (200.)	530. UJ ug/kg (530.)	--	--
Benzo(b)fluoranthene	200. U ug/kg (200.)	630. UJ ug/kg (630.)	--	--
Benzo(g,h,i)perylene	200. U ug/kg (200.)	370. U ug/kg (370.)	--	--
Benzo(k)fluoranthene	200. U ug/kg (200.)	560. UJ ug/kg (560.)	--	--
Chrysene	200. U ug/kg (200.)	820. UJ ug/kg (820.)	--	--
Dibenzo(a,h)anthracene	200. U ug/kg (200.)	370. U ug/kg (370.)	--	--
Fluoranthene	200. U ug/kg (200.)	1200. ug/kg (370.)	--	--
Fluorene	200. U ug/kg (200.)	370. U ug/kg (370.)	--	--
Hexachlorobutadiene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--

Sample Identifier Sample Collect Date Analyte	01B26101 4/28/1999	01B26101D 4/28/1999	01B26101DRE 4/27/1999	01B26101RE 4/27/1999
Indeno(1,2,3-cd)pyrene	200. U ug/kg (200.)	370. U ug/kg (370.)	--	--
Naphthalene	200. U ug/kg (200.)	12. U ug/kg (12.)	--	--
Phenanthrene	200. U ug/kg (200.)	470. ug/kg (370.)	--	--
Pyrene	420. UJ ug/kg (420.)	2300. UJ ug/kg (2300.)	--	--
Volatile Organic Compounds				
1,1,1,2-Tetrachloroethane	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
1,1,1-Trichloroethane	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
1,1,2,2-Tetrachloroethane	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
1,1,2-Trichloroethane	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
1,1-Dichloroethane	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
1,1-Dichloroethene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
1,1-Dichloropropene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
1,2,3-Trichlorobenzene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
1,2,3-Trichloropropane	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
1,2,4-Trichlorobenzene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
1,2,4-Trimethylbenzene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
1,2-Dibromo-3-chloropropane	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
1,2-Dichlorobenzene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
1,2-Dichloroethane	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
1,2-Dichloropropane	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
1,3,5-Trimethylbenzene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
1,3-Dichlorobenzene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
1,3-Dichloropropane	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
1,4-Dichlorobenzene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
2,2-Dichloropropane	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
2-Butanone	120. U ug/kg (120.)	120. U ug/kg (120.)	--	--
2-Chlorotoluene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
2-Hexanone	12. U ug/kg (12.)	12. U ug/kg (12.)	--	--
4-Chlorotoluene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
4-Methyl-2-pentanone	12. U ug/kg (12.)	12. U ug/kg (12.)	--	--
Acetone	120. U ug/kg (120.)	120. U ug/kg (120.)	--	--

Sample Identifier Sample Collect Date Analyte	01B26101 4/28/1999	01B26101D 4/28/1999	01B26101DRE 4/27/1999	01B26101RE 4/27/1999
Benzene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
Bromobenzene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
Bromochloromethane	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
Bromodichloromethane	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
Bromoform	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
Bromomethane	12. U ug/kg (12.)	12. U ug/kg (12.)	--	--
Carbon disulfide	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
Carbon tetrachloride	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
Chlorobenzene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
Chloroethane	12. U ug/kg (12.)	12. U ug/kg (12.)	--	--
Chloroform	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
Chloromethane	12. U ug/kg (12.)	12. U ug/kg (12.)	--	--
Dibromochloromethane	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
Dibromomethane	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
Dichlorodifluoromethane	12. U ug/kg (12.)	12. U ug/kg (12.)	--	--
Ethylbenzene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
Hexachlorobutadiene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
Isopropylbenzene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
m-Xylene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
Methylene chloride	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
n-Butylbenzene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
n-Propylbenzene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
Naphthalene	200. U ug/kg (200.)	12. U ug/kg (12.)	--	--
o-Xylene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
p-Isopropyltoluene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
p-Xylene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
sec-Butylbenzene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
Styrene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
tert-Butylbenzene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
Tetrachloroethene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
Toluene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--

Sample Identifier Sample Collect Date Analyte	01B26101 4/28/1999	01B26101D 4/28/1999	01B26101DRE 4/27/1999	01B26101RE 4/27/1999
Trichloroethene	6. U ug/kg (6.)	6.1 U ug/kg (6.1)	--	--
Trichlorofluoromethane	12. U ug/kg (12.)	12. U ug/kg (12.)	--	--
Vinyl acetate	12. U ug/kg (12.)	12. U ug/kg (12.)	--	--
Vinyl chloride	12. U ug/kg (12.)	12. U ug/kg (12.)	--	--

Sample Identifier	01B26201	01B26201RE	01B26301	01B26301RE
Sample Collect Date	4/28/1999	4/27/1999	4/28/1999	4/27/1999
Analyte				
Metals				
Arsenic	--	11. mg/kg (1.3)	--	14. mg/kg (1.1)
Barium	8.7 mg/kg (1.)	--	12. mg/kg (1.)	--
Cadmium	0.63 U mg/kg (0.63)	--	0.55 U mg/kg (0.55)	--
Chromium	3.4 mg/kg (1.)	--	4.2 mg/kg (1.)	--
Lead	17. mg/kg (6.)	--	38. mg/kg (6.)	--
Mercury	0.32 U mg/kg (0.32)	--	0.27 U mg/kg (0.27)	--
Selenium	6.3 U mg/kg (6.3)	--	5.5 U mg/kg (5.5)	--
Silver	2.5 U mg/kg (2.5)	--	2.2 U mg/kg (2.2)	--
Petroleum Hydrocarbons				
Total Petroleum Hydrocarbons (C8-C40)	39000. ug/kg (5100.)	--	1200000. ug/kg (22000.)	--
Semivolatile Organic Compounds				
1,2,4-Trichlorobenzene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
1,2-Dichlorobenzene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
1,3-Dichlorobenzene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
1,4-Dichlorobenzene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
Acenaphthene	210. U ug/kg (210.)	--	1800. U ug/kg (1800.)	--
Acenaphthylene	210. U ug/kg (210.)	--	1800. U ug/kg (1800.)	--
Anthracene	210. U ug/kg (210.)	--	1800. U ug/kg (1800.)	--
Benzo(a)anthracene	410. ug/kg (210.)	--	1800. U ug/kg (1800.)	--
Benzo(a)pyrene	370. ug/kg (210.)	--	1800. U ug/kg (1800.)	--
Benzo(b)fluoranthene	490. ug/kg (210.)	--	1800. U ug/kg (1800.)	--
Benzo(g,h,i)perylene	210. U ug/kg (210.)	--	1800. U ug/kg (1800.)	--
Benzo(k)fluoranthene	360. ug/kg (210.)	--	1800. U ug/kg (1800.)	--
Chrysene	590. ug/kg (210.)	--	1800. U ug/kg (1800.)	--
Dibenzo(a,h)anthracene	210. U ug/kg (210.)	--	1800. U ug/kg (1800.)	--
Fluoranthene	520. ug/kg (210.)	--	1800. U ug/kg (1800.)	--
Fluorene	210. U ug/kg (210.)	--	1800. U ug/kg (1800.)	--
Hexachlorobutadiene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--

Sample Identifier Sample Collect Date Analyte	01B26201 4/28/1999	01B26201RE 4/27/1999	01B26301 4/28/1999	01B26301RE 4/27/1999
Indeno(1,2,3-cd)pyrene	210. U ug/kg (210.)	--	1800. U ug/kg (1800.)	--
Naphthalene	210. U ug/kg (210.)	--	12. U ug/kg (12.)	--
Phenanthrene	210. U ug/kg (210.)	--	1800. U ug/kg (1800.)	--
Pyrene	590. ug/kg (210.)	--	1800. U ug/kg (1800.)	--

Volatile Organic Compounds

1,1,1,2-Tetrachloroethane	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
1,1,1-Trichloroethane	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
1,1,2,2-Tetrachloroethane	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
1,1,2-Trichloroethane	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
1,1-Dichloroethane	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
1,1-Dichloroethene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
1,1-Dichloropropene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
1,2,3-Trichlorobenzene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
1,2,3-Trichloropropane	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
1,2,4-Trichlorobenzene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
1,2,4-Trimethylbenzene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
1,2-Dibromo-3-chloropropane	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
1,2-Dichlorobenzene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
1,2-Dichloroethane	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
1,2-Dichloropropane	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
1,3,5-Trimethylbenzene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
1,3-Dichlorobenzene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
1,3-Dichloropropane	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
1,4-Dichlorobenzene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
2,2-Dichloropropane	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
2-Butanone	190. U ug/kg (190.)	--	120. U ug/kg (120.)	--
2-Chlorotoluene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
2-Hexanone	19. U ug/kg (19.)	--	12. U ug/kg (12.)	--
4-Chlorotoluene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
4-Methyl-2-pentanone	19. U ug/kg (19.)	--	12. U ug/kg (12.)	--
Acetone	190. U ug/kg (190.)	--	120. U ug/kg (120.)	--

Sample Identifier Sample Collect Date Analyte	01B26201 4/28/1999	01B26201RE 4/27/1999	01B26301 4/28/1999	01B26301RE 4/27/1999
Benzene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
Bromobenzene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
Bromochloromethane	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
Bromodichloromethane	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
Bromoform	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
Bromomethane	19. U ug/kg (19.)	--	12. U ug/kg (12.)	--
Carbon disulfide	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
Carbon tetrachloride	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
Chlorobenzene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
Chloroethane	19. U ug/kg (19.)	--	12. U ug/kg (12.)	--
Chloroform	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
Chloromethane	19. U ug/kg (19.)	--	12. U ug/kg (12.)	--
Dibromochloromethane	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
Dibromomethane	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
Dichlorodifluoromethane	19. U ug/kg (19.)	--	12. U ug/kg (12.)	--
Ethylbenzene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
Hexachlorobutadiene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
Isopropylbenzene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
m-Xylene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
Methylene chloride	10. ug/kg (10.)	--	6. U ug/kg (6.)	--
n-Butylbenzene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
n-Propylbenzene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
Naphthalene	210. U ug/kg (210.)	--	12. U ug/kg (12.)	--
o-Xylene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
p-Isopropyltoluene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
p-Xylene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
sec-Butylbenzene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
Styrene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
tert-Butylbenzene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
Tetrachloroethene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
Toluene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--

Sample Identifier Sample Collect Date Analyte	01B26201 4/28/1999	01B26201RE 4/27/1999	01B26301 4/28/1999	01B26301RE 4/27/1999
Trichloroethene	9.5 U ug/kg (9.5)	--	6. U ug/kg (6.)	--
Trichlorofluoromethane	19. U ug/kg (19.)	--	12. U ug/kg (12.)	--
Vinyl acetate	19. U ug/kg (19.)	--	12. U ug/kg (12.)	--
Vinyl chloride	19. U ug/kg (19.)	--	12. U ug/kg (12.)	--

Sample Identifier	01B26401	01B26401RE	01B26501	01B26501RE
Sample Collect Date	4/28/1999	4/27/1999	4/28/1999	4/27/1999
Analyte				
Metals				
Arsenic	--	14. mg/kg (1.1)	--	46. mg/kg (1.1)
Barium	16. mg/kg (1.)	--	17. mg/kg (1.)	--
Cadmium	0.71 mg/kg (1.)	--	0.54 U mg/kg (0.54)	--
Chromium	12. mg/kg (1.)	--	5.8 mg/kg (1.)	--
Lead	89. mg/kg (5.)	--	74. mg/kg (5.)	--
Mercury	0.27 U mg/kg (0.27)	--	0.27 U mg/kg (0.27)	--
Selenium	5.4 U mg/kg (5.4)	--	5.4 U mg/kg (5.4)	--
Silver	2.2 U mg/kg (2.2)	--	2.2 U mg/kg (2.2)	--
Petroleum Hydrocarbons				
Total Petroleum Hydrocarbons (C8-C40)	380000. ug/kg (8600.)	--	160000. ug/kg (4300.)	--
Semivolatile Organic Compounds				
1,2,4-Trichlorobenzene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
1,2-Dichlorobenzene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
1,3-Dichlorobenzene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
1,4-Dichlorobenzene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
Acenaphthene	180. U ug/kg (180.)	--	890. U ug/kg (890.)	--
Acenaphthylene	180. U ug/kg (180.)	--	890. U ug/kg (890.)	--
Anthracene	180. U ug/kg (180.)	--	890. U ug/kg (890.)	--
Benzo(a)anthracene	230. UJ ug/kg (230.)	--	890. U ug/kg (890.)	--
Benzo(a)pyrene	180. U ug/kg (180.)	--	890. U ug/kg (890.)	--
Benzo(b)fluoranthene	350. UJ ug/kg (350.)	--	890. U ug/kg (890.)	--
Benzo(g,h,i)perylene	180. U ug/kg (180.)	--	890. U ug/kg (890.)	--
Benzo(k)fluoranthene	180. U ug/kg (180.)	--	890. U ug/kg (890.)	--
Chrysene	310. UJ ug/kg (310.)	--	890. U ug/kg (890.)	--
Dibenzo(a,h)anthracene	180. U ug/kg (180.)	--	890. U ug/kg (890.)	--
Fluoranthene	340. ug/kg (180.)	--	6200. ug/kg (890.)	--
Fluorene	180. U ug/kg (180.)	--	890. U ug/kg (890.)	--
Hexachlorobutadiene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--

Sample Identifier Sample Collect Date Analyte	01B26401 4/28/1999	01B26401RE 4/27/1999	01B26501 4/28/1999	01B26501RE 4/27/1999
Indeno(1,2,3-cd)pyrene	180. U ug/kg (180.)	--	890. U ug/kg (890.)	--
Naphthalene	180. U ug/kg (180.)	--	890. U ug/kg (890.)	--
Phenanthrene	180. U ug/kg (180.)	--	890. U ug/kg (890.)	--
Pyrene	730. UJ ug/kg (730.)	--	6100. ug/kg (890.)	--
Volatile Organic Compounds				
1,1,1,2-Tetrachloroethane	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
1,1,1-Trichloroethane	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
1,1,2,2-Tetrachloroethane	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
1,1,2-Trichloroethane	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
1,1-Dichloroethane	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
1,1-Dichloroethene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
1,1-Dichloropropene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
1,2,3-Trichlorobenzene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
1,2,3-Trichloropropane	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
1,2,4-Trichlorobenzene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
1,2,4-Trimethylbenzene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
1,2-Dibromo-3-chloropropane	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
1,2-Dichlorobenzene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
1,2-Dichloroethane	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
1,2-Dichloropropane	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
1,3,5-Trimethylbenzene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
1,3-Dichlorobenzene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
1,3-Dichloropropane	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
1,4-Dichlorobenzene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
2,2-Dichloropropane	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
2-Butanone	130. U ug/kg (130.)	--	130. U ug/kg (130.)	--
2-Chlorotoluene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
2-Hexanone	13. U ug/kg (13.)	--	13. U ug/kg (13.)	--
4-Chlorotoluene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
4-Methyl-2-pentanone	13. U ug/kg (13.)	--	13. U ug/kg (13.)	--
Acetone	130. U ug/kg (130.)	--	130. U ug/kg (130.)	--

Sample Identifier Sample Collect Date Analyte	01B26401 4/28/1999	01B26401RE 4/27/1999	01B26501 4/28/1999	01B26501RE 4/27/1999
Benzene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
Bromobenzene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
Bromochloromethane	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
Bromodichloromethane	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
Bromoform	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
Bromomethane	13. U ug/kg (13.)	--	13. U ug/kg (13.)	--
Carbon disulfide	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
Carbon tetrachloride	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
Chlorobenzene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
Chloroethane	13. U ug/kg (13.)	--	13. U ug/kg (13.)	--
Chloroform	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
Chloromethane	13. U ug/kg (13.)	--	13. U ug/kg (13.)	--
Dibromochloromethane	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
Dibromomethane	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
Dichlorodifluoromethane	13. U ug/kg (13.)	--	13. U ug/kg (13.)	--
Ethylbenzene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
Hexachlorobutadiene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
Isopropylbenzene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
m-Xylene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
Methylene chloride	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
n-Butylbenzene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
n-Propylbenzene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
Naphthalene	180. U ug/kg (180.)	--	890. U ug/kg (890.)	--
o-Xylene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
p-Isopropyltoluene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
p-Xylene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
sec-Butylbenzene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
Styrene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
tert-Butylbenzene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
Tetrachloroethene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
Toluene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--

Sample Identifier Sample Collect Date Analyte	01B26401 4/28/1999	01B26401RE 4/27/1999	01B26501 4/28/1999	01B26501RE 4/27/1999
Trichloroethene	6.5 U ug/kg (6.5)	--	6.5 U ug/kg (6.5)	--
Trichlorofluoromethane	13. U ug/kg (13.)	--	13. U ug/kg (13.)	--
Vinyl acetate	13. U ug/kg (13.)	--	13. U ug/kg (13.)	--
Vinyl chloride	13. U ug/kg (13.)	--	13. U ug/kg (13.)	--

Sample Identifier	01B26601	01B26601RE	01B26701	01B26701D
Sample Collect Date	4/28/1999	4/27/1999	4/28/1999	4/28/1999
Analyte				
Metals				
Arsenic	--	30. mg/kg (1.1)	--	--
Barium	20. mg/kg (1.)	--	18. mg/kg (1.)	14. mg/kg (1.)
Cadmium	0.55 U mg/kg (0.55)	--	0.56 U mg/kg (0.56)	0.57 U mg/kg (0.57)
Chromium	4.8 mg/kg (1.)	--	3.8 mg/kg (1.)	3.9 mg/kg (1.)
Lead	64. mg/kg (6.)	--	40. mg/kg (6.)	27. mg/kg (6.)
Mercury	0.27 U mg/kg (0.27)	--	0.28 U mg/kg (0.28)	0.28 U mg/kg (0.28)
Selenium	5.5 U mg/kg (5.5)	--	5.6 U mg/kg (5.6)	5.7 U mg/kg (5.7)
Silver	2.2 U mg/kg (2.2)	--	2.2 U mg/kg (2.2)	2.3 U mg/kg (2.3)
Petroleum Hydrocarbons				
Total Petroleum Hydrocarbons (C8-C40)	57000. ug/kg (4400.)	--	13000. ug/kg (4500.)	4500. U ug/kg (4500.)
Semivolatile Organic Compounds				
1,2,4-Trichlorobenzene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
1,2-Dichlorobenzene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
1,3-Dichlorobenzene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
1,4-Dichlorobenzene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
Acenaphthene	180. U ug/kg (180.)	--	190. U ug/kg (190.)	190. U ug/kg (190.)
Acenaphthylene	180. U ug/kg (180.)	--	190. U ug/kg (190.)	190. U ug/kg (190.)
Anthracene	180. U ug/kg (180.)	--	190. U ug/kg (190.)	190. U ug/kg (190.)
Benzo(a)anthracene	550. ug/kg (180.)	--	190. U ug/kg (190.)	190. U ug/kg (190.)
Benzo(a)pyrene	550. ug/kg (180.)	--	190. U ug/kg (190.)	190. U ug/kg (190.)
Benzo(b)fluoranthene	610. ug/kg (180.)	--	190. U ug/kg (190.)	190. U ug/kg (190.)
Benzo(g,h,i)perylene	240. ug/kg (180.)	--	190. U ug/kg (190.)	190. U ug/kg (190.)
Benzo(k)fluoranthene	500. ug/kg (180.)	--	190. U ug/kg (190.)	190. U ug/kg (190.)
Chrysene	570. ug/kg (180.)	--	190. U ug/kg (190.)	190. U ug/kg (190.)
Dibenzo(a,h)anthracene	180. U ug/kg (180.)	--	190. U ug/kg (190.)	190. U ug/kg (190.)
Fluoranthene	640. ug/kg (180.)	--	190. U ug/kg (190.)	190. U ug/kg (190.)
Fluorene	180. U ug/kg (180.)	--	190. U ug/kg (190.)	190. U ug/kg (190.)
Hexachlorobutadiene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)

Sample Identifier	01B26601	01B26601RE	01B26701	01B26701D
Sample Collect Date	4/28/1999	4/27/1999	4/28/1999	4/28/1999
Analyte				
Indeno(1,2,3-cd)pyrene	190. ug/kg (180.)	--	190. U ug/kg (190.)	190. U ug/kg (190.)
Naphthalene	15. U ug/kg (15.)	--	190. U ug/kg (190.)	190. U ug/kg (190.)
Phenanthrene	280. ug/kg (180.)	--	190. U ug/kg (190.)	190. U ug/kg (190.)
Pyrene	690. ug/kg (180.)	--	190. U ug/kg (190.)	190. U ug/kg (190.)

Volatile Organic Compounds

1,1,1,2-Tetrachloroethane	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
1,1,1-Trichloroethane	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
1,1,2,2-Tetrachloroethane	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
1,1,2-Trichloroethane	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
1,1-Dichloroethane	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
1,1-Dichloroethene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
1,1-Dichloropropene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
1,2,3-Trichlorobenzene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
1,2,3-Trichloropropane	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
1,2,4-Trichlorobenzene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
1,2,4-Trimethylbenzene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
1,2-Dibromo-3-chloropropane	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
1,2-Dichlorobenzene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
1,2-Dichloroethane	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
1,2-Dichloropropane	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
1,3,5-Trimethylbenzene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
1,3-Dichlorobenzene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
1,3-Dichloropropane	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
1,4-Dichlorobenzene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
2,2-Dichloropropane	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
2-Butanone	150. U ug/kg (150.)	--	120. U ug/kg (120.)	130. U ug/kg (130.)
2-Chlorotoluene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
2-Hexanone	15. U ug/kg (15.)	--	12. U ug/kg (12.)	13. U ug/kg (13.)
4-Chlorotoluene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
4-Methyl-2-pentanone	15. U ug/kg (15.)	--	12. U ug/kg (12.)	13. U ug/kg (13.)
Acetone	150. U ug/kg (150.)	--	120. U ug/kg (120.)	130. U ug/kg (130.)

Sample Identifier Sample Collect Date Analyte	01B26601 4/28/1999	01B26601RE 4/27/1999	01B26701 4/28/1999	01B26701D 4/28/1999
Benzene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
Bromobenzene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
Bromochloromethane	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
Bromodichloromethane	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
Bromoform	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
Bromomethane	15. U ug/kg (15.)	--	12. U ug/kg (12.)	13. U ug/kg (13.)
Carbon disulfide	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
Carbon tetrachloride	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
Chlorobenzene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
Chloroethane	15. U ug/kg (15.)	--	12. U ug/kg (12.)	13. U ug/kg (13.)
Chloroform	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
Chloromethane	15. U ug/kg (15.)	--	12. U ug/kg (12.)	13. U ug/kg (13.)
Dibromochloromethane	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
Dibromomethane	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
Dichlorodifluoromethane	15. U ug/kg (15.)	--	12. U ug/kg (12.)	13. U ug/kg (13.)
Ethylbenzene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
Hexachlorobutadiene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
Isopropylbenzene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
m-Xylene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
Methylene chloride	7.7 U ug/kg (7.7)	--	6.3 ug/kg (6.)	6.3 U ug/kg (6.3)
n-Butylbenzene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
n-Propylbenzene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
Naphthalene	15. U ug/kg (15.)	--	190. U ug/kg (190.)	190. U ug/kg (190.)
o-Xylene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
p-Isopropyltoluene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
p-Xylene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
sec-Butylbenzene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
Styrene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
tert-Butylbenzene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
Tetrachloroethene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
Toluene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)

Sample Identifier Sample Collect Date Analyte	01B26601 4/28/1999	01B26601RE 4/27/1999	01B26701 4/28/1999	01B26701D 4/28/1999
Trichloroethene	7.7 U ug/kg (7.7)	--	6.2 U ug/kg (6.2)	6.3 U ug/kg (6.3)
Trichlorofluoromethane	15. U ug/kg (15.)	--	12. U ug/kg (12.)	13. U ug/kg (13.)
Vinyl acetate	15. U ug/kg (15.)	--	12. U ug/kg (12.)	13. U ug/kg (13.)
Vinyl chloride	15. U ug/kg (15.)	--	12. U ug/kg (12.)	13. U ug/kg (13.)

Sample Identifier	01B26701DRE	01B26701RE	01B26801	01B26801RE
Sample Collect Date	4/27/1999	4/27/1999	4/28/1999	4/27/1999
Analyte				
Metals				
Arsenic	5. mg/kg (1.1)	6. mg/kg (1.1)	--	5.1 mg/kg (1.1)
Barium	--	--	14. mg/kg (1.)	--
Cadmium	--	--	0.56 U mg/kg (0.56)	--
Chromium	--	--	3.7 mg/kg (1.)	--
Lead	--	--	44. mg/kg (6.)	--
Mercury	--	--	0.28 U mg/kg (0.28)	--
Selenium	--	--	5.6 U mg/kg (5.6)	--
Silver	--	--	2.2 U mg/kg (2.2)	--
Petroleum Hydrocarbons				
Total Petroleum Hydrocarbons (C8-C40)	--	--	12000. ug/kg (4500.)	--
Semivolatile Organic Compounds				
1,2,4-Trichlorobenzene	--	--	6.7 U ug/kg (6.7)	--
1,2-Dichlorobenzene	--	--	6.7 U ug/kg (6.7)	--
1,3-Dichlorobenzene	--	--	6.7 U ug/kg (6.7)	--
1,4-Dichlorobenzene	--	--	6.7 U ug/kg (6.7)	--
Acenaphthene	--	--	190. U ug/kg (190.)	--
Acenaphthylene	--	--	190. U ug/kg (190.)	--
Anthracene	--	--	190. U ug/kg (190.)	--
Benzo(a)anthracene	--	--	190. U ug/kg (190.)	--
Benzo(a)pyrene	--	--	190. U ug/kg (190.)	--
Benzo(b)fluoranthene	--	--	190. U ug/kg (190.)	--
Benzo(g,h,i)perylene	--	--	190. U ug/kg (190.)	--
Benzo(k)fluoranthene	--	--	190. U ug/kg (190.)	--
Chrysene	--	--	190. U ug/kg (190.)	--
Dibenzo(a,h)anthracene	--	--	190. U ug/kg (190.)	--
Fluoranthene	--	--	200. ug/kg (190.)	--
Fluorene	--	--	190. U ug/kg (190.)	--
Hexachlorobutadiene	--	--	6.7 U ug/kg (6.7)	--

Sample Identifier Sample Collect Date Analyte	01B26701DRE 4/27/1999	01B26701RE 4/27/1999	01B26801 4/28/1999	01B26801RE 4/27/1999
Indeno(1,2,3-cd)pyrene	--	--	190. U ug/kg (190.)	--
Naphthalene	--	--	13. U ug/kg (13.)	--
Phenanthrene	--	--	190. U ug/kg (190.)	--
Pyrene	--	--	190. U ug/kg (190.)	--
Volatile Organic Compounds				
1,1,1,2-Tetrachloroethane	--	--	6.7 U ug/kg (6.7)	--
1,1,1-Trichloroethane	--	--	6.7 U ug/kg (6.7)	--
1,1,2,2-Tetrachloroethane	--	--	6.7 U ug/kg (6.7)	--
1,1,2-Trichloroethane	--	--	6.7 U ug/kg (6.7)	--
1,1-Dichloroethane	--	--	6.7 U ug/kg (6.7)	--
1,1-Dichloroethene	--	--	6.7 U ug/kg (6.7)	--
1,1-Dichloropropene	--	--	6.7 U ug/kg (6.7)	--
1,2,3-Trichlorobenzene	--	--	6.7 U ug/kg (6.7)	--
1,2,3-Trichloropropane	--	--	6.7 U ug/kg (6.7)	--
1,2,4-Trichlorobenzene	--	--	6.7 U ug/kg (6.7)	--
1,2,4-Trimethylbenzene	--	--	6.7 U ug/kg (6.7)	--
1,2-Dibromo-3-chloropropane	--	--	6.7 U ug/kg (6.7)	--
1,2-Dichlorobenzene	--	--	6.7 U ug/kg (6.7)	--
1,2-Dichloroethane	--	--	6.7 U ug/kg (6.7)	--
1,2-Dichloropropane	--	--	6.7 U ug/kg (6.7)	--
1,3,5-Trimethylbenzene	--	--	6.7 U ug/kg (6.7)	--
1,3-Dichlorobenzene	--	--	6.7 U ug/kg (6.7)	--
1,3-Dichloropropane	--	--	6.7 U ug/kg (6.7)	--
1,4-Dichlorobenzene	--	--	6.7 U ug/kg (6.7)	--
2,2-Dichloropropane	--	--	6.7 U ug/kg (6.7)	--
2-Butanone	--	--	130. U ug/kg (130.)	--
2-Chlorotoluene	--	--	6.7 U ug/kg (6.7)	--
2-Hexanone	--	--	13. U ug/kg (13.)	--
4-Chlorotoluene	--	--	6.7 U ug/kg (6.7)	--
4-Methyl-2-pentanone	--	--	13. U ug/kg (13.)	--
Acetone	--	--	130. U ug/kg (130.)	--

Sample Identifier Sample Collect Date Analyte	01B26701DRE 4/27/1999	01B26701RE 4/27/1999	01B26801 4/28/1999	01B26801RE 4/27/1999
Benzene	--	--	6.7 U ug/kg (6.7)	--
Bromobenzene	--	--	6.7 U ug/kg (6.7)	--
Bromochloromethane	--	--	6.7 U ug/kg (6.7)	--
Bromodichloromethane	--	--	6.7 U ug/kg (6.7)	--
Bromoform	--	--	6.7 U ug/kg (6.7)	--
Bromomethane	--	--	13. U ug/kg (13.)	--
Carbon disulfide	--	--	6.7 U ug/kg (6.7)	--
Carbon tetrachloride	--	--	6.7 U ug/kg (6.7)	--
Chlorobenzene	--	--	6.7 U ug/kg (6.7)	--
Chloroethane	--	--	13. U ug/kg (13.)	--
Chloroform	--	--	6.7 U ug/kg (6.7)	--
Chloromethane	--	--	13. U ug/kg (13.)	--
Dibromochloromethane	--	--	6.7 U ug/kg (6.7)	--
Dibromomethane	--	--	6.7 U ug/kg (6.7)	--
Dichlorodifluoromethane	--	--	13. U ug/kg (13.)	--
Ethylbenzene	--	--	6.7 U ug/kg (6.7)	--
Hexachlorobutadiene	--	--	6.7 U ug/kg (6.7)	--
Isopropylbenzene	--	--	6.7 U ug/kg (6.7)	--
m-Xylene	--	--	6.7 U ug/kg (6.7)	--
Methylene chloride	--	--	6.7 U ug/kg (6.7)	--
n-Butylbenzene	--	--	6.7 U ug/kg (6.7)	--
n-Propylbenzene	--	--	6.7 U ug/kg (6.7)	--
Naphthalene	--	--	13. U ug/kg (13.)	--
o-Xylene	--	--	6.7 U ug/kg (6.7)	--
p-Isopropyltoluene	--	--	6.7 U ug/kg (6.7)	--
p-Xylene	--	--	6.7 U ug/kg (6.7)	--
sec-Butylbenzene	--	--	6.7 U ug/kg (6.7)	--
Styrene	--	--	6.7 U ug/kg (6.7)	--
tert-Butylbenzene	--	--	6.7 U ug/kg (6.7)	--
Tetrachloroethene	--	--	6.7 U ug/kg (6.7)	--
Toluene	--	--	6.7 U ug/kg (6.7)	--

Sample Identifier Sample Collect Date Analyte	01B26701DRE 4/27/1999	01B26701RE 4/27/1999	01B26801 4/28/1999	01B26801RE 4/27/1999
Trichloroethene	--	--	6.7 U ug/kg (6.7)	--
Trichlorofluoromethane	--	--	13. U ug/kg (13.)	--
Vinyl acetate	--	--	13. U ug/kg (13.)	--
Vinyl chloride	--	--	13. U ug/kg (13.)	--

Sample Identifier	01B26901	01B26901RE	01B27001	01B27101
Sample Collect Date	4/28/1999	4/27/1999	4/27/1999	4/27/1999
Analyte				
Metals				
Arsenic	--	20. mg/kg (1.1)	--	--
Barium	30. mg/kg (1.)	--	--	--
Cadmium	0.56 U mg/kg (0.56)	--	--	--
Chromium	4.4 mg/kg (1.)	--	--	--
Lead	83. mg/kg (6.)	--	--	--
Mercury	0.28 U mg/kg (0.28)	--	--	--
Selenium	5.6 U mg/kg (5.6)	--	--	--
Silver	2.2 U mg/kg (2.2)	--	--	--
Petroleum Hydrocarbons				
Total Petroleum Hydrocarbons (C8-C40)	55000. ug/kg (4400.)	--	120000. ug/kg (4600.)	350000. ug/kg (4300.)
Semivolatile Organic Compounds				
1,2,4-Trichlorobenzene	6.7 U ug/kg (6.7)	--	--	--
1,2-Dichlorobenzene	6.7 U ug/kg (6.7)	--	--	--
1,3-Dichlorobenzene	6.7 U ug/kg (6.7)	--	--	--
1,4-Dichlorobenzene	6.7 U ug/kg (6.7)	--	--	--
Acenaphthene	180. U ug/kg (180.)	--	380. U ug/kg (380.)	350. U ug/kg (350.)
Acenaphthylene	180. U ug/kg (180.)	--	380. U ug/kg (380.)	350. U ug/kg (350.)
Anthracene	180. U ug/kg (180.)	--	380. U ug/kg (380.)	350. U ug/kg (350.)
Benzo(a)anthracene	180. U ug/kg (180.)	--	380. U ug/kg (380.)	350. U ug/kg (350.)
Benzo(a)pyrene	180. U ug/kg (180.)	--	380. U ug/kg (380.)	350. U ug/kg (350.)
Benzo(b)fluoranthene	180. U ug/kg (180.)	--	380. U ug/kg (380.)	350. U ug/kg (350.)
Benzo(g,h,i)perylene	180. U ug/kg (180.)	--	380. U ug/kg (380.)	350. U ug/kg (350.)
Benzo(k)fluoranthene	180. U ug/kg (180.)	--	380. U ug/kg (380.)	350. U ug/kg (350.)
Chrysene	180. U ug/kg (180.)	--	380. U ug/kg (380.)	350. U ug/kg (350.)
Dibenzo(a,h)anthracene	180. U ug/kg (180.)	--	380. U ug/kg (380.)	350. U ug/kg (350.)
Fluoranthene	180. U ug/kg (180.)	--	380. U ug/kg (380.)	350. U ug/kg (350.)
Fluorene	180. U ug/kg (180.)	--	380. U ug/kg (380.)	350. U ug/kg (350.)
Hexachlorobutadiene	6.7 U ug/kg (6.7)	--	--	--

Sample Identifier Sample Collect Date Analyte	01B26901 4/28/1999	01B26901RE 4/27/1999	01B27001 4/27/1999	01B27101 4/27/1999
Indeno(1,2,3-cd)pyrene	180. U ug/kg (180.)	--	380. U ug/kg (380.)	350. U ug/kg (350.)
Naphthalene	13. U ug/kg (13.)	--	380. U ug/kg (380.)	350. ug/kg (350.)
Phenanthrene	180. U ug/kg (180.)	--	380. U ug/kg (380.)	520. ug/kg (350.)
Pyrene	180. U ug/kg (180.)	--	440. UJ ug/kg (440.)	1400. UJ ug/kg (1400.)
Volatile Organic Compounds				
1,1,1,2-Tetrachloroethane	6.7 U ug/kg (6.7)	--	--	--
1,1,1-Trichloroethane	6.7 U ug/kg (6.7)	--	--	--
1,1,2,2-Tetrachloroethane	6.7 U ug/kg (6.7)	--	--	--
1,1,2-Trichloroethane	6.7 U ug/kg (6.7)	--	--	--
1,1-Dichloroethane	6.7 U ug/kg (6.7)	--	--	--
1,1-Dichloroethene	6.7 U ug/kg (6.7)	--	--	--
1,1-Dichloropropene	6.7 U ug/kg (6.7)	--	--	--
1,2,3-Trichlorobenzene	6.7 U ug/kg (6.7)	--	--	--
1,2,3-Trichloropropane	6.7 U ug/kg (6.7)	--	--	--
1,2,4-Trichlorobenzene	6.7 U ug/kg (6.7)	--	--	--
1,2,4-Trimethylbenzene	6.7 U ug/kg (6.7)	--	--	--
1,2-Dibromo-3-chloropropane	6.7 U ug/kg (6.7)	--	--	--
1,2-Dichlorobenzene	6.7 U ug/kg (6.7)	--	--	--
1,2-Dichloroethane	6.7 U ug/kg (6.7)	--	--	--
1,2-Dichloropropane	6.7 U ug/kg (6.7)	--	--	--
1,3,5-Trimethylbenzene	6.7 U ug/kg (6.7)	--	--	--
1,3-Dichlorobenzene	6.7 U ug/kg (6.7)	--	--	--
1,3-Dichloropropane	6.7 U ug/kg (6.7)	--	--	--
1,4-Dichlorobenzene	6.7 U ug/kg (6.7)	--	--	--
2,2-Dichloropropane	6.7 U ug/kg (6.7)	--	--	--
2-Butanone	130. U ug/kg (130.)	--	--	--
2-Chlorotoluene	6.7 U ug/kg (6.7)	--	--	--
2-Hexanone	13. U ug/kg (13.)	--	--	--
4-Chlorotoluene	6.7 U ug/kg (6.7)	--	--	--
4-Methyl-2-pentanone	13. U ug/kg (13.)	--	--	--
Acetone	130. U ug/kg (130.)	--	--	--

Sample Identifier Sample Collect Date Analyte	01B26901 4/28/1999	01B26901RE 4/27/1999	01B27001 4/27/1999	01B27101 4/27/1999
Benzene	6.7 U ug/kg (6.7)	--	5.7 U ug/kg (5.7)	5.3 U ug/kg (5.3)
Bromobenzene	6.7 U ug/kg (6.7)	--	--	--
Bromochloromethane	6.7 U ug/kg (6.7)	--	--	--
Bromodichloromethane	6.7 U ug/kg (6.7)	--	--	--
Bromoform	6.7 U ug/kg (6.7)	--	--	--
Bromomethane	13. U ug/kg (13.)	--	--	--
Carbon disulfide	6.7 U ug/kg (6.7)	--	--	--
Carbon tetrachloride	6.7 U ug/kg (6.7)	--	--	--
Chlorobenzene	6.7 U ug/kg (6.7)	--	--	--
Chloroethane	13. U ug/kg (13.)	--	--	--
Chloroform	6.7 U ug/kg (6.7)	--	--	--
Chloromethane	13. U ug/kg (13.)	--	--	--
Dibromochloromethane	6.7 U ug/kg (6.7)	--	--	--
Dibromomethane	6.7 U ug/kg (6.7)	--	--	--
Dichlorodifluoromethane	13. U ug/kg (13.)	--	--	--
Ethylbenzene	6.7 U ug/kg (6.7)	--	5.7 U ug/kg (5.7)	5.3 U ug/kg (5.3)
Hexachlorobutadiene	6.7 U ug/kg (6.7)	--	--	--
Isopropylbenzene	6.7 U ug/kg (6.7)	--	--	--
m-Xylene	6.7 U ug/kg (6.7)	--	--	--
Methyl tert-butyl ether (MTBE)	--	--	5.7 U ug/kg (5.7)	5.3 U ug/kg (5.3)
Methylene chloride	6.7 U ug/kg (6.7)	--	--	--
n-Butylbenzene	6.7 U ug/kg (6.7)	--	--	--
n-Propylbenzene	6.7 U ug/kg (6.7)	--	--	--
Naphthalene	13. U ug/kg (13.)	--	380. U ug/kg (380.)	350. ug/kg (350.)
o-Xylene	6.7 U ug/kg (6.7)	--	--	--
p-Isopropyltoluene	6.7 U ug/kg (6.7)	--	--	--
p-Xylene	6.7 U ug/kg (6.7)	--	--	--
sec-Butylbenzene	6.7 U ug/kg (6.7)	--	--	--
Styrene	6.7 U ug/kg (6.7)	--	--	--
tert-Butylbenzene	6.7 U ug/kg (6.7)	--	--	--
Tetrachloroethene	6.7 U ug/kg (6.7)	--	--	--

Sample Identifier Sample Collect Date Analyte	01B26901 4/28/1999	01B26901RE 4/27/1999	01B27001 4/27/1999	01B27101 4/27/1999
Toluene	6.7 U ug/kg (6.7)	--	5.7 U ug/kg (5.7)	5.3 U ug/kg (5.3)
Trichloroethene	6.7 U ug/kg (6.7)	--	--	--
Trichlorofluoromethane	13. U ug/kg (13.)	--	--	--
Vinyl acetate	13. U ug/kg (13.)	--	--	--
Vinyl chloride	13. U ug/kg (13.)	--	--	--
Xylenes (total)	--	--	5.7 U ug/kg (5.7)	5.3 U ug/kg (5.3)

Sample Identifier	01B27201	01B27301	01B27401	01B27501
Sample Collect Date	4/27/1999	4/27/1999	4/27/1999	4/27/1999
Analyte				
Petroleum Hydrocarbons				
Total Petroleum Hydrocarbons (C8-C40)	46000. ug/kg (5400.)	240000. ug/kg (4300.)	300000. ug/kg (4300.)	310000. ug/kg (4300.)
Semivolatile Organic Compounds				
Acenaphthene	220. U ug/kg (220.)	1800. U ug/kg (1800.)	1400. U ug/kg (1400.)	2800. U ug/kg (2800.)
Acenaphthylene	220. U ug/kg (220.)	1800. U ug/kg (1800.)	1400. U ug/kg (1400.)	2800. U ug/kg (2800.)
Anthracene	220. U ug/kg (220.)	1800. U ug/kg (1800.)	1400. U ug/kg (1400.)	2800. U ug/kg (2800.)
Benzo(a)anthracene	220. U ug/kg (220.)	1800. U ug/kg (1800.)	1400. U ug/kg (1400.)	2800. U ug/kg (2800.)
Benzo(a)pyrene	220. U ug/kg (220.)	1800. U ug/kg (1800.)	1400. U ug/kg (1400.)	2800. U ug/kg (2800.)
Benzo(b)fluoranthene	220. U ug/kg (220.)	1800. U ug/kg (1800.)	1400. U ug/kg (1400.)	2800. U ug/kg (2800.)
Benzo(g,h,i)perylene	220. U ug/kg (220.)	1800. U ug/kg (1800.)	1400. U ug/kg (1400.)	2800. U ug/kg (2800.)
Benzo(k)fluoranthene	220. U ug/kg (220.)	1800. U ug/kg (1800.)	1400. U ug/kg (1400.)	2800. U ug/kg (2800.)
Chrysene	220. U ug/kg (220.)	1800. U ug/kg (1800.)	1400. U ug/kg (1400.)	2800. U ug/kg (2800.)
Dibenzo(a,h)anthracene	220. U ug/kg (220.)	1800. U ug/kg (1800.)	1400. U ug/kg (1400.)	2800. U ug/kg (2800.)
Fluoranthene	220. U ug/kg (220.)	1800. U ug/kg (1800.)	1400. U ug/kg (1400.)	2800. U ug/kg (2800.)
Fluorene	220. U ug/kg (220.)	1800. U ug/kg (1800.)	1400. U ug/kg (1400.)	2800. U ug/kg (2800.)
Indeno(1,2,3-cd)pyrene	220. U ug/kg (220.)	1800. U ug/kg (1800.)	1400. U ug/kg (1400.)	2800. U ug/kg (2800.)
Naphthalene	220. U ug/kg (220.)	1800. U ug/kg (1800.)	1400. U ug/kg (1400.)	2800. U ug/kg (2800.)
Phenanthrene	220. U ug/kg (220.)	1800. U ug/kg (1800.)	1400. U ug/kg (1400.)	2800. U ug/kg (2800.)
Pyrene	220. U ug/kg (220.)	1800. UJ ug/kg (1800.)	1400. U ug/kg (1400.)	2800. U ug/kg (2800.)
Volatile Organic Compounds				
Benzene	6.8 U ug/kg (6.8)	5.4 U ug/kg (5.4)	5.4 U ug/kg (5.4)	5.3 U ug/kg (5.3)
Ethylbenzene	6.8 U ug/kg (6.8)	5.4 U ug/kg (5.4)	5.4 U ug/kg (5.4)	5.3 U ug/kg (5.3)
Methyl tert-butyl ether (MTBE)	6.8 U ug/kg (6.8)	5.4 U ug/kg (5.4)	5.4 U ug/kg (5.4)	5.3 U ug/kg (5.3)
Naphthalene	220. U ug/kg (220.)	1800. U ug/kg (1800.)	1400. U ug/kg (1400.)	2800. U ug/kg (2800.)
Toluene	6.8 U ug/kg (6.8)	5.4 U ug/kg (5.4)	5.4 U ug/kg (5.4)	5.3 U ug/kg (5.3)
Xylenes (total)	6.8 U ug/kg (6.8)	5.4 U ug/kg (5.4)	5.4 U ug/kg (5.4)	5.3 U ug/kg (5.3)

Sample Identifier	01B27601	01B27601RE	01B27701	01B27701RE
Sample Collect Date	4/29/1999	4/27/1999	4/29/1999	4/27/1999
Analyte				
Metals				
Arsenic	--	2.2 mg/kg (1.)	--	3.5 mg/kg (1.1)
Barium	15. mg/kg (1.)	--	14. mg/kg (1.)	--
Cadmium	0.52 U mg/kg (0.52)	--	0.54 U mg/kg (0.54)	--
Chromium	5.3 mg/kg (1.)	--	4.3 mg/kg (1.)	--
Lead	69. mg/kg (5.)	--	30. mg/kg (5.)	--
Mercury	0.26 U mg/kg (0.26)	--	0.27 U mg/kg (0.27)	--
Selenium	5.2 U mg/kg (5.2)	--	5.4 U mg/kg (5.4)	--
Silver	2.1 U mg/kg (2.1)	--	2.2 U mg/kg (2.2)	--
Petroleum Hydrocarbons				
Total Petroleum Hydrocarbons (C8-C40)	120000. ug/kg (4200.)	--	56000. ug/kg (4300.)	--
Semivolatile Organic Compounds				
1,2,4-Trichlorobenzene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
1,2-Dichlorobenzene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
1,3-Dichlorobenzene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
1,4-Dichlorobenzene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
Acenaphthene	690. U ug/kg (690.)	--	900. U ug/kg (900.)	--
Acenaphthylene	690. U ug/kg (690.)	--	900. U ug/kg (900.)	--
Anthracene	690. U ug/kg (690.)	--	900. U ug/kg (900.)	--
Benzo(a)anthracene	690. U ug/kg (690.)	--	900. U ug/kg (900.)	--
Benzo(a)pyrene	690. U ug/kg (690.)	--	900. U ug/kg (900.)	--
Benzo(b)fluoranthene	690. U ug/kg (690.)	--	900. U ug/kg (900.)	--
Benzo(g,h,i)perylene	690. U ug/kg (690.)	--	900. U ug/kg (900.)	--
Benzo(k)fluoranthene	690. U ug/kg (690.)	--	900. U ug/kg (900.)	--
Chrysene	690. U ug/kg (690.)	--	900. U ug/kg (900.)	--
Dibenzo(a,h)anthracene	690. U ug/kg (690.)	--	900. U ug/kg (900.)	--
Fluoranthene	690. U ug/kg (690.)	--	900. U ug/kg (900.)	--
Fluorene	690. U ug/kg (690.)	--	900. U ug/kg (900.)	--
Hexachlorobutadiene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--

Sample Identifier Sample Collect Date Analyte	01B27601 4/29/1999	01B27601RE 4/27/1999	01B27701 4/29/1999	01B27701RE 4/27/1999
Indeno(1,2,3-cd)pyrene	690. U ug/kg (690.)	--	900. U ug/kg (900.)	--
Naphthalene	690. U ug/kg (690.)	--	900. U ug/kg (900.)	--
Phenanthrene	690. U ug/kg (690.)	--	900. U ug/kg (900.)	--
Pyrene	690. U ug/kg (690.)	--	900. U ug/kg (900.)	--
Volatile Organic Compounds				
1,1,1,2-Tetrachloroethane	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
1,1,1-Trichloroethane	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
1,1,2,2-Tetrachloroethane	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
1,1,2-Trichloroethane	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
1,1-Dichloroethane	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
1,1-Dichloroethene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
1,1-Dichloropropene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
1,2,3-Trichlorobenzene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
1,2,3-Trichloropropane	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
1,2,4-Trichlorobenzene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
1,2,4-Trimethylbenzene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
1,2-Dibromo-3-chloropropane	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
1,2-Dichlorobenzene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
1,2-Dichloroethane	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
1,2-Dichloropropane	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
1,3,5-Trimethylbenzene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
1,3-Dichlorobenzene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
1,3-Dichloropropane	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
1,4-Dichlorobenzene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
2,2-Dichloropropane	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
2-Butanone	130. U ug/kg (130.)	--	140. U ug/kg (140.)	--
2-Chlorotoluene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
2-Hexanone	13. U ug/kg (13.)	--	14. U ug/kg (14.)	--
4-Chlorotoluene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
4-Methyl-2-pentanone	13. U ug/kg (13.)	--	14. U ug/kg (14.)	--
Acetone	130. U ug/kg (130.)	--	140. U ug/kg (140.)	--

Sample Identifier	01B27601	01B27601RE	01B27701	01B27701RE
Sample Collect Date	4/29/1999	4/27/1999	4/29/1999	4/27/1999
Analyte				
Benzene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
Bromobenzene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
Bromochloromethane	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
Bromodichloromethane	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
Bromoform	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
Bromomethane	13. U ug/kg (13.)	--	14. U ug/kg (14.)	--
Carbon disulfide	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
Carbon tetrachloride	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
Chlorobenzene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
Chloroethane	13. U ug/kg (13.)	--	14. U ug/kg (14.)	--
Chloroform	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
Chloromethane	13. U ug/kg (13.)	--	14. U ug/kg (14.)	--
Dibromochloromethane	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
Dibromomethane	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
Dichlorodifluoromethane	13. U ug/kg (13.)	--	14. U ug/kg (14.)	--
Ethylbenzene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
Hexachlorobutadiene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
Isopropylbenzene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
m-Xylene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
Methylene chloride	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
n-Butylbenzene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
n-Propylbenzene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
Naphthalene	690. U ug/kg (690.)	--	900. U ug/kg (900.)	--
o-Xylene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
p-Isopropyltoluene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
p-Xylene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
sec-Butylbenzene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
Styrene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
tert-Butylbenzene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
Tetrachloroethene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
Toluene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--

Sample Identifier Sample Collect Date Analyte	01B27601 4/29/1999	01B27601RE 4/27/1999	01B27701 4/29/1999	01B27701RE 4/27/1999
Trichloroethene	6.3 U ug/kg (6.3)	--	7.1 U ug/kg (7.1)	--
Trichlorofluoromethane	13. U ug/kg (13.)	--	14. U ug/kg (14.)	--
Vinyl acetate	13. U ug/kg (13.)	--	14. U ug/kg (14.)	--
Vinyl chloride	13. U ug/kg (13.)	--	14. U ug/kg (14.)	--

Sample Identifier	01B27801	01B27801RE	01B27901	01B27901RE
Sample Collect Date	4/29/1999	4/27/1999	4/29/1999	4/27/1999
Analyte				
Metals				
Arsenic	--	2.7 mg/kg (1.1)	--	7.3 mg/kg (1.2)
Barium	8. mg/kg (1.)	--	27. mg/kg (1.)	--
Cadmium	0.55 U mg/kg (0.55)	--	0.64 mg/kg (1.)	--
Chromium	2.5 mg/kg (1.)	--	6.1 mg/kg (1.)	--
Lead	16. mg/kg (6.)	--	350. mg/kg (6.)	--
Mercury	0.27 U mg/kg (0.27)	--	0.3 U mg/kg (0.3)	--
Selenium	5.5 U mg/kg (5.5)	--	6.1 U mg/kg (6.1)	--
Silver	2.2 U mg/kg (2.2)	--	2.4 U mg/kg (2.4)	--
Petroleum Hydrocarbons				
Total Petroleum Hydrocarbons (C8-C40)	60000. ug/kg (4400.)	--	57000. ug/kg (4900.)	--
Semivolatile Organic Compounds				
1,2,4-Trichlorobenzene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
1,2-Dichlorobenzene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
1,3-Dichlorobenzene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
1,4-Dichlorobenzene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
Acenaphthene	180. U ug/kg (180.)	--	1000. U ug/kg (1000.)	--
Acenaphthylene	180. U ug/kg (180.)	--	1000. U ug/kg (1000.)	--
Anthracene	180. U ug/kg (180.)	--	1000. U ug/kg (1000.)	--
Benzo(a)anthracene	180. U ug/kg (180.)	--	1000. U ug/kg (1000.)	--
Benzo(a)pyrene	180. U ug/kg (180.)	--	1000. U ug/kg (1000.)	--
Benzo(b)fluoranthene	180. U ug/kg (180.)	--	1000. U ug/kg (1000.)	--
Benzo(g,h,i)perylene	180. U ug/kg (180.)	--	1000. U ug/kg (1000.)	--
Benzo(k)fluoranthene	180. U ug/kg (180.)	--	1000. U ug/kg (1000.)	--
Chrysene	180. U ug/kg (180.)	--	1000. U ug/kg (1000.)	--
Dibenzo(a,h)anthracene	180. U ug/kg (180.)	--	1000. U ug/kg (1000.)	--
Fluoranthene	180. U ug/kg (180.)	--	1000. U ug/kg (1000.)	--
Fluorene	180. U ug/kg (180.)	--	1000. U ug/kg (1000.)	--
Hexachlorobutadiene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--

Sample Identifier Sample Collect Date Analyte	01B27801 4/29/1999	01B27801RE 4/27/1999	01B27901 4/29/1999	01B27901RE 4/27/1999
Indeno(1,2,3-cd)pyrene	180. U ug/kg (180.)	--	1000. U ug/kg (1000.)	--
Naphthalene	12. U ug/kg (12.)	--	1000. U ug/kg (1000.)	--
Phenanthrene	180. U ug/kg (180.)	--	1000. U ug/kg (1000.)	--
Pyrene	180. U ug/kg (180.)	--	1000. U ug/kg (1000.)	--
Volatile Organic Compounds				
1,1,1,2-Tetrachloroethane	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
1,1,1-Trichloroethane	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
1,1,2,2-Tetrachloroethane	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
1,1,2-Trichloroethane	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
1,1-Dichloroethane	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
1,1-Dichloroethene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
1,1-Dichloropropene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
1,2,3-Trichlorobenzene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
1,2,3-Trichloropropane	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
1,2,4-Trichlorobenzene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
1,2,4-Trimethylbenzene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
1,2-Dibromo-3-chloropropane	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
1,2-Dichlorobenzene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
1,2-Dichloroethane	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
1,2-Dichloropropane	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
1,3,5-Trimethylbenzene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
1,3-Dichlorobenzene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
1,3-Dichloropropane	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
1,4-Dichlorobenzene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
2,2-Dichloropropane	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
2-Butanone	120. U ug/kg (120.)	--	160. U ug/kg (160.)	--
2-Chlorotoluene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
2-Hexanone	12. U ug/kg (12.)	--	16. U ug/kg (16.)	--
4-Chlorotoluene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
4-Methyl-2-pentanone	12. U ug/kg (12.)	--	16. U ug/kg (16.)	--
Acetone	120. U ug/kg (120.)	--	160. U ug/kg (160.)	--

Sample Identifier Sample Collect Date Analyte	01B27801 4/29/1999	01B27801RE 4/27/1999	01B27901 4/29/1999	01B27901RE 4/27/1999
Benzene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
Bromobenzene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
Bromochloromethane	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
Bromodichloromethane	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
Bromoform	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
Bromomethane	12. U ug/kg (12.)	--	16. U ug/kg (16.)	--
Carbon disulfide	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
Carbon tetrachloride	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
Chlorobenzene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
Chloroethane	12. U ug/kg (12.)	--	16. U ug/kg (16.)	--
Chloroform	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
Chloromethane	12. U ug/kg (12.)	--	16. U ug/kg (16.)	--
Dibromochloromethane	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
Dibromomethane	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
Dichlorodifluoromethane	12. U ug/kg (12.)	--	16. U ug/kg (16.)	--
Ethylbenzene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
Hexachlorobutadiene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
Isopropylbenzene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
m-Xylene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
Methylene chloride	6.5 ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
n-Butylbenzene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
n-Propylbenzene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
Naphthalene	12. U ug/kg (12.)	--	1000. U ug/kg (1000.)	--
o-Xylene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
p-Isopropyltoluene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
p-Xylene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
sec-Butylbenzene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
Styrene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
tert-Butylbenzene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
Tetrachloroethene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
Toluene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--

Sample Identifier Sample Collect Date Analyte	01B27801 4/29/1999	01B27801RE 4/27/1999	01B27901 4/29/1999	01B27901RE 4/27/1999
Trichloroethene	6. U ug/kg (6.)	--	7.9 U ug/kg (7.9)	--
Trichlorofluoromethane	12. U ug/kg (12.)	--	16. U ug/kg (16.)	--
Vinyl acetate	12. U ug/kg (12.)	--	16. U ug/kg (16.)	--
Vinyl chloride	12. U ug/kg (12.)	--	16. U ug/kg (16.)	--

Sample Identifier	01B28001	01B28001RE		
Sample Collect Date	4/29/1999	4/27/1999		
Analyte				
Metals				
Arsenic	--	1.5 mg/kg (1.2)		
Barium	9.9 mg/kg (1.)	--		
Cadmium	0.61 U mg/kg (0.61)	--		
Chromium	3. mg/kg (1.)	--		
Lead	33. mg/kg (6.)	--		
Mercury	0.3 U mg/kg (0.3)	--		
Selenium	6.1 U mg/kg (6.1)	--		
Silver	2.4 U mg/kg (2.4)	--		
Petroleum Hydrocarbons				
Total Petroleum Hydrocarbons (C8-C40)	45000. ug/kg (4900.)	--		
Semivolatile Organic Compounds				
1,2,4-Trichlorobenzene	8.5 U ug/kg (8.5)	--		
1,2-Dichlorobenzene	8.5 U ug/kg (8.5)	--		
1,3-Dichlorobenzene	8.5 U ug/kg (8.5)	--		
1,4-Dichlorobenzene	8.5 U ug/kg (8.5)	--		
Acenaphthene	1000. U ug/kg (1000.)	--		
Acenaphthylene	1000. U ug/kg (1000.)	--		
Anthracene	1000. U ug/kg (1000.)	--		
Benzo(a)anthracene	1000. U ug/kg (1000.)	--		
Benzo(a)pyrene	1000. U ug/kg (1000.)	--		
Benzo(b)fluoranthene	1000. U ug/kg (1000.)	--		
Benzo(g,h,i)perylene	1000. U ug/kg (1000.)	--		
Benzo(k)fluoranthene	1000. U ug/kg (1000.)	--		
Chrysene	1000. U ug/kg (1000.)	--		
Dibenzo(a,h)anthracene	1000. U ug/kg (1000.)	--		
Fluoranthene	1000. J ug/kg (1000.)	--		
Fluorene	1000. U ug/kg (1000.)	--		
Hexachlorobutadiene	8.5 U ug/kg (8.5)	--		

Sample Identifier	01B28001	01B28001RE		
Sample Collect Date	4/29/1999	4/27/1999		
Analyte				
Indeno(1,2,3-cd)pyrene	1000. U ug/kg (1000.)	--		
Naphthalene	17. U ug/kg (17.)	--		
Phenanthrene	1000. U ug/kg (1000.)	--		
Pyrene	1000. J ug/kg (1000.)	--		

Volatile Organic Compounds

1,1,1,2-Tetrachloroethane	8.5 U ug/kg (8.5)	--		
1,1,1-Trichloroethane	8.5 U ug/kg (8.5)	--		
1,1,2,2-Tetrachloroethane	8.5 U ug/kg (8.5)	--		
1,1,2-Trichloroethane	8.5 U ug/kg (8.5)	--		
1,1-Dichloroethane	8.5 U ug/kg (8.5)	--		
1,1-Dichloroethene	8.5 U ug/kg (8.5)	--		
1,1-Dichloropropene	8.5 U ug/kg (8.5)	--		
1,2,3-Trichlorobenzene	8.5 U ug/kg (8.5)	--		
1,2,3-Trichloropropane	8.5 U ug/kg (8.5)	--		
1,2,4-Trichlorobenzene	8.5 U ug/kg (8.5)	--		
1,2,4-Trimethylbenzene	8.5 U ug/kg (8.5)	--		
1,2-Dibromo-3-chloropropane	8.5 U ug/kg (8.5)	--		
1,2-Dichlorobenzene	8.5 U ug/kg (8.5)	--		
1,2-Dichloroethane	8.5 U ug/kg (8.5)	--		
1,2-Dichloropropane	8.5 U ug/kg (8.5)	--		
1,3,5-Trimethylbenzene	8.5 U ug/kg (8.5)	--		
1,3-Dichlorobenzene	8.5 U ug/kg (8.5)	--		
1,3-Dichloropropane	8.5 U ug/kg (8.5)	--		
1,4-Dichlorobenzene	8.5 U ug/kg (8.5)	--		
2,2-Dichloropropane	8.5 U ug/kg (8.5)	--		
2-Butanone	170. U ug/kg (170.)	--		
2-Chlorotoluene	8.5 U ug/kg (8.5)	--		
2-Hexanone	17. U ug/kg (17.)	--		
4-Chlorotoluene	8.5 U ug/kg (8.5)	--		
4-Methyl-2-pentanone	17. U ug/kg (17.)	--		
Acetone	170. U ug/kg (170.)	--		

Sample Identifier	01B28001	01B28001RE		
Sample Collect Date	4/29/1999	4/27/1999		
Analyte				
Benzene	8.5 U ug/kg (8.5)	--		
Bromobenzene	8.5 U ug/kg (8.5)	--		
Bromochloromethane	8.5 U ug/kg (8.5)	--		
Bromodichloromethane	8.5 U ug/kg (8.5)	--		
Bromoform	8.5 U ug/kg (8.5)	--		
Bromomethane	17. U ug/kg (17.)	--		
Carbon disulfide	8.5 U ug/kg (8.5)	--		
Carbon tetrachloride	8.5 U ug/kg (8.5)	--		
Chlorobenzene	8.5 U ug/kg (8.5)	--		
Chloroethane	17. U ug/kg (17.)	--		
Chloroform	8.5 U ug/kg (8.5)	--		
Chloromethane	17. U ug/kg (17.)	--		
Dibromochloromethane	8.5 U ug/kg (8.5)	--		
Dibromomethane	8.5 U ug/kg (8.5)	--		
Dichlorodifluoromethane	17. U ug/kg (17.)	--		
Ethylbenzene	8.5 U ug/kg (8.5)	--		
Hexachlorobutadiene	8.5 U ug/kg (8.5)	--		
Isopropylbenzene	8.5 U ug/kg (8.5)	--		
m-Xylene	8.5 U ug/kg (8.5)	--		
Methylene chloride	8.5 U ug/kg (8.5)	--		
n-Butylbenzene	8.5 U ug/kg (8.5)	--		
n-Propylbenzene	8.5 U ug/kg (8.5)	--		
Naphthalene	17. U ug/kg (17.)	--		
o-Xylene	8.5 U ug/kg (8.5)	--		
p-Isopropyltoluene	8.5 U ug/kg (8.5)	--		
p-Xylene	8.5 U ug/kg (8.5)	--		
sec-Butylbenzene	8.5 U ug/kg (8.5)	--		
Styrene	8.5 U ug/kg (8.5)	--		
tert-Butylbenzene	8.5 U ug/kg (8.5)	--		
Tetrachloroethene	8.5 U ug/kg (8.5)	--		
Toluene	8.5 U ug/kg (8.5)	--		

Sample Identifier	01B28001	01B28001RE		
Sample Collect Date	4/29/1999	4/27/1999		
Analyte				
Trichloroethene	8.5 U ug/kg (8.5)	--		
Trichlorofluoromethane	17. U ug/kg (17.)	--		
Vinyl acetate	17. U ug/kg (17.)	--		
Vinyl chloride	17. U ug/kg (17.)	--		

Footnotes: Values in parentheses are detection limits

NAS Key West - April 1999 Groundwater Sampling

Sample Identifier	01G00402	01G00402DL	01G00502	01G00502DL
Sample Collect Date	4/30/1999	4/30/1999	4/29/1999	4/29/1999
Analyte				
All Analyses				
Ethane	0.47 J ug/l (0.)	8.6 J ug/l (50.)	0.8 ug/l (0.)	18. J ug/l (50.)
Ethene	0.5 U ug/l (0.5)	7.1 J ug/l (50.)	0.5 U ug/l (0.5)	15. J ug/l (50.)
Methane	380. J ug/l (0.)	5500. ug/l (50.)	380. J ug/l (0.)	2600. ug/l (50.)

Sample Identifier	01G00802	01G00802DL	01G00902	01G00902DL
Sample Collect Date	4/30/1999	4/30/1999	4/30/1999	4/30/1999
Analyte				
All Analyses				
Ethane	0.83 ug/l (0.)	25. U ug/l (25.)	0.2 J ug/l (0.)	5. U ug/l (5.)
Ethene	0.5 U ug/l (0.5)	25. U ug/l (25.)	0.5 U ug/l (0.5)	5. U ug/l (5.)
Methane	370. J ug/l (0.)	2200. ug/l (25.)	260. J ug/l (0.)	440. ug/l (5.)

Sample Identifier	01G06002	01G06002DL		
Sample Collect Date	4/29/1999	4/29/1999		
Analyte				

All Analyses

Ethane	1.7 ug/l (0.)	50. U ug/l (50.)		
Ethene	0.5 U ug/l (0.5)	50. U ug/l (50.)		
Methane	390. J ug/l (0.)	3800. ug/l (50.)		

Footnotes: Values in parentheses are detection limits

APPENDIX F

APPENDIX F

BASIS OF DESIGN

The purpose of this Remedial Action Plan (RAP) is to present a plan for remediation of petroleum and arsenic contamination at the Trumbo Point Fuel Farm facility in accordance with the requirements of Chapter 62-770, Florida Administrative Code (FAC) (effective September 23, 1997). Implementation of this RAP will include the following tasks:

- Source removal through excavation and soil treatment of petroleum contaminated soil,
- Source removal through multi-phase extraction,
- Source removal through a program of passive product removal,
- Source control through excavation of arsenic contaminated areas,
- Implementation of a Monitored Natural Attenuation remedy, and
- Establishment of Land-Use Controls (LUCs).

<u>Remedial Action Considerations: Site Conditions</u>

Based on field data and laboratory analytical results, as presented in this RAP as well as in the Contamination Assessment Report (CAR), the site conditions are as follows.

The TPFF is used for a variety of purposes. Activities and area-specific physical characteristics taking place at different locations on the facility can be used to divide the TPFF into five areas:

- Pier 1, used by the Naval Acoustics Warfare Center, is entirely paved, and seawalls confine all waterfront areas. Ecological and residential human receptors are non-existent under the current use of this area. Future use is foreseen to be of a light industrial nature. The potential for offsite migration of contaminants from this area is thought to be minimal.

- Piers 2 and 3 are part of the TPFF leased by the Navy to the Coast Guard. Activities here are of a light industrial nature. This area is almost entirely paved, and seawalls confine all waterfront areas. Ecological and residential human receptors are non-existent under the current use of this area. Future use is foreseen to be of a light industrial nature. The potential for offsite migration of contaminants from this area is thought to be minimal.

- The U.S. Coast Guard Station is also on land leased by the Navy to the Coast Guard. This area includes large unpaved regions, and does not include any waterfront. This area is used for administrative offices, residential structures, and recreational facilities. Ecological receptors are minimal in this area, but residential human receptors exist. The potential for offsite migration of contaminants is thought to be minimal.

- The Navy Tank Area is a large, unpaved area currently vacant. The area formerly held a number of ASTs and associated piping. Future uses of this area are thought to include activities of a varied industrial nature. Ecological receptors are minimal is this area. Future recreational vehicle users parking in this area may be considered residential human receptors. The potential for offsite migration of contaminants is thought to be minimal.

- The Key West Pipeline Company Area is a large, unpaved area separated by fencing and a berm from the rest of the facility. The area includes three large ASTs and associated piping. The current land use is thought to continue for the foreseeable future. Ecological receptors are minimal in this area, and residential human receptors are non-existent. The potential for offsite migration of contaminants is thought to be moderate.

Soils encountered during the CA monitoring well installation program and soil boring investigation did not vary appreciably from one area of the TPFF to another. From land surface to a depth of approximately 3 feet bls, a hard, sandy limestone fill material mixed with gravel and shell fragments is present. Material from 3 feet bls to approximately 13 feet is generally a soft, silty to sandy limestone mud. A sandy to gravelly limestone occurs from 13 feet bls to the maximum depth investigated during the CA (50 feet). Based on OVA headspace readings and analytical data, the lateral extent of contaminated soil is 260,000 ft^2 spread over 21 product-contaminated soil areas. Based on a groundwater depth of approximately 7 feet bls, the estimated volume of contaminated soil is 1,820,000 ft^3 or 67,400 yd^3. The degree and nature of contamination varies widely over the different product-contaminated soil regions.

The depth to groundwater varies from approximately 3 feet to 7 feet bls, and fluctuates with tidal influence. The general groundwater flow direction in the surficial aquifer is radially away from the center of the TPFF, towards the seawalls. Free product was observed in 20 monitoring wells associated with product-contaminated areas FP-3, FP-5, FP-6, FP-15, FP-16, FP-17, and FP-21. Observed free product depths ranged from a sheen to 6.65 feet. Results of constant-rate pumping tests conducted on March 19, 1996 and April 11, 1994 indicate a hydraulic conductivity (k) of 2.88×10^{-2} ft/day in the shallow aquifer (less than 13 feet bls) to 1.63 ft/day in the deep aquifer (greater than 13 feet bls). Hydraulic gradient (i) values ranging from 8.0×10^{-4} ft/ft to 1.0×10^{-2} ft/ft were observed during the CA for the shallow aquifer and from 2.5×10^{-4} ft/ft to 1.0×10^{-3} ft/ft for the deep aquifer. Porosity values of 0.45 for the shallow aquifer and 0.20 for the deep aquifer were measured during the CA. Using these values to calculate pore water velocities, the shallow aquifer was found to have a pore water velocity range of 5.12×10^{-5} ft/day to 6.4×10^{-4} ft/day, while the deep aquifer was found to have a pore water velocity range of 2.04×10^{-3} ft/day to 8.15×10^{-3} ft/day.

The chemicals of concern for media at the TPFF are as follows.

Subsurface soil and groundwater:

- benzene, ethylbenzene, toluene, total xylenes, and methyl tert-butyl ether;
- naphthalene and the 15 method-listed polynuclear aromatic hydrocarbons (PAHs);
- TRPH.

Groundwater only:

- 1,2-dichloroethane and priority pollutant volatile organic halocarbons;
- 1,2-dibromoethane;
- total lead.

Surface soil:

- arsenic.

Remedial Action Considerations: Technology-Specific Concerns

Excavation with Onsite Soil Washing. Excavation with onsite soil washing was chosen as a remedial technology for two of the 21 product-contaminated soil areas. The disruptive nature of excavation restricted consideration of its use to areas where the product-contaminated soil is not overlain by buildings, existing storage tanks, extensive utilities, and the like. Furthermore, the expense and effort involved with this remedial alternative dictate that the derived benefit be commensurate with the cost. The benefit of this technology is source removal; thus, only large source areas are candidates for this technology. The two product-contaminated source areas meeting these criteria are FP-16 and FP-17. Both contain relatively large quantities of mobile product, spread over a relatively large area, with minimal surface obstructions.

Onsite soil washing was chosen over other ex-situ soil treatment options primarily due to cost, and its effectiveness in treating soil to industrial soil cleanup goal (SCG) standards. Other considerations included the space available for a temporary treatment facility on the Navy Tanks Area land, and the safety and logistical difficulties associated with transport of contaminated soil to offsite treatment facilities.

The excavation will be conducted in accordance with all applicable safety standards, including the use of shoring, trench escape ladders, fencing, and breathing space monitoring. The excavated areas will be exposed only a portion at a time, and will be backfilled with treated soil as soon as possible. This precaution is taken to prevent the formation of rainwater-filled ponds in the excavated areas. The excavated and treated soils will be staged in holding areas, to allow for variations in the speed of the treatment process.

Surface Soil Excavation. Excavation was chosen as the remedial alternative for surface soil contamination. Since the COC for surface soils is arsenic, any soil treatment technology would only remove and concentrate, not destroy, the COC. Given the hard and fine-grained nature of the soil at the TPFF, it would be unlikely that soil-washing technology would be effective. Soil washing generally depends on separating fine-grained material bearing the contaminant from the bulk of coarser-grained material.

Excavation and removal of the surface soil material greatly reduce risks due to exposure. Backfilling with clean soil from a mainland source will be expensive.

Soil stabilization, i.e., mixing the contaminated surface soil with concrete, is superfluous when the surface soil is already quite hard in its natural state.

The primary concern with capping is the effect that a concrete cap will have on stormwater runoff. This concern could be addressed through the specification of stormwater retention ponds. The concern focussed on stormwater runoff may be considered part of a conservative design process, since the natural surface at the TPFF is none too pervious in the first place.

Multiphase Extraction. The fine-grained, low-permeability soil at the TPFF is not likely to be amenable to conventional product removal strategies such as product removal trenches or pump-and-treat technology. This conclusion is evident after calculating the time to pump a pore volume of the aquifer using reasonable assumptions (see Chapter 3). Furthermore, the pilot product recovery system, utilizing product recovery trenches, did not lead to a recommendation of this technology as a viable alternative by the consultant (IT Corporation). Given these previous result and conclusion, a technology that will work in fine-grain, impermeable material was sought. Multi-phase extraction best achieves this objective. Multi-phase extraction has an advantage over other technologies in fine-grained soils: the vacuum applied helps hold open the limited pore space, resulting in greater recovery. Since this technology will be used on several product-contaminated soil areas, with such areas being subject to rotation in and out of the multi-phase extraction scheme, a temporary multiphase extraction system using vacuum trucks is preferable to permanent systems. Using vacuum trucks results in a lower cost as well.

Multi-phase extraction will be applied to those areas not undergoing excavation that have exhibited an average of 0.1 foot or greater of product in one or more wells. Multi-phase extraction is not as effective for very thin product layers thus this restriction.

Passive Product Recovery. For those areas with very thin product layers, passive product recovery using in-well skimmers is proposed. Typically, the areas averaging less than 0.1 foot of product in all wells are on the pier areas of the TPFF, and have very limited potential for migration of contaminant. These areas are capped by existing pavement, and often partially or fully contained by existing seawalls. In this situation, the only purpose of product recovery is to prevent future exposure of receptors to contaminants. Since the likelihood of exposure to product is so low, less aggressive means of product recovery are acceptable. In-well product skimmers work well with product thickness as low as a sheen, have a low cost, and are effective, if somewhat slow.

Monitored Natural Attenuation. Preliminary evidence suggests that the dissolved phase plume in the Key West Pipeline area is naturally attenuating. Reduction/oxidation values measured in the groundwater of less than -200 mV are optimal for natural attenuation. The presence of elevated levels of methane provide additional supporting evidence that attenuation is occurring. Sulfate reduction appears to be the primary microbial process facilitating natural attenuation. The strongest line of evidence is reduction in contaminant concentrations over time. The NA program is designed to provide this evidence. If data indicate that NA is not working then the existing seawall will be extended to prevent the dissolved plume form entering the Fleming Key Cut surface water at concentrations harmful to the environment.

Land-Use Controls. Two situations could potentially result in human exposure to contaminants at the TPFF. First, the remote possibility exists that a water supply well could be installed on the base, resulting in exposure to dissolved contamination. This is a highly unlikely possibility; no water supply wells are known to exist on Key West, and drinking water is supplied by pipeline from the mainland. However, to prevent the possibility that human receptors could be exposed to dissolved contamination from groundwater, a land-use control preventing such water supply wells is proposed.

Second, an excavation scenario may expose workers to subsurface petroleum and arsenic contamination above acceptable levels. A land-use control requiring the communication of possible exposure to personnel doing invasive construction work will be incorporated into the Base Master Plan.

APPENDIX G

APPENDIX G

REMEDIAL ACTION PLAN CHECKLIST

REMEDIAL ACTION PLAN CHECKLIST

Bureau of Petroleum Storage Systems
Florida Department of Environmental Protection

Facility Name:	Trumbo Point Fuel Farm	Preapproval Site	☐
Location:	NAS Key West	State Cleanup Site:	☐
FAC ID No.:		Voluntary Cleanup Site:	☒
Reviewer:		Date SAR Received:	
Consultant:	Harding Lawson Associates	Date SAR Approved:	

This checklist should not be applied in blanket fashion. Technical judgment may be necessary in determining the applicability of some items. However, all information listed that is relevant to the remedial design should be provided.

PAGE(S)

I. GENERAL

8-1 (1)	RAP signed, sealed, and dated by Florida P.E. (per Section 471.025, FS)
Section 1.0 (2)	indication whether proposed plan is for preapproval program, state contracted cleanup, or voluntary cleanup
Section 2.0 (3)	recap of SAR information and conclusions pertinent to RAP preparation
Figures 2-4, 2-5, and 2-6	(a) horizontal and vertical extent of contamination in soil and groundwater
Table 3-1	(b) volumes of affected soil and groundwater
Appendix C	(c) estimated mass of chemicals of concern in vadose zone, smear zone, and free product
Section 2.3	(d) depth to water table
Section 2.3	(e) groundwater flow direction and gradient
Section 2.3	(f) hydraulic conductivity of aquifer and method of determination
Section 2.3	(g) transmissivity of aquifer and method of determination
Section 2.3	(h) confining layer location
Section 2.3	(i) lithology of site
Appendix E (4)	current sampling results [within nine (9) months] used for remediation system design
NA (5)	latest date underground storage tanks and product lines have tested tight
Section 2.0 (6)	potable water considerations
Section 2.3	(a) method of potable water supply to area
Section 2.3	(b) locations of private wells within 1/4-mile, and public wells within 1/2-mile radius of site
NA	(c) indication whether FDEP district office drinking water program was notified if contaminated groundwater could be expected to reach any public or private water well. Method of notification, person notified, and date
Figure 2-3 (7)	underground utilities which may enhance transport of chemicals of concern

Appendix C (8) cleanup time

Appendix C (a) estimated time of cleanup: groundwater; soil

Appendix C (b) method used to determine cleanup time

Already fenced (9) fencing treatment area required, unless public access is restricted by institutional controls

Section 4.0 (10) discussion of required maintenance for proposed equipment, including site visit frequency and special O&M considerations

NA (11) all local, state, and federal permits obtained and conditions stated

Appendix H (12) itemized cost estimate for project: capital, operation, maintenance, sampling, and closure

Appendix H (13) feasibility of leasing equipment considered (cost cannot exceed purchase price)

Appendix B (14) alternative analysis or discussion of other alternatives considered

Appendix B (15) cost-effective analysis provided if design is innovative

Section 4.1.3 (16) statement that signed and sealed as-built (record) drawings will be provided

NA (17) nuisance noise and odor to neighbors avoided by careful location of equipment items and exhaust stacks or other mitigating measures

NA (18) retainage evaluation wells per 11/15/96 guidance specified (if preapproval cleanup)

II. Free Product Removal

Figure 3-2 (1) free product plume identification

Sect.4.3,4.4 (2) description of free product recovery system

NA (3) oil/water separator sizing calculations and detention time

NA (4) free product storage tank of adequate size for reasonable maintenance frequency

NA (5) automated product pump shutdown for high level in product tank

Section 4.3 (6) disposition of free product after its recovery

III. Soil Remediation - General

Appendix C (1) volume of contaminated soil

NA (2) recap of Source Removal activities and soil volume already excavated

Section 4.1 (3) indication that contaminated soil will be remediated, or rationale for 'no action' alternative for soil remediation provided

Section 4.1 (4) disposition of excavated, contaminated soil

Section 4.1 (5) indication that hazardous soil (e.g., ignitable, corrosive, reactive, toxic, or petroleum refining waste) will be disposed of properly

IV. Land Farming of Soil

NA (1) adequate surface area available (_____ sq ft) to spread soil 6 to 12 inches thick

NA (2) location of land farming operation

NA (3) land farming area is flat (less than 5% slope)

NA (4) impermeable base provided. Type: _____

NA (5) surface water runoff controls provided

NA _____ (6) groundwater monitoring plan proposed if land farm is outside of immediate contamination area

NA _____ (7) frequency of tilling provided

NA _____ (8) frequency and details of nutrient application or other enhancements provided (if proposed)

NA _____ (9) soil sampling frequency and sampling methods provided

NA _____ (10) potential for land farm causing nuisance conditions evaluated

NA _____ (11) underlying soil and groundwater monitoring procedures provided and acceptable

NA _____ (12) land farming will be continued until the chemicals of concern are below the applicable soil cleanup target levels (SCTLs)

NA _____ (13) cost-effectiveness evaluated

NA _____ (14) ultimate disposition of soil discussed

NA _____ (15) need to fence land farm area considered

V. Landfilling of Soil

Section 4.2 (1) landfill lined and permitted by FDEP

TBD _____ (2) name and location of landfill provided along with conditions of acceptance

Appendix B (3) cost-effectiveness considerations

VI. Soil Thermal Treatment

NA _____ (1) name and location of thermal treatment facility provided

NA _____ (2) facility is permitted for thermal treatment of petroleum contaminated soil

NA _____ (3) indication of whether pretreatment soil samples will be collected at site or at thermal treatment facility

NA _____ (4) cost-effectiveness evaluation

VII. Commercial Bioremediation of Soil

NA _____ (1) name and location of bioremediation facility provided

NA _____ (2) facility is permitted for bioremediation of petroleum contaminated soil

NA _____ (3) indication of whether pretreatment soil samples will be collected at site or at bioremediation facility

NA _____ (4) cost-effectiveness evaluation

VIII. In Situ Bioventing of Soil

NA _____ (1) soil cleanup criteria identification

NA _____ (2) estimated mass of chemicals of concern in the vadose zone

NA _____ (3) pilot study [per Rule 62-770.700(2), FAC]

NA _____ (a) soil temperature, permeability, pH, moisture

NA _____ (b) nutrient requirements

NA _____ (c) presence of suitable indigenous microbes

NA _____ (d) oxygen requirement (usually as pounds of air to pound of hydrocarbon degraded)

NA _____ (4) layout

NA _____ (a) location of air injection and air extraction wells with respect to contaminated soil plume location and depth

NA _____ (b) location and depth of soil gas monitoring probes with respect to contaminated soil plume and the air injection and extraction wells

NA _____ (5) mechanical details, equipment sizing calculations, and operational parameters

NA _____ (a) well type — vertical or horizontal

NA _____ (b) well construction details

NA _____ (c) indication whether soil vacuum pump will be used alone (with induced influx of air from unsealed surface acting as oxygen source) or accompanied by air injection pump as oxygen source

NA _____ (d) vacuum pump/blower specifications and horsepower

NA _____ (e) method and design details of moisture addition if site soil is dry

NA _____ (f) method and design details of nutrient delivery system, if necessary

NA _____ (6) estimated cleanup time

NA _____ (7) instruments, controls, gauges, and valves

NA _____ (a) subsurface soil gas monitoring probes

NA _____ (b) pressure gauges

NA _____ (c) shutoff/throttling valves

NA _____ (d) nutrient and moisture addition control devices and meters

NA _____ (8) monitoring plan: CO 2; pertinent bioremediation parameters; chemicals of concern

NA _____ (9) air emissions

NA _____ (a) generally, no air emissions treatment necessary because vapor flow rates are so low and biodegradation of petroleum results in production of CO 2 and water

NA _____ (b) evaluation of need for off-gas treatment if pilot test indicated that a significant amount of hydrocarbon volatilization will occur

IX. Soil Vacuum Extraction

NA _____ (1) prerequisites

NA _____ (a) relatively permeable soil

NA _____ (b) depth to groundwater > 3 ft

NA _____ (c) relatively volatile chemicals of concern

NA _____ (2) pilot study [per Rule 62-770.700(2), FAC] or rationale to forego pilot study

NA _____ (a) pilot test components designed and located for cost-effective subsequent integration into full-scale design

NA _____ (b) diagram of pilot layout indicating location of vapor extraction well, and radial distance of monitoring wells from the vapor extraction well

NA _____ (c) air flow rate (cfm)

NA _____ (d) radius of influence (ft); vacuum (inches of water) at limit of radius of influence

NA _____ (e) water elevations at monitoring wells to assess groundwater mounding; observed mound (inches)

NA _____ (f) vacuum readings at monitoring wells and at various radial distances from extraction well to aid in full-scale design

NA _____ (g) measurement of off-gas concentrations of volatile organic compounds (VOCs) for the purpose of selecting and sizing cost-effective off-gas treatment for full-scale system

NA _____ (h) determination of soil's permeability (rule of thumb: permeability should be greater than 10^{-9} sq cm)

NA _____ (3) full-scale design

NA _____ (a) location(s) and radius of influence (ft); overlapping radii for adequate coverage of contaminated soil plume

NA _____ (b) vapor extraction well(s) construction details

NA _____ 1) no. of wells; cfm each well; total cfm; well type (vertical or horizontal); well diameter; well depth; water table (ft bls); screen slot size; screened interval (ft bls); well sealed w/bentonite or non-shrinking grout at screen design depth to prevent short-circuiting

NA _____ 2) screen location close to water table to optimize collection of vapors across vadose depth but not so close as to collect excessive water

NA _____ (c) pneumatic design

NA _____ 1) operating vacuum @ wellhead(s) (inches of water)

NA _____ 2) calculation of piping system friction losses

NA _____ 3) calculation of vacuum pump motor (hp) based on system losses plus required vacuum at wellhead

NA _____ (d) vacuum source type: regenerative blower; positive displacement vacuum pump; other

NA _____ 1) design: cfm @ inches of water; operating cfm @ inches of water

NA _____ 2) mfr; model; motor hp; rpm; performance curves; hp calculations or curves

NA _____ 3) nonferrous materials of construction and/or assembly to minimize potential for sparking and friction

NA _____ 4) explosion proof motor specified

NA _____ (e) moisture separator/condensation trap ("knock out pot") prior to inlet of vacuum pump

NA _____ (f) surface sealing provided for vacuum extraction, or existing concrete or asphalt adequate

(g) safety

NA _____ 1) system operation at approximately 25% of Lower Explosive Limit (LEL)

NA _____ 2) bleed valve provided to control flammable vapor concentrations

NA _____ (h) instrumentation, gauges, and appurtenances

NA _____ 1) vacuum gauges at each well; temperature gauges (@ vacuum pump and/or exhaust gas stack)

NA _____ 2) sample ports for influent from each well, and for the off-gas from the treatment unit

NA _____ 3) air flow control: shutoff/throttling valve at each well; other air flow control device or method

NA _____ 4) high level switch in knock out pot to either shut down vacuum pump or drain the pot (w/proper disposal of the contaminated water)

NA _____ (i) air emissions (general)

NA _____ 1) expected concentrations and quantities of any VOCs discharged to air

NA _____ 2) method of cost-effective off-gas treatment to be provided during first month of system operation (provide details in Section X or XI for carbon adsorption or thermal oxidation of off-gas, or details of any alternative method proposed)

NA _____ (j) system monitoring proposal

NA _____ 1) provision to sample and analyze air emissions for VOCs, weekly for first month, monthly for next two months, quarterly thereafter

NA _____ 2) soil cleanup criteria provided

NA _____ 3) provision for monitoring wells to serve as vacuum measurement locations (at various radial distances from extraction wells), or other provisions for verification of proper operation

NA _____ 4) acknowledge that air emissions control must be continued until VOCs are less than 13.7 lbs/day

X. VAPOR-PHASE CARBON ADSORPTION (for control of air emissions)

NA _____ (1) cost-effectiveness evaluation in comparison to other alternatives

NA _____ (2) mechanical details, sizing calculations, and operational parameters

NA _____ (a) gas flow rate

NA _____ (b) gas temperature

NA _____ (c) effect of moisture level on adsorption

NA _____ (d) identification of chemicals of concern

NA _____ (e) concentrations of chemicals of concern

NA _____ (f) retention (expressed as a percent or pounds of chemicals of concern adsorbed per pound of carbon)

NA _____ (g) carbon usage rate

NA _____ (h) configuration of carbon vessels in series

NA _____ (i) pressure drop

NA _____ (j) pressure relief valve for carbon vessels

NA _____ (k) proper disposal/regeneration and replacement of spent carbon

NA _____ (3) instrumentation, controls, gauges, and valves

NA _____ (a) high pressure shutdown switch and pressure relief valve

NA _____ (b) pressure gauges

NA _____ (c) temperature gauges

NA _____ (d) sampling ports

NA _____ (4) safety

NA _____ (a) evaluation of need to isolate carbon units from other equipment items in the process train by an in-line flame arrestor

NA _____ (b) identification of the Lower Explosive Limit (LEL) for chemicals of concern

NA _____ (c) observance of appropriate requirements in Series 500 articles of the National Electrical Code — equipment shall meet either Class I, Group D, Division 1 or Class I, Group D, Division 2 hazardous area requirements, whichever is applicable, when an equipment item is located in a hazardous area as defined by the code

XI. THERMAL/CATALYTIC OXIDATION (for control of air emissions)

NA _____ (1) cost-effectiveness evaluation in comparison to other alternatives

NA _____ (2) mechanical details, equipment sizing calculations, and operational parameters

NA _____ (a) type — thermal or catalytic

NA _____ (b) combustion air flow rate

NA _____ (c) supplemental fuel type — propane or natural gas

NA _____ (d) temperature and retention time

NA _____ (e) stack height

NA _____ (f) stack diameter

NA _____ (3) instrumentation, controls, gauges, and valves: schematic or mobile unit manufacturer's drawings indicating instrumentation, controls, gauges, and valves for all process streams (contaminant-laden influent, fuel gas, and combustion air)

NA _____ (4) safety considerations include, but are not limited to

NA _____ (a) bleed valve or dilution control valve to maintain influent flammable vapor concentration at 25% of the Lower Explosive Limit (LEL)

NA _____ (b) evaluation of whether a flame arrestor should be installed in the pipeline between thermal oxidation unit and a soil vapor vacuum extraction pump which feeds the oxidizer

NA _____ (c) air purge prior to re-ignition

NA _____ (d) observance of appropriate requirements in Series 500 articles of the National Electrical Code — equipment shall meet either Class I, Group D, Division 1 or Class I, Group D, Division 2 hazardous area requirements, whichever is applicable, when an equipment item is located in a hazardous area as defined by the code

NA _____ (e) use of thermal or catalytic oxidizers which meet appropriate fire codes for handling natural or propane gas and prevention of furnace explosions — National Fire Protection Association, Industrial Risk Insurer's, Factory Mutual, etc. Some of the most important safety shutdowns for gas-fired burners occur upon: high gas pressure; low gas pressure; loss of combustion supply air; loss or failure to establish flame; loss of control system actuating energy; power failure

XII. GROUNDWATER EXTRACTION

NA _____ (1) feasibility of using existing on-site wells for groundwater extraction considered

NA _____ (2) recovery well summary

NA _____ (a) recovery well or trench location(s) and construction details included

NA _____ (b) recovery well depth appropriate for depth of contamination reported in SAR. The recovery well depth should optimize petroleum mass recovery relative to groundwater recovery

NA _____ (c) well diameter

NA _____ (d) screened interval appropriate

NA _____(3) predicted horizontal and vertical area of influence with hydraulic gradient provided

NA _____(4) expected drawdown in recovery well or trench (____ ft)

NA _____(5) consideration of multiple well configuration to minimize drawdown

NA _____(6) groundwater pump(s) description design

NA _____ (a) hydraulic design considerations acceptable (including friction losses and suction lift)

NA _____ (b) pump characteristic curve, design flow rate (_____ gpm at _____ ft TDH provided); mfr; model; motor hp

NA _____(7) automated well level controls provided for stopping/starting groundwater pump(s)

NA _____(8) totalizing flowmeter installed on influent line from each groundwater recovery pump

NA _____(9) check valve provided on pump discharge piping if not integral to pump

NA _____(10) shutoff/throttling valve provided on pump discharge piping

XIII. GROUNDWATER TREATMENT SYSTEM - GENERAL

NA _____ (1) influent concentrations summary

NA _____ (a) expected or calculated influent concentrations acceptable (based upon pumping test dynamic sample, weighted averaging procedure, or other reasonable assumptions)

NA _____ (b) summary of the expected influent concentrations (ppb): benzene _____; toluene _____; ethylbenzene _____; xylenes _____; MTBE _____; naphthalene _____; EDB _____; 1,2-dichloroethane _____; others

NA _____(2) discharge to sewage treatment plant

NA _____ (a) feasibility of discharge to sewage treatment plant evaluated

NA _____ (b) consideration given to less time and/or level of treatment required to meet sewage system pretreatment standards

NA _____(3) site piping summary

NA _____ (a) schematics of all treatment components, piping, valves, controls and appurtenances provided

NA _____ (b) influent and effluent sampling ports provided

NA _____ (c) piping type and size provided

NA _____(4) iron fouling

NA _____ (a) groundwater analyses (ppm): total _____; dissolved

NA _____ (b) consideration whether iron fouling should be controlled by filtration of influent to remove particulately-bound iron, and/or by removal or sequestering of dissolved iron to prevent precipitation in process equipment items (generally, "normal" concentration of dissolved iron in water is approx. 0.1 to 0.3 ppm, and unless the pH of the water falls below 5, it rarely exceeds 1 ppm)

NA _____(5) consideration whether pretreatment or other measures necessary to prevent fouling by calcium carbonate (Langelier Index calculation based on groundwater samples may aid in this consideration)

NA _____(6) need for pretreatment or O&M for biofouling considered

XIV. Air Stripping Treatment Process

NA _____ (1) packed tower

NA _____ (a) type, size, and surface area of packing

NA _____ (b) calculations, criteria, design parameters

NA _____ 1) tower height

NA _____ 2) tower diameter

NA _____ 3) packing height

NA _____ 4) water flow rate

NA _____ 5) air flow rate

NA _____ 6) blower hp

NA _____ 7) air/water ratio

NA _____ 8) pressure drop across packing

NA _____ (c) pressure gauge to indicate effects of fouling over time

NA _____ (d) mist eliminator

NA _____ (e) observation port

NA _____ (f) O&M considerations (fouling potential)

NA _____ (2) diffused aerator (tank type)

NA _____ (a) calculations, parameters (tank volume; contact time; air flow rate; pressure drop; removal efficiency of chemicals of concern) and design assumptions

NA _____ (3) low profile air stripper

NA _____ (a) number of trays; water flow rate; air flow rate; air/water ratio; pressure drop; blower hp; mist eliminator

NA _____ (4) general

NA _____ (a) air emissions calculations; emissions stack height

NA _____ (b) equipment description if emissions treatment necessary

NA _____ (c) automated recovery well shutdown when blower failure occurs

NA _____ (d) sampling of effluent, daily for first three days, monthly for next two months, quarterly thereafter

XV. Liquid-Phase Carbon Adsorption

NA _____ (1) indication whether adsorption is for primary treatment of groundwater or polishing of effluent

NA _____ (2) carbon specifications

NA _____ (3) carbon unit(s) sizing calculations (carbon usage rate, contact time, pressure losses)/design assumptions

NA _____ (4) isotherm data from pilot study needed if carbon adsorption used as primary treatment and total VOA concentrations are appreciable (VOA > 100 ppb typically) in order to estimate carbon capacity required and sampling frequency

NA _____ (5) TOC in groundwater determined and effect on carbon usage considered

NA _____ (6) need for sand filter or cartridge unit prior to carbon unit considered

NA _____ (7) pressure gauge and pressure relief valve provided on carbon (and sand) filter

NA _____ (8) carbon disposal and replacement method

NA _____ (9) series configuration of carbon units considered to allow for maximum carbon utilization and prevention of contaminant breakthrough to system effluent

NA _____ (10) automated recovery well shutdown if primary carbon unit pressure too high

NA _____ (11) schedule for sampling between and after carbon adsorption units

XVI. In Situ Air Sparging of Groundwater

NA _____ (1) prerequisites

NA _____ (a) no or little free product which could spread via sparge turbulence, or prolong sparging

NA _____ (b) volatile (C_3 -C_{10}) petroleum fractions with Henry's Constant ^{3} 0.00001 atm * m 3 /mol (approx. rule of thumb, unless biosparging is proposed)

NA _____ (c) no high concentrations of metals (iron, magnesium) to form oxides which plug aquifer or well screens, or high concentrations of dissolved calcium, which could react with CO_2 in air to clog aquifer w/calcium carbonate (notes: Langelier Index calculation regarding equilibrium between calcium carbonate and dissolved CO_2 may be helpful. Generally, precipitation of dissolved iron is less likely when water is acidic, approx. pH less than 6)

NA _____ (2) pilot study [per Rule 62-770.700(2), FAC] or rationale to forego pilot study

NA _____ (a) three-stage pilot study recommended: vapor extraction only; sparging only; combined extraction and sparging

NA _____ (b) pilot test components designed and located for cost-effective subsequent integration into full-scale design

NA _____ (c) diagram of pilot layout indicating locations of air injection well, vapor extraction well, and radial distance of monitoring wells from the air injection well

NA _____ (d) air flow rates for each stage (cfm): vapor extraction; sparging; combined

NA _____ (e) radius of influence for each stage (ft): vapor extraction; sparging; combined

NA _____ (f) groundwater mounding observed during each stage (inches): vapor extraction; sparging; combined

NA _____ (g) measurement of parameters which are pertinent to full-scale design at various radial distances from the air injection well (for example: vacuum readings; pressure readings; water elevations; dissolved oxygen; pH; conductivity)

NA _____ (h) measurement of vapor extraction system off-gas concentrations of chemicals of concern for the purpose of selecting and sizing cost-effective off-gas treatment for full-scale system

NA _____ (i) determination of soil's permeability (should be greater than 10^{-9} sq cm for sparging to be feasible)

NA _____ (j) need for plume control evaluated

NA _____ (3) full-scale design

NA _____ (a) groundwater contamination plume coverage

NA _____ 1) location(s) and radius of influence for full-scale air injection well(s)

NA _____ 2) adequate coverage by overlapping radii of influence if multiple well system

NA _____ (b) air injection well(s): no. of wells; well design; operating air pressure at wellheads; cfm each well; total cfm

NA _____ (c) avoidance of long screen allowing air to diffuse at top portion only, where air flow resistance is least (typ screen is 1 to 3 ft long)

NA _____ (d) well depth and screened interval (or depth of sparge tip) appropriate w/respect to depth of contamination

NA _____ (e) vapor extraction well(s) in conjunction w/sparging situated properly to recover volatiles and prevent their release to atmosphere

NA _____ 1) injection cfm of air typically 20 to 80% of vapor extraction cfm (0.2 to 0.8)

NA _____ 2) automatic shutdown of air injection upon loss of, or low, vapor extraction system vacuum, or failure of vacuum pump motor, in order to prevent air emissions

NA _____ 3) adequate and cost-effective treatment of vapor extraction system off-gas proposed to prevent air emissions

NA _____ (f) compressor

NA _____ 1) design: cfm @ psig; operating cfm @ psig

NA _____ 2) type; mfr; model; motor hp; rpm; performance curves; air filter at compressor inlet; oil trap or oil-free compressor to avoid introducing more contamination to aquifer

NA _____ (g) safety: pressure relief valve at discharge of compressor and/or high pressure switch for automatic shutdown

NA _____ (h) instrumentation and gauges: pressure indicating gauges at each sparging well

NA _____ (i) air flow control: shutoff/throttling valve at each well; other flow control device or method

XVII. In Situ/Enhanced Bioreclamation

NA _____ (1) pilot study [per Rule 62-770.700(2), FAC]

Section 4.5 (2) groundwater parameters (pH, DO, TDS, N, P, Temp, TOC, Alk, etc.) evaluated

Section 4.5 (3) monitoring program discussion. TOC to be monitored

NA _____ (4) additional oxygen source provision

NA _____ (5) oxygen and nutrients method of application and application rate to contaminated area evaluated

NA _____ (6) suitable soil present (non-clayey, good transport, low adsorption properties)

XVIII. Lead Removal

NA _____ (1) discussion of area(s) where groundwater lead concentration exceeds 15 ppb

NA _____ (2) lead concentrations (ppb): unfiltered (_____); filtered (_____); background (_____)

NA _____ (3) proposal for lead removal by filtration if unfiltered sample is greater than 15 ppb and filtered sample is less than 15 ppb

NA _____ (4) method of lead removal, including pertinent design calculations

XIX. Infiltration Gallery

NA _____ (1) field percolation test (preferably with double-ring infiltrometer) provided if gallery base is located in vadose zone

NA_____(2) infiltration gallery construction details and location (upgradient location if site layout allows)

NA_____(3) gallery calculations/assumptions with mounding analysis

NA_____(4) piezometer and cleanout pipe in gallery

NA_____(5) geotextile filter fabric to be installed around and above gallery

NA_____(6) discussion or modeling of gallery's effect on plume migration

XX. Injection Well

NA_____(1) discussion of injection zone and relevant lithology information

NA_____(2) injection well location and proposed construction details

NA_____(3) screened interval appropriate

NA_____(4) effluent discharge pump description, pump characteristic curve, and design flow rate (____ gpm at ____ ft TDH)

NA_____5) carbon polishing unit (or equivalent)

NA_____(6) air release valve at highest point of effluent discharge piping

NA_____(7) injection rate (well hydraulics) calculations

NA_____(8) Underground Injection Control (UIC) permit conditions met

NA_____(9) evaluation of injection well's effect on potable wells and plume migration

XXI. Alternative Effluent Disposal Methods

NA_____(1) cost-effectiveness comparison of alternatives (including general permit fee of $2,500 per year in the cost estimate for NPDES disposal, if it is one of the alternatives being compared)

NA_____(2) for surface water discharge

NA_____ (a) conditions for NPDES general permit met

NA_____ (b) indication that notice of intent for NPDES permit will be submitted after RAP approval

NA_____(3) if applicable, consumptive use permit obtained from Water Management District

NA_____(4) approval from municipality for sewer discharge, and conditions and effluent standards to be met

NA_____(5) applicable permits for stormwater discharge

XXII. Sampling Requirements

NA_____(1) designated monitoring wells and their sampling frequency [per Rule 62-770.700, FAC] highest concentrations _____; downgradient _____

NA_____(2) monthly sampling of influent from recovery well(s) for first six months, quarterly thereafter

NA_____(3) sampling of system effluent, daily for first three days, monthly for next two months, quarterly thereafter

NA_____(4) filing of annual status reports acknowledgment

NA_____(5) water-table contours and depth and extent of free product to be determined at monthly or quarterly sampling event

NA _____(6) sampling program includes appropriate chemicals of concern/procedures as specified in Rule 62-770.700, FAC

NA _____(7) periodic maintenance and site inspection limited to twice a month for first quarter and monthly thereafter, or justification for alternative frequency provided

XXIII. CHEMICAL OXIDATION

NA _____(1) general

NA _____ (a) indication of media to be remediated: groundwater; soil

NA _____ (b) application: in situ or ex situ

NA _____(2) design and technical considerations

NA _____ (a) process description, including diagrams, sketches, schematics, or flowsheets as necessary to illustrate

NA _____ (b) identification of all chemicals involved (e.g.: hydrogen peroxide; ozone; catalysts, including a breakdown of individual catalyst ingredients; etc.)

NA _____ (c) identification of the specific petroleum hydrocarbons to be oxidized

NA _____ (d) mass of the hydrocarbons to be oxidized

NA _____ (e) stoichiometry of the chemical reactions involved (or at least an indication of the amount or reactants required per pound of hydrocarbon degraded): the theoretical amount vs. the actual amount to be used in the field

NA _____ (f) description of any sidestreams, wastes, spent catalysts, effluents, air emissions, or residues remaining in the treated groundwater or soil, and the nature, volume and fate or disposition of these substances

NA _____ (g) design parameters (e.g.: permeability; radius of influence; etc.)

NA _____ (h) operational parameters (e.g.: flow rates; temperatures; pressures; pH; residence times; concentrations; total dissolved solids; etc.)

NA _____ (i) list of sampling parameters to include in the analysis of groundwater and/or soil during active remediation and post remediation monitoring periods, to track both the progress of the cleanup of chemicals of concern and the fate of any chemicals unique to the process

NA _____ (j) pilot study [per Rule 62-770.700(2), FAC]

NA _____(3) environmental and regulatory considerations (applicable items may include, but are not necessarily limited to, those listed below)

NA _____ (a) air emissions (Rule 62-770.700, FAC, applies)

NA _____ (b) identification of any special permits that may be needed

NA _____ (c) for in situ, injection type aquifer remediation processes via Class V, Group 4 aquifer remediation wells, Chapter 62-528, FAC, applies for underground injection

NA _____ 1) disclosure of complete chemical analysis of injected fluid required by law (no exceptions)

NA _____ 2) injected fluid must meet primary and secondary drinking water standards of Chapter 62-550, FAC

NA _____ 3) monitoring of appropriate injected fluid constituents required

NA _____ 4) background water quality samples, especially for parameters common to the injected fluid and the background

NA _____ 5) injection conducted in such a way that unwanted migration of both injected fluid and petroleum chemicals of concern is avoided

NA _____ 6) appropriate underground injection control inventory and design information included in Remedial Action Plan [requirements for inventory and design information are indicated in guidance memorandum "Proposed Injection Well(s) for In Situ Aquifer Remediation at a Petroleum Remedial Action Site"]

NA _____ (4) safety (applicable items may include, but are not necessarily limited to, those listed below)

NA _____ (a) material safety data sheets, toxicity, or other information pertinent to the chemicals and catalysts involved

NA _____ (b) safe handling of chemicals: avoidance of mixing, premature mixing, or improper storage of incompatible chemicals

NA _____ (c) fire and explosion safety and prevention considerations

NA _____ 1) Lower Explosive Level (LEL) considerations

NA _____ 2) potential for vapor migration, either passively or by convection, or driven by air or other gases used, or generated by the heat of exothermic chemical reactions or the vaporization of free product by such heat

NA _____ 3) the minimum tolerable distance between underground storage tanks and product piping and any in situ heat-generating process

NA _____ 4) observance of National Electrical Code (typically Series 500 articles for Class I, Group D, Division 1 or 2 hazardous area requirements)

NA _____ 5) appropriate chemical-resistant and/or spark-resistant materials of construction for equipment items

NA _____ 6) safety devices (e.g.: pressure relief valves; rupture disks; flame arrestors; etc.)

NA _____ 7) safe shutdown of systems in the event of power failure or unsafe operating conditions

NA _____ 8) personal protection of workers

NA _____ 9) safety considerations regarding adjacent neighbors and passersby

APPENDIX H

APPENDIX H

COST ESTIMATE

Project Present Value Cost Summary Report

Folder: KEY WEST

Project

Name: TPFF Key West RAP
ID: NAS Key West
Location: KEY WEST NAS, FLORIDA
Description: Remedial Action Plan, Cost Estimate for Trumbo Point Fuel Farm

Site

Name: Trumbo Point Fuel Farm
ID: TPFF
Type: None
Description:

Phase Element Type	Phase Element Name	Capital Cost	O&M Cost
Remedial Action	Excavation of Arsenic in Surfa	662,865	
Remedial Action	Excavation/Soil Washing	742,719	
Remedial Action	Land Use Controls	9,750	
Remedial Action	Monitoring Well Installation	51,581	
Remedial Action	Multi-phase Extraction	8,769	164,475
Remedial Action	Natural Attenuation	41,427	0
Remedial Action	Passive Free Product Recovery	25,795	169,055
	Site Totals	**1,542,905**	**333,530**
	Project Totals	**$1,542,905**	**$333,530**

Note: All costs are shown as "Present Value" costs
(with markups, non-escalated)

Cost Database Date: 1/1/99

Print Date: **12/13/99 11:07:39 AM**

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Project Escalated Cost Summary Report

Folder: KEY WEST

Project
Name: TPFF Key West RAP
ID: NAS Key West
Location: KEY WEST NAS, FLORIDA
Description: Remedial Action Plan, Cost Estimate for Trumbo Point Fuel Farm

Cost Category (Phase Element)	Direct Cost	Markups	Total Costs
Remedial Design	$0	$0	$0
Remedial Action (Capital)	$1,149,765	$393,140	$1,542,905
Remedial Action (O&M)	$144,483	$189,047	$333,530
Subtotal:	$1,294,249	$582,186	$1,876,435
		Escalation Dollars:	$55,717
		Total Project Cost	$1,932,152

Note: All costs are shown as "Present Value" costs **(with markups and escalation)**

Cost Database Date: 1/1/99

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Project Cost Over Time Report (With Markups)

Folder: KEY WEST

Project **Name:** TPFF Key West RAP **Location:** KEY WEST NAS, FLORIDA
ID: NAS Key West

	Site	Calendar Year 1 2000	Calendar Year 2 2001	Calendar Year 3 2002	Calendar Year 4 2003	Calendar Year 5 2004	Row Total
None	Trumbo Point Fuel Farm	1,619,482	94,638	98,878	39,904	23,533	$1,876,435
	SubTotal (With Markups)	1,619,482	94,638	98,878	39,904	23,533	$1,876,435
	Escalation Factor	1.0246	1.0427	1.0614	1.0822	1.1056	
	Grand Total (With Markups, Escalated)	$1,659,321	$98,679	$104,949	$43,184	$26,018	$1,932,151

Cost Database Date: 1/1/99

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3/36

Site Cost Over Time Report (With Markups)

Folder: KEY WEST

Project	**Name:** TPFF Key West RAP **ID:** NAS Key West	**Location:** KEY WEST NAS, FLORIDA
Site	**Name:** Trumbo Point Fuel Farm **ID:** TPFF	**Initial Date:** 8/1999

	Phase Element	Calendar Year 1 2000	Calendar Year 2 2001	Calendar Year 3 2002	Calendar Year 4 2003	Calendar Year 5 2004	Row Total
Remedial Action	Excavation of Arsenic in Surfa	662,865					$662,865
Remedial Action	Excavation/Soil Washing (Capit	742,719					$742,719
Remedial Action	Land Use Controls (Capital)	9,750					$9,750
Remedial Action	Monitoring Well Installation (	51,581					$51,581
Remedial Action	Multi-phase Extraction (Capita	8,769					$8,769
Remedial Action	Multi-phase Extraction (O&M)	54,598	54,734	55,142			$164,474
Remedial Action	Natural Attenuation (Capital)	28,108	3,330	3,330	3,330	3,330	$41,428
Remedial Action	Natural Attenuation (O&M)	0					$0
Remedial Action	Passive Free Product Recovery	25,795					$25,795

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4/36

	Phase Element	Calendar Year 1 2000	Calendar Year 2 2001	Calendar Year 3 2002	Calendar Year 4 2003	Calendar Year 5 2004	Row Total
Remedial Action	Passive Free Product Recovery	35,297	36,574	40,406	36,574	20,203	$169,054
SubTotal (With Markups)		1,619,482	94,638	98,878	39,904	23,533	$1,876,435
Escalation Factor		1.0246	1.0427	1.0614	1.0822	1.1056	
Grand Total (With Markups, Escalated)		$1,659,321	$98,679	$104,949	$43,184	$26,018	$1,932,151

Cost Database Date: 1/1/99

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5/36

Phase Element Direct Cost Summary Report

Folder: KEY WEST

Project	**Name:**	TPFF Key West RAP
	ID:	NAS Key West
	Location:	KEY WEST NAS, FLORIDA
Site	**Name:**	Trumbo Point Fuel Farm
	ID:	TPFF
	Initial Date:	8/1999

Phase Element

Name: Excavation of Arsenic in Surface Soil
Type: Remedial Action
Start Date: 1/2000

Media/Waste Type: Soil
Contaminant: Metals
Approach: Ex Situ

Description: Excavation of Arsenic Contaminated Surface Soil

Seq #	Technology	Direct Costs
1	Excavation	141,293
1	Off-site Transportation and Landfill Disposal	369,657
	Total Direct Capital Costs	**510,950**

Total Phase Element Direct Costs **$510,950**

Note: All costs are shown as "Present Value" costs
Cost Database Date: 1/1/99

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Phase Element Direct Cost Detail Report

Folder: KEY WEST

Project	**Name:** TPFF Key West RAP **ID:** NAS Key West	**Location:** KEY WEST NAS, FLORIDA
Site	**Name:** Trumbo Point Fuel Farm **ID:** TPFF	**Initial Date:** 8/1999
Phase Element	**Name:** Excavation of Arsenic in Surface Soil **Type:** Remedial Action	**Start Date:** 1/2000 **Media/Waste Type:** Soil **Contaminant:** Metals **Approach:** Ex Situ

Technology: Excavation

Task: N/A

Assembly	Description	Quantity	Units of Measure	Material Costs	Labor Costs	Equipment Costs	Extended Costs	Cost Override
33170803	Decontaminate Heavy Equipment	1.00	EA	0.00	217.68	0.00	$217.68	☐
33080584	Plastic Laminate Waste Pile Cover	63,005.28	SF	0.12	0.01	0.00	$8,499.41	☐
33021709	TAL Metals (EPA 6010/7000s), Soil Analysi	50.00	EA	334.28	0.00	0.00	$16,714.00	☐
33020401	Disposable Materials per Sample	50.00	EA	8.73	0.00	0.00	$436.32	☐
17030423	Unclassified Fill, 6" Lifts, Off-Site, Includes Delivery, Spreading, and Compaction	8,454.82	CY	4.29	0.79	1.87	$58,724.65	☐
17030418	Delivered & Dumped, Backfill with Stone	1,688.96	BCY	23.64	0.42	0.86	$42,094.62	☐
17030278	3 CY, Crawler-mounted, Hydraulic Excavatc	6,755.85	CY	0.00	0.65	1.51	$14,606.15	☐

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7/36

Phase Element	Name: Excavation of Arsenic in Surface Soil Type: Remedial Action	Start Date: 1/2000 Media/Waste Type: Soil Contaminant: Metals Approach: Ex Situ

Total Direct Cost:	$141,292.83
Total Technology Direct Costs:	$141,292.83

Comments:

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8/36

Phase Element

Name: Excavation of Arsenic in Surface Soil
Type: Remedial Action

Start Date: 1/2000
Media/Waste Type: Soil
Contaminant: Metals
Approach: Ex Situ

Technology: Off-site Transportation and Landfill Disposal

Task: N/A

Assembly	Description	Quantity	Units of Measure	Material Costs	Labor Costs	Equipment Costs	Extended Costs	Cost Override
33190211	Dump Truck Transportation Hazardous Waste 300 - 399 Miles	102,000.00	MI	2.16	0.00	0.00	$220,228.20	☐
33190102	Bulk Solid Hazardous Waste Loading Into Truck	6,800.00	CY	0.00	0.51	1.47	$13,428.64	☐
17020401	Dump Charges	6,800.00	CY	20.00	0.00	0.00	$136,000.00	☑
						Total Direct Cost:	**$369,656.84**	

Comments:

Total Technology Direct Costs: **$369,656.84**

Total Phase Element Direct Costs **$510,949.67**

Note: All costs are shown as "Present Value" costs
Cost Database Date: 1/1/99

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9/36

Phase Element Direct Cost Summary Report

Folder: KEY WEST

Project	**Name:**	TPFF Key West RAP
	ID:	NAS Key West
	Location:	KEY WEST NAS, FLORIDA
Site	**Name:**	Trumbo Point Fuel Farm
	ID:	TPFF
	Initial Date:	8/1999

Phase Element

Name: Excavation/Soil Washing
Type: Remedial Action
Start Date: 1/2000

Media/Waste Type: Soil
Contaminant: Fuels
Approach: Ex Situ

Description: Excavation of FP-16 and FP-17

Seq #	Technology	Direct Costs
1	Excavation	64,551
2	Excavation	12,327
1	Soil Washing	458,428
1	User Defined Estimate	12,604
	Total Direct Capital Costs	**547,911**

Total Phase Element Direct Costs **$547,911**

Note: All costs are shown as "Present Value" costs
Cost Database Date: 1/1/99

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Phase Element Direct Cost Detail Report

Folder: KEY WEST

Project	**Name:** TPFF Key West RAP **ID:** NAS Key West	**Location:** KEY WEST NAS, FLORIDA
Site	**Name:** Trumbo Point Fuel Farm **ID:** TPFF	**Initial Date:** 8/1999
Phase Element	**Name:** Excavation/Soil Washing **Type:** Remedial Action	**Start Date:** 1/2000 **Media/Waste Type:** Soil **Contaminant:** Fuels **Approach:** Ex Situ

Technology: Excavation

Task: N/A

Assembly	Description	Quantity	Units of Measure	Material Costs	Labor Costs	Equipment Costs	Extended Costs	Cost Override
17030415	Backfill with Excavated Material	9,964.96	CY	0.31	1.90	0.70	$28,964.15	☐
17030418	Delivered & Dumped, Backfill with Stone	668.15	BCY	23.64	0.42	0.86	$16,652.57	☐
33170803	Decontaminate Heavy Equipment	1.00	EA	0.00	217.68	0.00	$217.68	☐
17030278	3 CY, Crawler-mounted, Hydraulic Excavatc	8,657.19	CY	0.00	0.65	1.51	$18,716.85	☐
						Total Direct Cost:	**$64,551.24**	

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11/36

Phase Element	Name: Excavation/Soil Washing Type: Remedial Action	Start Date: 1/2000 Media/Waste Type: Soil Contaminant: Fuels Approach: Ex Situ

Comments:

Total Technology Direct Costs:	$64,551.24

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12/36

Phase Element

Name: Excavation/Soil Washing
Type: Remedial Action

Start Date: 1/2000
Media/Waste Type: Soil
Contaminant: Fuels
Approach: Ex Situ

Technology: Soil Washing

Task: N/A

Assembly	Description	Quantity	Units of Measure	Material Costs	Labor Costs	Equipment Costs	Extended Costs	Cost Override
17030510	Dry Roll Gravel, Steel Roller	2,800.00	SY	0.00	0.33	0.14	$1,316.84	☐
33130916	Assemble/Disassemble Soil Washing System	2.00	EA	0.00	15,510.80	7,553.08	$46,127.76	☐
33130915	Mobilize/Demobilize Soil Washing System	4,000.00	MI	2.39	0.00	0.00	$9,579.60	☐
33090702	CIP, Reinforced Concrete Containment Wa Including Forms	12.04	CY	145.71	272.84	0.43	$5,044.47	☐
19040625	6,000 Gallon Horizontal Plastic Sump with 6 NPT Connection	2.00	EA	4,533.64	432.51	0.00	$9,932.30	☐
19040407	21,000 Gallon, Steel Closed Stationary Aboveground Wastewater Holding Tank, Rental	4.00	MO	1,249.44	0.00	0.00	$4,997.76	☐
33130918	Decontaminate Soil Washing System	20.00	EA	0.00	187.04	0.00	$3,740.80	☐
18010102	Gravel, Delivered & Dumped	622.22	CY	19.70	1.39	1.50	$14,055.95	☐
33130922	50 Tons per Hour Soil Washing System, Monthly Rental	2.00	MO	107,764.20	0.00	0.00	$215,528.39	☐
17030347	Standby, 926, 2.0 CY Wheel Loader	44.00	HR	0.00	0.00	10.12	$445.44	☐
17030222	926, 2.0 CY, Wheel Loader	120.00	HR	0.00	25.54	39.37	$7,789.38	☐
17030109	Pad Subgrade Preparation	622.22	CY	0.00	1.20	2.25	$2,145.23	☐
19020313	5' x 5' x 5' Reinforced Concrete Sump	2.00	EA	1,356.02	1,013.48	80.45	$4,899.90	☐
33330125	Alkylbenzene Sulfonate Surfactant, Bulk	24,000.00	LB	1.22	0.00	0.00	$29,198.40	☐

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13/36

Phase Element

Name: Excavation/Soil Washing
Type: Remedial Action

Start Date: 1/2000
Media/Waste Type: Soil
Contaminant: Fuels
Approach: Ex Situ

33420302	Process Water, Supplied by Water Line	360.00	KGAL	2.90	0.00	0.00	$1,044.76	☐
33130917	Startup/Shakedown - Soil Washing System	1.00	EA	0.00	13,521.95	0.00	$13,521.95	☐
33330127	Non-ionic Polymeric Flocculant	4,800.00	LB	3.41	0.00	0.00	$16,389.12	☐
33290412	15 GPM Submersible Sump Pump	2.00	EA	783.64	51.65	0.00	$1,670.57	☐
33231306	High Sump Level Switch for Avoiding Overflow	2.00	EA	175.36	106.50	0.00	$563.72	☐
33197105	Non-Radioactive Process Water Treatment/Disposal, Subcontracted	15,000.00	GAL	1.14	0.00	0.00	$17,164.50	☐
33197103	Process Water Hauling Fee, Subcontracted	15,000.00	GAL	0.27	0.00	0.00	$4,071.00	☐
33130928	Maintenance/Spare Parts, 50 Tons per Hour System	6,000.00	TON	1.49	0.00	0.00	$8,919.00	☐
33130923	Operational Labor, 50 Tons per Hour Systei	138.00	HR	0.00	270.44	0.00	$37,320.58	☐
33420101	Electrical Charge	45,000.00	KWH	0.07	0.00	0.00	$2,961.00	☐

Total Direct Cost: **$458,428.42**

Total Technology Direct Costs: **$458,428.42**

Comments:

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14/36

Phase Element

Name: Excavation/Soil Washing
Type: Remedial Action

Start Date: 1/2000
Media/Waste Type: Soil
Contaminant: Fuels
Approach: Ex Situ

Technology: User Defined Estimate

Task: N/A

Assembly	Description	Quantity	Units of Measure	Material Costs	Labor Costs	Equipment Costs	Extended Costs	Cost Override
20020105	12.47 KV - 120/240V, 1, 50 KV, Oil, Pad-mounted Transformer	4.00	EA	2,416.68	394.81	19.98	$11,325.88	☐
20020522	15 KV, 350 MCM, Shielded Cable, Copper	200.00	LF	5.04	1.10	0.25	$1,278.06	☐
						Total Direct Cost:	**$12,603.94**	

Total Technology Direct Costs: **$12,603.94**

Comments:
Relocation of electrical lines and transformers.

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15/36

Phase Element

Name: Excavation/Soil Washing
Type: Remedial Action

Start Date: 1/2000
Media/Waste Type: Soil
Contaminant: Fuels
Approach: Ex Situ

Technology: Excavation

Task: N/A

Assembly	Description	Quantity	Units of Measure	Material Costs	Labor Costs	Equipment Costs	Extended Costs	Cost Override
33170803	Decontaminate Heavy Equipment	1.00	EA	0.00	217.68	0.00	$217.68	☐
17030277	2 CY, Crawler-mounted, Hydraulic Excavatc	1,573.96	CY	0.00	0.64	1.57	$3,467.43	☐
17030415	Backfill with Excavated Material	1,819.26	CY	0.31	1.90	0.70	$5,287.86	☐
17030418	Delivered & Dumped, Backfill with Stone	134.59	BCY	23.64	0.42	0.86	$3,354.44	☐

Total Direct Cost: **$12,327.41**

Comments:

Total Technology Direct Costs: **$12,327.41**

Total Phase Element Direct Costs **$547,911.01**

Note: All costs are shown as "Present Value" costs
Cost Database Date: 1/1/99

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16/36

Phase Element Direct Cost Summary Report

Folder: KEY WEST

Project	**Name:**	TPFF Key West RAP
	ID:	NAS Key West
	Location:	KEY WEST NAS, FLORIDA
Site	**Name:**	Trumbo Point Fuel Farm
	ID:	TPFF
	Initial Date:	8/1999

Phase Element

Name: Land Use Controls
Type: Remedial Action
Start Date: 1/2000

Media/Waste Type: N/A
Contaminant: Fuels
Approach: None

Description:

Seq #	Technology	Direct Costs
1	User Defined Estimate	9,750
	Total Direct Capital Costs	**9,750**

Total Phase Element Direct Costs **$9,750**

Note: All costs are shown as "Present Value" costs
Cost Database Date: 1/1/99

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Phase Element Direct Cost Detail Report

Folder: KEY WEST

Project	**Name:** TPFF Key West RAP **ID:** NAS Key West	**Location:** KEY WEST NAS, FLORIDA
Site	**Name:** Trumbo Point Fuel Farm **ID:** TPFF	**Initial Date:** 8/1999

Phase Element

Name: Land Use Controls
Type: Remedial Action

Start Date: 1/2000
Media/Waste Type: N/A
Contaminant: Fuels
Approach: None

Technology: User Defined Estimate

Task: N/A

Assembly	Description	Quantity	Units of Measure	Material Costs	Labor Costs	Equipment Costs	Extended Costs	Cost Override
33220150	User Defined Labor Cost 01	65.00	HR	0.00	150.00	0.00	$9,750.00	☑

Total Direct Cost: $9,750.00

Total Technology Direct Costs: $9,750.00

Comments:
Land Use Controls

Total Phase Element Direct Costs $9,750.00

Note: All costs are shown as "Present Value" costs
Cost Database Date: 1/1/99

Print Date: 12/13/99 11:21:48 AM

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18/36

Phase Element Direct Cost Summary Report

Folder: KEY WEST

Project	**Name:**	TPFF Key West RAP
	ID:	NAS Key West
	Location:	KEY WEST NAS, FLORIDA
Site	**Name:**	Trumbo Point Fuel Farm
	ID:	TPFF
	Initial Date:	8/1999

Phase Element

Name: Monitoring Well Installation
Type: Remedial Action
Start Date: 1/2000

Media/Waste Type: Groundwater
Contaminant: Fuels
Approach: None

Description: Monitoring wells (13) for free product recovery.

Seq #	Technology	Direct Costs
1	Groundwater Monitoring Well	35,388
	Total Direct Capital Costs	**35,388**

Total Phase Element Direct Costs **$35,388**

Note: All costs are shown as "Present Value" costs
Cost Database Date: 1/1/99

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Phase Element Direct Cost Detail Report

Folder: KEY WEST

Project	**Name:** TPFF Key West RAP **ID:** NAS Key West	**Location:** KEY WEST NAS, FLORIDA
Site	**Name:** Trumbo Point Fuel Farm **ID:** TPFF	**Initial Date:** 8/1999
Phase Element	**Name:** Monitoring Well Installation **Type:** Remedial Action	**Start Date:** 1/2000 **Media/Waste Type:** Groundwater **Contaminant:** Fuels **Approach:** None

Technology: Groundwater Monitoring Well

Task: Aquifer 1

Assembly	Description	Quantity	Units of Measure	Material Costs	Labor Costs	Equipment Costs	Extended Costs	Cost Override
33021776	BTEX/MTBE/TVPH (EPA 8020/8015 Mod), Soil Analysis	15.00	EA	73.07	0.00	0.00	$1,096.05	☐
33020303	Organic Vapor Analyzer Rental, per Day	10.00	DAY	109.60	0.00	0.00	$1,096.00	☐
33230101	2" PVC, Schedule 40, Well Casing	120.00	LF	1.08	1.84	3.60	$781.87	☐
33220112	Field Technician	75.00	HR	0.00	13.55	0.00	$1,016.11	☐
33170808	Decontaminate Rig, Augers, Screen (Renta Equipment)	3.00	DAY	143.59	0.00	0.00	$430.76	☐
33022150	BTEX/MTBE/TVPH (EPA 8020/8015 Mod), Water Analysis	15.00	EA	115.08	0.00	0.00	$1,726.20	☐

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20/36

Phase Element

Name: Monitoring Well Installation
Type: Remedial Action

Start Date: 1/2000
Media/Waste Type: Groundwater
Contaminant: Fuels
Approach: None

33230301	2" PVC, Well Plug	15.00	EA	5.24	2.75	5.40	$200.96	☐
33022134	Polynuclear Aromatic Hydrocarbons,PAH (SW 3510/SW 8310), Water Analysis	15.00	EA	206.41	0.00	0.00	$3,096.15	☐
33231101	Hollow Stem Auger, 8" Dia Borehole, Depth <= 100 ft	210.00	LF	0.00	5.03	9.88	$3,131.54	☐
33021732	Total Petroleum Hydrocarbons (SW 5030/SW 8015), Soil Analysis	15.00	EA	80.37	0.00	0.00	$1,205.55	☐
33021722	Polynuclear Aromatic Hydrocarbons(PAH) (SW 8310),w/prep, Soil Analysis	15.00	EA	115.08	0.00	0.00	$1,726.20	☐
33021694	Total Petroleum Hydrocarbons (SW8015), Water Analysis	15.00	EA	73.07	0.00	0.00	$1,096.05	☐
33021604	Total Suspended Solids (EPA 160.2), Wate Analysis	15.00	EA	11.12	0.00	0.00	$166.87	☐
33021603	Total Dissolved Solids (EPA 160.1), Water Analysis	15.00	EA	13.15	0.00	0.00	$197.28	☐
33021102	Soil Moisture Content ASTM D2216	15.00	EA	22.47	0.00	0.00	$337.02	☐
33022140	Ethylene Dibromide (EDB) (EPA 501.4)	15.00	EA	85.85	0.00	0.00	$1,287.75	☐
33231172	Split Spoon Sample, 2" x 24", During Drilling	45.00	EA	39.12	0.00	0.00	$1,760.40	☐
33231178	Move Rig/Equipment Around Site	15.00	EA	54.69	79.16	155.36	$4,338.01	☐
33231182	Furnish 55 Gallon Drum for Drill Cuttings & Development Water	15.00	EA	79.16	0.00	0.00	$1,187.46	☐
33231401	2" Screen, Filter Pack	105.00	LF	2.80	1.56	3.06	$778.94	☐
33231811	2" Well, Portland Cement Grout	75.00	LF	1.04	0.00	0.00	$78.10	☐
33232101	2" Well, Bentonite Seal	15.00	EA	8.31	6.19	12.16	$399.95	☐
33230201	2" PVC, Schedule 40, Well Screen	75.00	LF	2.49	2.37	4.65	$712.70	☐
					Total Direct Cost:		**$27,847.92**	

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21/36

Phase Element

Name: Monitoring Well Installation
Type: Remedial Action

Start Date: 1/2000
Media/Waste Type: Groundwater
Contaminant: Fuels
Approach: None

Task: General Aquifers

Assembly	Description	Quantity	Units of Measure	Material Costs	Labor Costs	Equipment Costs	Extended Costs	Cost Override
33010101	Mobilize/DeMobilize Drilling Rig & Crew	1.00	LS	0.00	550.64	1,080.74	$1,631.39	☐
33232422	Suspension Cable, Teflon Coated	244.00	FT	1.40	0.00	0.00	$342.31	☐
33232421	Emptying Stand (1-7/8" Outside Diameter)	1.00	EA	392.72	0.00	0.00	$392.72	☐
33232407	Disposable Bailer, Polyethylene, 1.5" Outside Diameter x 36"	15.00	EA	11.77	0.00	0.00	$176.57	☐
33231504	Surface Pad, Concrete, 2' x 2' x 4"	15.00	EA	36.99	57.21	4.08	$1,474.24	☐
33231193	Well Development Equipment Rental (Daily	4.00	DAY	136.23	0.00	0.00	$544.93	☐
33020405	Monitoring Well Slug Testing Equipment Rental	3.00	WK	591.84	0.00	0.00	$1,775.52	☐
33232423	Hand Reel	1.00	EA	14.55	0.00	0.00	$14.55	☐
33231189	Furnish 55 Gallon Drum for Development/Purge Water	15.00	EA	79.16	0.00	0.00	$1,187.46	☐

Total Direct Cost: **$7,539.68**

Comments:
Monitoring well installation for free product recovery.

Total Technology Direct Costs: **$35,387.60**

Total Phase Element Direct Costs **$35,387.60**

Note: All costs are shown as "Present Value" costs
Cost Database Date: 1/1/99

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22/36

Phase Element Direct Cost Summary Report

Folder: KEY WEST

Project	**Name:**	TPFF Key West RAP
	ID:	NAS Key West
	Location:	KEY WEST NAS, FLORIDA
Site	**Name:**	Trumbo Point Fuel Farm
	ID:	TPFF
	Initial Date:	8/1999

Phase Element

Name: Multi-phase Extraction
Type: Remedial Action
Start Date: 1/2000

Media/Waste Type: Free Product
Contaminant: Fuels
Approach: Ex Situ

Description: Vacuum Truck Extraction of Free Product

Seq #	Technology	Direct Costs
1	Free Product Removal	6,328
	Total Direct Capital Costs	**6,328**
0	Operations and Maintenance	74,241
	Total Direct O&M Costs	**74,241**
	Total Phase Element Direct Costs	**$80,569**

Note: All costs are shown as "Present Value" costs
Cost Database Date: 1/1/99

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Phase Element Direct Cost Detail Report

Folder: KEY WEST

Project	**Name:** TPFF Key West RAP **ID:** NAS Key West	**Location:** KEY WEST NAS, FLORIDA
Site	**Name:** Trumbo Point Fuel Farm **ID:** TPFF	**Initial Date:** 8/1999
Phase Element	**Name:** Multi-phase Extraction **Type:** Remedial Action	**Start Date:** 1/2000 **Media/Waste Type:** Free Product **Contaminant:** Fuels **Approach:** Ex Situ

Technology: Free Product Removal

Task: N/A

Assembly	Description	Quantity	Units of Measure	Material Costs	Labor Costs	Equipment Costs	Extended Costs	Cost Override
33310214	Air Compressor, 20 CFM	1.00	EA	874.61	0.00	0.00	$874.61	☐
33260101	1" Carbon Steel Piping	56.00	LF	0.90	2.34	0.08	$185.96	☐
33230807	Product Recovery Pump, Shallow Depths (<=20 ft), 6 gpm, Controls & Compressor, Pneumatic	1.00	EA	3,332.01	319.50	0.00	$3,651.51	☐
33109656	550 Gallon Single-wall Steel Aboveground Tank	1.00	EA	1,265.88	327.67	0.00	$1,593.55	☐
33020561	Nylon Tubing, 1/4" Outside Diameter	56.00	LF	0.39	0.00	0.00	$22.10	☐

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24/36

Phase Element	Name: Multi-phase Extraction Type: Remedial Action	Start Date: 1/2000 Media/Waste Type: Free Product Contaminant: Fuels Approach: Ex Situ

Total Direct Cost:	**$6,327.72**
Total Technology Direct Costs:	**$6,327.72**

Comments:
vacuum truck free product recovery

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25/36

Phase Element

Name: Multi-phase Extraction
Type: Remedial Action

Start Date: 1/2000
Media/Waste Type: Free Product
Contaminant: Fuels
Approach: Ex Situ

Technology: Operations and Maintenance (12 - months only)

Task: Miscellaneous

Assembly	Description	Quantity	Units of Measure	Material Costs	Labor Costs	Equipment Costs	Extended Costs	Cost Override
99020110	Annual Maintenance Materials and Labor	1.00	LS	25.31	25.31	12.66	$63.28	☑
33220112	Field Technician	588.00	HR	0.00	13.55	0.00	$7,966.28	☐
33220106	Staff Engineer	144.00	HR	0.00	24.76	0.00	$3,565.99	☐
33199921	DOT Steel Drum, 55 Gallon	3.00	EA	79.16	0.00	0.00	$237.49	☐
33190340	Non Haz Drummed Site Waste - Load, Transp, & Landfill Disp (55-Gal Drums)	3.00	EA	199.55	0.00	0.00	$598.66	☐
33010425	Disposable Coveralls (Tyvek)	120.00	EA	4.34	0.00	0.00	$520.98	☐
33010423	Disposable Gloves (Latex)	120.00	PAIR	0.16	0.00	0.00	$19.73	☐
33010204	Mobilize Crew, 100 Miles, per Person	1.00	EA	82.20	0.00	0.00	$82.20	☐
33010202	Per Diem (per person)	18.00	DAY	107.96	0.00	0.00	$1,943.21	☐
					Total Direct Cost:		**$14,997.82**	

Task: Free Product Removal

Assembly	Description	Quantity	Units of Measure	Material Costs	Labor Costs	Equipment Costs	Extended Costs	Cost Override
33190341	Free Product Disposal	36,850.00	GAL	0.27	0.00	0.00	$10,096.90	☐
					Total Direct Cost:		**$10,096.90**	

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26/36

Phase Element	Name: Multi-phase Extraction Type: Remedial Action	Start Date: 1/2000 Media/Waste Type: Free Product Contaminant: Fuels Approach: Ex Situ

Comments:
Operations and Maintenance

Total Technology Direct Costs:	**$25,094.72**
Total Phase Element Direct Costs	**$31,422.44**

Note: All costs are shown as "Present Value" costs
Cost Database Date: 1/1/99

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27/36

28/36

Phase Element Direct Cost Summary Report

Folder: KEY WEST

Project	**Name:**	TPFF Key West RAP
	ID:	NAS Key West
	Location:	KEY WEST NAS, FLORIDA
Site	**Name:**	Trumbo Point Fuel Farm
	ID:	TPFF
	Initial Date:	8/1999

Phase Element

Name: Natural Attenuation
Type: Remedial Action
Start Date: 1/2000

Media/Waste Type: Groundwater
Contaminant: Fuels
Approach: In Situ

Description: Monitored Natural Attenuation

Seq #	Technology	Direct Costs
1	Natural Attenuation	16,563
1	Professional Labor - RA	4,720
	Total Direct Capital Costs	**21,283**
0	Operations and Maintenance	0
	Total Direct O&M Costs	**0**
	Total Phase Element Direct Costs	**$21,283**

Note: All costs are shown as "Present Value" costs
Cost Database Date: 1/1/99

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Phase Element Direct Cost Detail Report

Folder: KEY WEST

Project	**Name:** TPFF Key West RAP **ID:** NAS Key West	**Location:** KEY WEST NAS, FLORIDA
Site	**Name:** Trumbo Point Fuel Farm **ID:** TPFF	**Initial Date:** 8/1999
Phase Element	**Name:** Natural Attenuation **Type:** Remedial Action	**Start Date:** 1/2000 **Media/Waste Type:** Groundwater **Contaminant:** Fuels **Approach:** In Situ

Technology: Natural Attenuation (12 - months only)

Task: Groundwater

Assembly	Description	Quantity	Units of Measure	Material Costs	Labor Costs	Equipment Costs	Extended Costs	Cost Override
33022139	BTEX/MTBE (Mod EPA 602), Water Analysis	27.00	EA	87.68	0.00	0.00	$2,367.36	☐
33020402	Decontamination Materials per Sample	27.00	EA	10.12	0.00	0.00	$273.13	☐
33020561	Nylon Tubing, 1/4" Outside Diameter	169.00	LF	0.39	0.00	0.00	$66.69	☐
33021509	Water Quality Parameter Testing Device	1.00	WK	233.81	0.00	0.00	$233.81	☐
33021603	Total Dissolved Solids (EPA 160.1), Water Analysis	27.00	EA	13.15	0.00	0.00	$355.10	☐
33021608	Nitrogen/Nitrite/Nitrate (EPA 300.1/354.1), Water Analysis	27.00	EA	23.77	0.00	0.00	$641.85	☐

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29/36

Phase Element **Name:** Natural Attenuation
Type: Remedial Action

Start Date: 1/2000
Media/Waste Type: Groundwater
Contaminant: Fuels
Approach: In Situ

33020401	Disposable Materials per Sample	27.00	EA	8.73	0.00	0.00	$235.61	☐
33021667	Sulfate (EPA 375.4), Water Analysis	27.00	EA	16.99	0.00	0.00	$458.68	☐
33022143	Lead (SW 3005/SW 7421), Water Analysis	27.00	EA	45.67	0.00	0.00	$1,233.10	☐
33230509	4" Submersible Pump Rental, Day	3.00	DAY	72.44	0.00	0.00	$217.31	☐
33021653	Chloride (EPA 300), Water Analysis	27.00	EA	18.27	0.00	0.00	$493.30	☐
					Total Direct Cost:		**$6,575.94**	

Task: General

Assembly	Description	Quantity	Units of Measure	Material Costs	Labor Costs	Equipment Costs	Extended Costs	Cost Override
33010104	Car or Van Mileage Charge	360.00	MI	0.50	0.00	0.00	$181.51	☐
33010202	Per Diem (per person)	6.00	DAY	107.96	0.00	0.00	$647.74	☐
33220108	Project Scientist	6.00	HR	0.00	24.10	0.00	$144.62	☐
33220112	Field Technician	54.00	HR	0.00	13.55	0.00	$731.60	☐
					Total Direct Cost:		**$1,705.46**	

Comments:
Natural attenuation sampling at Key West Pipeline area.

Total Technology Direct Costs: **$8,281.40**

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30/36

Phase Element

Name: Natural Attenuation
Type: Remedial Action

Start Date: 1/2000
Media/Waste Type: Groundwater
Contaminant: Fuels
Approach: In Situ

Technology: Professional Labor - RA

Task: Professional Labor Percentage

Assembly	Description	Quantity	Units of Measure	Material Costs	Labor Costs	Equipment Costs	Extended Costs	Cost Override
33220149	Lump Sum Percentage Labor Cost	1.00	LS	0.00	4,720.40	0.00	$4,720.40	☑

Total Direct Cost: $4,720.40

Comments:

Total Technology Direct Costs: $4,720.40

Total Phase Element Direct Costs $13,001.80

Note: All costs are shown as "Present Value" costs
Cost Database Date: 1/1/99

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31/36

Phase Element Direct Cost Summary Report

Folder: KEY WEST

Project	**Name:**	TPFF Key West RAP
	ID:	NAS Key West
	Location:	KEY WEST NAS, FLORIDA
Site	**Name:**	Trumbo Point Fuel Farm
	ID:	TPFF
	Initial Date:	8/1999

Phase Element

Name: Passive Free Product Recovery
Type: Remedial Action
Start Date: 1/2000

Media/Waste Type: Free Product
Contaminant: Fuels
Approach: Ex Situ

Description: In-well Passive Free Product Removal

Seq #	Technology	Direct Costs
1	Free Product Removal	18,156
	Total Direct Capital Costs	**18,156**
0	Operations and Maintenance	70,242
	Total Direct O&M Costs	**70,242**
	Total Phase Element Direct Costs	**$88,398**

Note: All costs are shown as "Present Value" costs
Cost Database Date: 1/1/99

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Phase Element Direct Cost Detail Report

Folder: KEY WEST

Project	**Name:** TPFF Key West RAP **ID:** NAS Key West	**Location:** KEY WEST NAS, FLORIDA
Site	**Name:** Trumbo Point Fuel Farm **ID:** TPFF	**Initial Date:** 8/1999
Phase Element	**Name:** Passive Free Product Recovery **Type:** Remedial Action	**Start Date:** 1/2000 **Media/Waste Type:** Free Product **Contaminant:** Fuels **Approach:** Ex Situ

Technology: Free Product Removal

Task: N/A

Assembly	Description	Quantity	Units of Measure	Material Costs	Labor Costs	Equipment Costs	Extended Costs	Cost Override
33109656	550 Gallon Single-wall Steel Aboveground Tank	1.00	EA	1,265.88	327.67	0.00	$1,593.55	☐
33020561	Nylon Tubing, 1/4" Outside Diameter	140.00	LF	0.39	0.00	0.00	$55.24	☐
33230804	Product Recovery Pump, 2" Oil Skimmer, 360 GPD, Controls & Compressor, Pneumatic	15.00	EA	750.00	319.50	0.00	$16,042.55	☑
33260101	1" Carbon Steel Piping	140.00	LF	0.90	2.34	0.08	$464.90	☐
					Total Direct Cost:		**$18,156.24**	

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33/36

Phase Element	Name: Passive Free Product Recovery Type: Remedial Action	Start Date: 1/2000 Media/Waste Type: Free Product Contaminant: Fuels Approach: Ex Situ

Comments:
Passive in-well free product recovery using skimmers.

Total Technology Direct Costs:	$18,156.24

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34/36

Phase Element

Name: Passive Free Product Recovery
Type: Remedial Action

Start Date: 1/2000
Media/Waste Type: Free Product
Contaminant: Fuels
Approach: Ex Situ

Technology: Operations and Maintenance (12 - months only)

Task: Miscellaneous

Assembly	Description	Quantity	Units of Measure	Material Costs	Labor Costs	Equipment Costs	Extended Costs	Cost Override
33010202	Per Diem (per person)	36.00	DAY	107.96	0.00	0.00	$3,886.42	☐
33220112	Field Technician	216.00	HR	0.00	13.55	0.00	$2,926.39	☐
33199921	DOT Steel Drum, 55 Gallon	3.00	EA	79.16	0.00	0.00	$237.49	☐
33190340	Non Haz Drummed Site Waste - Load, Transp, & Landfill Disp (55-Gal Drums)	3.00	EA	199.55	0.00	0.00	$598.66	☐
33010425	Disposable Coveralls (Tyvek)	93.00	EA	4.34	0.00	0.00	$403.76	☐
33010423	Disposable Gloves (Latex)	93.00	PAIR	0.16	0.00	0.00	$15.29	☐
33010204	Mobilize Crew, 100 Miles, per Person	1.00	EA	82.20	0.00	0.00	$82.20	☐
99020110	Annual Maintenance Materials and Labor	1.00	LS	218.85	218.85	109.43	$547.13	☑
					Total Direct Cost:		**$8,697.34**	

Task: Free Product Removal

Assembly	Description	Quantity	Units of Measure	Material Costs	Labor Costs	Equipment Costs	Extended Costs	Cost Override
33190341	Free Product Disposal	1,801.00	GAL	0.27	0.00	0.00	$493.47	☐
33220106	Staff Engineer	62.00	HR	0.00	24.76	0.00	$1,535.36	☐
33420101	Electrical Charge	422.00	KWH	0.07	0.00	0.00	$27.77	☐
33220112	Field Technician	308.00	HR	0.00	13.55	0.00	$4,172.81	☐

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35/36

Phase Element

Name: Passive Free Product Recovery
Type: Remedial Action

Start Date: 1/2000
Media/Waste Type: Free Product
Contaminant: Fuels
Approach: Ex Situ

Total Direct Cost:	**$6,229.41**
Total Technology Direct Costs:	**$14,926.75**
Total Phase Element Direct Costs	**$33,082.99**

Comments:
Operations and Maintenance

Note: All costs are shown as "Present Value" costs
Cost Database Date: 1/1/99

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36/36

TABLE X-1

DIRECT CONTACT WITH AND INCIDENTAL INGESTION OF SUBSURFACE SOIL
EXCAVATION WORKER
TRUMBO FUEL FARM RBCA
NAS KEY WEST
PIER D-1 SUBSURFACE

15-Nov-98

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SOIL	CS	chemical-specific	chemical-specific	
INGESTION RATE	IR	480	mg/day	USEPA, 1995
FRACTION INGESTED	FI	100%	unitless	Assumption
ADHERENCE FACTOR	AF	1	mg/cm²-event	USEPA, 1995
ABSORPTION FRACTION	ABS	chemical-specific	unitless	USEPA, 1995
SURFACE AREA EXPOSED	SA	5,750	cm²	USEPA, 1992
DOSE ABSORBED PER EVENT	DA_{event}	chemical-specific	mg/cm²-event	USEPA, 1992
CONVERSION FACTOR	CF	1.00E-09	kg/ug	Organic conversion
CONVERSION FACTOR	CF	1.00E-06	kg/mg	Inorganic conversion
BODY WEIGHT	BW	70	kg	USEPA, 1991
EXPOSURE FREQUENCY	EF	30	days/year [1]	Assumption
EXPOSURE DURATION	ED	1	years	USEPA, 1991
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	1	years	USEPA, 1991

[1] Units for exposure frequency are events/year in the calculation of the dermally absorbed dose.
USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors"; OSWER Directive 9285.6-03.
USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B; January 1992.
USEPA, 1995. Supplemental Guidance to RAGS : Region IV, Human Health Risk Assessment Bulletin No. 3.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR $(mg/kg\text{-}day)^{-1}$

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$INTAKE_{-INGESTION} = \frac{CS \times IR \times FI \times CF \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

$$INTAKE_{-DERMAL} = \frac{DAevent \times SA \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

Where:

$$DA_{event} = CS \times AF \times ABS \times CF$$

Note: For noncarcinogenic effects, AT = ED

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL CSF $(mg/kg\text{-}day)^{-1}$	CANCER RISK INGESTION	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	DERMAL CSF [2] $(mg/kg\text{-}day)^{-1}$	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	I	3.9	mg/kg	3.1E-08	1.5	4.7E-08	0.001	3.8E-10	1.79	6.7E-10	4.8E-08
SUMMARY CANCER RISK						5E-08				7E-10	5E-08

[1] USEPA Region IV guidance specifies absorption factors of 1% for organics and 0.1% for inorganics (November 1995).
[2] Calculated from oral CSFs.
NE = not evaluated.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	DERMAL RfD [2] (mg/kg-day)	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	I	3.9	mg/kg	2.2E-06	0.0003	7.3E-03	0.001	2.6E-08	0.000294	9.0E-05	7.4E-03
SUMMARY HAZARD INDEX						0.01				9.0E-05	0.01

[1] USEPA Region IV guidance specifies absorption factors of 1% for organics and 0.1% for inorganics (November 1995).
[2] Calculated from oral RfDs.
ND = no data available.

TABLE X-2

INHALATION OF PARTICULATES - SUBSURFACE SOIL
TRUMBO FUEL FARM RBCA
NAS KEY WEST
PIER D-1 SUBSURFACE

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
SOIL CONCENTRATION	C	chemical-specific	chemical-specific	
PART. EMISSION FACTOR	PEF	12000000	m^3/kg	
CONCENTRATION AIR	CA	chemical-specific	mg/m^3	
INHALATION RATE	IR	2.5	m^3/hour	USEPA, 1995
BODY WEIGHT	BW	70	kg	USEPA, 1991
EXPOSURE TIME	ET	8	hours/day	Assumption
EXPOSURE FREQUENCY	EF	30	days/year	Assumption
EXPOSURE DURATION	ED	1	years	Assumption
CONVERSION FACTOR	CF	0.001	mg/ug	Organics only
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	1	years	USEPA, 1991

[1] PEF has been derived in the PEF Appendix to this report.
USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance.
Standard Default Exposure Factors; OSWER Directive 9285.6-03.
USEPA, 1995. Supplemental Guidance to RAGS : Region IV, Human Health Risk Assessment Bulletin No. 3.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x INHALATION CANCER SLOPE FACTOR (mg/kg-day)$^{-1}$

'HAZARD QUOTIENT = INTAKE (mg/kg-day) / INHALATION REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE} = \frac{\text{CA x IR x ET x EF x ED}}{\text{BW x AT x 365 days/yr}}$$

Where:

CA = C x CF x (1/PEF)

Note: For noncarcinogens, AT = ED.

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	AIR CONCENTRATION (mg/m^3)	INTAKE (mg/kg-day)	INHALATION CSF (mg/kg-day)^-1	CANCER RISK
Arsenic	I	3.9	mg/kg	3.25E-07	1.1E-10	50	5.5E-09
					SUMMARY CANCER RISK		5E-09

NE = not evaluated.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	AIR CONCENTRATION (mg/m^3)	INTAKE (mg/kg-day)	INHALATION RfD (mg/kg-day)	HAZARD QUOTIENT
Arsenic	I	3.9	mg/kg	3.25E-07	7.6E-09	ND	
					SUMMARY HAZARD INDEX		0E+00

ND = no data available.

TABLE X-3

INCIDENTAL INGESTION OF AND DIRECT CONTACT WITH GROUNDWATER (SITE WORKER)
SITE WORKER (NON-POTABLE GROUNDWATER)
TRUMBO POINT FUEL FARM RBCA
NAS KEY WEST
PIER D-1

15-Nov-98

OCTOBER 1998

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical-specific	ug/liter	
INGESTION RATE [1]	IR	0.026	liters/day	USEPA, 1995
SURFACE AREA [2]	SA	3,120	cm2	USEPA, 1989
EVENT FREQUENCY	EV	1	events/day	Assumption
BODY WEIGHT	BW	70	kg	USEPA, 1991
DOSE ABSORBED PER EVENT	DAevent	chemical-specific	mg/cm2-event	Calculated
EXPOSURE TIME	ET	0.33	hours/day	Assumption
EXPOSURE FREQUENCY	EF	250	days/year	Assumption
EXPOSURE DURATION	ED	25	years	Assumption
DIFFUSION DEPTH PER EVENT	PCevent	chemical-specific	cm/event	Calculated per USEPA, 1992 [3]
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	25	years	USEPA, 1995
CONVERSION FACTOR	CF1	0.001	mg/ug	
CONVERSION FACTOR	CF2	0.001	liter/cm3	

[1] Ingestion Rate = 0.026 l/day = 10 ml/hour x 2.6 hours/day x 0.001 l/ml
[2] Surface area assumes hands and arms are exposed.
[3] PCevent is calculated in Appendix ?
USEPA, 1989. Exposure Factors Handbook; EPA/600/8-89/043; May 1989.
USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters."
USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B.
USEPA, 1995. Supplemental Guidance to RAGS: Region 4 Bulletins, Bulletin No. 3, November 1995.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times EF \times ED \times CF1}{BW \times AT \times 365\ \text{days/yr}}$$

$$\text{INTAKE-DERMAL} = \frac{DAevent \times EV \times EF \times ED \times SA}{AT \times BW \times 365\ \text{days/yr}}$$

Where:
DAevent = PCevent x CW x CF1 x CF2

Note: For noncarcinogenic effects, AT = ED.

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	WATER CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	PCEVENT[2] (cm/event)	INTAKE DERMAL (mg/kg-day)	DERMAL CSF [1, 3] (mg/kg-day)^-1	CANCER RISK DERMAL	TOTAL CANCER RISK
Tetrachloroethene	ORGANIC	6.1	ug/L	5.5E-07	0.052	2.9E-08	4.80E-02	3.2E-06	0.052	1.7E-07	**1.9E-07**
Arsenic	INORGANIC	2.9	ug/L	2.6E-07	1.5	4.0E-07	0.00033	1.0E-08	1.53	1.6E-08	**4.1E-07**
			ug/L								
					SUMMARY CANCER RISK	**4E-07**				**2E-07**	**6E-07**

[1] Relative potency factors were applied to the CSFs of carcinogenic PAHs. Relative potency factors are derived in "Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons," USEPA, 1993.
[2] This chemical-specific value is calculated in Appendix ?
[3] Calculated from oral CSFs.
ND = no data available.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	WATER CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	PCEVENT[1] (cm/event)	INTAKE DERMAL (mg/kg-day)	DERMAL RfD [2] (mg/kg-day)^-1	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Tetrachloroethene	ORGANIC	6.1	ug/L	1.6E-06	0.052	3.0E-05	0.048	8.9E-06	0.01	8.9E-04	**9.2E-04**
Arsenic	INORGANIC	2.9	ug/L	7.4E-07	0.0003	2.5E-03	0.00033	2.9E-08	0.000294	9.9E-05	**2.6E-03**
			ug/L								
			ug/L								
					SUMMARY HAZARD INDEX	**2E-03**				**1E-03**	**3E-03**

[1] This chemical-specific value is calculated in Appendix ?
[2] Calculated from oral RfDs.
ND = no data available.

TABLE X-4

INCIDENTAL INGESTION OF AND DIRECT CONTACT WITH GROUNDWATER (SITE WORKER)
SITE WORKER (NON-POTABLE GROUNDWATER)
TRUMBO POINT FUEL FARM RBCA
NAS KEY WEST
PIERS D-2 AND D-3

15-Nov-98

OCTOBER 1998

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical-specific	ug/liter	
INGESTION RATE [1]	IR	0.026	liters/day	USEPA, 1995
SURFACE AREA [2]	SA	3,120	cm2	USEPA, 1989
EVENT FREQUENCY	EV	1	events/day	Assumption
BODY WEIGHT	BW	70	kg	USEPA, 1991
DOSE ABSORBED PER EVENT	DAevent	chemical-specific	mg/cm2-event	Calculated
EXPOSURE TIME	ET	0.33	hours/day	Assumption
EXPOSURE FREQUENCY	EF	250	days/year	Assumption
EXPOSURE DURATION	ED	25	years	Assumption
DIFFUSION DEPTH PER EVENT	PCevent	chemical-specific	cm/event	Calculated per USEPA, 1992 [3]
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	25	years	USEPA, 1995
CONVERSION FACTOR	CF1	0.001	mg/ug	
CONVERSION FACTOR	CF2	0.001	liter/cm3	

[1] Ingestion Rate = 0.026 l/day = 10 ml/hour x 2.6 hours/day x 0.001 l/ml
[2] Surface area assumes hands and arms are exposed.
[3] PCevent is calculated in Appendix ?
USEPA, 1989. Exposure Factors Handbook; EPA/600/8-89/043; May 1989.
USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters."
USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B.
USEPA, 1995. Supplemental Guidance to RAGS: Region 4 Bulletins, Bulletin No. 3, November 1995.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

INTAKE-INGESTION = $\frac{CW \times IR \times EF \times ED \times CF1}{BW \times AT \times 365 \text{ days/yr}}$

INTAKE-DERMAL = $\frac{DAevent \times EV \times EF \times ED \times SA}{AT \times BW \times 365 \text{ days/yr}}$

Where:
DAevent = PCevent x CW x CF1 x CF2

Note: For noncarcinogenic effects, AT = ED.

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	WATER CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	PCEVENT[2] (cm/event)	INTAKE DERMAL (mg/kg-day)	DERMAL CSF [1, 3] (mg/kg-day)^-1	CANCER RISK DERMAL	TOTAL CANCER RISK
Bromodichloromethane	ORGANIC	1.1	ug/L	1.0E-07	0.062	6.2E-09	8.62E-03	1.0E-07	0.062	6.4E-09	1E-08
Bromoform	ORGANIC	6.5	ug/L	5.9E-07	0.0079	4.7E-09	0.00724	5.1E-07	0.0079	4.1E-09	9E-09
Dibromochloromethane	ORGANIC	3.6	ug/L	3.3E-07	0.084	2.7E-08	ND				3E-08
			ug/L								
					SUMMARY CANCER RISK	4E-08				1E-08	5E-08

[1] Relative potency factors were applied to the CSFs of carcinogenic PAHs. Relative potency factors are derived in "Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons," USEPA, 1993.
[2] This chemical-specific value is calculated in Appendix ?
[3] Calculated from oral CSFs.
ND = no data available.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	WATER CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	PCEVENT[1] (cm/event)	INTAKE DERMAL (mg/kg-day)	DERMAL RfD [2] (mg/kg-day)^-1	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Bromodichloromethane	ORGANIC	1.1	ug/L	2.8E-07	0.02	1.4E-05	8.62E-03	2.9E-07	0.02	1.4E-05	2.8E-05
Bromoform	ORGANIC	6.5	ug/L	1.7E-06	0.02	8.3E-05	0.00724	1.4E-06	0.02	7.2E-05	1.5E-04
Dibromochloromethane	ORGANIC	3.6	ug/L	9.2E-07	0.02	4.6E-05	ND				4.6E-05
			ug/L								
					SUMMARY HAZARD INDEX	1E-04				9E-05	2E-04

[1] This chemical-specific value is calculated in Appendix ?
[2] Calculated from oral RfDs.
ND = no data available.

TABLE X-5

INCIDENTAL INGESTION OF AND DIRECT CONTACT WITH GROUNDWATER (SITE WORKER)
SITE WORKER (NON-POTABLE GROUNDWATER)
TRUMBO POINT FUEL FARM RBCA
NAS KEY WEST
COAST GUARD STATION

15-Nov-98

OCTOBER 1998

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical-specific	ug/liter	
INGESTION RATE [1]	IR	0.026	liters/day	USEPA, 1995
SURFACE AREA [2]	SA	3,120	cm2	USEPA, 1989
EVENT FREQUENCY	EV	1	events/day	Assumption
BODY WEIGHT	BW	70	kg	USEPA, 1991
DOSE ABSORBED PER EVENT	DAevent	chemical-specific	mg/cm2-event	Calculated
EXPOSURE TIME	ET	0.33	hours/day	Assumption
EXPOSURE FREQUENCY	EF	250	days/year	Assumption
EXPOSURE DURATION	ED	25	years	Assumption
DIFFUSION DEPTH PER EVENT	PCevent	chemical-specific	cm/event	Calculated per USEPA, 1992 [3]
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	25	years	USEPA, 1995
CONVERSION FACTOR	CF1	0.001	mg/ug	
CONVERSION FACTOR	CF2	0.001	liter/cm3	

[1] Ingestion Rate = 0.026 l/day = 10 ml/hour x 2.6 hours/day x 0.001 l/ml
[2] Surface area assumes hands and arms are exposed.
[3] PCevent is calculated in Appendix ?
USEPA, 1989. Exposure Factors Handbook; EPA/600/8-89/043; May 1989.
USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters."
USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B.
USEPA, 1995. Supplemental Guidance to RAGS: Region 4 Bulletins, Bulletin No. 3, November 1995.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

INTAKE-INGESTION = $\frac{\text{CW x IR x EF x ED x CF1}}{\text{BW x AT x 365 days/yr}}$

INTAKE-DERMAL = $\frac{\text{DAevent x EV x EF x ED x SA}}{\text{AT x BW x 365 days/yr}}$

Where:
DAevent = PCevent x CW x CF1 x CF2

Note: For noncarcinogenic effects, AT = ED.

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	WATER CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	PCEVENT[2] (cm/event)	INTAKE DERMAL (mg/kg-day)	DERMAL CSF [1, 3] (mg/kg-day)^-1	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	INORGANIC	4	ug/L	3.6E-07	1.5	5.5E-07	0.00033	1.4E-08	1.53	2.2E-08	6E-07
			ug/L								
			ug/L								
			ug/L								
					SUMMARY CANCER RISK	5E-07				2E-08	6E-07

[1] Relative potency factors were applied to the CSFs of carcinogenic PAHs. Relative potency factors are derived in "Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons," USEPA, 1993.
[2] This chemical-specific value is calculated in Appendix ?
[3] Calculated from oral CSFs.
ND = no data available.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	WATER CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	PCEVENT[1] (cm/event)	INTAKE DERMAL (mg/kg-day)	DERMAL RfD [2] (mg/kg-day)^-1	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	INORGANIC	4	ug/L	1.0E-06	0.003	3.4E-04	3.30E-04	4.0E-08	0.000294	1.4E-04	4.8E-04
			ug/L								
			ug/L								
			ug/L								
					SUMMARY HAZARD INDEX	3E-04				1E-04	5E-04

[1] This chemical-specific value is calculated in Appendix ?
[2] Calculated from oral RfDs.
ND = no data available

TABLE X-6

DIRECT CONTACT WITH AND INCIDENTAL INGESTION OF SUBSURFACE SOIL
EXCAVATION WORKER
TRUMBO FUEL FARM RBCA
NAS KEY WEST
NAVY TANK FARM

15-Nov-98

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SOIL	CS	chemical-specific	chemical-specific	
INGESTION RATE	IR	480	mg/day	USEPA, 1995
FRACTION INGESTED	FI	100%	unitless	Assumption
ADHERENCE FACTOR	AF	1	mg/cm²-event	USEPA, 1995
ABSORPTION FRACTION	ABS	chemical-specific	unitless	USEPA, 1995
SURFACE AREA EXPOSED	SA	5,750	cm²	USEPA, 1992
DOSE ABSORBED PER EVENT	DA_{event}	chemical-specific	mg/cm²-event	USEPA, 1992
CONVERSION FACTOR	CF	1.00E-09	kg/ug	Organic conversion
CONVERSION FACTOR	CF	1.00E-06	kg/mg	Inorganic conversion
BODY WEIGHT	BW	70	kg	USEPA, 1991
EXPOSURE FREQUENCY	EF	30	days/year [1]	Assumption
EXPOSURE DURATION	ED	1	years	USEPA, 1991
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	1	years	USEPA, 1991

[1] Units for exposure frequency are events/year in the calculation of the dermally absorbed dose.
USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors"; OSWER Directive 9285.6-03.
USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B; January 1992.
USEPA, 1995. Supplemental Guidance to RAGS : Region IV, Human Health Risk Assessment Bulletin No. 3.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR $(mg/kg\text{-}day)^{-1}$

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$INTAKE_{-INGESTION} = \frac{CS \times IR \times FI \times CF \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

$$INTAKE_{-DERMAL} = \frac{DAevent \times SA \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

Where:

DA_{event} = CS x AF x ABS x CF

Note: For noncarcinogenic effects, AT = ED

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL CSF $(mg/kg\text{-}day)^{-1}$	CANCER RISK INGESTION	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	DERMAL CSF [2] $(mg/kg\text{-}day)^{-1}$	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	I	4	mg/kg	3.2E-08	1.5	4.8E-08	0.001	3.9E-10	1.79	6.9E-10	4.9E-08
SUMMARY CANCER RISK						5E-08				7E-10	5E-08

[1] USEPA Region IV guidance specifies absorption factors of 1% for organics and 0.1% for inorganics (November 1995).
[2] Calculated from oral CSFs.
NE = not evaluated.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	DERMAL ABS [1]	INTAKE DERMAL (mg/kg-day)	DERMAL RfD [2] (mg/kg-day)	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Arsenic	I	4	mg/kg	2.3E-06	0.0003	7.5E-03	0.001	2.7E-08	0.000294	9.2E-05	7.6E-03
SUMMARY HAZARD INDEX						0.01				9.2E-05	0.01

[1] USEPA Region IV guidance specifies absorption factors of 1% for organics and 0.1% for inorganics (November 1995).
[2] Calculated from oral RfDs.
ND = no data available.

TABLE X-7

INHALATION OF PARTICULATES - SUBSURFACE SOIL
TRUMBO FUEL FARM RBCA
NAS KEY WEST
NAVY TANK FARM

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
SOIL CONCENTRATION	C	chemical-specific	chemical-specific	
PART. EMISSION FACTOR	PEF	12000000	m^3/kg	
CONCENTRATION AIR	CA	chemical-specific	mg/m^3	
INHALATION RATE	IR	2.5	m^3/hour	USEPA, 1995
BODY WEIGHT	BW	70	kg	USEPA, 1991
EXPOSURE TIME	ET	8	hours/day	Assumption
EXPOSURE FREQUENCY	EF	30	days/year	Assumption
EXPOSURE DURATION	ED	1	years	Assumption
CONVERSION FACTOR	CF	0.001	mg/ug	Organics only
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	1	years	USEPA, 1991

[1] PEF has been derived in the PEF Appendix to this report.
USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance:
Standard Default Exposure Factors; OSWER Directive 9285.6-03.
USEPA, 1995. Supplemental Guidance to RAGS : Region IV, Human Health Risk Assessment Bulletin No. 3.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x INHALATION CANCER SLOPE FACTOR $(mg/kg\text{-}day)^{-1}$

'HAZARD QUOTIENT = INTAKE (mg/kg-day) / INHALATION REFERENCE DOSE (mg/kg-day)

$$INTAKE = \frac{CA \times IR \times ET \times EF \times ED}{BW \times AT \times 365\ days/yr}$$

Where:

CA = C x CF x (1/PEF)

Note: For noncarcinogens, AT = ED.

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	AIR CONCENTRATION (mg/m^3)	INTAKE (mg/kg-day)	INHALATION CSF (mg/kg-day)^-1	CANCER RISK
Arsenic	I	4	mg/kg	3.33E-07	1.1E-10	50	5.6E-09
					SUMMARY CANCER RISK		6E-09

NE = not evaluated.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	SOIL CONCENTRATION	UNITS	AIR CONCENTRATION (mg/m^3)	INTAKE (mg/kg-day)	INHALATION RfD (mg/kg-day)	HAZARD QUOTIENT
Arsenic	I	4	mg/kg	3.33E-07	7.8E-09	ND	
					SUMMARY HAZARD INDEX		0E+00

ND = no data available.

TABLE X-8

INCIDENTAL INGESTION OF AND DIRECT CONTACT WITH GROUNDWATER (SITE WORKER)
SITE WORKER (NON-POTABLE GROUNDWATER)
TRUMBO POINT FUEL FARM RBCA
NAS KEY WEST
NAVY TANK FARM

15-Nov-98

OCTOBER 1998

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical-specific	ug/liter	
INGESTION RATE [1]	IR	0.026	liters/day	USEPA, 1995
SURFACE AREA [2]	SA	3,120	cm2	USEPA, 1989
EVENT FREQUENCY	EV	1	events/day	Assumption
BODY WEIGHT	BW	70	kg	USEPA, 1991
DOSE ABSORBED PER EVENT	DAevent	chemical-specific	mg/cm2-event	Calculated
EXPOSURE TIME	ET	0.33	hours/day	Assumption
EXPOSURE FREQUENCY	EF	250	days/year	Assumption
EXPOSURE DURATION	ED	25	years	Assumption
DIFFUSION DEPTH PER EVENT	PCevent	chemical-specific	cm/event	Calculated per USEPA, 1992 [3]
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	25	years	USEPA, 1995
CONVERSION FACTOR	CF1	0.001	mg/ug	
CONVERSION FACTOR	CF2	0.001	liter/cm3	

[1] Ingestion Rate = 0.026 l/day = 10 ml/hour x 2.6 hours/day x 0.001 l/ml
[2] Surface area assumes hands and arms are exposed.
[3] PCevent is calculated in Appendix ?
USEPA, 1989. Exposure Factors Handbook; EPA/600/8-89/043; May 1989.
USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters."
USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B.
USEPA, 1995. Supplemental Guidance to RAGS: Region 4 Bulletins, Bulletin No. 3, November 1995.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{\text{CW x IR x EF x ED x CF1}}{\text{BW x AT x 365 days/yr}}$$

$$\text{INTAKE-DERMAL} = \frac{\text{DAevent x EV x EF x ED x SA}}{\text{AT x BW x 365 days/yr}}$$

Where:
DAevent = PCevent x CW x CF1 x CF2

Note: For noncarcinogenic effects, AT = ED.

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	WATER CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	PCEVENT[2] (cm/event)	INTAKE DERMAL (mg/kg-day)	DERMAL CSF [1, 3] (mg/kg-day)^-1	CANCER RISK DERMAL	TOTAL CANCER RISK
Benzene	ORGANIC	4.8	ug/L	4.4E-07	0.029	1.3E-08	2.10E-02	1.1E-06	0.029	3.2E-08	**4.5E-08**
Arsenic	INORGANIC	6.3	ug/L	5.7E-07	1.5	8.6E-07	0.00033	2.3E-08	1.53	3.5E-08	**8.9E-07**
			ug/L								
					SUMMARY CANCER RISK	**9E-07**				**7E-08**	**9E-07**

[1] Relative potency factors were applied to the CSFs of carcinogenic PAHs. Relative potency factors are derived in "Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons," USEPA, 1993.
[2] This chemical-specific value is calculated in Appendix ?
[3] Calculated from oral CSFs.
ND = no data available.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	WATER CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	PCEVENT[1] (cm/event)	INTAKE DERMAL (mg/kg-day)	DERMAL RfD [2] (mg/kg-day)^-1	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Tetrachloroethene	ORGANIC	4.8	ug/L	1.2E-06	0.003	4.1E-04	2.10E-02	3.1E-06	0.003	1.0E-03	**1.4E-03**
Arsenic	INORGANIC	6.3	ug/L	1.6E-06	0.0003	5.3E-03	0.00033	6.3E-08	0.000294	2.2E-04	**5.6E-03**
			ug/L								
			ug/L								
					SUMMARY HAZARD INDEX	**6E-03**				**1E-03**	**7E-03**

[1] This chemical-specific value is calculated in Appendix ?
[2] Calculated from oral RfDs.
ND = no data available.

TABLE X-9

INCIDENTAL INGESTION OF AND DIRECT CONTACT WITH GROUNDWATER (SITE WORKER)
SITE WORKER (NON-POTABLE GROUNDWATER)
TRUMBO POINT FUEL FARM RBCA
NAS KEY WEST
KEY WEST PIPELINE

15-Nov-98

OCTOBER 1998

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION WATER	CW	chemical-specific	ug/liter	
INGESTION RATE [1]	IR	0.026	liters/day	USEPA, 1995
SURFACE AREA [2]	SA	3,120	cm2	USEPA, 1989
EVENT FREQUENCY	EV	1	events/day	Assumption
BODY WEIGHT	BW	70	kg	USEPA, 1991
DOSE ABSORBED PER EVENT	DAevent	chemical-specific	mg/cm2-event	Calculated
EXPOSURE TIME	ET	0.33	hours/day	Assumption
EXPOSURE FREQUENCY	EF	250	days/year	Assumption
EXPOSURE DURATION	ED	25	years	Assumption
DIFFUSION DEPTH PER EVENT	PCevent	chemical-specific	cm/event	Calculated per USEPA, 1992 [3]
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1991
NONCANCER	AT	25	years	USEPA, 1995
CONVERSION FACTOR	CF1	0.001	mg/ug	
CONVERSION FACTOR	CF2	0.001	liter/cm3	

[1] Ingestion Rate = 0.026 l/day = 10 ml/hour x 2.6 hours/day x 0.001 l/ml
[2] Surface area assumes hands and arms are exposed.
[3] PCevent is calculated in Appendix ?
USEPA, 1989. Exposure Factors Handbook; EPA/600/8-89/043; May 1989.
USEPA, 1991. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Parameters."
USEPA, 1992. Dermal Exposure Assessment: Principles and Applications; EPA/600/8-91/011B.
USEPA, 1995. Supplemental Guidance to RAGS: Region 4 Bulletins, Bulletin No. 3, November 1995.

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

$$\text{INTAKE-INGESTION} = \frac{CW \times IR \times EF \times ED \times CF1}{BW \times AT \times 365\ \text{days/yr}}$$

$$\text{INTAKE-DERMAL} = \frac{DAevent \times EV \times EF \times ED \times SA}{AT \times BW \times 365\ \text{days/yr}}$$

Where:
DAevent = PCevent x CW x CF1 x CF2

Note: For noncarcinogenic effects, AT = ED.

CARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	WATER CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL CSF [1] (mg/kg-day)^-1	CANCER RISK INGESTION	PCEVENT[2] (cm/event)	INTAKE DERMAL (mg/kg-day)	DERMAL CSF [1, 3] (mg/kg-day)^-1	CANCER RISK DERMAL	TOTAL CANCER RISK
Benzene	ORGANIC	283	ug/L	2.6E-05	0.029	7.5E-07	2.10E-02	6.5E-05	0.029	1.9E-06	**2.6E-06**
Trichloroethene	ORGANIC	3.4	ug/L	3.1E-07	0.011	3.4E-09	0.016	5.9E-07	0.011	6.5E-09	**9.9E-09**
Arsenic	INORGANIC	10.2	ug/L	9.3E-07	1.5	1.4E-06	0.00033	3.7E-08	1.53	5.6E-08	**1.4E-06**
					SUMMARY CANCER RISK	**2E-06**				**2E-06**	**4E-06**

[1] Relative potency factors were applied to the CSFs of carcinogenic PAHs. Relative potency factors are derived in "Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons," USEPA, 1993.
[2] This chemical-specific value is calculated in Appendix ?
[3] Calculated from oral CSFs.
ND = no data available.

NONCARCINOGENIC EFFECTS

COMPOUND	INORGANIC OR ORGANIC I/O	WATER CONCENTRATION	UNITS	INTAKE INGESTION (mg/kg-day)	ORAL RfD (mg/kg-day)	HAZARD QUOTIENT INGESTION	PCEVENT[1] (cm/event)	INTAKE DERMAL (mg/kg-day)	DERMAL RfD [2] (mg/kg-day)^-1	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Benzene	ORGANIC	283	ug/L	7.2E-05	0.003	2.4E-02	2.10E-02	1.8E-04	0.003	6.0E-02	**8.4E-02**
Trichloroethene	ORGANIC	3.4	ug/L	8.6E-07	0.006	1.4E-04	0.016	1.7E-06	0.006	2.8E-04	**4.2E-04**
Arsenic	INORGANIC	10.2	ug/L	2.6E-06	0.0003	8.6E-03	0.00033	1.0E-07	0.000294	3.5E-04	**9.0E-03**
			ug/L								
					SUMMARY HAZARD INDEX	**3E-02**				**6E-02**	**9E-02**

[1] This chemical-specific value is calculated in Appendix ?
[2] Calculated from oral RfDs.
ND = no data available.