PHASE I RCRA FACILITY INVESTIGATION REPORT
MOTIVA ENTERPRISES LLC
DELAWARE CITY REFINERY
RCRA CORRECTIVE ACTION PERMIT NO. HW09A13

FEBRUARY 2005

URS JOB NO. 20240412

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LIST OF ACRONYMS

RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
USEPA	United States Environmental Protection Agency
msl	Mean sea level
USGS	United States Geologic Survey
IPOPRS	Identification of Potential for Occurring or Past Release Study
VRS	Verification of Release Study
CMS	Corrective Measures Study
SWMU(s)	Solid Waste Management Unit(s)
WWTP	Wastewater Treatment Plant
NPDES	National Pollutant Discharge Elimination System
DMSA(s)	Dredged Material Storage Area(s)
COC(s)	Constituent(s) of concern
BTEX	Benzene, toluene, ethylbenzene, and xylenes
NAPL	Non-aqueous phase liquid
TDS	Total dissolved solids
TOC	Total organic carbon
VOC(s)	Volatile organic compound(s)
SVOC(s)	Semivolatile organic compound(s)
TPH	Total petroleum hydrocarbons
FPH	Free-phase hydrocarbon
FID	Flame ionization detector
TVHC	Total volatile hydrocarbons
NETL	New England Testing Laboratory, Inc.
PID	Photoionization detector
PAC	Physical Acoustics Corporation
gpm	Gallons per minute
MTBE	Methyl tertiary butyl ether
DRO	Diesel range organics
GRO	Gasoline range organics
ROST™	Rapid Optical Screening Tool™
CPT	Cone Penetrometer Testing

LIST OF ACRONYMS (cont.)

ft/min	Feet per minute
1,1,1-TCA	1,1,1-Tetrachloroethane
URS(s)	Uniform Risk-based Remediation Standard(s)
bgs	Below ground surface
ppm	Parts per million
µg/kg	Micrograms per kilogram
µg/l	Micrograms per liter
mg/kg	Milligrams per kilogram
mg/l	Milligrams per liter
AST	Above ground storage tank
NTUs	Nephelometric turbidity units
CPI	Corrugated Plate Interceptor
IDL	Instrument Detection Limit
CRDL	Contract Required Detection Limit
TEL	Tetraethyl Lead
USACE	United States Army Corps of Engineers
DNREC	Department of Natural Resources and Environmental Control
TCLP	Toxicity Characteristics Leaching Procedure
MEK	Methyl Ethyl Ketone
PVC	Polyvinyl Chloride
PCE	Tetrachloroethene
PHCs	Petroleum Hydrocarbons
QA/QC	Quality Assurance/Quality Control

1.0 INTRODUCTION

This Phase I RCRA Facility Investigation Report presents the results of the Resource Conservation and Recovery Act Facility Investigation performed at the Delaware City, Delaware Refinery, with modifications agreed to at a July 24, 2001 meeting held between Motiva Enterprises LLC, the United States Environmental Protection Agency, and the Delaware Department of Natural Resources and Environmental Control. The Resource Conservation and Recovery Act (RCRA) Facility Investigation was implemented in accordance with Motiva Enterprises LLC's (Motiva's) former Corrective Action Permit No. DED 00 232 9738, issued for the Delaware City Refinery. Since the completion of this investigation, Permit DED 00 232 9738 has been superceded by Corrective Action Permit HW09A13, which was issued by the Delaware Department of Natural Resources and Environmental Control (DNREC) on September 30, 2003.

The scope of work presented in this Report was performed in accordance with the RCRA Facility Investigation (RFI) Work Plan dated September 1998. The RFI Work Plan was originally submitted to the United States Environmental Protection Agency (USEPA) on June 28, 1996. The EPA reviewed the Work Plan and provided comments to Motiva. Various revisions were made to the Work Plan throughout the review process. Conditional approval to initiate the RFI was granted by the EPA in a letter dated July 29, 1998. The approval was contingent on submittal of the revised RFI Work Plan containing all previously agreed to changes and the changes requested in the July 29, 1998 letter. The revised RFI Work Plan was submitted to the EPA in September 1998. The investigative field program for the RFI was conducted from January 1999 through February 2000.

1.1 OBJECTIVES OF THE RFI

The objectives of the RFI performed at the Delaware City Refinery were to:

1. Evaluate biological, geologic, hydrogeologic, hydrologic, soil and air characteristics of each unit and the surrounding area.

2. Characterize each unit and the nature, extent, distribution, and rate of migration of releases of hazardous waste and/or hazardous waste constituents from each unit, and the spatial relationship of each unit to other units.

3. Evaluate the effectiveness of corrective measures for each unit, and evaluate the effectiveness of any corrective measure that has or will be taken in response to a release from the unit.

4. Identify potential receptors of identified releases of hazardous waste and/or hazardous waste constituents from each unit.

5. Determine the need for corrective measures for releases.

This Report presents information towards meeting the objectives of #1 and # 2. Since submission of the Draft Report, additional investigations have been discussed and approved by DNREC/EPA. It was agreed that:

- A Phase II RFI would be necessary to address various areas at the refinery.
- The Human Health Risk Assessment would be completed following approval of the Phase I RFI Report. The Human Health Risk Assessment will be evaluated, completed and submitted as part of the Phase II RFI Investigation Report.
- Soil sampling will be performed to evaluate concentrations of metals in background soils and to assess potential incremental risks to human health and the environment, relative to concentrations detected in soils within the Refinery. The field sampling is scheduled to take place during March 2005, and a report summarizing the analytical results will be submitted within 60-days of receipt of the analytical data.
- The Ecological Risk Assessment is ongoing. Additional sampling was performed during October 2003 in accordance with a scope of work submitted to EPA to address data gaps identified in the Screening Ecological Risk Assessment. A Report summarizing the results of the additional sampling is in preparation.
- Additional soil sampling will be performed at SWMU 26 (Tetraethyl Lead Equipment Laydown Area) to evaluate potential risks to environmental receptors. It is anticipated that the field investigation will be implemented during February 2005, and a report summarizing the findings will be submitted within 60-days of receipt of the analytical data.
- Additional soil sampling will be performed in the former Naphthalene Tank Farm to evaluate soil quality in soils deeper than those sampled during previous investigations. The investigation will be implemented during February 2005, and a report summarizing the findings will be submitted within 60-days of receipt of the results.
- The ongoing investigation of impacted groundwater south of the Refinery will be continued upon approval of the Continued Delineation of Southern Extent of Groundwater Impacts Work Plan. Field work will be implemented within four (4) weeks of Work Plan approval. Reports will be submitted in accordance with the schedule

specified in the Work Plan to the extent possible, due to uncertainties regarding property access agreements and physical site accessibility.

All work completed since the initiation of the Verification of Release Study (VRS) through the Phase II RFI, as well as an evaluation of any interim/corrective measures implemented, will be compiled in a comprehensive Phase II RFI Report at the completion of the Phase II RFI.

1.2 SITE LOCATION AND PHYSIOGRAPHY

The Delaware City Refinery is located on a 5,050-acre tract of land approximately 1 mile northwest of Delaware City, Delaware. This area of New Castle County is characterized by level topography composed of unconsolidated sediments. Ground surface elevations range from approximately 70 feet above mean sea level (msl) on the western side of the Refinery to msl at the eastern property boundary, which borders the Delaware River. The site is shown on the Delaware City and St. Georges USGS 7.5-minute quadrangles (see Figure 1). The land north and south of the Refinery is mostly farmland, with the exception of several industrial complexes located immediately north and west of the Refinery.

The manufacturing facilities occupy approximately 1,000 of the 5,050 acres of the property. The Refinery produces mainly gasoline and heating oil. The Refinery went on stream in 1956 and has a daily rated capacity of 140,000 barrels per calendar day (150,000 barrels per stream day).

1.3 BACKGROUND

On November 8, 1988, the EPA issued modifications to RCRA Corrective Action Permit No. DED 00 232 9738, which was issued to the Texaco Refining and Marketing Inc. Delaware City, Delaware Refinery (Figure 1). The effective date of the modifications was December 15, 1988. Part II of the permit sets forth specific conditions, the results of which are to be submitted to the EPA in accordance with 40 CFR Section 270.11(d). The conditions of Parts II.A.1 and II.A.2 were fulfilled with the submission of the Background Information Survey Report (Dames & Moore, May 1991), the Identification of the Potential for an Occurring or Past Release Study (IPOPRS) Report (Dames & Moore, May 1991), and the Verification of Release Study (VRS) Report (Dames & Moore, March 31, 1995). The final requirement of Part A (II.A.3) is to conduct a RCRA Facility Investigation (RFI) and Corrective Measures Study (CMS) at Solid Waste Management Units (SWMUs) where releases of hazardous waste and/or hazardous waste constituents to the environment have been identified. Requirements for the RFI are discussed in detail in Part D of the permit.

2.0 REPORT ORGANIZATION

The remainder of this report is presented in Sections 3.0 through 9.0. Section 3.0 discusses the history of the Solid Waste Management Units and Corrective Action Permit compliance. Section 3.0 also includes summaries of the IPOPRS Report, the VRS Report, and the RFI Work Plan.

Section 4.0 discusses the history of the general operating and waste management practices at the individual SWMUs. Section 5.0 presents a summary of the investigative task undertaken during the RFI and Section 6.0 presents the results of the RFI. Section 7.0 presents the Quality Assurance/Quality Control program for the RFI. Section 8.0 presents a summary of the results of the RFI, and Section 9.0 presents references.

The Ecological Risk Assessment for the RFI is ongoing, and data validation reports were previously submitted to EPA under cover dated November 19, 2001.

3.0 SOLID WASTE MANAGEMENT UNITS/PERMIT COMPLIANCE

A total of 28 SWMUs were included by the USEPA in Motiva's Corrective Action Permit, issued on December 15, 1988. After the permit was issued, Motiva identified five additional SWMUs (SWMUs 29 through 33).

Two (2) SWMUs included in the original Corrective Action (SWMUs 5 and 6, Flyash Settling Ponds No. 1 and 2) are operated under Solid Waste Permit SW-96/01, issued by the Delaware Department of Natural Resources and Environmental Control (DNREC). Three additional SWMUs included in the original Corrective Action Permit have been closed, and are in post-closure care periods in accordance with post-closure permits issued by DNREC. The closed RCRA Landfill (SWMU 25) is managed under Post-Closure Care Permit HW09A14. The former Land Treatment Unit (SWMU 23) is managed under Post-Closure Care Permit HW06A07 and the portion of the Stormwater Channel (SWMU 20b.1) formerly known as the CPI Surge Basin is managed under Post-Closure Care Permit HW08A06.

The remainder of this section presents a summary of previous RCRA Corrective Action permit compliance submittals.

3.1 IPOPRS AND REQUEST FOR INFORMATION REPORTS

A six-volume document entitled "Identification of Potential for an Occurring or Past Release Study (IPOPRS) Report," and a second document entitled "Request for Information Report" were delivered to the USEPA on May 28, 1991. The IPOPRS and Request for Information Reports included a background information survey and evaluated the potential for an occurring or past release of hazardous waste or hazardous waste constituents from the selected SWMUs as shown in Table 1. The IPOPRS and the Request for Information Reports provided detailed information on the SWMUs.

The IPOPRS Report identified the potential for an occurring or past release and recommended a VRS at eight SWMUs:

- SWMU 3 - Neutralization Tanks 1 and 2
- SWMU 9 - Facility Sewer System
- SWMU 15 - Tank Bottom Weathering Areas
- SWMU 18 - Fire Training Area

SWMU 20a	-	Wastewater Treatment Plant - Off-loading Area for Recovered Crude Holding Tank
SWMU 20b	-	Stormwater Channel, Guard Basin 4, and API Separator No. 2
SWMU 21	-	Cooling Water Channel and Guard Basins 5 and 6
SWMU 24b	-	Dredged Material Storage Area 2

During the Background Information Survey, Motiva identified and recommended a VRS for four SWMUs:

SWMU 30	-	Sewer Overflow Area
SWMU 31	-	Slurry Oil Dumpster
SWMU 32	-	Stained Soil Within the Oily Sewer Backup Areas
SWMU 33	-	Pier 2 and Pier 3

The USEPA reviewed Motiva's IPOPRS Report and issued a letter, dated September 22, 1992. In their letter, the USEPA accepted the recommendations contained in the IPOPRS Report, with the following conditions:

1. For SWMU 20a (Wastewater Treatment Plant): As part of the VRS, soil samples must be collected at the Final Effluent Filter Area and the Off-Loading Area for the Recovered Crude Holding Tank.

2. For SWMU 20b (Stormwater Channel, Guard Basin No. 4, and API Separator No. 2) and SWMU 21 (Guard Basins 5 and 6): The VRS must include sediment and groundwater samples.

The USEPA also reviewed the "Request for Information Report" submitted under RCRA Section 3007 in May 1991. This report contained information regarding 13 Units or accumulation areas (Unit A through Unit M) at the Refinery. In the original permit, these 13 accumulation areas composed SWMU 14. In their September 22, 1992 letter, USEPA recommended that Motiva voluntarily include soil sampling for Unit F: Used Drum Storage Area, and Unit K: Heat Exchanger Bundle Cleaning Area in the VRS Work Plan or consider performing interim measures. The VRS Work Plan was revised to include these two areas.

3.2 VERIFICATION OF RELEASE STUDY REPORT

As specified in the Corrective Action Permit (Section II.C.4), three SWMUs required a VRS:

SWMU 12	-	Used Solvent Storage Area
SWMU 13	-	Old Drum Storage Area
SWMU 26	-	Tetraethyl Lead Equipment Laydown Area

Table 2, which was taken from the USEPA's September 22, 1992, acceptance letter, summarizes the agreed-upon actions for each SWMU. After receiving the acceptance letter, Motiva decided to address SWMU 33 during the RFI. Thus, the VRS Report detailed the results of the field investigation at 14 SWMUs and two accumulation areas (Unit F and Unit K) instead of the originally agreed upon 15 SWMUs and two accumulation areas.

The VRS Report was delivered to the USEPA on March 31, 1995. The VRS Report detailed the field investigation and results of the verification investigation that was conducted at the Refinery from September 1994 through January 1995. The VRS Report recommended that RFIs be conducted at 11 SWMUs and 1 accumulation area:

SWMU 9	-	Facility Sewer System
SWMU 15	-	Tank Bottom Weathering Areas
SWMU 18	-	Fire Training Area
SWMU 20a.1	-	Off-loading Area for Recovered Crude Holding Tank
SWMU 20b.1	-	Stormwater Channel
SWMU 20b.2	-	Guard Basin No. 4
SWMU 20b.3	-	API Separator No. 2
SWMU 24b	-	Dredged Material Storage Area No. 2
SWMU 26	-	Tetraethyl Lead Equipment Laydown Area
SWMU 31	-	Stained Soil Near the Former Location of the Slurry Oil Dumpster
SWMU 32	-	Stained Soil Within Oily Sewer Backup Areas
Unit F	-	Used Drum Storage Areas

The USEPA reviewed Motiva's VRS Report and issued a letter dated October 25, 1995. In their letter, the USEPA accepted the recommendations contained in the VRS Report, with the following conditions:

1. For the following SWMUs and one accumulation area, samples collected during the RFI must be analyzed for all parameters listed in the approved VRS Work Plan plus vanadium:
   SWMU 15
   SWMU 20b.1
   SWMU 20b.2
   SWMU 31
   SWMU 32
   Unit F
2. Additional verification sampling is required at SWMU 13: Old Drum Storage Area.
3. An RFI is required at SWMU 21: Cooling Water Channel and Guard Basins No. 5 and 6.

A summary of SWMU status following completion of the VRS is presented on Figure 2.

3.3 RCRA FACILITY INVESTIGATION

As specified in the Corrective Action Permit (Part II - Section D), one SWMU required an RFI:

SWMU 24a - Dredged Material Storage Area No. 1

Thus, the RFI Work Plan detailed investigative activities to evaluate environmental conditions at 15 SWMUs and 1 accumulation area:

SWMU 9	-	Facility Sewer System
SWMU 13	-	Old Drum Storage Area
SWMU 15	-	Tank Bottom Weathering Areas
SWMU 18	-	Fire Training Area
SWMU 20a.1	-	Off-Loading Area for Recovered Crude Holding Tank
SWMU 20b.1	-	Stormwater Channel
SWMU 20b.2	-	Guard Basin No. 4
SWMU 20b.3	-	API Separator No. 2
SWMU 21	-	Cooling Water Channel and Guard Basins 5 and 6
SWMU 24a	-	Dredged Material Storage Area No. 1
SWMU 24b	-	Dredged Material Storage Area No. 2
SWMU 26	-	Tetraethyl Lead Equipment Laydown Area
SWMU 31	-	Stained Soil Near the Former Location of the Slurry Oil Dumpster
SWMU 32	-	Stained Soil Within Oily Sewer Backup Areas
SWMU 33	-	Stained Soil Near Piers 2 and 3

Unit F - Used Drum Storage Areas

As previously discussed in Section 1.0, the RFI Work Plan was conditionally approved by the EPA in a letter dated July 29, 1998, and the revised RFI Work Plan was submitted to EPA in September 1998.

4.0 SOURCE CHARACTERIZATION

This chapter discusses the potential source characterization for the SWMUs requiring RFIs, and presents a summary of the general operating and waste management practices at the individual SWMUs. Detailed information regarding historic activities at the SWMUs is presented in the IPOPRS Report.

4.1 SWMU 9 - FACILITY SEWER SYSTEM

SWMU 9, the Refinery sewer system, encompasses the entire Refinery (Figure 2). Within the Main Refinery Sewer systems, there are hundreds of thousands of feet of underground sewers underlying the Refinery, which are divided into three major sewer systems:

- The Stormwater Sewer System, which receives stormwater runoff from catch basins within the roads and units of the Refinery and some process wastewater.
- The Oily Water Sewer System, which receives process wastewater, storage tank drawoff, process area washdown water, laboratory wastewater, and septic system wastewater.
- The Chemical Sewer System, which is not used during routine operations.

Since the Refinery was built in the mid-1950s, these three sewer systems have transported stormwater and wastewater to the Refinery's Wastewater Treatment Plant (WWTP). Discharges from the WWTP are monitored in accordance with the Refinery's National Pollutant Discharge Elimination System (NPDES) Permit.

The construction materials for the underground sewer line pipes differ depending on the type of fluid flowing through the pipes. A detailed discussion of the different types of pipe used for each sewer system is contained in Volume 3, Chapter 9, Section 2, pages 2 through 4 of the IPOPRS Report.

Based on analyses conducted in 1977 by The Dravo Corporation during the redesign of the WWTP, it is known that the sewer system has transported hazardous constituents. Currently, waste associated with the operations of the process units using the sewer system is handled and disposed of in accordance with applicable federal and state regulations. A more detailed description of SWMU 9 is contained in Volume 3, Chapter 9, Section 2 of the IPOPRS Report.

4.2 SWMU 13 - OLD DRUM STORAGE AREA

As shown on Figure 2, SWMU 13 was originally an unpaved area used for the storage of old drums that is located south of the Flyash Settling Pond (SWMU 5) and adjacent to the Fire Training Area (SWMU 18). A more detailed description of SWMU 13 is contained in Chapter 8, Section 1 of the VRS Report, dated March 31, 1995. In 2004, DuPont Company began construction of a new acid regeneration plant at SWMU 14, which is expected to be completed by summer 2005. Adrawing of the prposed plant was provided by letter dated February 4, 2004 to EPA and DNREC.

4.3 SWMU 15 - TANK BOTTOM WEATHERING AREAS

SWMU 15 is comprised of the Tank Bottom Weathering Areas in the Crude Oil, General Services, and Vacuum Residuum Tank Farms, and the Catalytic Cracker Feed Tank. Since this SWMU 15 is comprised of areas in several tank farms, it is located in several different areas of the Refinery. The locations of the SWMU are shown on Figure 2.

Prior to 1983, oily tank bottoms, which were generated during tank cleaning, were allowed to weather within the bermed areas adjacent to 24 storage tanks. Collectively, the weathering areas near each of these 24 tanks make up SWMU 15.

Several tank bottom weathering areas within the General Services Tank Farm (SWMU 15) are located adjacent to the Oily Sewer Backup Areas (SWMU 32). The locations of SWMU 15 and SWMU 32 are shown on Figure 2.

SWMUs 15 and 32 at the General Service Tank Farm and Crude Tank Farm are differentiated by historic activities and events, and containment areas. SWMU 32 at the General Service Tank Farm adjoins SWMU 15 and likewise involves catch basins to the Oily Water Sewer System; however, SWMU 32 is differentiated by a separate containment area and potential impacts due to oily liquid that backed up from the sewer system. Crude Tank 9, which is included in SWMU 32, is not included in SWMU 15 because tank bottoms were reportedly never placed on the ground in the tank berm area.

The containment areas used as tank bottom weathering areas are:

- Crude Tanks 1 through 8 and 10 through 12
- General Service Tanks 281 through 286
- General Service Tanks 248 and 268

- Catalytic Cracker Feed Tank 66
- Vacuum Residue Tanks 74 through 77

Prior to approximately 1983, the tank bottoms generated during tank cleaning operations were allowed to weather within the unlined containment areas. Typically, each tank was cleaned every 8 to 10 years. Motiva estimated that each of the 24 tanks had been cleaned two or three times. During tank cleaning, accumulations of the more viscous (un-pumpable) residue were placed in the corner of the tank containment area nearest the oily sewer catch basin and were walled off with earthen dikes. After the bottoms had weathered from a period ranging from several weeks to several months, the tank bottoms were removed and placed in the Refinery's landfill.

Current procedures are designed to minimize the waste generated and include slurrying and processing the majority of the tank bottoms before opening the tank. A more detailed description of SWMU 15 is contained in Volume 3, Chapter 15, Section 2 of the IPOPRS Report.

4.4 SWMU 18 - FIRE TRAINING AREA

The Fire Training Area was designated SWMU 18 in Motiva's Corrective Action Permit. Approximately twice a year since the late 1950s, SWMU 18 was used to train Refinery personnel in fire-fighting skills. Following sale of the Refinery to Premcor, Inc. in May 2004, the Fire Training Area has no lomger been used for this purpose, and is currently inactive. SWMU 18 is bordered on the north by "T" Street, on the east and south by SWMU 13, and on the west by open land (Figure 2).

The Fire Training Area consisted of a 100-feet square concrete pad surrounded by gravel-covered ground. Previously, Refinery personnel practiced extinguishing fires in mock structures in the area with fire suppressing foam and water. The concrete pad was designed to collect any runoff of water, spent foam, and unburned hydrocarbon in a central catch basin. The catch basin was connected to the Oily Water Sewer System, and the runoff was directed to the WWTP.

A 500-gallon aboveground gasoline storage tank, which was located in the northwest corner of the area, delivered fuel to the Fire Training Area through an underground fuel line. A fuel truck dispensed diesel fuel into the concrete trench. Hydrocarbons and fire-fighting foam were used at the Fire Training Area. Unburned hydrocarbons may contain hazardous constituents. The fire-fighting foam may contain cellosolve solvent, an Appendix VIII constituent (the MSDS was attached to the IPOPRS Report). A more detailed description of SWMU 18 is contained in Volume 3, Chapter 18, Section 2 of the IPOPRS Report.

On May 29, 1990, a No. 2 diesel fuel discharge was documented at the Fire Training Area. The quantity of fuel discharged was unknown. Motiva cleaned the discharged fuel up with a vacuum truck, and cleaned up the remaining stained soil to the satisfaction of DNREC. In 1990, the Refinery's Hazardous Waste Landfill was still in operation, and it is likely therefore that the stained soil was disposed there. No further information is available regarding this discharge.

4.5 SWMU 20A.1 - OFF LOADING AREA FOR RECOVERED CRUDE HOLDING TANK

The WWTP was designated as SWMU 20 in the Corrective Action Permit. For ease of writing the IPOPRS Report, SWMU 20 was divided into SWMU 20a (the main Wastewater Treatment Plant area) and SWMU 20b, which consists of the Stormwater Channel, Guard Basin No. 4, and API Separator No. 2. For the purpose of the VRS, SWMU 20a was further divided into SWMUs 20a.1 (Recovered Crude Holding Tank) and 20a.2 (Final Effluent Filter Area). SWMU 20b was further divided into SWMU 20b.1 (Stormwater Channel), SWMU 20b.2 (Guard Basin No. 4), and SWMU 20b.3 (API Separator No. 2). The remainder of this Section discusses SWMU 20a.1. SWMU 20b is discussed in Sections 4.6 through 4.8.

SWMU 20a.1 is located south of the CPI Surge Basin and west of the main WWTP (Figure 2). The unit is bordered on the north by "G" Street, on the west by the Crude Oil Tank Farm, and on the south and east by portions of the WWTP. Periodically, oil recovered from other areas of the Refinery is unloaded from tank trucks to the Recovered Crude Holding Tank through a pressurized pipeline. Historically, during the unloading process, some oil dripped on the ground surface, which was gravel covered. Prior to implementation of the VRS, a concrete pad with curbing on the east, west and south sides was constructed so that any oil that dripped during unloading dropped on an impervious surface, and could be cleaned up with an absorbent material. Land to the east, west and south of the concrete unloading pad is gravel covered, and drains to a drainage swale that slopes from west to east, and enters a NPDES permitted stormwater outfall. North of the concrete pad is an asphalt road that slopes to the east, and also drains to the NPDES permitted stormwater outfall. During periods of light rain, water is contained on the concrete pad; during periods of heavier rainfall, the water may exceed the capacity of the curbing, and flow down the road or into the drainage swale. It is known that soil has been excavated from the drainage swale downgradient of SWMU 20a.1; however, this was in response to leaks from the pad where the Thermal Desorption Unit was operated, and it is not believed that SWMU 20a.1 contributed to the oily sediment. A more detailed description of SWMU 20a.1 is contained in Volume 3, Chapter 20(A), Section 2 of the IPOPRS Report. Currently, the unloading area consists of a concrete pad.

4.6 SWMU 20B.1 - STORMWATER CHANNEL

The Stormwater Channel is located just north of the main WWTP (Figure 2). The channel has received effluent from the Refinery's storm sewer network and from the WWTP since operations began in the mid-1950s. The Refinery stormwater sewer historically discharged to the western margin of the channel.

Prior to 1980, the Stormwater Channel received untreated Refinery stormwater and a portion of clean process wastewater. The channel was dredged twice before 1980 to remove accumulated solids. In 1980, a weir was constructed approximately 200 feet downstream of the stormwater outfall into the Stormwater Channel, creating an impoundment known as the CPI Surge Basin. The weir was constructed to divert dry weather flow to the WWTP. The weir also allowed excess stormwater to exit the Basin during precipitation events. After the weir was constructed, solids accumulated in the CPI Surge Basin. Effective May 2, 1991, the USEPA designated the solids in the CPI Surge Basin a listed hazardous waste (F037). After November 22, 1994, the flow from the sewer system was diverted directly to the WWTP. The CPI Surge Basin has been closed in accordance with Motiva's RCRA Part B permit and is currently in post-closure monitoring. A more detailed description of SWMU 20b.1 is contained in Volume 4, Chapter 20(B), subsection 2.1 of the IPOPRS Report.

The Delaware DNREC issued Corrective Action Permit HW09A13 for the Delaware City Refinery on September 30, 2003. Permit Condition II.B.2 states "If the Department determines, on the basis of information submitted by the Permittee pursuant to permit condition II.C (RCRA Facility Investigation), II.H (Emergency Response; Release Reporting), or II.J (Solid Waste Management Unit Assessment) or any other information, that corrective action is necessary to protect human health or the environment from a release of hazardous waste or constituents from a SWMU/AOC, the Permittee may be required to implement Interim Measures.

In accordance with Permit Condition II.B.3, which states, "Within 90 days of receipt of the Corrective Action Permit from the Department, Motiva shall submit an Interim Measures Workplan for design and installation of remedial actions at SWMU 20b & 24b (Bermed Area)". Motiva submitted an Interim Measures Work Plan for Portions of Solid Waste Management Units 20b and 24b. Following receipt of comments and revisions, the final Work Plan was submitted on August 26, 2004. DNREC approved the Interim Measures Work Plan for Portions of Solid Waste Management Units 20b and 24b, contingent on approval of the Quality Assurance Project Plan and the Sampling and Analysis Plan, which were submitted during October 2004.

4.7 SWMU 20B.2 - GUARD BASIN NO. 4

Guard Basin No. 4 lies east of Guard Basins No. 5 and 6, and southwest and west of Dredged Material Storage Area No. 2 (DMSA No. 2). The location of Guard Basin No. 4 is shown on Figure 2. Guard Basin No. 4 was constructed in the mid-1950s in pre-existing lowlands to receive stormwater run-off and treated effluent from the Refinery's WWTP. The basin is reportedly unlined.

Guard Basin No. 4 receives flow from the Stormwater Channel and recovered groundwater from the interceptor trench located south of DMSA No. 2. Before the 1980 upgrade of the WWTP, untreated stormwater runoff from the Refinery flowed directly through the Stormwater Channel into Guard Basin No. 4.

Guard Basin No. 4 was dredged in 1970 and 1980 to remove some of the accumulated solids. Numerous Refinery drawings, which were discussed in the IPOPRS Report, show the dredged areas. The dredged materials were disposed of in DMSA No. 2 (SWMU 24b). A more detailed description of SWMU 20b.2 is contained in Volume 4, Chapter 20(B), subsection 2.2 of the IPOPRS Report.

Currently, Guard Basin No. 4 is open and being used by the Refinery. In the future, Guard Basin No. 4 will be permanently by-passed and closed. Premcor anticipates submitting a WPCC application shortly. The application will be submitted once the final drawings stamped by a Delaware-registered Professional Engineer are received. The application will cover the diversion of water from Guard Basin No. 4 and the water recovered from the interceptor trench. Implementation of the bypass will be dependent on issuance of the WPCC permit, which DNREC has indicated could potentially take 6 months. Until the permit is issued, a schedule cannot be projected for closure of Guard Basin No. 4.

4.8 SWMU 20B.3 - API SEPARATOR NO. 2

API Separator No. 2 is located approximately 150 feet northeast of the Guard Basins (Figure 3). The Separator was built in 1956 during the initial construction of the Refinery. The Separator receives water and floating material that flows over the adjustable weirs at Guard Basins No. 4, 5, and 6. The weir overflow is conveyed by metal flumes over the effluent channel north of the Guard Basins into concrete-lined trenches that drain into the Separator.

The Separator removes floating material (mostly algae) from the water by gravity separation. Floating material is skimmed into a sump on the west side of the Separator and pumped to the WWTP. The effluent from the API Separator is discharged to the main Refinery effluent channel. The Refinery monitors the effluent quality at this outfall under its NPDES permit. A more detailed description of SWMU 20b.3 is contained in Volume 4, Chapter 20(B), subsection 2.3 of the IPOPRS Report.

4.9 SWMU 21 – COOLING WATER EFFLUENT CHANNEL AND GUARD BASINS NO. 5 AND 6

The Cooling Water Channel and Guard Basins No. 5 and 6 are designated as SWMU 21 in Motiva's Corrective Action Permit. The Guard Basins are located northwest of Guard Basin No. 4, and southwest of API Separator No. 2 (Figure 2). Both basins receive only once-through, non-contact cooling water. The cooling water is Delaware River water pumped from the Cooling Water Intake Canal and then returned to the river through Guard Basins No. 5 and 6. These two basins were constructed in the mid-1950s in pre-existing lowlands to receive non-contact cooling water from the Refinery. The bottoms of the guard basins were originally approximately 5 feet above msl. The elevation of the water in the basins is approximately 13.2 feet above msl. Both of the basins are unlined.

The water that flows through Guard Basins No. 5 and No. 6 is Delaware River water that has flowed through heat exchangers at the Refinery. During the summer, the water is chlorinated. Under normal operating conditions, the river water does not contact the hot hydrocarbons cooled by the heat exchangers. However, if a heat exchanger develops a leak, hydrocarbons may enter the cooling water.

In 1970 and 1980, during the dredging of Guard Basin No. 4, Guard Basins No. 5 and 6 also received flow from the Stormwater Channel for short periods of time. A more detailed description of SWMU 21 is contained in Volume 4, Chapter 21, Section 2 of the IPOPRS Report.

4.10 SWMU 24A - DREDGED MATERIAL STORAGE AREA NO. 1

Since its initial construction in the 1950s, the Refinery has periodically dredged fine-grained river sediment from several areas in or near the Delaware River. The sediment was transported by pipeline into diked land disposal sites known as Dredged Material Storage Areas (DMSAs). The IPOPRS Report discussed six DMSAs that the Refinery used for disposal of the dredged material. These six areas, which collectively were SWMU 24, are known as DMSAs No. 1, 2, 3, 4, 5, and the Red Lion Disposal Area. For the purpose of the VRS, each areas number was assigned the appropriate letter of the alphabet following the SWMU designation. Thus, DMSA No. 1 is SWMU 24a and DMSA No. 2 is SWMU 24b.

The DMSAs consist of dredged material contained within earthen dikes constructed on several portions of property belonging to the Refinery, usually on lowland areas near the Delaware River. SWMU 24a (DMSA No. 1), which is an 85-acre site, is bordered on the north by adjoining property, on the east by the Delaware River, on the south by the main Refinery Effluent Channel, and on the west by the RCRA Landfill (Figure 2). The main source of all material placed in the DMSAs has been the Cooling Water Intake Canal and the Entrance Channel to Motiva's Marine Terminal. A more detailed description of SWMU 24a is contained in Volume 5, Chapter 24, Section 2 of the IPOPRS Report.

DMSA No. 1 was specified in the Corrective Action permit as requiring an RFI. This was based on the findings of a Dames & Moore report entitled "Hydrogeologic Investigation-Phase II, Delaware Refinery, Delaware City, Delaware, Getty Refining and Marketing Company", dated January 9, 1979. This report summarized the hydrogeology of the landfill, based primarily on data obtained from monitoring wells installed in 1978. The proximity of DMSA No. 1 to the RCRA Landfill is shown on Figure 2. The concentrations of several constituents and decreased pH levels in samples collected from wells 5, 8, and 9A, and the positioning of the wells relative to the Landfill led the authors to speculate that the primary source of the constituents detected in these wells was DMSA No. 1. These three wells were located on the eastern edge of the Landfill, and the authors of the report interpreted this area to be downgradient of groundwater flow emanating from DMSA No. 1.

Of the "hazardous constituents" detected in these three wells, only lead was detected at concentrations exceeding the drinking water standards in effect in 1978. Lead was detected at concentrations of 82 µg/l and 123 µg/l in the groundwater samples collected from wells 8 and 9A, respectively. No collaborating evidence of the leachability of lead from the dredged material disposed of in DMSA No. 1 was presented in the 1979 report to support the speculation that the

dredged material was the source of the lead. No sediment or groundwater sampling was conducted within DMSA No. 1.

As discussed on pages 6 and 7 in Section 3.1 of Volume 5 of the IPOPRS Report, characterization of dredged material with the same origin as those disposed of in DMSA No. 1 indicate that the material is not capable of releasing significant concentrations of lead based on EP Toxicity tests.

4.11 SWMU 24B - DREDGED MATERIAL STORAGE AREA NO. 2

DMSA No. 2, a 137-acre site, has been used for the storage of dredged material since the 1950's (Figure 2). DMSA No. 2 is unique because a portion of it has received material dredged from Guard Basin No. 4. Guard Basin No. 4 was dredged in 1970 and in 1980, and each time the dredged sediment from the Guard Basin was placed in DMSA No. 2. In 1970, the sediment was placed predominantly in the southwest corner of DMSA No. 2. Some of the material was also placed north of this area. It is unknown whether the sediment was piled, ponded, or was allowed to spread out.

Prior to dredging Guard Basin No. 4 in 1980, a berm was constructed in the southwest corner of DMSA No. 2 to isolate the dredged sediment from Guard Basin No. 4 from the rest of DMSA No. 2. The southwest corner of DMSA No. 2 is known as the Oily Sludge Area. There is the potential that the oily sediment dredged from Guard Basin No. 4 prior to 1980 spread beyond the limits of the present Oily Sludge Area.

After construction of the dike, sediments dredged from Guard Basin No. 4 in 1980 were placed in the Oily Sludge Area. There is the potential that constituents of concern (COCs) have migrated through the berm after its construction.

In order to evaluate the potential that oily sediment may have spread beyond limits of the present Oily Sludge Area or migrated through the berm after its construction, the scope of work originally proposed for implementation during the VRS was carried out during the RFI. Six borings were advanced through the lowland area of DMSA No. 2 in an effort to identify potentially impacted soils. Continuous split-spoon samples were collected, and the samples were subjected to headspace screening with a Photoionization Detector (PID). As shown on the boring logs in Appendix A of the Phase I RFI Report, the majority of the PID readings were not elevated.

The bottom of the Oily Sludge Area is approximately 6-feet above mean sea level, and the top of the oily sludge area is approximately 19-feet above mean sea level. The borings advanced within the Lowland Area were advanced to approximately 8-feet above mean sea level. It was believed that these borings would identify any material that had spread into the Lowland Area before construction of the berm, as well as any material that might have potentially migrated through the berm after construction.

The Delaware DNREC issued Corrective Action Permit HW09A13 for the Delaware City Refinery on September 30, 2003. Permit Condition II.B.2 states "If the Department determines, on the basis of information submitted by the Permittee pursuant to permit condition II.C (RCRA Facility Investigation), II.H (Emergency Response; Release Reporting), or II.J (Solid Waste Management Unit Assessment) or any other information, that corrective action is necessary to protect human health or the environment from a release of hazardous waste or constituents from a SWMU/AOC, the Permittee may be required to implement Interim Measures.

In accordance with Permit Condition II.B.3, which states, "Within 90 days of receipt of the Corrective Action Permit from the Department, Motiva shall submit an Interim Measures Workplan for design and installation of remedial actions at SWMU 20b & 24b (Bermed Area)",Motiva submitted an Interim Measures Work Plan for Portions of Solid Waste Management Units 20b and 24b. Following receipt of comments and revisions, the final Work Plan was submitted on August 26, 2004. DNREC approved the Interim Measures Work Plan for Portions of Solid Waste Management Units 20b and 24b, contingent on approval of the Quality Assurance Project Plan and the Sampling and Analysis Plan, which were submitted during October 2004.

4.12 SWMU 26 - TETRAETHYL LEAD EQUIPMENT LAYDOWN AREA

The Tetraethyl Lead Pit is located slightly north of Motiva's hazardous waste landfill (Figure 2). The 15-foot-diameter pit was formerly used to dispose of manufacturing parts such as piping, valves, abandoned cut-up vessels, tools, etc. that were used in the production of fuels containing tetraethyl lead. In the late 1970s, the contents of the area were transferred to the onsite RCRA Landfill and the pit was backfilled with dredged material. The origin of the dredged material used to fill SWMU 26 could not be determined from available records.

During the USEPA's 1986 visit, sparse vegetation was observed in the area of the pit. Presently, the area is heavily vegetated and the former site of the laydown area is difficult to locate.

4.13 SWMU 31 - STAINED SOIL NEAR THE FORMER LOCATION OF THE SLURRY OIL DUMPSTER

SWMU 31 is the area of stained soil near the former location of a steam-heated dumpster used for the temporary storage of slurry oil. This stained area was identified during Motiva's Background Information Survey.

The dumpster was placed near the western boundary of the Refinery in 1983 for temporary storage of slurry oil. It was located approximately 60 feet northeast of the sulfur deposition pit, between the railroad tracks and the elevated access road. Figure 2 shows the former location of the dumpster with respect to surrounding features. Trucks emptied slurry oil into the southern side of the dumpster. The slurry oil transferred to the dumpster was reportedly produced at the Fluid Coker. In addition, small quantities of vacuum residue were deposited in the dumpster. The soil was apparently stained by overflows or spillage during filling or emptying of the dumpster. A more detailed description of SWMU 31 is contained in Volume 6, Chapter 31, Section 2 of the IPOPRS Report.

4.14 SWMU 32 - STAINED SOIL WITHIN OILY SEWER BACKUP AREAS

SWMU 32 is the stained soil near the General Service Storage Tanks, and at Tank 9 in the Crude Oil Tank Farm (Figure 2). This SWMU was identified by the Refinery during their Background Information Survey. Stormwater overflow in the eastern part of the containment area occurs when the capacity of the Oily Water Sewer System is exceeded during heavy rains. Under normal conditions, the valves to the Stormwater Sewer System in the General Service Tank and Product Tank Area are closed. When the area requires draining, the valves to the Oily Water Sewer System are opened. This allows for stormwater collected in catch basins in this containment area to be transported to the Refinery's WWTP via the Oily Water Sewer System. Two contributors to the Oily Water Sewer System are the tank drains and the heating coil condensate from the crude tanks. Normally, these constituents flow through the Oily Water Sewer System to the WWTP. However, during periods of heavy rain, the Oily Water Sewer's capacity is exceeded, causing the stormwater in the eastern portion of the containment area to form temporary pools of water with residual quantities of floating hydrocarbon liquids. When the sewers can accept the water, the pools drain, leaving residual hydrocarbons on the soil of the containment area, thereby staining the soil.

Historically, this also occurred at the catch basins located in the Crude Oil Tank Farm (the reason Tank 9 is included in SWMU 32). In 1992, the sewers within the Crude Oil Tank Farm were reconfigured. Currently, the Stormwater Catch Basins and the tank drains are piped

separately in the Crude Oil Tank Farm. Since the hydrocarbons do not flow through the same lines as the stormwater, hydrocarbons are no longer present in the stormwater backups during periods of heavy precipitation.

4.15 SWMU 33 - PIERS 2 AND 3

Areas of stained soil near Piers 2 and 3, which are located on the Delaware River, comprise SWMU 33 (see Figure 2). The piers are used to transfer crude oil to the Refinery and refined product to and from tankers and barges. SWMU 33 was not included in Motiva's Corrective Action permit. It was identified following discussions with Motiva personnel regarding historic operations at Piers 2 and 3. Leaking valves in the piping used to transfer oil between the tankers and the Refinery have caused these areas of stained soil.

Motiva previously collected subsurface soil samples from the areas and submitted them for analysis of total petroleum hydrocarbons (TPH). The analytical results indicate that the soil near the valves has been impacted with petroleum hydrocarbons (PHCs). The extent of the PHC-impacted soil is not known. A slotted metal drum was previously placed in the ground at Pier 2. Free-phase hydrocarbon has been observed floating on the water table in this "sump" in the past.

4.16 UNIT F – OLD DRUM STORAGE AREAS

Several used drum storage areas were located at the Refinery. They are designated as Unit F: Area A through Area G. The descriptions that are presented below for each area describe the conditions at the time of the USEPA visit, and were obtained from the May 1991 "Request For Information Report". Following that, a brief description of the current conditions is also included. The locations of the areas are shown on Figures 3, 4, and 5.

Area A

Area A is located on the west side of the Refinery in a large undeveloped area. The dimensions of Area A were approximately 50 feet by 150 feet. Piles of construction debris, old pallets, and rubber waste were placed in this area. In addition, approximately 20 to 30 used drums were resting on the ground. Many of the drums were empty and lacked lids. Several of the drums contained what appeared to be dry, powdery coke, while others contained a black oily liquid. Stained soil was observed near the drums.

Presently, no drums are stored at this area, and the piles of debris have been removed. Wood and pallets are presently stored in the area.

Area B

Area B is located north of the Central Control Building in a metal scrap yard on the western side of the Refinery. The dimensions of Area B were approximately 50 feet by 300 feet. Approximately 50 to 100 open, used drums were located in this area. The unlabeled drums were mostly empty. A few drums contained what appeared to be trash.

Presently, few drums are stored in this area. The area is used to store Refinery equipment that has been taken out of service during maintenance projects on units within the Refinery. For this reason, the area is much larger at this time than when the VRS was being conducted.

Area C

Area C is located on the north side of "R" Street, north of the Sulfur Plant (Unit 28). The dimensions of Area C were approximately 15 feet by 15 feet. Approximately 15 empty, unlabeled, used drums were stored on bare soil.

Presently, a portion of the area is fenced, and a contractor's equipment is stored within the area. The western portion of the area was recently excavated for the construction of a new cooling water header. This is discussed in Section 6.4.16.

Area D

Area D is located west of the warehouse, on the eastern side of a low metal building. The dimensions of Area D were approximately 10 feet by 40 feet. Approximately 48 sealed drums rested on pallets on concrete pads on the eastern side of the building. Several of the drums contained what appeared to be solid catalyst pellets and ceramic support material.

Presently, nothing is stored in this area.

Area E

Area E lies north of the warehouse, in a large gravel area on the northern side of "C" Street. The dimensions of Area E were approximately 20 feet by 20 feet. Approximately 20 open, unlabeled drums were stacked on pallets. The drums appeared to be empty and clean. Reportedly, this area had been used in the past to stack empty drums prior to their removal by a drum recycler.

Presently, this area is used to store new equipment during major maintenance projects within the Refinery. The only other equipment observed in this area since the VRS was conducted has been office trailers staged there temporarily.

Area F

Area F is located adjacent to the north side of the warehouse. The dimensions of Area F were approximately 15 feet by 20 feet. The area was defined by lengths of portable concrete curbing. Approximately 30 open, empty drums were stacked on their sides on sand-covered asphalt. Empty lubricating oil drums were temporarily stored at this area prior to their removal by a drum recycler. The sand on the asphalt near the drums was stained with traces of an oily substance that apparently had drained from the open drums that were lying on their sides. The stained sand occupied an area approximately 5 feet wide and 20 feet long in front of the drums. Surface water in this area flows to a stormwater catch basin located approximately 30 feet north of the warehouse.

Presently, no drums are stored in this area. The only materials observed in the area have been wooden pallets and totes.

Area G

Area G is located east of the second stage aeration tanks at the WWTP. The dimensions of Area G were approximately 15 feet by 14 feet. Approximately 20 open drums were stored on the ground in this area. Some of the drums contained what appeared to be oily, sludge-like material. Others contained discarded rubber boots and gloves.

Presently, several drums have been observed in the area. The drums are empty and unlabeled, and are stored on pallets. The area is also used as a laydown area for assorted equipment.

4.17 TOLUENE AREA

An area of the Refinery underlain by groundwater impacted primarily with benzene, toluene, ethylbenzene, and xylenes (BTEX) is commonly referred to as the "Toluene Area". The approximate area of impacted groundwater is shown on Figure 2. The following discussion presents a summary of the investigations conducted to address this area.

Motiva Enterprises Investigations

A 1979 Delaware Department of Natural Resources and Environmental Control (DNREC) State Facilities Permit (WPCC 3077/78) issued to the Refinery required the installation of monitoring wells D1 and D2 near two 168,000-gallon and one 1,200,000-gallon nitrogen-grade toluene storage tanks. Monitoring wells "Crude West" and "Crude South" were installed near Crude Oil Storage Tank No.9 in 1979 and 1980 in accordance with State Facilities Permit WPCC-3091/78. Each well was screened in the Columbia aquifer. Following installation, these wells were sampled several times per year and the samples were submitted for analysis of total organic carbon (TOC). Generally, wells D1 and D2 had higher concentrations of TOC than the Crude West and Crude South wells. The analytical results are summarized on Table A-1 of Appendix A of Dames & Moore's February 1994 report entitled "Additional Investigation of Petroleum Hydrocarbon Compounds In Groundwater".

In March 1983, Refinery personnel discovered a floating non-aqueous phase liquid (NAPL) in well D1. Motiva collected a sample of the NAPL, but the results indicated that the NAPL did not match any of the Refinery's crude oils, intermediate products, or final products. Refinery personnel periodically pumped water and the NAPL from the well to the oily water sewer for treatment at the Refinery's WWTP.

Motiva installed four additional wells (D3 through D6) near well D1 in 1983. These four wells and well D2 were sampled and analyzed for benzene, toluene, xylenes, TOC, pH, specific conductivity, phenols, and total dissolved solids (TDS) in June 1983. The analytical results are summarized on Table A-2 of Appendix A of the above referenced Dames & Moore report. The results indicated that well D3 exhibited the highest levels of TOC and TDS. No benzene, toluene, or xylenes were detected in the samples submitted for analysis.

Dames & Moore 1990 Investigation

Dames & Moore installed four additional monitoring wells (D7 through D10) in 1990 and five monitoring wells (D11 through D15) in 1991. The locations of these wells are shown on Figure 2, and boring logs and well construction details were presented in Appendix F of the RFI Work Plan. Generally, these wells are screened in the shallow Columbia aquifer.

Table A-3 of Appendix A of the previously referenced Dames & Moore 1994 report summarizes the available BTEX, TOC, and total petroleum hydrocarbon (TPH) data for wells D4 through D15 from February 1990 through April 1993. Well D3 had not been sampled since 1983 because it could not be located. The data contained in this table show that historically, wells D14 and D15 exhibited the highest concentrations of BTEX (ranging from 2,510 µg/l to 5,982 µg/l).

In 1990 and 1991, sixteen monitoring wells were sampled and the samples were submitted for analysis of volatile organic compounds (VOCs). VOCs were detected in fourteen of the sixteen samples submitted. Table A-4 of Appendix A of the above referenced document summarizes the analytical results of this groundwater sampling round.

Eleven monitoring wells were sampled and the samples were submitted for analysis of semi-volatile organic compounds (SVOCs) in December 1990. The analytical results are presented on Table A-5 of Appendix A of the above referenced document. The only SVOC detected was naphthalene. Naphthalene was detected in well D2 and well D6 at concentrations of 2.8 µg/l and 3.0 µg/l, respectively.

In summary, VOCs were detected in fourteen of the sixteen monitoring wells in 1990 and 1991. During this period, wells D1, D2, Crude West, and Crude South exhibited higher levels of BTEX than the other wells installed as part of the Toluene Investigation. Naphthalene was detected in two of the groundwater samples collected from eleven monitoring wells in December 1990. Following the installation of the five wells in 1991, D14 and D15 exhibited the highest concentrations of BTEX.

Several chlorinated VOCs were detected in groundwater samples collected from upgradient and downgradient monitoring wells on the Refinery. Due to their extent, these chlorinated VOCs were attributed to the plume of chlorinated VOCs known to exist west of the Refinery.

Dames & Moore 1993 Investigation

From January through July 1993, Dames & Moore conducted an additional investigation of the BTEX impacted groundwater underlying the Refinery. The investigation was performed in a phased approach. Initially, groundwater sampling was conducted through a Hydropunch drilling program. Following evaluation of the data generated during this phase of the investigation, Dames & Moore selected appropriate locations and installed four monitoring wells (D16 through D19). The locations of the monitoring wells and Hydropunch borings are shown on Figure 2.

Hydropunch Program

Of the ten groundwater samples submitted for analysis from the Hydropunch program, nine contained detectable levels of VOCs. The three Hydropunch grab samples that contained the highest concentration of VOCs were H-8 (25,280 µg/l), H-9 (578 µg/l), and H-10 (249 µg/l).

Benzene was detected at the greatest concentrations in the samples submitted for analysis. The maximum benzene concentration detected was in the sample collected from H-8 (25,000 µg/l).

The Hydropunch grab samples were also analyzed for total petroleum hydrocarbons (TPH). TPH concentrations ranged from 0.026 mg/l (H-7) to 0.168 mg/l (H-8). Nine of the ten samples exhibited TPH concentrations of less than 0.100 mg/l.

Monitoring Well Installation and Bail-Down Test

Dames & Moore installed monitoring wells D16 through D19 from February 10 through February 16, 1993 in and around the Bulk Storage Tank Farm. Each well was completed with 15 feet of 4-inch PVC screen (0.020-inch slot-size), and was screened across the water table in the Columbia Formation aquifer. Each well was developed on February 23, 1993.

Following well installation and development, well D17 was found to contain free-phase hydrocarbon (FPH) on the water table. Dames & Moore conducted a bail-down test on well D17 on March 30, 1993, to more accurately evaluate the thickness of the hydrocarbon. The actual thickness of the hydrocarbon was estimated to be 0.35 feet. A sample of the hydrocarbon was subsequently collected and submitted for analysis. Figure 4 of Dames & Moore's February 1994 report entitled "Additional Investigation of Petroleum Hydrocarbon Compounds In Groundwater" shows the graphical presentation of the bail-down test.

Soil Gas Survey

Dames & Moore retained Tracer Research Corporation (Tracer) of Tucson, Arizona to perform a soil gas survey in the Bulk Storage Tank Farm. The purpose of the survey was to identify the potential source areas(s) of the FPH found in well D17. From April 12 through 14, 1993, Tracer collected 51 soil gas measurements and analyzed them using a gas chromatograph equipped with a flame ionizing detector (FID). The soil vapor was analyzed for BTEX and total volatile hydrocarbons (TVHC). The samples were collected at depths ranging from 3 to 6.5 feet, in the unsaturated sandy vadose zone.

TVHCs were detected in 46 of the 51 soil gas samples analyzed. The two maximum TVHC concentrations detected occurred near Tanks 202 and 203, the same area where the maximum concentration of VOCs was detected during the Hydropunch groundwater sampling event. Total xylenes were detected in ten of the samples, toluene was detected in six of the samples, and benzene was detected in one of the samples. No ethylbenzene was detected in any of the samples analyzed.

Investigation of Tank Contents

Motiva collected samples from six of the Bulk Storage Tanks (Tanks 165-167 and 185-187) on March 17, 1993. The samples were submitted to New England Testing Laboratory, Inc. (NETL) of North Providence, Rhode Island for analysis. The results of the analyses were compared to the analysis of the sample collected from well D17 and indicated that none of the tanks near D17 contained products which were similar to the weathered free-phase hydrocarbon found in well D17.

Dames & Moore reviewed a 1971 tank inventory for the Delaware City Refinery to determine whether the tanks near well D17 had contained gasoline. The four tanks closest to well D17 are Tanks 166, 167, 186, and 187. The 1971 tank inventory showed that Tanks 166 and 186 had contained heavy aromatic gasoline, and that Tanks 167 and 187 were used for general service, which may have included gasoline storage. Historic contents of the general service tanks are unknown, although the contents of most tanks had remained the same since 1971.

Additional Monitoring Well Installation

Dames & Moore installed four additional monitoring wells (D20 through D23) from June 21 to June 23, 1993, to further evaluate the area near well D17. Each well was constructed with 15 feet of 4-inch inside diameter PVC screen (0.020-inch slot size), and was screened across the water table. During drilling, continuous split-spoon soil samples were collected and screened with a photoionization detector (PID). Soil boring logs were presented in Appendix F of the RFI Work Plan. Hydrocarbon odors were noted during the borehole advancement at all four locations. The locations of the monitoring wells are presented on Figure 2. Dames & Moore recorded groundwater elevations in June and July 1993 from 12 wells in the Bulk Storage Tank Farm area. FPH was detected in wells D9 and D17. No hydrocarbons were found in any of the other D-series wells.

Acoustical Testing

Based on the results of the investigation, Dames & Moore believed it was possible that one of the tanks in the Bulk Storage Tank Farm could be leaking. In June 1993, Physical Acoustics Corporation (PAC) of Princeton, New Jersey used acoustic emission sensors to test 12 tanks that were routinely used for gasoline storage. The tanks tested were Tanks 135 through 137, 145 through 147, 161 through 163, and 181 through 183.

PAC determined that nine of the twelve tanks tested were not leaking. Of the three remaining tanks, PAC stated that two were leaking. Tanks 146 and 162 were leaking, and the results for Tank 183 were inconclusive. PAC recommended retesting Tank 183 during a quiet period to eliminate any interference from nearby equipment.

Based on PACs acoustical results, Motiva removed Tank 146 from service, and inspected and repaired Tank 162. Tank 183 was retested in December 1993, and PAC stated that it was not leaking. Based on the position of the leaking tanks, and the predominant groundwater flow direction in the area, Tanks 146 and 162 did not appear to be the source of the FPH found in wells D9 or D17.

Groundwater Quality

The analytical results from the April and July 1993 sampling rounds indicated that one of the sources of dissolved BTEX in groundwater was located west of wells D14 and D15. The location of the area of historic BTEX detections is shown on Figure 2. The impacted groundwater appeared to trend eastward from wells D14 and D15 toward well D9. Near well D9, the BTEX appeared to follow the groundwater flow, which is generally north-northeast to southwest. Beneath the Bulk Storage Tank Farm, the impacted groundwater appeared to flow to the north. The southern extent of the dissolved BTEX appeared to be near the Refinery's southern border. The northern extent of the BTEX appeared to be at the RCRA Landfill and the Land Treatment Unit (LTU).

Evaluation of BTEX Sources

In 1991, Dames & Moore identified the most probable sources of the dissolved BTEX to be near or within Unit 25 (Reformer), Unit 29 (Desulfurization Train 1), and Unit 32 (Udex or Tetra). These areas are shown on Figure 2, and are immediately west of wells D14 and D15. Each of these areas manufactured various petroleum hydrocarbons and intermediates. Each area also contained underground pump-out lines that were abandoned in the early 1980s. If the manufactured products had leaked from the pump-out lines into underlying soil or groundwater, this source would be consistent with the presence of BTEX in wells D14 and D15. No additional measures, however, were taken to verify that these units were the sources of the dissolved BTEX in groundwater, and no remedial measures were implemented.

The dissolved BTEX impacted groundwater beneath the Crude Oil Tank Farm and the Bulk Storage Tank Farm was believed to originate partly from the area west of wells D14 and D15 and from the tank farms themselves. Two tanks were identified as leaking during the acoustical

testing of the previously mentioned tanks. However, due to their locations and the predominant groundwater flow direction in the vicinity, these tanks did not appear to be the source of the free-phase hydrocarbon on the water table in wells D9 or D17.

1994 Hydrocarbon Recovery System Installation and Operation

From September 12 through October 31, 1994 Dames & Moore installed a hydrocarbon recovery system at well D17 in the Bulk Storage Tank Farm. The system consisted of a top-loading pneumatic pump, an air compressor and a holding tank. Motiva intended to pump the recovered water and free-phase hydrocarbon (FPH) into the tank, and send it to their WWTP in batches. The pump in well D17 was started on October 31, 1994 at an initial rate of 3.5 gallons per minute (gpm). Since that time, the system has run almost continually, with one exception. During the summer of 1995, the eastern seaboard experienced drought conditions. The water level in well D17 declined enough that the pump could not operate. The system was restarted on January 30, 1996. The system was shut down on November 9, 1999 after MTBE was detected in the recovered groundwater. Dames & Moore had previously collected measurements at the system, and had estimated that at a pumping rate of 1.5 gpm, approximately 2,100 gallons of water and 100 gallons of free-phase hydrocarbon were being recovered per day.

Verification of Release Study

While collecting the groundwater measurements for the VRS in January 1995, Dames & Moore found FPH on the water table in newly installed wells 9MW-1, 9MW-2, and 24bMW-4 as well as D9, D14, D17, D20, and D22. FPH in the SWMU 9 wells was believed to be related to the Toluene Area. Samples of the FPH were collected from 9MW-1, 9MW-2, and 24bMW-4, and were submitted to NETL for analysis. The analytical results of the samples collected from SWMU 9 indicated that the FPH collected from well 9MW-1 contained a bi-modal distribution of hydrocarbon components. This effect usually occurs as the result of two products or process streams being mixed. The FPH collected from well 9MW-2 contained a uniform distribution of components in its profile. NETL determined that the sample collected from 9MW-2 had volatility between that of gasoline and kerosene. Jet fuel or a similar product was hypothesized as a possibility. The sample from well 24bMW-4 was found to consist of a weathered light crude oil.

4.18 AREA SOUTH OF RIVER ROAD

A portion of the 5,050 acres owned by the Refinery lies south of River Road, opposite the Crude Oil Tank Farm. This parcel of land consists of approximately 1,400 acres, and is bordered by

River Road to the north and east, Dragon Run to the south, and St. Georges - Clarks Corner Road to the west. A paleochannel which has been identified beneath the Refinery, and which is discussed in Section 6.3, has been shown to continue beneath this section of the Refinery's property.

Until the RFI, no environmental studies had been performed in this area. One production well (P16) and one temperature observation well (L6) are located on this parcel of land. Well P16 was drilled in 1955 and was completed in the Potomac Formation aquifer at an approximate total depth of 705 feet bgs. Well L6 is interpreted as being screened in the upper sands of the Potomac Formation.

5.0 SUMMARY OF FIELD INVESTIGATION

The following sections present a summary of the investigative tasks performed to evaluate the overall quality of surface water and sediment, soil, and groundwater.

5.1 SURFACE WATER/SEDIMENT INVESTIGATION

URS performed a limited investigation of the small cooling water effluent channel that conveys once through non-contact cooling water from the CONECTIV power plant at the Refinery to the main cooling water effluent channel. The channel begins east of River Road where the piping from the power plant ends. The channel then flows along East "R" Street until entering more piping which conveys the cooling water to the main effluent channel. The channel is monitored at a National Pollutant Discharge Elimination System (NPDES) Permit sampling point No. DE-0000256.

Investigative tasks included collecting samples of the water and sediment in the channel for analysis of the constituents listed in Motiva's Corrective Action Permit Part II.D.2.a.3.b, measuring the depth and width of the channel, measuring the velocity of the water within the channel, and obtaining dissolved oxygen readings.

Samples of the sediment and water in the cooling water effluent channel were collected on November 19, 1999. The analytical results of the surface water and sediment samples are summarized on Tables 3 and 4, respectively and are discussed in Section 6.1.

5.2 SOIL INVESTIGATION

The RFI Work Plan proposed 172 soil borings to evaluate soil quality. Not all of the borings could be advanced due to difficult access conditions and underground utility concerns in several areas. These areas are discussed in the applicable subsections of Section 6.4.

Continuous split-spoon soil samples were collected from the soil borings advanced to evaluate soil quality. The soil borings were logged by a URS geologist. Two soil samples were collected from the majority of the soil borings in accordance with the headspace screening procedure described in Section 6.4.3. When the sample collected from the base of the boring exhibited the highest PID headspace reading, only that sample was submitted for analysis.

The majority of the soil samples were submitted for analysis of total petroleum hydrocarbons (TPH) for diesel range organics (DRO) by modified method 8100 and TPH for gasoline range organics (GRO) by modified method 8260B. Soil samples were further analyzed based on the TPH analytical results and/or photoionization detector (PID) headspace screening results. Selected soil samples were further analyzed for modified Skinner List constituents or constituents of concern (COCs) relevant to a particular SWMU. At certain SWMUs (e.g. SWMU 24a), the soil samples were not submitted for analysis of TPH. These samples were submitted for modified Skinner List constituents based on the PID headspace screening procedure detailed in Section 6.4.3. Additionally, surface soil samples were collected from most SWMUs for analysis of modified Skinner List metals, to evaluate human health and ecological risks. The analytical program and results for each SWMU are detailed in Sections 6.4.1 through 6.4.18.

All subsurface soil samples collected for analysis of COCs were collected in a split-spoon sampler. A sample was collected from each split-spoon sampler and placed in laboratory supplied sample containers. The samples were stored and chilled with ice until the completion of the headspace screening, which determined what depth interval(s) would be submitted for analysis. Samples collected for analysis of VOCs were collected in accordance with EPA sampling method 5035.

Nineteen monitoring wells were installed during the RFI. During monitoring well installation, soil samples were collected continuously or at 5-feet depth intervals. The soil samples were logged by a URS geologist. Logs of the soil borings, including PID headspace readings, and monitoring well construction details are provided as Appendix A. Except for SWMU 33, no soil samples were submitted for laboratory analysis from the borings advanced for monitoring well installation.

Thirty-six of the proposed 37 ROST™/CPT probes proposed in the RFI Work Plan were advanced during January 1999. The ROST™ qualitatively evaluates soil quality by identifying petroleum hydrocarbon materials containing aromatic hydrocarbon constituents in the soil. A detailed description of the ROST™ methodology and a copy of the Fugro Geosciences Report were included in Dames & Moore's "Hydrocarbon Monitoring Interim Report" dated August 5, 1999.

Soil samples were also collected from various areas of the Refinery to evaluate general soil characteristics. The areas to be sampled were selected by a computer program that considered all

SWMUs and randomly generated a sample location and depth. The characteristics evaluated were:

- Relative permeability
- Bulk Density
- Cation exchange capacity
- Soil organic content
- Soil pH
- Particle size distribution

Samples were collected from eight of the 10 areas proposed in the RFI Work Plan. Samples were not collected from SWMU 20b.2 (Guard Basin No. 4) and Area C of Unit F. The sediment in Guard Basin No. 4 was under water, and due to Refinery safety considerations associated with the sampling from a boat with a ponar dredge (i.e., requirements to obtain large volume sediment samples in 5-gallon buckets), permission to collect these sediment samples was not granted. Additionally, the sediment in Guard Basin No. 4 originated from discharges from the wastewater treatment plant as well as the refinery's stormwater sewer system, and was not believed to be representative of Site conditions, due to the likelihood that this sediment contained considerably more oil (due to historic discharges from the stormwater sewer) than the sediment from other randomly selected areas. Area C of Unit F was excavated during the time the RFI investigative program was being implemented. The area was backfilled; however, it was not known if the material excavated from the area was used for the backfill material. Additionally, the material was disturbed and was not believed to be representative of Site conditions.

The eight samples were collected at random depth intervals. The areas sampled and the depth to the top of the sampling interval were:

Area of Refinery	Depth to Top of Sampling Interval in Feet Below Ground Surface
SWMU 31	0.5-foot
Area B of Unit F	1-foot
Area D of Unit F	1-foot
Area G of Unit F	6-feet
SWMU 15 – Boring 15B-7	5-feet
SWMU 15 – Boring 15B-20	8-feet
SWMU 20b.3	1-foot
SWMU 26	5.5-feet

The results of the analyses performed on the soil characterization samples are summarized on Table 5 and are discussed in Section 6.2.

5.3 GROUNDWATER INVESTIGATION

The groundwater investigation for the RFI was performed in a phased approach. Initially, a series of ROST™/CPT probes were advanced at SWMU 9, SWMU 24b, and the Toluene Area. After evaluating the results of the ROST™/CPT program, three (3) wells were installed at SWMU 9 and three (3) wells were installed in the Toluene Area. The locations of the wells are shown on Figure 2. Thirteen other wells were installed in various SWMUs as part of the RFI.

Following installation of all new wells, URS developed the monitoring wells. The wells were developed using a combination of pumping, surging, and re-circulation. During well development, the turbidity of the discharge water was measured. The wells were developed until the lowest turbidity measurement was recorded after a maximum of two (2) hours development. The lowest turbidity measurement recorded at each well is presented in the applicable subsections of Section 6.4.

URS collected two rounds of groundwater samples during the RFI. To evaluate potential differences in groundwater quality between the wet and dry seasons, one sampling round was performed in April 1999 (wet season) and one sampling round was performed in July 1999 (dry season). Prior to each sampling event, groundwater elevation monitoring was performed at all accessible wells within the Refinery limits. The data collected on March 29, 1999 are shown on Figure 6. The groundwater analytical data are discussed in Section 6.3.2 and applicable sections of 6.4. A summary of field measurements collected during the groundwater sampling events is provided in Appendix B.

6.0 RFI RESULTS

This chapter presents the analytical data obtained from the investigative program for the RFI. The chapter is divided into surface water/sediment characterization (Section 6.1), soil characterization (Section 6.2), hydrogeology and groundwater quality (Section 6.3), and unit characterization (Section 6.4).

6.1 SURFACE WATER/SEDIMENT CHARACTERIZATION

URS performed a limited investigation of the small cooling water channel that carries once through non-contact cooling water from the CONECTIV power plant to the Refinery's main effluent channel. As stated in Section 5.1, URS collected water and sediment samples from the cooling water channel. The samples were collected on November 19, 1999, and were submitted for analysis of the constituents listed in Motiva's Corrective Action Permit Part II.D.2.a.3.b. The analytical results of the samples are summarized on Tables 3 and 4. Based on the results, it does not appear that Refinery operations have impacted the water or sediment in the channel.

After collection of the samples, URS measured the velocity of the channel, measured the depth and width of the channel, and collected dissolved oxygen readings in the water in the channel.

There is only one point that URS could access the channel to measure the depth. A small bridge located at the NPDES sampling point is at the north end of East 4th Street. The depth of the channel at this point was measured to be 10 feet below the top of the banks. The width was also measured to be 10 feet. The width of the channel is consistent along the length of the channel.

The velocity and dissolved oxygen measurements were collected on February 3, 2000. The velocity of the water in the channel was measured to be 68.92 feet per minute, and the dissolved oxygen was recorded as 0.13 milligrams per liter on February 3, 2000. These measurements were also collected from the bridge at the NPDES sampling point.

After researching the history of the cooling water channel with Refinery personnel, it was apparent that the cooling water channel has not been significantly modified since it was created in 1956. URS compared the as-built drawing to the actual conditions observed in the field, and concluded that it was not necessary to re-survey the cooling water channel.

6.2 SOIL CHARACTERIZATION

URS collected and submitted soil samples for laboratory analysis to evaluate soil quality and collected bulk samples to characterize general soil parameters. The results of the analyses for the soil characterization samples are presented on Table 5. The results of the soil quality samples are discussed in 6.4.

The majority of the soil characterization samples were silty sand with varying amounts of gravel and organics. The sample collected from soil boring location 15B-20 was classified as well-graded sand with silt, and the sample collected from SWMU 26 was classified as silty clay with sand.

A copy of the laboratory report is included in Appendix C.

6.3 HYDROGEOLOGY AND GROUNDWATER QUALITY

This section provides an overview of the regional geology and hydrogeology in the area of the Delaware City Refinery as well a summary of the groundwater quality beneath the site. The results of aquifer testing and free-phase hydrocarbon evaluations performed during the RFI are also presented. A hydrologic model for the site is summarized in Section 6.3.9 and is provided as Appendix D.

6.3.1 Geology

The Refinery lies within the Atlantic Coastal Plain physiographic province, approximately 12 miles south of the boundary with the Piedmont province (the "fall line"). The coastal plain in this area consists of a wedge of unconsolidated sediments deposited on a seaward-sloping crystalline basement. According to Sundstrom and Pickett (1971) the typical sedimentary sequence in this area consists of (in descending order):

- Holocene Age silts and clays
- Columbia Formation (Pleistocene age) (fine to coarse sand and gravel)
- Marshalltown Formation (Cretaceous age) (silty fine sand)
- Englishtown Formation (Cretaceous age) (fine sand)
- Merchantville Formation (Cretaceous age) (sandy silt and clay)
- Magothy Formation (Cretaceous age) (sand)
- Potomac Formation (Cretaceous age) (clays with interbedded sands)

A general description of these units is:

- Holocene Silts and Clays. These fine-grained sediments were deposited along tidal flats and stream and river channels. They are usually dark gray, slightly micaceous, and organic rich. There may be irregularly distributed lenses of fine sand.

- Columbia Formation. In the Refinery area, the Columbia Formation sediments were deposited by Pleistocene age streams onto much older Cretaceous sediments. Boreholes drilled during foundation investigations in the area indicate that prior to construction of the Refinery, the upper few feet (from 0 to 10 feet) of the formation were typically composed of orange-brown to brown silty clay to clayey silt and underlain by tens of feet of medium- to coarse-grained sand with varying amounts of gravel. In places, construction activities have altered the natural sequence by placement of fill above the Columbia soils and excavation of the natural soils. Thin, laterally discontinuous layers of finer-grained silts and clays are present within the sand and gravel, and it is suggested that these were deposited in lower energy environments within the fluvial system.

  The color of the sand varies widely from orange to black through shades of yellow and brown, with the oxidation state of iron and manganese-bearing minerals usually controlling the colors. Zones cemented by iron oxides and hydroxides ("ironstones") are occasionally present, usually near the water table.

- Marshalltown Formation. The Marshalltown is a dark greenish gray, glauconitic, very silty, fine sand. In the general vicinity of the Refinery, it is a leaky confining unit and not an aquifer (Woodruff, 1986). The Marshalltown, Englishtown, and Merchantville Formations comprise the Matawan Group.

- Englishtown Formation. The Englishtown consists of light gray and rust brown, well sorted, micaceous, rarely glauconitic, fine sand with interbedded layers of dark gray silty sand (Sundstrom and Pickett, 1971). It is considered a minor aquifer capable of yielding small amounts of water (Woodruff, 1986). It is lumped together with the confining units in Woodruff's map of the total thickness of the confining units between the water-table aquifer and the uppermost artesian aquifer "capable of consistently supplying water to wells" (Woodruff, 1988).

- Merchantville Formation. This is the oldest formation in the Matawan Group and is generally a gray (green to blue), micaceous, glauconitic, sandy silt to silty clay to silty fine

sand. As with the Marshalltown, it is a semi-confining unit and not an aquifer (Woodruff, 1986).

- Magothy Formation. The Magothy Formation typically consists of fine- to medium-grained sand with layers of gray and black clayey silt containing lignite and pyrite. Test holes in the Refinery area indicate that the Magothy is generally thin or absent (Sundstrom and Pickett, 1971).

- Potomac Formation. The Potomac Formation consists predominately of variegated red, gray, purple, yellow, and white silts and clays with some interbedded white, gray, and red-brown sands. The sediments were deposited in a fluvial environment and exhibit lithologic variability vertically and horizontally. The Potomac silts and clays exhibit very low permeabilities. Thicker, laterally continuous sandy zones in the Potomac are used by the Refinery for water supply.

The relationships between these units are shown on Figure 7, a northwest-southeast cross section (adapted from Woodruff, 1986) through the study area. Figure 8 shows the location of the cross section. As shown in the section, the older formations subcrop beneath a discontinuous cover of Pleistocene sediment. Figure 9 shows the subcrop and outcrop zones for these older formations in New Castle County. The study area is within the mapped subcrop bands of the Englishtown and Merchantville Formations; therefore, these units would be expected to lie either directly beneath the Pleistocene or Holocene age sediments or outcrop at the surface if the younger deposits have been eroded. Units younger than the Englishtown Formation (such as the Marshalltown Formation) would not be expected to be present below the Pleistocene in the study area. In places, such as for the Refinery's production well No. P-16 (Delaware Geologic Survey No. EC13-6) shown in Figure 7, the Pleistocene channel eroded through the upper Cretaceous formations into the Potomac Formation.

The postulated base of the Pleistocene sediments in Well P-16 as shown in Woodruff's cross section (Figure 7) was previously believed to be unusual because of the extreme elevation difference between this postulated contact and those in nearby wells. For instance, the base of the channel in wells north of well P-16 is seen to be between -50 and -60 feet (below msl), whereas the cross section (Figure 7) shows the Pleistocene base for well P-16 at approximately -140 feet. URS advanced several soil borings south of the P-16 location. One soil boring (boring PC-A) was advanced approximately 700-feet south of well P-16. The contact between the Pleistocene-age Columbia Formation sediments and the Cretaceous-age Potomac Formation sediments was found at approximately -95 feet. The information obtained from the soil borings advanced south of the Refinery is presented in cross-section H-H' on Figure 10.

Along the present-day stream valleys in this area, erosion has removed most of the Pleistocene sediments (Woodruff, 1986). Figure 8 shows the approximate eastern edge of the Columbia Formation sands, based on borings drilled in the 1950s during construction of the Refinery. The exact location of the sand edge is questionable because of the possibility of mistaking thin remnants of the Columbia Formation with sand lenses in the underlying Cretaceous formations. Clearly, however, the Columbia Formation thins dramatically east of the Refinery towards the Delaware River. Woodruff (1986) illustrates this trend by mapping the limit of Columbia Formation sediments with a thickness greater than 40 feet. His 40-foot isopach contour is westward of the sand edge shown in Figure 8 (as must be the case for the correlations to agree) except near the landfill facility.

Figure 11 shows the total thickness of confining beds between the water-table aquifer and the uppermost confined aquifer "capable of consistently supplying water to wells" as mapped by Woodruff (1988). Woodruff maps an area (control points DC53-23 and DC53-31) on the eastern edge of the study area (near the present location of the Refinery's Wastewater Treatment Plant (WWTP) where there are no confining beds between the water-table aquifer and the uppermost confined aquifer. In this area, the subcropping sands would also be part of the water-table aquifer.

6.3.2 Configuration of the Columbia Formation Aquifer

The sands of the Columbia Formation aquifer were deposited on an irregular topographic surface. In most areas, the pre-existing topographic surface was eroded into the Merchantville Formation. The Merchantville Formation, which consists of silts and clays, forms a confining layer for the base of the Columbia Formation aquifer. A prominent north-south trending paleochannel passes under the Land Treatment Unit and the tank farms located on the eastern portion of the Refinery. This paleochannel eroded completely through the Merchantville Formation and into the underlying Potomac Formation, as shown on cross sections A-A', B-B', C-C', and H –H' (Figure 10). The Potomac Formation in this area consists predominantly of clay, which prevents the paleochannel from acting as a significant conduit for vertical migration of groundwater. East of the paleochannel, the base of the Columbia Formation aquifer rises to an elevation of approximately zero feet msl near the dredged material storage areas. Further east of this area, the Columbia Formation appears to "pinch out," and is not present. This situation has a pronounced effect on groundwater flow within the Columbia Formation aquifer. Cross sections D-D' through G-G' (Figure 10) show the configuration of the Columbia Formation aquifer in a north-south direction.

The base of the Columbia Formation at its highest elevation (31 feet above msl) is near the western edge of the site at monitoring well MW-1S. Generally, the base of the formation slopes downward in an easterly direction toward the paleochannel. East of the paleochannel, the base of the Columbia Formation slopes upward. Figure 12 is an isopach map showing the saturated thickness of the Columbia Formation aquifer. This map was produced using the groundwater elevations measured on March 29, 1999, and the base of the aquifer shown on Figure 13. The base of the aquifer shown on Figure 13 represents the bottom of the lowest sand or gravel layer present in the Columbia Formation. This figure was produced by evaluating soil boring logs and well completion details from across the site. In some cases, clay is shown at the bottom of the Columbia Formation on the boring logs. This clay was not included in the saturated thickness of the aquifer.

6.3.3 Groundwater Flow Regime

Groundwater at the site originates mainly as rainfall recharge on the site. The precipitation that falls on the site re-evaporates, runs off to the Stormwater Sewer System, or recharges the underlying water table aquifer. A groundwater elevation contour map of the Columbia Formation aquifer is shown on Figure 6. Flow net analysis of the map shows that groundwater generally flows west to east across the site. Groundwater flow, however, is not uniform across the site due to variations in the aquifer transmissivity. Groundwater elevation contours in the west-central part of the site exhibit a wider spacing than other portions of the site, indicating a zone of relatively higher transmissivity.

As groundwater approaches the eastern boundary of the site, groundwater flow in the easterly direction is restricted due to the thinning of the saturated thickness of the Columbia Formation aquifer. This thinning results from the rise in elevation of the top of the Merchantville Formation clay, which forms the base of the Columbia Formation aquifer. The rise in elevation of the top of the Merchantville Formation is shown in cross section A-A' (Figure 10) and on the structure contour map of the base of the Columbia Formation depicted on Figure 13.

The north-south trending paleochannel identified on the eastern portion of the Refinery lies beneath the tank farms and the Land Treatment Unit. The channel is eroded through the Merchantville Formation, which results in the Columbia Formation lying unconformably on the Potomac Formation clay. The channel, which is filled with Columbia Formation sediment, causes a significant increase in the saturated thickness of the Columbia Formation aquifer. The saturated thickness of the aquifer in the paleochannel is approximately 55 to 85 feet beneath the site, while the saturated thickness of the aquifer in the area immediately west of the channel is approximately 20 feet. The paleochannel is believed to extend northward to Red Lion Creek and

southward to Dragon Run Creek. Assuming uniform permeability, the transmissivity in the paleochannel would be approximately three to four times greater than the transmissivity of the aquifer immediately west of the channel. As a result, a significant portion of the groundwater flow is diverted to the north and to the south in this paleochannel. In the east-central portion of the Refinery, within a zone of approximately 1000 feet wide, groundwater flows eastward across the channel. Groundwater in this zone discharges toward the Delaware River. However, part of this eastward flowing groundwater may diverge and discharge into the Cooling Water Effluent Channel, and part of it may diverge and flow northward beneath the Landfill because the Columbia Formation pinches out to the east of the landfill.

6.3.4 Surface Water Runoff

Surface water runoff is for the most part diverted to the Refinery Stormwater Sewer System, which carries the runoff to the wastewater treatment plant (WWTP). Following treatment at the WWTP, the water is discharged to the Stormwater Channel, which flows into Guard Basin No. 4, before being discharged to the main Effluent Channel.

6.3.5 Aquifer Recharge Conditions

Due to the impervious surfaces located within the Refinery, surface runoff is expected to be larger than that observed under natural conditions. It follows that the recharge rate from rainfall is expected to be lower than that observed under natural conditions. However, this reduction in the recharge rate may be offset in part by artificial recharge sources present due to site operations. Additionally, during periods of heavy precipitation, the WWTP cannot manage the large quantities of water being delivered via the entire sewer system. During these times, portions of the Oily Water Sewer System that drain some areas are closed (e.g. Tank Farm Areas) to allow the WWTP to treat stormwater that cannot be diverted. As a result, these areas contribute to aquifer recharge.

Throughout much of the site, the Columbia Formation sands are covered by a layer of clay ranging in thickness from approximately one foot to ten feet. The rainfall recharge rate would be expected to be lower in areas that are covered by this clay layer compared with areas where the Columbia Formation sands are exposed and areas where the Columbia Formation sands have been covered by a layer of coarse fill material. Some of the surficial fill material may actually consist of Columbia Formation sand that was excavated from the western portion of the site in the area of the present day Industrial Waste Landfill.

6.3.6 Groundwater Quality

To evaluate groundwater quality, two rounds of groundwater sampling were performed during the RFI. In accordance with the RFI Work Plan, one round was performed during April 1999 (wet season) and the second round was performed during July 1999 (dry season). Prior to the initiation of each groundwater sampling event, groundwater elevation measurements were collected from all accessible wells within the Refinery limits. The measured groundwater elevations collected on March 29, 1999 are shown on Figure 6.

Groundwater samples were collected from new and existing wells (except those that exhibited free-phase hydrocarbon on the water table) as listed on Table 6. The groundwater sampling rounds were intended to provide a comprehensive representation of groundwater quality beneath the entire Refinery. The groundwater analytical data for the two sampling events are presented in Section 6.4 on a SWMU specific basis. Analytical data for monitoring wells that were not part of a SWMU evaluation are presented in Appendix E (this data includes wells in the Stack Gas Scrubber Area, the Toluene Area, the Industrial Waste Landfill, the Land Treatment Unit, and the RCRA Landfill).

The groundwater analytical results indicate that the most widespread refinery related constituents in groundwater are benzene and methyl tertiary butyl ether (MTBE). Locally, there are additional refinery related constituents in groundwater such as ethylbenzene, toluene, xylenes, naphthalene, some metals and degradation products of MTBE. The area of historic BTEX detections is shown on Figure 2, and an isoconcentration map of benzene detections from the recent RFI groundwater samples is shown on Figure 14. It is important to note that these figures illustrate that the aerial extent of BTEX and benzene in groundwater and do not represent a groundwater plume derived from a sole source. It is likely that the occurrence of BTEX in groundwater is due to several potential sources. The suspected primary source areas include the Bulk Storage Tank Farm and the pump-out lines at the Desulfurizer Unit. The presence of MTBE in groundwater is shown on Figure 15. It appears that two potential source areas exist for MTBE; one in the Bulk Storage Tank Farm, and one near the Desulfurizer Unit.

6.3.7 Aquifer Testing

URS conducted aquifer tests on various wells throughout the Refinery. The aquifer testing included slug testing and aquifer pumping tests. The remainder of this section presents a summary of the tasks undertaken and the results of the aquifer-testing program.

6.3.7.1 Slug Testing

Slug tests were performed on wells 9MW-8 (one of the newly installed wells near wells 9MW-1 and 9MW-2), MW-4S, D2, Crude South, D11, D21, 24bMW-2, 24aMW-1, and 33MW-1. The RFI Work Plan stipulated that a slug test be performed on well 24bMW-5; however, free-phase hydrocarbon was present on the water table when the slug tests were being performed. As an alternative, URS performed a slug test on nearby well 20bMW-4. The slug tests were performed from November 12, 1999 through November 26, 1999.

Slug testing consists of injecting a slug of known volume into the well and recording the rise in the head of the water within the well. The initial rise in the water level was monitored with an electronic water level meter and with a data logger and pressure transducer as it recovered, or fell (known as a falling head test). Once the water level had recovered to 95% of its original level, the slug was withdrawn, causing a fall in the water level. Once again, the recovering water level was monitored as it rose (known as a rising head test). The results of the slug testing are summarized on Table 7.

Hydraulic conductivities calculated from the data recorded during the slug testing ranged from 5.67×10^{-5} feet per minute (ft/min. [well 24aMW-1]) to 0.122 ft/min (well 20bMW-4). Plots of the data recorded during the slug testing are included in Appendix F.

6.3.7.2 Aquifer Pumping Tests

URS conducted two (2) aquifer-pumping tests as part of the investigative tasks performed for the RFI. The pumping tests were performed to evaluate aquifer characteristics and assist in projecting drawdowns and resultant zones of capture for potential remedial activities at the Refinery. Prior to initiating the pumping tests, stepped rate tests were performed on each of the pumping wells to determine the optimum/appropriate pumping rates for the duration of the tests. A stepped-rate pumping test was performed at well 36D September 22, 1999, and a stepped-rate pumping test was performed at well D1 on October 1, 1999.

Long term (24 to 48-hour) pumping tests were performed at well 36D, located in the Pleistocene Channel, and at well D1, located outside of the Pleistocene Channel. Prior to initiation of each pumping test, antecedent water levels were monitored in selected wells with data loggers and pressure transducers. Wells that were not equipped with data loggers were monitored for several hours preceding the test and were monitored during the recovery phase of the test until they had recovered to 95% or more of their pre-pump test levels. The data loggers and pressure transducers continued to monitor water levels during the pumping and recovery portions of the tests.

Well 36D Pumping Test

The constant-rate pumping test performed at well 36D was initiated at 1300 hours on September 27, 1999. The test was terminated at 1830 hours on September 28, 1999 because water levels in the pumping and observation wells had stabilized. A total of 180,016 gallons of water were pumped over the course of the 29½-hour test for an average pumping rate of 101.7 gallons per minute (gpm).

During the pumping test, the maximum drawdown observed in the pumping well was approximately 5 feet. Recovering water levels were monitored in wells without data loggers for a period of one (1) hour, at which time they had recovered to 95% or more of their pre-pump test levels. Hydrographs of the data recorded from the pumping well and the observation wells are presented in Appendix G. Table 8 presents a summary of the transmissivity (T) and storativity (S) value(s) (where applicable) calculated for the pumping and observation wells.

Well D1 Pumping Test

The pumping test performed at well D1 was initiated at 1300 hours on October 6, 1999. The test was terminated at 0930 hours on October 8, 1999 because water levels in the pumping and observation wells had stabilized. The test was initiated as a constant-rate pumping test. However, during the course of the test, a barrier boundary was reached and the water level in the pumping well drew down to the pump intake. Consequently, the pumping rate of the test was not constant. A total of 53,255 gallons of water were pumped over the course of the 44½-hour test for an average pumping rate of 19.95 gpm.

During the pumping test, the maximum drawdown observed in the pumping well was approximately 7 feet. Recovering water levels were monitored in wells without data loggers for a period of three (3) hours, at which time they had recovered to 95% or more of their pre-pump test levels. Hydrographs of the data recorded from the pumping well and the observation wells are presented in Appendix G. Table 8 presents a summary of the transmissivity (T) and storativity (S) value(s) (where applicable) calculated for the pumping and observation wells near well D1.

6.3.8 Free-Phase Hydrocarbon Evaluation

This section presents a summary of the free-phase hydrocarbon evaluation conducted at the Refinery. A detailed presentation of the free-phase hydrocarbon evaluation is presented in a report that was submitted to the EPA as part of the RCRA Corrective Action Program entitled "Hydrocarbon Monitoring Interim Report" dated August 5, 1999.

6.3.8.1 Objectives and Investigative Tasks

The objectives of the free-phase hydrocarbon investigation were to:

- Evaluate the degree and extent of free-phase hydrocarbon present on the water table in several areas of the Refinery.
- Evaluate the apparent versus actual free-phase hydrocarbon thickness in these areas.
- Evaluate potential source areas of the free-phase hydrocarbon.

During the early stages of the RFI, URS subcontracted Fugro Geosciences, Inc. (Fugro) of Houston, Texas to perform Cone Penetrometer Testing (CPTs) and Rapid Optical Screening Tool (ROST™) testing at selected locations. After evaluating the results of the ROST™ investigation, URS installed six (6) monitoring wells to verify the information provided by the testing. Following well installation and development, URS monitored existing and newly installed monitoring wells to evaluate the presence of free-phase hydrocarbon on the water table.

Selected wells that exhibited free-phase hydrocarbon on the water table were subsequently subjected to baildown testing to evaluate actual hydrocarbon thicknesses. URS also performed an evaluation of potential source areas including sampling and analysis of hydrocarbon.

6.3.8.2 Free-Phase Hydrocarbon Evaluation Conclusions

The conclusions reached from the free-phase hydrocarbon evaluation were the following:

- Free-phase hydrocarbon has been detected on the water table in 13 wells at the Delaware City Refinery. The wells are D1, D9, D14, D15, D17, D20, D22, D24, 9MW-1, 9MW-2, 9MW-3, 24bMW-4, and 33MW-2.

- On March 29, 1999, apparent hydrocarbon thicknesses ranged from 0.10-foot (well D24) to 10.0 feet (well 24bMW-4).

- Estimated actual hydrocarbon thicknesses based on the results of the baildown testing ranged from 0.10 feet (9MW-3) to 0.61 feet (well D9).

- A possible source of the free-phase hydrocarbon in well D9 is the Truck Loading Rack. Well D9 lies hydraulically downgradient of this area. The Truck Loading Rack has been in operation since the Refinery opened in 1956. Other possible sources exist, such as the Bulk Storage and Crude Oil Tank Farms, and the Sewer System; however, no source has been positively identified.

- The source of the free-phase hydrocarbon in the Bulk Storage Tank Farm wells is believed to have been one or more of the above ground storage tanks within the Tank Farm.

- Monitoring well 9MW-3 is located east of the Cat Cracker. This area of the Refinery processes some of the heavier hydrocarbon products. The free-phase hydrocarbon in this well has a dark color and resembles a more viscous hydrocarbon when compared to the southern process area wells. A potential source of the hydrocarbon is the Oily Water Sewer. A portion of the Oily Water Sewer is present upgradient of this area; however, this source has not been positively verified.

- The source of the free-phase hydrocarbon in well 24bMW-4 is believed to be the Oily Sludge Area of DMSA No. 2.

- The source of the free-phase hydrocarbon in the southern process area wells is believed to have been the abandoned pump-out lines that were located in Units 25, 29 and 32. Since these lines were abandoned, they are not believed to be an active source. No source has been positively identified, however.

- The source of the free-phase hydrocarbon in well 33MW-2 is believed to be historic releases from leaking valves. The valves have been repaired; therefore, they do not represent an active source. However, soil in the area of the former leaking valves could represent an ongoing source of impacts to groundwater. This will be addressed as part of the Phase II RFI.

Motiva received comments in reference to the "Hydrocarbon Monitoring Interim Report" from the EPA in a letter dated November 2, 1999. Based on the comments received, URS revised

several of the hydrocarbon thicknesses estimated from the baildown testing. The revised estimated thicknesses range from 0.10 feet (well 9MW-3) to 1.1 feet (well D20). An isopach map of the estimated free-phase hydrocarbon thickness is shown on Figure 16. The Oily Sludge Area of DMSA No. 2 is not included on Figure 16 because baildown testing was not performed in the area.

Additionally, after receiving the groundwater analytical results from the first RFI sampling round, it was apparent that MTBE was present in groundwater near some of the areas of free-phase hydrocarbon. The analytical results potentially refuted the conclusions that active sources were not present in the Bulk Storage Tank Farm. At the time, Motiva was implementing a tank testing program to determine if any active sources are present in the tank farm. In addition, URS was evaluating installation of hydrocarbon recovery systems in the wells that exhibited hydrocarbon on the water table within Bulk Storage Tank Farm and well 33MW-2. Work Plans documenting the investigative tasks and/or remedial strategy for each area referenced in the Hydrocarbon Monitoring Interim Report except Area 3 (Oily Sludge Area of DMSA No. 2) were submitted to the EPA at the time of the RFI Report submission. Motiva, EPA, and DNREC met on December 20, 2000 following submission of the Work Plans. During the meeting, it was agreed that Motiva would concentrate on removing the sources of the dissolved hydrocarbon constituents in groundwater while delineating the extent of the dissolved constituents in groundwater. Revision 2 – Dissolved Phase Monitoring Work Plan (URS, December 31, 2001) was approved by EPA in their letter dated January 24, 2002, pending submission of a Quality Assurance Project Plan (QAPP). Motiva subsequently submitted a QAPP that was approved by EPA in their letter dated July 31, 2002.

Motiva considered Area 1 (Bulk Storage Tank Farm) and Area 5 (Piers 2 & 3) priority areas. Area 1 was considered a priority due to the MTBE in groundwater and Area 5 was considered a priority due to its proximity to a surface water body. Currently, four (4) hydrocarbon recovery systems are in operation at wells in Area 1, and one hydrocarbon recovery system is in operation at well 33MW-2 located near Pier 3. A recovery system is also operating at wells D9 and TW-1 (Area 2), and four (4) recovery systems are operating in the Southern Process Area (Area 4). In accordance with Corrective Action Permit HW09A13, interim measures will be evaluated for the Oily Sludge Area of DMSA No. 2, and will be addressed during the Corrective Measures Study (CMS) of the ongoing RFI/CMS.

6.3.9 Hydrologic Modeling

This section of the Report summarizes the methods that were used to construct and calibrate a numerical model of groundwater flow and solute transport in the Columbia Formation aquifer

beneath the Delaware City Refinery. The calibrated model was used to simulate several potential remedial alternative scenarios for use at the site.

The overall objective of the groundwater model was to develop a tool to evaluate potential remedial alternative strategies and to provide the USEPA with information necessary to make a potential groundwater remedy decision. Specifically, the objectives of the groundwater model were to:

- Calibrate the groundwater flow model so that the simulated and observed groundwater elevations are within acceptable limits (approximately one-foot).

- Calibrate the transport model so that the simulated benzene plumes match the observed benzene distribution as closely as possible.

- Simulate the effects of remedial alternative strategies within the model flow domain.

The specific details concerning the approach, construction, and calibration of the groundwater model have been presented previously in the RFI Work Plan (Dames & Moore, September 1998) and the Conceptual Model Report (Dames & Moore, June 25, 1999). The Groundwater Flow and Solute Transport Model is presented in Appendix D. Additionally, the Groundwater Flow and Solute Transport Model is currently being updated with information obtained to date during investigation of the migration of constituents south of the Refinery.

6.4 UNIT CHARACTERIZATION

Each SWMU was characterized based on the media and constituents of concern (COCs) identified during the VRS, where applicable. Subsections 6.4.1 through 6.4.16 present a summary of the VRS results for each SWMU/Unit, followed by a detailed description of the RFI field activities and a summary of the analytical results. Sections 6.4.17 and 6.4.18 present a description of the RFI field activities and a summary of the analytical results for the Toluene Area and the Area South of River Road.

6.4.1 SWMU 9 - Facility Sewer System

As part of the VRS, a groundwater investigation was implemented at SWMU 9. Because the sewer system is so vast and inaccessible, it was determined that the most efficient way to evaluate the sewer system was to install monitoring wells downgradient of major portions of the sewer system. If COCs had leaked from the sewer system, they would most likely appear in

groundwater downgradient of the sewers. URS installed seven monitoring wells downgradient of major portions of the sewer system to evaluate the potential that the sewer system had released COCs to groundwater. The VRS Work Plan proposed groundwater sampling at 13 monitoring wells in SWMU 9 (7 new wells, 6 existing wells). Only 10 wells were sampled due to FPH on the water table in three of the wells. Each groundwater sample was submitted for analysis of modified Skinner List constituents. The modified Skinner List is provided as Table 9.

Seven VOCs were detected in the ten samples submitted for laboratory analysis. Various SVOCs and metals were also detected in the samples. The majority of the detections occurred in samples collected from wells near the "Toluene Area." The analytical results of the VRS investigation at SWMU 9 are summarized in the VRS report in subsection 6.3 (pages 18 through 21) and in Table 6-3. Figure 17 of this report presents VRS detections and detection limits that exceeded EPA Region III Risk-based concentrations (dated 4/25/03) for tap water.

Based on the results of the VRS, URS investigated the facility sewer system to evaluate the extent and degree of free-phase and dissolved hydrocarbon constituents present in the groundwater. The investigation of the extent and degree of FPH present on the water table surface, the potential source area(s), and the rate and direction of migration of the hydrocarbon was focused in the area of monitoring wells 9MW-1 and 9MW-2.

To delineate the extent of hydrocarbon constituents, URS initially performed soil probes using a combination of the Rapid Optical Screening Tool (ROST™) and the Cone Penetrometer Test (CPT). These technologies can be useful in identifying specific hydrocarbon types and possible source areas. The scope of work and the results of the ROST™/CPT investigation were detailed in the Hydrocarbon Monitoring Interim Report (Dames & Moore, August 5, 1999).

After evaluating the results of the ROST™ investigation, URS installed three wells (9MW-8 through 9MW-10) to verify the information provided by the ROST™ testing at SWMU 9. Following well installation and development, URS monitored existing and newly installed monitoring wells to evaluate the presence of free-phase hydrocarbon on the water table. Wells that had free-phase hydrocarbon on the water table were subsequently sampled for free-phase hydrocarbon fingerprint testing to evaluate potential source areas. The wells were also subjected to bail down testing to estimate the actual hydrocarbon thicknesses in the subsurface. The monitoring well installation and development program, hydrocarbon monitoring and sampling, and the bail down testing are also detailed in the Hydrocarbon Monitoring Interim Report (Dames & Moore, August 5, 1999).

SWMU 9 Groundwater Sampling and Analysis

A Refinery-wide evaluation of groundwater quality is presented in Section 6.3. The remainder of this section presents a summary of the results of the RFI groundwater investigation for SWMU 9.

As part of the field program for the RFI, two rounds of groundwater samples were collected and submitted for laboratory analysis. Groundwater sampling was performed in April 1999 and in July 1999. Groundwater samples were collected from existing wells 9MW-5, 9MW-6, and 9MW-7 as well as newly installed wells 9MW-8, 9MW-9, and 9MW-10. All groundwater samples from SWMU 9 were analyzed for benzene, toluene, ethylbenzene, total xylenes (BTEX) and methyl tertiary butyl ether (MTBE). In addition, well 9MW-6 was analyzed for halogenated volatile organic compounds, phenols, chloride, total and dissolved iron, total and dissolved manganese, sodium, sulfate, and total dissolved solids (TDS).

The groundwater samples collected from SWMU 9 were submitted to New England Testing Laboratory, Inc. (NETL), of North Providence, Rhode Island. Groundwater analytical results from SWMU 9 are summarized on Table 10. Detected concentrations and detection limits that exceeded EPA Region III Risk-based tap water concentrations (dated 4/25/03) are summarized on Figure 18.

6.4.2 SWMU 13 – Old Drum Storage Area

The VRS field program at SWMU 13 consisted of a subsurface soil investigation. The proposed scope of work was to advance three soil borings to a depth of 8 feet below ground surface (bgs). Clearance could not be obtained to operate a drilling rig at the boring locations; therefore, the borings were advanced using hand augers. Two of the borings could only be advanced to depths of 2-feet below ground surface (bgs), and the third boring was advanced to a depth of 5.5 feet bgs. A soil sample was collected from each boring based on the screening criteria contained in the approved VRS Work Plan. Each soil sample was submitted for laboratory analysis of modified Skinner List VOCs and metals.

The only VOCs detected in the soil samples submitted for laboratory analysis were toluene and total xylenes. The only metal detected above the observed range of concentrations in eastern U.S. soils (USEPA, 1988) was cadmium. The analytical results of the VRS investigation at SWMU 13 are summarized in the VRS report in subsection 8.3 (page 27) and in Table 8-1. Figures 19 and 20 of this report summarize VRS detections and detection limits that exceed

Region III Risk-based soil concentrations (dated 4/25/03) for residential and industrial soils (Figure 19), as well as the soil to groundwater migration pathway (Figure 20).

Because the borings could not be completed to their proposed depth during the VRS, the EPA requested additional sampling. The RFI investigative program for SWMU 13 consisted of advancing three soil borings near the same locations proposed in the VRS. Each boring was advanced to a depth of 10 feet bgs. The locations of the borings are shown on Figure 21.

As part of the RFI, URS collected continuous split-spoon samples from each boring. Each soil sample was screened with a PID according to the headspace screening procedures detailed in Appendix A of the RFI Work Plan.

Once native material was encountered, a sample from the first soil interval was collected from each boring and submitted for analysis of modified Skinner List metals, aluminum and bismuth. Two additional soil samples from each boring were collected and submitted for analysis of TPH by modified methods 8100 and 8260 based on the following PID headspace screening criteria:

- If all PID headspace readings exceeded 10 parts per million (ppm), the first sample submitted for analysis was collected from the depth interval exhibiting the highest PID headspace reading. The second sample submitted for analysis was collected from the base of the boring.

- If all PID headspace readings were less than 10 ppm, the samples from the first native material depth interval and the 8 to 10 foot depth interval (base of boring) were submitted for laboratory analysis.

- If PID headspace readings were both less than and greater than 10 ppm at different depth intervals, the first sample submitted for analysis was collected from the depth interval with the highest PID headspace reading. The second sample submitted for analysis was collected from the first depth interval to exhibit a PID headspace reading of less than 10 ppm at a depth greater than the interval exhibiting the highest PID headspace reading, if possible. If no PID headspace readings of less than 10 ppm were recorded at a depth greater than the interval exhibiting the highest reading, the second sample was collected from the base of the boring.

After completion of the borings, URS submitted one soil sample for analysis of modified Skinner List VOCs, aluminum, and bismuth. The sample was collected from the 0 – 2 feet depth interval of boring 13B-3, which exhibited the highest PID headspace reading from the three borings.

SWMU 13 - Soil Analytical Results

The results of the total petroleum hydrocarbons (TPH) analyses are summarized on Table 11, the results of the VOC analyses are summarized on Table 12, and the results of the modified Skinner List metals plus aluminum and bismuth are summarized on Table 13. Detected concentrations of constituents that exceeded Region III Risk-based screening levels for residential and industrial soil dated 4/25/03 are summarized on Figure 21. Figure 22 presents analytical results and detection limits that exceeded Region III Risk-based screening criteria for soil to groundwater migration dated 4/25/03.

Total petroleum hydrocarbons (TPH) for diesel range organics (DRO) was not detected above the method detection limit in the six samples submitted from SWMU 13. TPH for gasoline range organics (GRO) was detected in four of the six samples submitted for analysis from SWMU 13 at concentrations ranging from 5.8 milligrams per kilogram (mg/kg) to 12.3 mg/kg. Ranges of detected TPH concentrations for DRO and GRO are summarized on Figures 23 and 24, respectively. Although TPH for GRO was detected in several samples, no volatile organic compounds were detected above the method detection limit in the soil sample submitted from boring 13B-3.

6.4.3 SWMU 15 – Tank Bottom Weathering Areas

The VRS field program at SWMU 15 consisted of a subsurface soil investigation. Thirty-three soil borings were advanced within tank farms where oily tank bottoms had been allowed to weather on the ground near catch basins for the Oily Water Sewer System. Each boring was advanced to a depth of 8 feet bgs. A soil sample was collected from each boring based on the screening criteria contained in the VRS Work Plan, and the samples were submitted for analysis of modified Skinner List and Tank Bottom constituents.

The only VOCs detected in the soil samples submitted for laboratory analysis were toluene, total xylenes, and chloroform. Various SVOCs were detected. Cadmium, total chromium, zinc, and arsenic were detected above the range of concentrations observed in eastern U.S. soils (USEPA, 1988). The analytical results of the VRS investigation at SWMU 15 are summarized in the VRS Report in subsection 9.3 (pages 29 and 30) and in Table 9-3. Figures 25a and 25b of this report summarize VRS detections and detection limits that exceed EPA Region III Risk-based screening criteria (dated 4/25/03) for residential and industrial soils. Figures 26a and 26b of this report summarizes VRS detections and detection limits that exceed EPA Region III Risk-based screening criteria (dated 4/25/03) for soil to groundwater migration pathway.

Based on the results of the VRS, the RFI investigative program for SWMU 15 consisted of advancing 70 soil borings. The borings were located around and within the Tank Bottom Weathering Areas that were found to contain impacted soil during the VRS. The locations of the borings advanced during the RFI are shown on Figures 27 through 29.

To determine the degree and extent of impacted soil, URS advanced each of the soil borings to a depth of 10 feet bgs. Continuous split-spoon samples were collected from each boring. Each soil sample was screened with a PID according to the headspace screening procedures detailed in Appendix A of the RFI Work Plan.

Two soil samples from each boring were collected and submitted for analysis of TPH by methods 8100 modified and 8260 modified based on the following PID headspace reading criteria:

- If all PID headspace readings exceeded 10 parts per million (ppm), the first sample submitted for analysis was collected from the depth interval exhibiting the highest PID headspace reading. The second sample submitted for analysis was collected from the base of the boring.

- If all PID headspace readings were less than 10 ppm, the samples from the 0 to 2-feet depth interval and the depth interval at the base of each boring were submitted for laboratory analysis.

- If PID headspace readings were both less than and greater than 10 ppm at different depth intervals, the first sample submitted for analysis was collected from the depth interval exhibiting the highest PID headspace reading. The second sample submitted for analysis was collected from the first depth interval to exhibit a PID headspace reading of less than 10 ppm at a depth greater than the interval exhibiting the highest PID headspace reading, if possible. If no PID headspace readings of less than 10 ppm were recorded at a depth greater than the interval exhibiting the highest reading, the second sample was collected from the base of the boring.

No further action was necessary if all TPH levels were below 10 ppm and metals concentrations in a tank area were below soil screening levels. If TPH was detected above 10 mg/kg in any of the samples submitted for analysis, the depth interval exhibiting the highest TPH concentration was analyzed for modified Skinner List constituents.

Following the completion of the borings at each tank area, one surface soil sample was collected for analysis of modified Skinner List and Tank Bottom metals plus TEL. The surface soil sample was collected from the boring location in each tank area that exhibited the highest PID headspace reading. The modified Skinner List is presented on Table 9, and Tank Bottom constituents are presented on Table 14.

SWMU 15 - Soil Analytical Results

The RFI Work Plan stipulated that two samples be collected from each of the 70 soil borings proposed for SWMU 15. However, when the maximum PID headspace reading correlated to the base of the boring, only that sample was submitted for laboratory analysis. Of the 126 soil samples submitted from SWMU 15 for TPH analysis, only 7 exhibited TPH concentrations that exceeded 10 mg/kg. Of these seven, six were analyzed for modified Skinner List constituents. Soil boring 15B-20A had two samples with a TPH concentration that exceeded 10 mg/kg. The sample exhibiting the highest TPH concentration was analyzed for modified Skinner List constituents.

Detected TPH concentrations exceeding 10 mg/kg ranged from 36.4 mg/kg (15B-30D – 8 to 10 feet) to 805.9 mg/kg (15B-20A – 0 to 2 feet). The results of the TPH analyses are summarized in Table 15 and summaries of detected ranges of TPH concentrations are presented on Figures 23 and 24.

The results of the VOC analyses are summarized in Table 16, the results of the SVOC analyses are summarized in Table 17, and the results of the inorganic analyses are summarized in Tables 18 and 19. RFI detections and detection limits that exceeded EPA Region III Risk-based screening criteria (dated 4/25/03) for residential and industrial soils are summarized on Figure 30, and the same information for soil to groundwater migration screening criteria is presented on Figure 31.

6.4.4 SWMU 18 – Fire Training Area

The VRS field program at the Fire Training Area consisted of a subsurface soil investigation. Three soil borings (18B-1, 18B-2, and 18B-3) were advanced to a depth of 8 feet bgs. A soil sample was collected from each boring based on the screening criteria contained in the VRS Work Plan. Each sample was submitted for analysis of VOCs +15 and TPH for DRO and GRO.

Various VOCs were detected in the soil samples. Low concentrations were detected in the samples collected from borings 18B-1 and 18B-3. The highest concentrations were detected in

the sample collected from boring 18B-2. TPH was detected at relatively low concentrations in the samples collected from borings 18B-1 and 18B-3. TPH was also detected at higher concentrations in the sample collected from boring 18B-2. The analytical results of the VRS investigation at SWMU 18 are summarized in the VRS report in subsection 10.3 (pages 33 and 34) and in Table 10-1. No VOCs were detected at concentrations exceeding the EPA Region III Risk-based screening criteria (dated 4/25/03) for residential or industrial soils in the VRS samples. A summary of VRS method detection limits that exceeded the EPA Region III Risk-based screening criteria (dated 4/25/03) is presented on Figure 32. Additionally, Figure 33 presents VRS detections and detection limits that exceeded the EPA Region III Risk-based screening criteria for soil to groundwater migration.

Based on the results of the VRS, the RFI investigative program for SWMU 18 consisted of advancing 11 soil borings and installing one monitoring well. The monitoring well was installed at the northeast corner of the SWMU in a location immediately downgradient of the area. One soil boring was installed at the northern end of the 500-gallon above ground gasoline storage tank (AST). A soil boring was also proposed for the southern end of the AST in the RFI Work Plan; however, an underground supply line used to supply fuel to the concrete pad could not be located with any certainty. URS concluded that the soil boring was not crucial to the investigation, and elected not to risk damaging the underground line.

Six soil borings were installed around the large trench on the concrete pad in cracked concrete sections, and four borings were advanced north of the concrete pad, in the sand and gravel material. The locations of the soil borings and the monitoring well are shown on Figure 34.

To determine the degree and extent of impacted soil, URS advanced each of the soil borings to a depth of 10 feet bgs. Continuous split-spoon samples were collected from each boring. Each soil sample was screened with a PID according to the headspace screening procedures detailed in Appendix A of the RFI Work Plan. Two soil samples from each boring were collected and submitted for analysis of TPH by methods 8100 modified and 8260 modified based on the PID headspace screening criteria described in Section 6.4.3. Figures 23 and 24 present ranges of detected TPH concentrations in soil samples collected during the RFI. In all except one soil boring advanced in SWMU 18, TPH concentrations decreased with depth.

After completion of the TPH analyses, two soil samples were analyzed for VOCs +15 and methyl tertiary butyl ether (MTBE). One sample was analyzed from the depth interval exhibiting the highest TPH concentration from the boring near the AST, and one sample was analyzed from the depth interval exhibiting the highest TPH concentration from the borings advanced within the concrete pad. The results of the soil sampling program for SWMU 18 are

summarized on Tables 20 (TPH results) and 21 (VOC results). Summaries of the detected VOC concentrations and detection limits that exceeded EPA Region III Risk-based Soil Screening Criteria (dated 4/25/03) for the VRS and RFI data are provided on Figures 32 and 33.

To determine if groundwater has been impacted by this SWMU, URS installed one monitoring well downgradient of the Fire Training Area on February 19, 1999. Monitoring well 18MW-1 was installed in accordance with the procedures contained in Appendix A of the RFI Work Plan. The well was constructed of 4-inch inside-diameter PVC screen and schedule-40 PVC riser pipe, and was installed to a depth of 40-feet bgs. The well was constructed so that it is screened across the water table, and to allow for seasonal fluctuations of the water table. During well installation, soil samples were collected at 5-foot depth intervals and were screened with a PID. No soil samples were submitted for laboratory analysis from boring 18MW-1. Monitoring well 18MW-1 was developed on March 3, 1999. The turbidity of the groundwater was 9.7 Nephelometric turbidity units (NTUs) at the completion of development. Groundwater samples were collected from well 18MW-1 on April 2 and July 28, 1999. The groundwater samples were submitted for analysis of VOCs +15, MTBE, and TPH DRO. The analytical results from the groundwater samples are summarized in Table 22. A summary of the detected concentrations and detection limits that exceeded EPA Region III Risk-based Tap Water Screening Criteria (dated 4/25/03) for the RFI groundwater data is provided on Figure 35.

6.4.5 SWMU 20a.1 – Off-loading Area For Recovered Crude Holding Tank

The VRS field program for SWMU 20a.1 consisted of a subsurface soil investigation. One soil boring was advanced to a depth of 6 feet bgs. The proposed depth of the boring was 8 feet, but physical obstructions prevented attaining this depth. One soil sample was collected from the boring based on the screening criteria contained in the VRS Work Plan. The soil sample was submitted for laboratory analysis of modified Skinner List parameters.

Toluene, ethylbenzene, and total xylenes were detected at low concentrations. Several SVOCs were also detected. No metals were detected above the observed range in eastern U.S. soils (USEPA, 1988). The analytical results of the VRS investigation at SWMU 20a.1 are summarized in the VRS report in subsection 11.3 (page 36) and in Table 11-1. Summaries of VRS detections and detection limits that exceeded EPA Region III Risk-based soil screening criteria (dated 4/25/03) are provided on Figures 36 and 37a of this Report.

Based on the results of the VRS, the proposed RFI investigative program for SWMU 20a.1 consisted of advancing five soil borings to a depth of 10-feet bgs. One boring was proposed for each side of the concrete pad at the off-loading area, and one boring was proposed

topographically downgradient of the pad. The soil boring proposed immediately east of the concrete pad (boring 20aB-1D) could not be advanced due to a large diameter underground pipeline that runs from the Oily Water CPI Separator to API Separator No. 1. The boring locations that were completed are shown on Figure 38.

To determine the degree and extent of impacted soil, URS collected continuous split-spoon samples from the four (4) soil borings advanced. Each soil sample was screened with a PID according to the headspace screening procedures detailed in Appendix A of the RFI Work Plan. Two soil samples from each boring were collected and submitted for analysis of TPH by modified methods 8100 and 8260 based on the PID headspace screening criteria described in Section 6.4.3. Summaries of ranges of detected TPH concentrations are presented on Figures 23 and 24 of this Report.

After completion of the borings, URS submitted one soil sample for analysis of modified Skinner List semivolatile organic compounds (SVOCs). The sample was submitted from the depth interval exhibiting the highest PID headspace reading from the four borings. A soil sample was also collected from the surface of the soil boring which exhibited the highest PID headspace reading. The surface soil sample was submitted for analysis of modified Skinner List metals. The results of the RFI soil analytical program for SWMU 20a.1 are summarized in Tables 23 (TPH results), 24 (SVOC results), and 25 (modified Skinner List metals results). Detected concentrations and detection limits that exceeded EPA Region III Risk-based soil screening criteria (dated 4/25/03) from SWMU 20a.1 are summarized on Figures 40 and 41.

6.4.6 SWMU 20b.1 – Stormwater Channel

The VRS field program for the Stormwater Channel consisted of a subsurface soil, groundwater, and sediment investigation. One subsurface soil sample was collected during the installation of monitoring well 20bMW-1, which was installed along the eastern bank of the Stormwater Channel. A groundwater sample was collected from this well following development, and two sediment samples (20bSD-1 and 20bSD-2) were collected from the middle of the Stormwater Channel. Each of the samples was submitted for analysis of modified Skinner List parameters.

The only VOCs detected in the samples submitted were the individual components of BTEX. Only ethylbenzene and total xylenes were detected in the soil sample collected from 20bMW-1. Several SVOCs were detected in the soil and groundwater samples. Various SVOCs were detected in the two sediment samples submitted from the Stormwater Channel. The only metals detected above the range of concentrations observed in eastern U.S. soils (USEPA, 1988) in any of the samples submitted were cadmium and selenium, and these were detected in the sediment

samples. The analytical results of the VRS at SWMU 20b.1 are summarized in the VRS Report in subsections 13.3, 13.4, and 13.5 (pages 40 through 43) and in Tables 13-4, 13-5, and 13-6. Summaries of VRS detections and detection limits that exceeded EPA Region III Risk-based soil screening criteria (dated 4/25/03) are presented on Figures 36 and 37a of this Report. A summary of VRS groundwater detections and detection limits that exceeded EPA Region III Tap Water Screening criteria dated 4/25/03 is presented on Figure 39 of this Report.

Based on the results of the VRS, the RFI program for the Stormwater Channel consisted of installing two monitoring wells (20bMW-4 and 20bMW-5) and collecting sediment samples at depth intervals greater than those collected during the VRS. Two borings were advanced within the Stormwater Channel to evaluate the vertical extent of impacted sediment. The locations of the borings are shown on Figure 40. The locations of the monitoring wells are shown on Figure 43.

Soil/Sediment Investigation

To determine the degree and extent of impacted sediment and any impacts to the underlying soil, URS advanced two borings through the Stormwater Channel sediment into the underlying soil. The RFI Work Plan stipulated that each boring be advanced to a total depth of 10-feet beneath the surface of the sediment. The RFI Work Plan also stipulated that one boring be advanced approximately five feet downstream of the former weir of the CPI Surge Basin, and one boring (20bSD-1A) be advanced approximately midway between the two VRS sampling locations. However, following the demolition of the weir at the former CPI Surge Basin, portions of the Stormwater Channel were filled in with riprap to prevent erosion. The area five feet downstream of the former CPI Surge Basin was too rocky to drive a split-spoon sampler. URS and representatives of the United States Army Corps of Engineers (USACE) and the Delaware Department of Natural Resources and Environmental Control (DNREC) discussed the situation, and it was agreed that the boring would be advanced approximately 50-feet downstream of the former weir. The location of the soil boring is shown on Figure 40.

Soil boring 20bSD-1A was advanced on August 13, 1999 to a total depth of 4.5 feet below the top of the sediment in the Stormwater Channel. Drilling indicated that riprap was encountered at this depth. The boring was offset two times in attempts to advance it to the proposed depth of 10-feet below the top of the sediment. Both attempts resulted in refusal at a depth of 4.5 feet. URS, the USACE, and DNREC representatives discussed the situation, and it was decided to collect the 0 to 2-feet and the 2 to 4-feet depth intervals for laboratory analysis of TPH DRO and GRO. A generalized description of the subsurface soils encountered and PID readings recorded are provided in Appendix A.

A sample for analysis by Toxicity Characteristic Leaching Procedure (TCLP) was also collected from soil boring 20bSD-1A. Samples for TCLP VOCs were collected from the 0 to 2-feet depth interval. The remainder of the sample was collected from a composite of the 0 to 2-feet and the 2 to 4-feet depth intervals. No TCLP constituents were detected at concentrations above TCLP regulatory limits. A summary of detection limits that exceeded TCLP regulatory limits is presented on Figure 42.

Soil boring 20bSD-2A was also advanced on August 13, 1999. The boring was advanced to a depth of 10-feet below the top of the sediment. Two samples from the boring were collected and submitted for analysis of TPH by modified methods 8100 and 8260 based on the PID headspace reading criteria described in subsection 6.4.3.

After completion of the TPH analyses, one soil sample was analyzed for modified Skinner List constituents, vanadium, TEL, and MTBE. The sample analyzed was from the depth interval exhibiting the highest TPH concentration from the two borings. The analytical results of the sediment sampling are summarized in Tables 27 through 30. Summaries of detected concentrations, as well as detection limits that exceeded EPA Region III Risk-based soil screening criteria dated 4/25/03 are presented on Figures 40 and 41.

URS also measured the depth from the water surface to the top of the sediment. Measurements were obtained along the entire length of the Stormwater Channel. These measurements, along with the surveyed elevation of the water surface and the known elevation of the bottom of the channel, were used to estimate the volume of sediment contained in the Stormwater Channel. URS estimated that the Stormwater Channel contains approximately 43,000 cubic yards of sediment.

Groundwater Investigation

BTEX and two SVOCs were detected in groundwater near the Stormwater Channel during the VRS. To further evaluate the degree and extent of impacts to groundwater, URS installed two monitoring wells in locations downgradient of the Stormwater Channel during the RFI. Each well was constructed of 4-inch inside-diameter PVC screen and schedule-40 PVC riser pipe. Both wells were installed to a depth of 12 feet bgs.

Each well was constructed so that it was screened across the water table, and to allow for seasonal fluctuations of the water table. Continuous soil samples were collected and subjected to PID headspace screening during well installation. No soil samples were collected for laboratory analysis from the borings. Monitoring wells 20bMW-4 and 20bMW-5 were developed on March

1, 1999. The turbidity of the groundwater in well 20bMW-4 was 7.9 Nephelometric Turbidity Units (NTUs) at the completion of development, and the turbidity of the groundwater in well 20bMW-5 was 9.7 NTUs at the completion of development. Groundwater samples were collected from the two wells on April 6, 1999. Well 20bMW-4 was sampled again on July 26, 1999 and well 20bMW-5 was sampled again on July 27, 1999. The groundwater samples collected from these wells were submitted to New England Testing Laboratory, Inc. for analysis of modified Skinner List constituents, vanadium, TEL, and MTBE. The groundwater analytical results for SWMU 20b.1 are summarized in Table 26. A summary of detected concentrations and detection limits that exceeded EPA Region III risked based screening criteria (dated 4/25/03) for tap water is presented on Figure 43.

6.4.7 SWMU 20b.2 – Guard Basin No. 4

The VRS field program for Guard Basin No. 4 consisted of a subsurface soil, groundwater, and sediment investigation. One subsurface soil sample was collected during the installation of monitoring well 20bMW-2, which was installed along the eastern bank of Guard Basin No. 4. A groundwater sample was collected from this well following development, and three sediment samples were collected from the middle of Guard Basin No. 4. Each of the samples collected was submitted for analysis of modified Skinner List parameters.

The only VOCs detected in each sample were the individual components of BTEX. Only total xylenes were detected in the groundwater sample submitted for analysis. Several SVOCs were detected in each sample submitted from SWMU 20b.2. However, the greatest concentration of these compounds occurred in the sediment samples. No metals were detected in the soil sample, but various total and dissolved metals were detected in the groundwater sample, and total cyanide, lead, mercury, and selenium were detected in the sediment samples. The analytical results of the VRS investigation at SWMU 20b.2 are summarized in the VRS Report in subsections 14.3, 14.4, and 14.5 (pages 45 through 47). Summaries of detected concentrations and detection limits that that exceeded EPA Region III Risk-based soil screening criteria (dated 4/25/03) during the VRS are presented on Figures 36, 37a, and 37b of this report. The same information for the VRS groundwater data compared to EPA Region III tap water screening criteria is presented on Figure 39.

Based on the results of the VRS, the RFI investigative program for SWMU 20b.2 consisted of advancing five borings within Guard Basin No. 4. The boring locations are shown on Figure 40.

To determine the degree and extent of impacted sediment and any impacts to the underlying soil, URS advance five borings through Guard Basin No. 4 sediment into the underlying soil. Three

borings were advanced in approximately the same location as the surface sediment samples collected during the VRS; however, samples were collected at each location to a total depth of 10 feet beneath the surface of the sediment. The two remaining borings were advanced on opposite sides of the Guard Basin, as shown on Figure 40. Continuous split-spoon samples were collected and subjected to PID headspace screening during installation of the boring. Two samples from each boring were collected and submitted for analysis of TPH by modified methods 8100 and 8260 based on the PID headspace reading criteria described in subsection 6.4.3.

After completion of the TPH analyses, one soil sample was analyzed for modified Skinner List constituents, vanadium, TEL, and MTBE. The sample analyzed was the sample exhibiting the highest TPH concentration from the five borings. The analytical results are summarized in Tables 32 through 35. Detected concentrations and detection limits that exceeded EPA Region III Risk-based soil screening criteria dated 4/25/03 are summarized on Figures 40 and 41.

URS also measured the depth from the water surface to the top of the sediment. Measurements were obtained along the length and width of Guard Basin No. 4. These measurements, along with the surveyed elevation of the water surface and the known elevation of the bottom of the basin, were used to estimate the volume of sediment contained in Guard Basin No. 4. URS estimated that Guard Basin No. 4 contains approximately 48,000 cubic yards of sediment.

6.4.8 SWMU 20b.3 – API Separator No. 2

The VRS field program for SWMU 20b.3 consisted of a subsurface soil and groundwater investigation. One subsurface soil sample was collected during the installation of monitoring well 20bMW-3, which was installed downgradient of the API Separator. A groundwater sample was collected from this well following development. Each sample was submitted for laboratory analysis of modified Skinner List parameters.

No VOCs were detected in the soil sample. The only VOCs detected in the groundwater sample were the individual components of BTEX. The only SVOC detected (di(n)butyl phthalate) was in the soil sample. Various metals were detected in the groundwater sample, and two metals (cadmium and nickel) were detected in the soil sample. The analytical results of the VRS at SWMU 20b.3 are summarized in the VRS Report in subsections 15.3 and 15.4 (pages 50 through 51). Figures 36 and 37b of this Report summarize VRS detections and detection limits that exceeded EPA Region III Risked-based soil screening criteria dated 4/25/03. A summary of groundwater detections and detection limits that exceeded EPA Region III Risk-based tap water screening criteria are presented on Figure 39.

Based on the results of the VRS, the RFI investigative program for API Separator No. 2 consisted of advancing three soil borings and installing one downgradient monitoring well. The location of the monitoring well is shown on Figure 43 and the locations of the soil borings are shown on Figures 44 and 45.

To determine the extent and degree of impacted soil, URS advanced three soil borings at SWMU 20b.3. One soil boring was advanced near monitoring well 20bMW-3, and one soil boring was advanced at each end of the API Separator to evaluate the degree and extent of impacted soil. Each soil boring was advanced to a depth of 10 feet bgs. Continuous split-spoon samples were collected from each boring. Each soil sample was screened with a PID according to the headspace screening procedures detailed in Appendix A of the RFI Work Plan.
Soil samples were collected from the 0 to 1 foot depth interval at each soil boring location and composited. The composite sample was submitted for analysis of modified Skinner List metals and TEL. Two samples from each boring were collected and submitted for analysis of BTEX, TEL, and MTBE based on the PID headspace screening criteria described in subsection 6.4.3. The soil analytical results are summarized on Tables 36 and 37. Summaries of RFI detections and detection limits that exceeded EPA Region III Risk-based soil screening criteria dated 4/25/03 are presented on Figures 44 and 45. Because the composite sample was collected from three locations, and thus cannot be plotted as a single location, detected concentrations that exceeded EPA Region III Risk-based screening concentrations for the soil to groundwater migration pathway are summarized in tabular form on Figure 45.

To determine the degree and extent of impacted groundwater, URS used upgradient information and installed one monitoring well downgradient of API Separator No. 2. The well was installed in accordance with the procedures detailed in Appendix A of the RFI Work Plan. Monitoring well 20bMW-6 was constructed of 4-inch inside-diameter PVC screen and schedule-40 PVC riser pipe. The well was installed to a depth of 14 feet bgs. The well was constructed so that it was screened across the water table, and to allow for seasonal fluctuations of the water table. Continuous soil samples were collected and subjected to PID headspace screening during well installation. No soil samples were collected for laboratory analysis from this boring. Monitoring well 20bMW-6 was developed on March 1 and 2, 1999. The turbidity of the discharge water was measured to be 91 NTUs at the completion of development. A soil boring log (including PID readings) and monitoring well construction detail for well 20bMW-6 is included in Appendix A. The groundwater analytical results are summarized on Table 38, and a summary of detections and detection limits that exceeded EPA Region III Risk-based tap water screening criteria dated 4/25/03 are presented on Figure 43.

6.4.9 SWMU 21 – Cooling Water Channel and Guard Basins No. 5 and 6

The VRS field program for SWMU 21 consisted of a subsurface soil, groundwater, and sediment investigation. Two subsurface soil samples were collected during the installation of monitoring wells 21MW-1 and 21MW-2, which were installed along the western bank of Guard Basin No. 6. Groundwater samples were collected from these wells following development, and seven sediment samples were collected from the Cooling Water Channel and Guard Basins No. 5 and 6. Each of the samples collected was submitted for analysis of modified Skinner List parameters.

No VOCs or SVOCs were detected in the groundwater samples submitted from SWMU 21. The only VOCs or SVOCs detected in the soil samples were di(n)butyl phthalate and phenol. Di(n)butyl phthalate was detected in the soil sample collected during the installation of monitoring well 21MW-1, and phenol was detected in the soil sample collected during the installation of monitoring well 21MW-2. The only VOC detected in the sediment samples collected was toluene. Toluene was only detected in the sediment sample 21SD-4. Various SVOCs were detected in the sediment samples, but were detected mainly in the samples collected from within the Cooling Water Channel, and those near the entrance of the Cooling Water Channel into the Guard Basins. Metals detections were low in the soil samples, but various metals were detected in the groundwater and sediment samples. The analytical results of the VRS at SWMU 21 are summarized in the VRS Report in subsections 16.3, 16.4, and 16.5 (pages 53 through 55) and in Tables 16-3, 16-4, and 16-5. Summaries of VRS detections and detection limits that exceeded EPA Region III Risk-based soil screening criteria dated 4/25/03 are presented on Figures 46 and 47 of this Report. Detected concentrations, as well as detection limits exceeding EPA Region III Risk-based tap water screening criteria for groundwater samples collected during the VRS are summarized on Figure 48.

Based on the results of the VRS, the RFI investigative program for SWMU 21 consisted of advancing four (4) borings within Guard Basins No. 5 and 6. The RFI Work Plan proposed advancing a boring in the Cooling Water Channel. However, the flow of the water within the channel and through the weir at the entrance to the Guard Basins was too turbulent to safely access the channel. The locations of the borings advanced in Guard Basins No. 5 and 6 are shown on Figure 49.

To determine the degree and extent of impacted sediment and any impacts to the underlying soil, URS advanced four borings through SWMU 21 sediment and into the underlying soil. The borings were advanced in approximately the same locations as the surface samples collected during the VRS; however, samples were collected at each location to a total depth of 10 feet beneath the surface of the sediment. Continuous split-spoon samples were collected and

subjected to PID headspace screening during installation of the borings. Two samples from each boring were submitted for analysis of modified Skinner List parameters based on the PID headspace screening criteria described in subsection 6.4.3. The results of the analyses are summarized in Tables 39, 40, and 41. Summaries of RFI detections and detection limits that exceeded EPA Region III Risk-based soil screening criteria dated 4/25/03 are presented on Figures 49 and 50.

URS also measured the depth from the water surface to the top of the sediment. Measurements were obtained along the length and width of Guard Basins No. 5 and 6. These measurements, along with the surveyed elevation of the water surface and the known elevation of the bottom of the basin, were used to estimate the volume of sediment contained in SWMU 21. URS estimated that Guard Basins No. 5 and 6 contain approximately 112,000 cubic yards of sediment.

6.4.10 SWMU 24a - Dredged Material Storage Area No. 1

Motiva disposes of material dredged from the various channels and basins necessary for Refinery operations in six areas. These six areas make up SWMU 24. The areas are known as Dredged Material Storage Areas (DMSAs) No. 1 through 5 (also known as SWMUs 24a through 24e) and the Red Lion Disposal Area. DMSA No. 1 was specified in the Corrective Action Permit as requiring an RFI based on the conclusions of a January 9, 1979 URS Report entitled "Hydrogeologic Investigation - Phase II, Existing Industrial Landfill, Delaware Refinery, Delaware City, Delaware, Getty Refining and Marketing Company".
Based on the requirements of Motiva's Corrective Action permit, the proposed investigative program for SWMU 24a was to advance seven soil borings within DMSA No. 1 and install four monitoring wells around DMSA No. 1. When the RFI field program was initiated, the entrance channel for the Refinery's piers was being dredged into DMSA No. 1. URS consulted with the USEPA case manager, and it was agreed that the soil borings could be postponed until the dredged material in DMSA No. 1 had adequate time to de-water.

On December 21 and 22, 1999, Dames and Moore advanced three soil borings within the lowland area of DMSA No. 1. The locations are shown on Figure 51. The remainder of DMSA No. 1 was still under water and inaccessible. Two of the three soil borings were advanced until native material was encountered. At the third location (boring 24aB-6), the drill rig began sinking into the dredged material before native material was encountered. The boring was only completed to a depth of 12-feet bgs.

Continuous soil samples were collected from each boring, and the samples were subjected to PID headspace screening. Two samples from each boring were collected and submitted for analysis

of modified Skinner List parameters based on the PID headspace screening criteria described in subsection 6.4.3. Although boring 24aB-6 could not be completed to the proposed depth, two soil samples were submitted for analysis to evaluate soil quality in the 0 to 12-feet depth interval. The analytical results of the soil samples submitted for analysis are summarized in Table 42. Summaries of detected concentrations and detection limits that exceeded EPA Region III Risk-based soil screening criteria dated 4/25/03 are presented on Figures 51 and 52.

To determine the potential degree and extent of impacts to groundwater, URS installed four monitoring wells around the perimeter of DMSA No. 1. The locations of the wells are shown on Figure 53. The monitoring wells were installed in accordance with the procedures contained in Appendix A of the RFI Work Plan. The wells were constructed of 4-inch inside-diameter PVC screen (0.020-inch slot size) and schedule-40 PVC riser pipe. The wells were installed to a depth of approximately 40 feet bgs. The wells were constructed so that they are screened across the water table, and to allow for seasonal fluctuations of the water table. During well installation, soil samples were collected at 5-foot depth intervals and were screened with a PID. No soil samples were submitted for laboratory analysis from these borings. Soil boring logs and monitoring well completion details, including PID headspace readings, are presented in Appendix A.

The monitoring wells were developed on February 26, 1999. The turbidity of the discharge water ranged from 16 NTUs (24aMW-1) to 999 NTUs (24aMW-4) at the completion of development. Groundwater samples were collected from each well in April and July 1999 and were submitted for analysis of modified Skinner List constituents. The groundwater analytical results are summarized on Table 43. A summary of detections and detection limits that exceeded EPA Region III Risk-based screening criteria for tap water (dated 4/25/03) is presented on Figure 53.

Soil boring logs for wells 24aMW-1 through 24aMW-4 are presented in Appendix A and the locations of the wells are shown on Figure 53. The soil boring logs indicate that these wells are screened, for the most part, in micaceous silty clays and clays with organics. These wells were installed on the berms of DMSA No. 1, which are constructed of material that was previously dredged into SWMU 24a. For this reason, the turbidity of the groundwater samples at the time of collection in April and July was high (see Appendix B). It is believed that the analytical results of the total metals analyses are invalid, and that the results of the dissolved metals analyses are questionable due to the high turbidities.

Additional ecological risk data has been obtained from SWMU 24a, and will be evaluated in the Baseline Ecological Risk Assessment Report.

6.4.11 SWMU 24b – Dredged Material Storage Area No. 2

The VRS field program for DMSA No. 2 consisted of a groundwater investigation and a limited subsurface soil investigation. The soil investigation was limited due to dredging activity, which resulted in the lowland area of SWMU 24b being under water. One soil sample was collected (24bB1) from the Oily Sludge Area of SWMU 24b. Groundwater samples were collected from three of the four wells installed around SWMU 24b. The fourth well was installed adjacent to the Oily Sludge Area, and exhibited free-phase hydrocarbon on the water table at the time the groundwater samples were collected. Two of the samples were submitted for laboratory analysis of modified Skinner List parameters, and one was submitted for analysis of BTEX.

No VOCs or SVOCs were detected in the groundwater samples. Metals concentrations in the groundwater samples were very low. The only VOCs detected in the soil sample submitted from the Oily Sludge Area were the individual components of BTEX. Various SVOCs and metals were also detected in the soil sample. The analytical results of the VRS investigation at SWMU 24b are summarized in the VRS Report in subsections 17.3 and 17.4 (pages 61 and 62) and in Tables 17-3 and 17-4. Summaries of the VRS soil detections and detection limits that exceeded EPA Region III Risk-based soil screening criteria dated 4/25/03 are provided on Figures 54 and 55 of this Report.

A sample of the free-phase hydrocarbon present in well 24bMW-4 was collected and submitted to NETL for gas chromatograph fingerprint analysis. The results of the analysis indicated that the hydrocarbon profile was consistent with expectations for a light crude oil. It also indicated that some slight degradation of the hydrocarbon might have occurred. The laboratory report and chromatograms for this sample were included in Appendix G of the RCRA Facility Investigation Work Plan dated September 1998.

Based on the results of the VRS, the proposed investigative program for SWMU 24b consisted of advancing the six borings that were proposed for the lowland area during the VRS, advancing four soil borings within the Oily Sludge Area to a depth of 25 feet bgs, conducting five ROST probes around the Oily Sludge Area, and installing one monitoring well south of the Oily Sludge Area. One of the soil borings proposed in the Oily Sludge Area (24bB-3) could not be accessed with a track-mounted drill rig. URS consulted with the EPA case manger concerning this location. It was agreed that the data obtained from the remaining three borings would be evaluated to determine the necessity of the final boring.

The soil borings within the lowland area of DMSA No. 2 were advanced to evaluate the potential that areas of SWMU 24b other than the Oily Sludge Area may have been impacted by historic dredging operations at Guard Basin No. 4, as specified in the VRS Work Plan. A copy of the section of the VRS Work Plan regarding the lowland area of SWMU 24b was provided as Appendix E of the RFI Work Plan.

To determine the degree and extent of impacted soil within the Oily Sludge Area, Dames and Moore advanced soil borings at three locations. The locations are shown on Figure 54. Soil borings 24bB-2, 24bB-4, and 24bB-5 were advanced to depths of 24, 18, and 26 feet bgs, respectively. Continuous soil samples were collected from each boring, and the samples were subjected to a PID headspace screening. Two samples from each boring were collected and submitted for analysis of TPH by modified methods 8100 and 8260 based on the PID headspace screening criteria described in subsection 6.4.3. If TPH was detected above 10 mg/kg in any of the samples submitted, the depth interval exhibiting the highest TPH concentration from the three borings was analyzed for modified Skinner List constituents and vanadium.

After completion of the borings, URS submitted one surface soil sample for analysis of modified Skinner List metals and Tank Bottom metals. The surface soil sample submitted for analysis was collected from the boring location (24bB-5) exhibiting the highest PID headspace reading from the borings. The analytical results of the soil samples collected from the Lowland Area of SWMU 24b are summarized in Tables 44 through 46, and the analytical results of the soil samples collected from the Oily Sludge Area of SWMU 24b are summarized in Tables 47 through 50. Detected concentrations and detection limits from the samples collected in both areas of SWMU 24b that exceeded USEPA Risk-based soil screening criteria dated 4/25/03 are summarized on Figures 54 and 55.

URS also performed five ROST™ probes on the road surrounding the Oily Sludge Area to evaluate the potential that hazardous waste/hazardous waste constituents are migrating from the oily sediment in the area. The locations of the ROST™ probes are shown on Figure 2. The results of the ROST™ investigation were presented previously in the Hydrocarbon Monitoring Interim Report dated August 5, 1999, and are discussed further in Section 6.3.4 of this report.

To evaluate impacts to groundwater, URS installed one monitoring well downgradient of the Oily Sludge Area. The location of the well is shown on Figure 53. During well installation, URS collected continuous split-spoon samples to document stratigraphy. Each soil sample was subjected to a PID headspace screening, but no samples were submitted for laboratory analysis. A soil boring log and monitoring well completion detail, including PID readings, is included in Appendix A.

Monitoring well 24bMW-5 was installed to a depth of 12 feet bgs on January 21, 1999. It was constructed of 10 feet of 4-inch inside-diameter PVC screen (0.010-inch slot size) and schedule-40 PVC riser pipe. The well was constructed so that the screen intersects the water table, and to allow for seasonal fluctuations. Well 24bMW-5 was installed in accordance with the procedures in Appendix A of the RFI Work Plan. Monitoring well 24bMW-5 was developed March 1, 1999. The turbidity of the discharge water at the completion of development was recorded as 170 NTUs. A groundwater sample was collected on April 23, 1999 and was submitted for analysis of modified Skinner List constituents. The analytical results of the groundwater sample collected from well 24bMW-5 are summarized in Table 51. Detected concentrations and detection limits that exceeded EPA Region III Risk-based screening criteria for tap water (dated 4/25/03) are summarized on Figure 53.

Additional ecological risk data has been obtained from SWMU 24b, and will be evaluated in the Baseline Ecological Risk Assessment Report.

6.4.12 SWMU 26 – Tetraethyl Lead Equipment Laydown Area

The VRS field program for SWMU 26 consisted of a subsurface soil investigation. Two soil borings (26B-1and 26B-2) were advanced to a depth of 8 feet bgs. One soil sample was collected from each boring based on the screening criteria contained in the VRS Work Plan. Each soil sample was submitted for analysis of total lead and BTEX.

Benzene was not detected above the method detection limit in either soil sample. Toluene, ethylbenzene, and total xylenes were detected in each sample. Total lead was also detected in each sample. The analytical results of the VRS investigation at SWMU 26 are summarized in the VRS Report in subsections 18.3 (pages 63 and 64) and in Table 18-1. None of the detected concentrations or detection limits of the samples analyzed during the VRS exceeded EPA Region III Risk-based soil screening criteria for residential or industrial soils dated 4/25/03 (see Figure 56). Figure 57 shows VRS detection limits that exceeded EPA Region III soil to groundwater migration screening criteria dated 4/25/03.

Based on the results of the VRS investigation, URS advanced three soil borings (26B-3 through 26B-5) near the former laydown area to evaluate the degree and extent of impacts to soils near this SWMU. The soil boring locations are shown on Figure 56. Each boring was advanced to a total depth of 10 feet bgs. Two soil samples were collected from each boring. One sample was collected from the base of each boring and a second sample was collected from the depth interval exhibiting the highest PID headspace reading. Each soil sample was submitted for analysis of

BTEX, modified Skinner List metals and TEL. The analytical results of the soil samples are summarized in Table 52. Detection limits and detected concentrations that exceeded EPA Region III Risk-based soil screening criteria dated are also summarized on Figures 56 and 57.

6.4.13 SWMU 31 – Slurry Oil Dumpster

The VRS field program for SWMU 31 consisted of a shallow subsurface soil investigation. One soil boring (31B-1) was advanced to a depth of 2 feet bgs. Two soil samples were collected as specified in the approved VRS Work Plan. One sample was submitted for analysis of modified Skinner List metals, and one sample was submitted for analysis of modified Skinner List VOCs and SVOCs.

The only VOCs detected in the sample submitted were the individual components of BTEX, which were all detected at low concentrations. Several SVOCs were also detected in the sample submitted for analysis. No metals were detected above the range observed in eastern U.S. soils (USEPA, 1988) in the sample submitted for modified Skinner List metals analyses. The analytical results of the VRS at SWMU 31 are summarized in the VRS Report in subsection 20.3 (pages 67 and 68) and in Table 20-1. Figures 58 and 59 of this Report provide summaries of VRS detection limits and detections that exceeded EPA Region III Risk-based soil screening criteria dated 4/25/03.

Based on the results of the VRS, the extent and degree of impacted soil in this area were evaluated by advancing four soil borings (31B-2 through 31B-5) in the area surrounding the boring advanced during the VRS. Each boring was advanced to a depth of 6 feet bgs.

Two samples from each boring were collected and submitted for analysis of TPH by modified methods 8100 and 8260 based on the PID headspace screening criteria described in subsection 6.4.3. The depth interval exhibiting the highest TPH concentration from the four borings was analyzed for modified Skinner List constituents. Generally, TPH concentrations decreased with depth.

After completion of the borings, URS submitted one surface soil sample for analysis of modified Skinner List metals and vanadium. The surface soil sample submitted for analysis was collected from the boring (31B-5) exhibiting the highest PID headspace reading from the four borings. The analytical results of the soil sampling program for SWMU 31 are summarized in Table 53 (TPH results) and Tables 54 through 56 (modified Skinner List results). Modified Skinner List analytical results, as well as detection limits that exceeded EPA Region III Risk-based soil screening criteria dated 4/25/03, are summarized on Figures 58 and 59.

6.4.14 SWMU 32 – Stained Soil Within Oily Sewer Backup Areas

The VRS field program for SWMU 32 consisted of a subsurface soil investigation. Four soil borings (32B-1 through 32B-4) were advanced to a depth of 8 feet bgs. One soil sample was collected from each boring based on the screening criteria contained in the VRS Work Plan. Each sample was submitted for laboratory analysis of modified Skinner List and Tank Bottom constituents. Modified Skinner List constituents are presented on Table 9 and Tank Bottom constituents are presented on Table 14.

The only VOCs detected in the samples submitted for analysis were BTEX and 1,1,1-trichloroethane (1,1,1-TCA). Several SVOCs were also detected in the soil samples. No metals were detected above the concentrations observed in eastern U.S. soils (USEPA, 1988). The analytical results of the VRS at SWMU 32 are summarized in the VRS Report in subsection 21.3 (pages 70 and 71) and in Tables 21-1. Figures 60 and 61 of this report provide a summary of VRS detections and detection limits that exceeded EPA Region III Risk-based soil screening criteria dated 4/17/03.

Based on the results of the VRS, eight soil borings were advanced to a depth of 8 feet bgs to evaluate the extent and degree of impacted soil in SWMU 32 during the RFI. The eight borings were advanced within the aboveground piping sleeperway along East Second Street. The soil boring locations are shown on Figure 62. The RFI Work Plan proposed 10 soil borings for SWMU 32; however, the berm that separates the sleeperway from the Tank 282 area was too steep to cross safely with the drill rig. It was believed that the potential to damage the piping existed if a mishap occurred while crossing the berm to access soil boring locations 32B-12 and 32B-13. Since soil borings were located both north and south of these locations, URS believed it was better to evaluate the analytical results of the surrounding locations rather than risk damaging the aboveground piping or injuring project personnel.

Each boring was advanced to a depth of 8 feet bgs. Continuous split-spoon soil samples were collected from each boring. Each sample collected was subjected to a PID headspace screening in accordance with the procedures in Appendix A of the RFI Work Plan. Two soil samples were collected from each boring and submitted for analysis of TPH by modified methods 8100 and 8260 based on the PID headspace screening criteria described in subsection 6.4.3. The depth interval exhibiting the highest TPH concentration from the eight soil borings was analyzed for modified Skinner List and Tank Bottom constituents plus MTBE.

After completion of the borings, URS submitted one surface soil sample for analysis of modified Skinner List and Tank Bottom metals. The surface soil sample submitted for analysis was collected from the boring exhibiting the highest PID headspace reading of the eight borings. The TPH soil analytical results for SWMU 32 are presented in Table 56 and the results of the modified Skinner List analyses are presented in Tables 57 through 59. Soil analytical results, as well as detection limits that exceeded EPA Region III Risk-based screening criteria (dated 4/25/03) are summarized on Figures 60 and 61.

6.4.15 SWMU 33 – Piers 2 and 3

As stated in Section 4.15, analytical results for soil samples collected in the past at SWMU 33 indicate that soils have been impacted with PHCs, and free-phase hydrocarbon has been observed on the water table surface in a "sump" near Pier 2. No other environmental studies have been conducted at this SWMU. Motiva decided to address this area during the RFI.

To determine the extent and degree of impacts to soil, four soil borings were advanced around each of the two areas making up SWMU 33. The boring locations are shown on Figure 64. Each boring was advanced to depth of 10 feet bgs. Continuous soil samples were collected from each boring with a standard split-spoon sampler. Each sample collected was subjected to a PID headspace screening in accordance with the procedures detailed in Appendix A of the RFI Work Plan.

Two samples from each boring were submitted for analysis of BTEX and TPH by modified methods 8100 and 8260 based on the PID headspace screening criteria described in Section 6.4.3. In addition, the sample exhibiting the highest PID headspace reading was submitted for analysis of modified Skinner List metals.

After completion of the borings, URS submitted one soil sample from each area for analysis of modified Skinner List VOCs, modified Skinner List SVOCs, TEL, and MTBE. The sample was collected from the depth interval exhibiting the highest PID headspace reading from the four borings advanced at each area. The results of the TPH and BTEX analyses are summarized in Tables 61 and 62, respectively. The results of the modified Skinner List analyses are summarized in Tables 63 through 65. Analytical results and detection limits that exceeded EPA Region III Risk-based soil screening criteria dated 4/25/03 are summarized on Figures 63 and 64.

To determine the extent and degree of potential impacts to groundwater, URS installed a monitoring well in the most downgradient boring location at each area. Groundwater elevations from two wells, along with the elevation of the Delaware River, were used to determine the

groundwater flow direction in the area. Well construction procedures are detailed in Appendix A of the RFI Work Plan. Each well was constructed of 2-inch inside-diameter PVC screen (0.010-inch slot size) and schedule-40 PVC riser pipe. Each well was constructed so that it is screened across the water table to allow for seasonal and tidal fluctuations.

Monitoring wells 33MW-1 and 33MW-2 were developed using a submersible pump on March 12, 1999. The turbidity of the discharge water from 33MW-1 was 4.2 NTUs and the turbidity of the discharge water from 33MW-2 was 14.7 NTUs at the completion of development. Groundwater samples were collected from monitoring well 33MW-1 on April 7 and July 29, 1999. Each groundwater sample was submitted for analysis of TPH for DRO and GRO, BTEX, TEL, and MTBE.

During the time between well development and the initial round of groundwater sampling, free-phase hydrocarbon accumulated on the water table in well 33MW-2. Because of this, groundwater samples were not collected from well 33MW-2. A sample of the free-phase hydrocarbon was submitted to NETL for gas chromatography fingerprint analysis, and bail down testing was performed to evaluate the thickness of the hydrocarbon in the subsurface. These tasks are discussed in Section 6.3.8. The analytical results of the groundwater samples collected from 33MW-1 are summarized on Table 66. Figure 65 summarizes detected concentrations as well as detection limits that exceeded EPA Region III Risk-based screening criteria for tap water dated 4/25/03.

URS installed a pressure transducer and data logger in monitoring well 33MW-1 on April 1, 1999. The data logger was set to collect water level measurements on an hourly basis for a period of one week in order to evaluate tidal influences. A hydrograph of the measurements recorded by the data logger is presented as Figure 66.

6.4.16 Unit F – Used Drum Storage Areas

The VRS field program for Unit F consisted of a shallow subsurface soil investigation. One shallow soil sample was collected from each area of the Unit. Each sample collected was submitted for laboratory analysis of modified Skinner List constituents.

VOCs were only detected in the samples collected from Area C and Area G. The only VOCs detected in the samples submitted were toluene and total xylenes. Various SVOCs were detected in many of the samples. Metals detected included arsenic, cadmium, total chromium, and selenium. The analytical results of the VRS at Unit F are summarized in the VRS Report in subsection 22.3 (pages 75 and 76) and in Table 22-1. Summaries of VRS detections and

detection limits that exceeded EPA Region III Risk-based soil screening criteria are presented on Figures 67a through 67c and 68a through 68c of this Report.

Based on the results of the VRS, several soil borings were advanced during the RFI at each area of Unit F to determine the degree and extent of impacted soil. Soil boring locations are shown on Figures 69a through 69c. The scope of work and results for all areas of Unit F, with the exception of Area C, are discussed in Section 6.4.16.1. Area C of Unit F is discussed in Section 6.4.16.2.

6.4.16.1 Scope of Work - Unit F

To evaluate the degree and extent of impacted soil, several soil borings were advanced at each area of Unit F. A separate scope of work for Area C of Unit F is presented later in this section because the work scope had to be modified due to conditions encountered during the investigation. Each boring was advanced to a depth of 10 feet bgs, if possible. Continuous split-spoon soil samples were collected from each boring. Each soil sample was screened with a PID according to the headspace screening procedures contained in Appendix A of the RFI Work Plan. Two samples from each boring were collected and submitted for analysis of TPH by modified methods 8100 and 8260 based on the PID headspace screening criteria described in Section 6.4.3. If TPH was detected above 10 mg/kg in any of the samples submitted for analysis, the depth interval exhibiting the highest TPH concentration from each area was analyzed for modified Skinner List constituents.

After completion of the borings, URS submitted one surface soil sample from each area, except Area F, for analysis of modified Skinner List metals and vanadium. The surface soil sample submitted for analysis was collected from the boring location exhibiting the highest PID headspace reading from the borings advanced at each area.

Soil Analytical Results – Area A of Unit F

During the RFI, three soil borings were advanced at Area A of Unit F. The results of the TPH analyses are presented on Table 67 and the results of the modified Skinner List analyses are presented on Tables 68 through 70. Summaries of ranges of detected TPH concentrations are provided on Figures 23 and 24. Summaries of detected modified Skinner List analytes, as well as detection limits that exceeded EPA Region III Risk-based soil screening criteria (dated 4/25/03) for the RFI soil samples are presented on Figures 69a and 70a.

Soil Analytical Results – Area B of Unit F

Five soil borings were advanced to evaluate Area B of Unit F during the RFI. The results of the TPH analyses are presented on Table 67, and the results of the surface soil sample are presented in Table 69. TPH was not detected above 10 mg/kg in the samples submitted for analysis from Area B of Unit F; therefore, a sample was not analyzed for modified Skinner List constituents. Summaries of ranges of detected TPH concentrations are provided on Figures 23 and 24. Summaries of detections and detection limits for the RFI soil samples that exceeded EPA Region III Risk-based soil screening criteria (dated 4/25/03) for the surface soil samples are provided on Figures 69a and 70a.

Soil Analytical Results – Area D of Unit F

As part of the RFI, three soil borings were advanced to evaluate soil quality at Area D of Unit F. The results of the TPH analyses are presented on Table 67. TPH was not detected at a concentration greater than 10 mg/kg; therefore, a sample was not analyzed for modified Skinner List constituents. Summaries of ranges of detected TPH concentrations are provided on Figures 23 and 24. Summaries of RFI detections and detection limits that exceeded EPA Region III Risk-based soil screening criteria (dated 4/25/03) for the surface soil sample are provided on Figures 69b and 70b.

Soil Analytical Results – Area E of Unit F

Four soil borings were advanced at Area E of Unit F during the RFI. The results of the TPH analyses are presented on Table 67, and the analytical results of the surface soil sample are presented on Table 69. TPH was not detected at a concentration of 10 mg/kg or greater; therefore, a subsurface sample was not analyzed for modified Skinner List constituents. Summaries of ranges of detected TPH concentrations are provided on Figures 23 and 24. A summary of RFI detections and detection limits that exceeded EPA Region III Risk-based soil screening criteria (dated 4/25/03) for the surface soil sample are provided on Figures 69b and 70b.

Soil Analytical Results – Area F of Unit F

Three soil borings were advanced at Area F of Unit F as part of the RFI. The results of the TPH analyses are presented on Table 67. TPH was not detected at a concentration of 10 mg/kg or greater; therefore, a subsurface sample was not analyzed for modified Skinner List constituents. Because the soil borings were advanced through asphalt, a surface soil sample was not collected

from Area F of Unit F. Summaries of ranges of detected TPH concentrations are provided on Figures 23 and 24.

Soil Analytical Results – Area G of Unit F

During the RFI, three soil borings were advanced to evaluate Area G of Unit F. The results of the TPH analyses are presented on Table 67, and the results of the surface soil sample are presented on Table 69. TPH was not detected at a concentration of 10 mg/kg or greater; therefore, a subsurface sample was not analyzed for modified Skinner List constituents. Summaries of ranges of detected TPH concentrations are provided on Figures 23 and 24. A summary of RFI detections and detection limits that exceeded EPA Region III Risk-based soil screening criteria (dated 4/25/03) for the surface soil sample are provided on Figures 69c and 70c.

6.4.16.2 Scope of Work - Area C of Unit F

The investigative program for Area C of Unit F differed from the scope of work proposed in the RFI Work Plan to accommodate conditions encountered in the field. At the time of the RFI field program, Motiva was installing new cooling water lines in the area of the proposed borings for Area C of Unit F. The excavation for the cooling water line was large enough that it made many of the proposed sampling locations inaccessible. URS moved the planned borings to alternate locations, but only two could be advanced in areas that were near the proposed locations. It was decided that additional samples would be collected from the sidewall of the excavation.

Each soil boring was advanced to a depth of 10 feet bgs. Continuous split-spoon soil samples were collected from each boring. Soil samples collected from the excavation were obtained by digging into the sidewall of the excavation at 2-feet depth intervals. Each soil sample was screened with a PID according to the headspace screening procedures contained in Appendix A of the RFI Work Plan.

Two samples from each boring and the excavation were collected and submitted for analysis of TPH by modified methods 8100 and 8260 based on the PID headspace screening criteria described in subsection 6.4.3. If TPH was detected above 10 mg/kg in any of the samples submitted, the depth interval exhibiting the highest TPH concentration was analyzed for modified Skinner List constituents. After completion of the borings, URS submitted one surface soil sample for analysis of modified Skinner List metals and vanadium. The surface soil sample submitted for analysis was collected from the sample location exhibiting the highest PID headspace reading from the three sampling locations.

Soil Analytical Results – Area C of Unit F

Two soil borings were advanced, and two samples were collected from the excavation for the cooling water lines to evaluate Area C of Unit F. The results of the TPH analyses are presented on Table 67, and the results of the surface soil analyses are presented on Table 70. TPH was not detected at a concentration greater than 10 mg/kg; therefore, a subsurface soil sample was not analyzed for modified Skinner List constituents. Summaries of ranges of detected TPH concentrations are provided on Figures 23 and 24. Summaries of detections and detection limits that exceeded EPA Region III Risk-based soil screening criteria (dated 4/25/03) for the surface soil sample are provided on Figures 69a and 70a.

6.4.17 Toluene Area

The Toluene Area, as it is commonly referred, is an area of historic detections of BTEX constituents in groundwater. The Toluene Area was not addressed during the VRS field program. The VRS field investigation did address the facility sewer system, and some wells that were installed now have free-phase hydrocarbon on the water table. The locations of these wells (9MW-1 and 9MW-2) as well as the area of historic BTEX detections are shown on Figure 2. During the review of the RFI Work Plan, Motiva decided to address this area of SWMU 9 and the Toluene Area on a site-wide basis during the RFI. Background information on the Toluene Area is presented in Section 4.17. Details of the investigation performed at the Toluene Area were provided in the Hydrocarbon Monitoring Interim Report dated August 5, 1999, and a summary is provided in Section 6.3.8 of this Report.

6.4.18 Area South of River Road

As stated in Section 4.18, prior to the RFI, no environmental studies had been conducted in the parcel of land south of River Road that is owned by the Refinery. URS advanced six soil borings in this area to evaluate the geometry of the Pleistocene Channel that has been identified beneath the Refinery. Two of the soil borings were converted to monitoring wells. The locations of the borings and monitoring wells are shown on Figure 2.

URS collected split-spoon soil samples at 5-foot depth intervals during the advancement of the soil borings. The sampling interval was sometimes increased to 10-feet at depths below 40-feet. Each soil sample was screened in the field with a PID in accordance with the headspace screening procedure described in Appendix A of the RFI Work Plan. The lithology of the subsurface materials encountered was logged according to the Unified Soil Classification System. Based on the lithology encountered, a determination was made as to the location of the

boring in reference to the Pleistocene Channel. If, for instance, it was determined that the location of the first boring was not near the center of the Channel, this boring was properly abandoned. Once it was confirmed that the center and edges of the paleochannel had been identified, a monitoring well was installed in the upper sands of the channel, and a monitoring well was installed east of the paleochannel.

Each monitoring well was constructed of 4-inch inside-diameter threaded-flush joint PVC screen and schedule-40 PVC riser pipe. Monitoring well D27 (previously identified as PC-1) was installed in the Pleistocene Channel to a depth of 38 feet bgs, and monitoring well D28 (previously identified as PC-2) was installed east of the channel to a depth of 36.5 feet bgs. The wells were re-named because the D-series wells have historically been installed to monitor dissolved phase constituents. It is believed that these wells will serve to monitor the dissolved phase constituents in the future, and the Motiva database has been revised accordingly.

Each well was constructed so that it is screened across the water table, and to allow for seasonal fluctuations of the water table. Monitoring wells D27 and D28 were developed on March 9, 1999 with a submersible pump. The turbidity of the discharge water from well D27 was 8 Nephelometric Turbidity Units (NTUS) at the completion of well development, and the turbidity of the discharge water from well D28 was 17 NTUs at the completion of development. Groundwater samples were collected from each well on April 1 and July 29, 1999. The groundwater samples were submitted for analysis of TPH by modified methods 8100 and 8260 and BTEX by method 8260B. The analytical results of the groundwater samples collected from wells PC-1 and PC-2 are summarized in Table 71. A summary of detected concentrations and detection limits that exceeded EPA Region III Risk-based tap water screening criteria are presented on Figure 71.

Additional Groundwater Sampling Event

After receiving the initial groundwater analytical data, it was apparent that there were areas where groundwater had been impacted with MTBE. The highest concentration of MTBE was detected in the groundwater samples collected from well D21, which is adjacent to Tank 167 in the Bulk Storage Tank Farm. To evaluate the extent of MTBE, URS re-sampled wells PC-1 and PC-2 on November 24, 1999. The groundwater samples were submitted to NETL for analysis of MTBE. MTBE was not detected above the method detection limit of 1 µg/l in either groundwater sample submitted for analysis. The analytical results of the groundwater samples collected on November 23 and 24, 1999 are summarized on Table 72.

7.0 QUALITY ASSURANCE/QUALITY CONTROL AND DATA VALIDATION

The following sections summarize the quality assurance/quality control program implemented during the RFI, as well as data validation performed following receipt of the analytical data from the laboratory.

7.1 QUALITY ASSURANCE/QUALITY CONTROL

During the RFI, quality assurance/quality control (QA/QC) samples were submitted for laboratory analysis. The QA/QC samples submitted consisted of trip blanks, storage blanks, equipment blanks, temperature blanks, and duplicate samples.

As a means to control and evaluate the variability of analytical results and the possible level of contamination, blanks were introduced into the total measurement system. The deionized water used for all blanks originated from a common source at the analytical laboratory. During soil sampling, the trip blanks and storage blanks were made of the sodium bisulfite preservative used in the soil vial. For every 20 water or soil samples collected, a minimum of one equipment blank was collected and submitted for analysis. One trip blank, one storage blank, and one temperature blank were included in each cooler shipped to the laboratory.

The purpose of the equipment blank is to address cross-contamination in the field between sampling sources due to insufficient decontamination procedures. This blank also addresses field preservation procedures, site environmental interferences, and the integrity of the blank water used for decontamination. Equipment blanks were collected by decontaminating a piece of sampling equipment in accordance with the procedures in Section 1.4 of the Sampling Plan of the RFI Work Plan. After the sampling equipment had been decontaminated, deionized water was poured over the piece of equipment. The water flowing off the equipment was collected in the appropriate sample containers. These samples are labeled, recorded, shipped and analyzed along with the other samples.

Trip blanks and storage blanks were included with samples being analyzed for volatile organic compounds. These blanks are intended to address interferences derived from improper sample container cleaning, integrity of the blank water/sample preservative, sample cross contamination during shipment and/or storage, and extraneous environmental conditions affecting the samples during the sampling event. The trip blanks and storage blanks during groundwater sampling events consisted of laboratory-cleaned 40-milliliter vials filled deionized, analyte-free water.

The trip blanks and storage blanks during soil sampling consisted of laboratory-cleaned 40-milliliter vials filled with the sodium bisulfite used for the preservation of the samples submitted for analysis of volatile organic compounds. Trip blanks traveled with the sample containers from the analytical laboratory, remained with the sample containers during sample collection, and accompanied the samples during shipment back to the laboratory. Storage blanks traveled an identical path, and provide a backup in the event that gross contamination is detected in the trip blank. Temperature blanks were included in each cooler to verify the temperature the samples were cooled to during shipment to the laboratory.

For every twenty field samples analyzed for a particular constituent, a duplicate sample was collected for analysis of the same constituent. The duplicate samples were submitted to the analytical laboratory "blind" (labeled as regular samples). The duplicate sample analytical results were intended to limit statistical bias in the summary data set.

A summary table of the blank data is provided in Appendix H.

7.2 DATA VALIDATION

Following receipt of the analytical data, URS initiated data validation. The data validation reports were presented previously under separate cover. The data validation reports presented a summary of the findings of the review of the data, a listing of the samples included in the review, copies of the data reports with data qualifying flags applied (if any), the data review checklist, supporting documentation, and an explanation of the qualifying flags used. The data validation review is based on the New England Testing Laboratory Quality Assurance Plan (June 18, 1996), URS's Quality Assurance Project Plan (March 1996, Appendix C of the RFI Work Plan), and the USEPA Region III Modifications to the National Functional Guidelines for Data Review. Modifications reflected the level of review requested and the specifics of the analytical method employed.

8.0 SUMMARY OF RESULTS

This section presents a summary of the Verification of Release Study results as well as the RFI results.

Verification of Release Study Results Summary

The VRS Report was delivered to the USEPA on March 31, 1995. The VRS Report detailed the field investigation and results of the verification investigation that was conducted at the Refinery from September 1994 through January 1995. The results of the VRS Report are presented herein:

- SWMU 3 (Neutralization Tanks 1 and 2) – No further action was recommended for SWMU 3 because metals detections were all low.

- SWMU 9 (Refinery Sewer System) – An Interim Corrective Measure was recommended for SWMU 9 to address the free-phase hydrocarbon present on the water table in the vicinity of 9MW-1 and 9 MW-2. An RFI was also recommended to address the dissolved BTEX constituents in groundwater and to evaluate potential source areas.

- SWMU 12 (Used Solvent Storage Area) – No further action was recommended for SWMU 12 because detected concentrations were all low.

- SWMU 13 (Old Drum Storage Area) – No further action was recommended for SWMU 13 because detected concentrations were all low.

- SWMU 15 (Tank Bottom Weathering Areas) – An RFI was recommended for SWMU 15 to address SVOCs detected in the soil.

- SWMU 18 (Fire Training Area) – An RFI was recommended for SWMU 18 to address VOCs and TPH detected in the soil.

- SWMU 20a.1 (Off-Loading Area for Recovered Crude Holding Tank) – An RFI was recommended for SWMU 20a.1 to address SVOCs detected in the soil.

- SWMU 20a.2 (Final Effluent Filter Area) – No further action was recommended for SWMU 20a.2 because only low levels of metals were detected.

- SWMU 20b.1 (Stormwater Channel) – An RFI was recommended for SWMU 20b.1 to address the SVOCs and BTEX in Stormwater Channel sediments, and to address BTEX in groundwater.

- SWMU 20b.2 (Guard Basin No. 4) – An RFI was recommended for SWMU 20b.2 to address SVOCs and BTEX in Guard Basin No. 4 sediment, and to address total xylenes in groundwater.

- SWMU 20b.3 (API Separator No. 2) – An RFI was recommended for SWMU 20b.3 to address BTEX in groundwater.

- SWMU 21 (Cooling Water Channel & Guard Basins Nos. 5 and 6) – No further action was recommended for SWMU 21 because it appeared that groundwater is not being impacted by the sediment in these Guard Basins.

- SWMU 24b (Dredged Material Storage Area No. 2) – An RFI was recommended for SWMU 24b to address SVOCs and BTEX detected in the soil sample collected from the oily sludge area and to implement borings in the marshland area to could not be implemented during the VRS due to access issues.

- SWMU 26 (Tetraethyl Lead Equipment Laydown Area) – An RFI was recommended for SWMU 26 to verify the location of this SWMU and to address the low levels of toluene, ethylbenzene and total xylenes in the soil.

- SWMU 30 (Sewer Overflow Area) – No further action was recommended for SWMU 30 because the detections were all low.

- SWMU 31 (Slurry Oil Dumpster) – An RFI was recommended for SWMU 31 to address SVOCs in the soils.

- SWMU 32 (Stained Soil Within Oily Sewer Backup Areas) – An RFI was recommended for SWMU 32 to address VOCs and SVOCs in the soils.

- Unit F (Used Drum Storage Areas) – An RFI was recommended for Unit F to address SVOCs and select metals in the soils.

- Unit K (Heat Exchanger Bundle Cleaning Areas) – No further action was recommended for Unit K because detections were all low.

RFI Results Summary

The summary presented in this Section is based on the data obtained during the RFI conducted at the Delaware City Refinery during 1999 and 2000. The data collected from SWMUs investigated during both the VRS and the RFI are also summarized on Figures 17 through 71.

- The groundwater analytical results indicate that the most widespread refinery related constituents in groundwater are benzene and methyl tertiary butyl ether (MTBE). The suspected source areas for these constituents are the Bulk Storage Tank Farm and the Southern Process Area (pump out lines located in Units 25, 29, and 32). Locally, there are additional refinery related constituents in groundwater such as ethylbenzene, toluene, xylenes, naphthalene, some metals and degradation products of MTBE.

- Free-phase hydrocarbon is present on the water table at five (5) primary areas; the Bulk Storage Tank Farm, the Oily Sludge Area of DMSA No. 2, the Southern Process Area, the Area of Well D9, and Pier 3. Hydrocarbon skimming pumps have been installed and are operational in wells that exhibit free-phase hydrocarbon in the Bulk Storage Tank Farm, the Southern Process Area, the Area of Well D9, and Well 33MW-2 at Pier 3.

- At SWMU 9, groundwater monitoring wells were installed downgradient of major portions of the Refinery sewer system to evaluate groundwater quality. Wells 9MW-1 through 9MW-7 were installed during the VRS, and wells 9MW-9 through 9MW-10 were installed during the RFI. Groundwater samples have not been collected from wells 9MW-1 and 9MW-2 because free-phase hydrocarbon was detected on the water table shortly after installation. Currently, a hydrocarbon skimming pump is operating at 9MW-1, and two (2) hydrocarbon skimming pumps are operating downgradient of 9MW-2.

  A groundwater sample was collected from well 9MW-3 following installation and development during the VRS. Benzene and naphthalene were detected at concentrations above EPA Region III Risk-based Tap Water screening criteria. During the RFI, free-phase hydrocarbon was detected in well 9MW-3.

  Well 9MW-4 was also sampled after installation and development during the VRS. The only constituent detected at a concentration above the EPA Region III Risk-based Tap Water

screening criterion was tetrachloroethene (PCE), detected at a concentration of 2.1 µg/l. PCE is known to originate from an off-site source west of the Refinery.

Wells 9MW-5, 9MW-6, and 9MW-7 were sampled during the VRS and the RFI. The only volatile organic compounds detected at concentrations above the EPA Region III Risk-based Tap Water screening criteria were PCE (9MW-5, 2.2 µg/l), benzene (9MW-6, 0.9J µg/l), chloroform (9MW-7, 4.7 µg/l), and MTBE (9MW-7, maximum detection 4.1 µg/l). The only inorganic detected at a concentration exceeding the EPA Region III Risk-based Tap Water screening criterion was manganese, detected in the sample collected from well 9MW-7 at a maximum concentration of 10.7 mg/l.

Wells 9MW-8, 9MW-9, and 9MW-10 were sampled during April and July 1999 as part of the RFI. Benzene was detected at concentrations exceeding the EPA Region III Risk-based Tap Water screening criteria in the samples collected from each well. Total xylenes were detected at concentrations exceeding the EPA Region III Risk-based Tap Water screening criteria in the samples collected from wells 9MW-8 and 9MW-9. MTBE was detected at a concentration exceeding the EPA Region III Risk-based Tap Water screening criterion in the samples collected from well 9MW-8, and the detection limits for the samples collected from well 9MW-9 exceeded the screening criterion as well. The concentration of toluene detected in the samples collected from well 9MW-9 also exceeded the EPA Region III Risk-based Tap Water screening criterion.

It appears that the wells installed to investigate SWMU can be divided into four groups as follows:

- Wells 9MW-4, 9MW-5, 9MW-6, and 9MW-7;
- Well 9MW-3;
- Wells 9MW-1, 9MW-2, 9MW-8, and 9MW-9.
- Well 9MW-10.

Based on the analytical results, wells 9MW-4, 9MW-5, 9MW-6, and 9MW-7 exhibit low concentrations of analytical constituents in groundwater, several of which originate offsite. The only refinery related constituents detected in groundwater at concentrations exceeding EPA Region III Risk-based Tap Water screening criteria were benzene and MTBE. The source or sources of the constituents found in these well will be further evaluated in the Phase II RFI.

Groundwater analytical results from well 9MW-3 exhibited benzene and naphthalene at concentrations above EPA Region III Tap Water screening criteria, and exhibited free-phase

hydrocarbon on the water table at the initiation of the RFI. Wells were installed downgradient of well 9MW-3 as part of the Free-phase Hydrocarbon investigation to evaluate the mobility and occurrence of hydrocarbon near the well; however, the source of the hydrocarbon has not been identified, and should be investigated during the Phase II RFI.

Wells 9MW-1 and 9MW-2 exhibited free-phase hydrocarbon on the water table shortly after installation. Analytical results from groundwater samples collected from wells 9MW-8 and 9MW-9 during the RFI showed relatively high levels of dissolved hydrocarbon constituents. During October 2003, free-phase hydrocarbon was detected in well 9MW-9; currently, free-phase hydrocarbon has not been detected in well 9MW-8. It appears that these wells may have a common source, but that more than one source may be present as well based on physical characteristics of the hydrocarbon. The hydrocarbon in the areas of wells 9MW-1 and 9MW-2 are similar; however, the hydrocarbon in 9MW-2 and wells located downgradient of 9MW-2 is much lighter in color than that in the area of 9MW-1. Wells have been installed downgradient of these areas to evaluate the mobility and occurrence of the hydrocarbon in the Southern Process Area, and sources have been hypothesized; however, no definitive source has been identified. The source(s) of groundwater impacts should be investigated as part of the Phase II RFI.

Groundwater analytical results from the samples collected from well 9MW-10 show that the only constituent detected at a concentration above the Region III Tap Water screening criteria was benzene, detected at a maximum concentration 7.5 µg/l. The fact that no other constituents were detected at concentrations exceeding screening criteria in groundwater samples suggests that 9MW-10 is not associated with the groundwater impacts at the Southern Process Area. Continued monitoring of well 9MW-10 should be included as part of the site-wide groundwater monitoring program when it is implemented.

- At SWMU 13, the Old Drum Storage Area, arsenic was detected at concentrations exceeding EPA Region III Risk-based soil screening criteria for residential soil, industrial soil, and soil to groundwater migration. An acid regeneration plant is being built at SWMU 13 and a Soil Management Plan was approved by EPA and DNREC in August 2004 handling excess soil fromconstruction activities. Once construction activities are completed in summer 2005, an ecological reconnaissance of the area will be performed to determine whether the habitat present at SWMU 13 prior to construction has been altered. If the habitat has not been altered, additional ecological risk sampling will be performed, as agreed to at the February 11, 2003 meeting with EPA.

- At SWMU 15, the Tank Bottom Weathering Areas, arsenic was detected at concentrations exceeding the EPA Region III Risk-based soil screening criteria for residential and industrial soil in borings advanced in the Crude Oil Tank Farm. Arsenic, cadmium, xylenes, and several SVOCs were detected at concentrations EPA Region III Risk-based soil screening criteria for soil to groundwater migration in borings advanced in the Crude Oil Tank Farm. Antimony was detected above the soil to groundwater migration criterion in a boring advanced in the Vacuum Residue Tank Farm. SWMU 15 has been eliminated from the Ecological Risk Assessment because it provides no habitat for wildlife (Problem Formulation For Screening Ecological Risk Assessment, URS, June 26, 2002).

- At SWMU 18, the Fire-Training Area, no analytical constituents were detected in soil samples at concentrations exceeding EPA Region III Risk-based soil screening criteria for residential or industrial soil. Benzene and MTBE were detected at concentrations exceeding the soil to groundwater migration criteria. MTBE was detected in groundwater at SWMU 18 at a concentration exceeding the EPA Region III Risk-based screening criterion for tap water. SWMU 18 has been eliminated from the Ecological Risk Assessment due to a lack of habitat to support wildlife (Problem Formulation For Screening Ecological Risk Assessment, URS, June 26, 2002).

- At SWMU 20a.1, the Off-loading Area for Recovered Crude Holding Tank, arsenic was detected at a concentration exceeding the USEPA Region III Risk-based soil screening criteria for industrial soil. SWMU 20a.1 has been eliminated from the Ecological Risk Assessment due to incomplete pathways to wildlife receptors (Problem Formulation For Screening Ecological Risk Assessment, URS, June 26, 2002).

- At SWMU 20b.1, the Stormwater Channel, no analytical constituents were detected at concentrations exceeding the EPA Region III Risk-based soil screening criteria for residential and industrial soil. Ethylbenzene, naphthalene, and xylenes were detected at concentrations exceeding EPA Region III soil to groundwater migration screening criteria. A soil sample was also analyzed for hazardous waste constituents by TCLP, and no detections exceeded the TCLP Regulatory Limits.

- At SWMU 20b.2, Guard Basin No. 4, arsenic, benzene, and several SVOCs were detected at concentrations exceeding EPA Region III Risk-based screening criteria for residential and industrial soil. Several VOCs, SVOCs, and metals were detected at concentrations exceeding the Region III soil to groundwater migration screening criteria. The reported analytical results are from sludge samples that were collected within Guard Basin No. 4, as well as the sediment underlying the "sludge."

- At SWMU 20b.3, API Separator No. 2, analytical constituents were not detected at concentrations exceeding EPA Region III Risk-based screening criteria for residential or industrial soil. Benzene was detected in one (1) soil sample at a concentration exceeding EPA Region III Risk-based screening criteria for soil to groundwater migration. Arsenic was detected in groundwater at concentrations exceeding EPA Region III Risk-based screening criterion for tap water. SWMU 20b.3 has been eliminated from the Ecological Risk Assessment due to a lack of habitat to support wildlife (Problem Formulation For Screening Ecological Risk Assessment, URS, June 26, 2002).

- At SWMU 21, the Cooling Water Channel and Guard Basins 5 and 6, arsenic was detected in each sediment sample collected. In the eight (8) samples submitted for analysis, five (5) detections exceeded EPA Region III Risk-based screening criteria for residential soil, and three (3) detections exceeded EPA Region III Risk-based screening criteria for industrial soil. Benzo(a)pyrene was also detected in one (1) sample at a concentration exceeding EPA Region III soil screening criteria for residential soil. Several VOCs, SVOCs, and metals were detected at concentrations exceeding EPA Region III Risk-based screening criteria for soil to groundwater migration. Additional ecological risk data is currently being obtained from SWMU 21, and will be evaluated in the Baseline Ecological Risk Assessment Report.

- At SWMU 24a, Dredged Material Storage Area No. 1, arsenic was detected in each sample at concentrations exceeding EPA Region III Risk-based screening criteria for industrial soil. Arsenic, cadmium, 4-Nitrophenol, and 1,4-Dioxane were detected at concentrations exceeding EPA Region III Risk-based screening criteria for soil to groundwater migration. Several metals and bis(2-ethylhexyl)phthalate were detected at concentrations exceeding EPA Region III Risk-based screening criteria for tap water. It is believed, however, that additional groundwater samples need to be collected to verify or refute the results obtained during the RFI. The high turbidity of the groundwater samples has resulted in questionable validity of the total and dissolved metals analyses.

- At SWMU 24b, Dredged Material Storage Area No. 2, analytical constituents were not detected at concentrations exceeding EPA Region III soil screening criteria for residential soil in the samples collected from the "Lowland Area."

  In the "Oily Sludge Area" of SWMU 24b, benzo(a)anthracene, benzo(a)pyrene and arsenic were detected in soil samples at concentrations exceeding EPA Region III Risk-based screening criteria for industrial soil. Several VOCs, SVOCs, and metals were detected at concentrations exceeding EPA Region III Risk-based screening criteria for soil to

groundwater migration. Benzene and arsenic were detected in a groundwater monitoring well associated with this portion of the SWMU at concentrations exceeding EPA Region III Risk-based screening criteria for tap water.

- At SWMU 26, the Tetraethyl Lead Pit, arsenic was the only constituent detected in soil at concentrations exceeding EPA Region III Risk-based screening criteria for residential and industrial soil. Arsenic and cadmium were detected at concentrations exceeding EPA Region III Risk-based screening criteria for soil to groundwater migration. A Work Plan was submitted to EPA to perform additional soil sampling at SWMU 26, and the Work Plan was approved in EPA's December 24, 2003 letter. The surface soil data collected during implementation of the additional work will be used in the Baseline Ecological Risk Assessment.

- At SWMU 31, the former location of the Slurry Oil Dumpster, benzo(a)pyrene was detected at a concentration exceeding EPA Region III Risk-based screening criteria for residential soil, and arsenic was detected at a concentration exceeding EPA Region III Risk-based screening criteria for industrial soil. Those two constituents as well as benzene, benzo(a)anthracene, and naphthalene were detected at concentrations exceeding EPA Region III Risk-based screening criteria for soil to groundwater migration. SWMU 31 has been eliminated from the ecological risk assessment due to incomplete pathways to ecological receptors (Problem Formulation For Screening Ecological Risk Assessment, URS, June 26, 2002).

- At SWMU 32, the Stained Soil Within Oily Sewer Backup Areas, benzo(a)pyrene was detected at a concentration exceeding the EPA Region III Risk-based screening criterion for residential soil. Several VOCs, SVOCs, and metals were detected at concentrations exceeding EPA Region III Risk-based screening criteria for soil to groundwater migration. SWMU 32 has been eliminated from the ecological risk assessment due to a lack of habitat to support wildlife (Problem Formulation For Screening Ecological Risk Assessment, URS, June 26, 2002).

- At SWMU 33, Piers 2 and 3, arsenic was the only constituent detected in soil samples at concentrations exceeding the EPA Region III Risk-based screening criterion for industrial soil. Several VOCs, SVOCs, and metals were detected at concentrations exceeding EPA Region III Risk-based screening criteria for soil to groundwater migration. MTBE was detected at a concentration exceeding EPA Region III Risk-based screening criteria for tap water in groundwater collected from well 33MW-1.

Following completion of the Phase I RFI, a hydrocarbon recovery system was installed at well 33MW-2 to recover free-phase hydrocarbon detected in the well. Additional ecological risk data has recently been obtained from SWMU 33, and will be evaluated in the Baseline Ecological Risk Assessment Report.

- At Area A of Unit F, no VOCs or SVOCs were detected at concentrations exceeding EPA Region III Risk-based soil screening criteria. Arsenic was detected in surface soil at a concentration exceeding EPA Region III Risk-based screening criteria for residential soil. Antimony and arsenic were detected in surface soil at concentrations exceeding EPA Region III Risk-based screening criteria for soil to groundwater migration. Area A of Unit F has been eliminated from the ecological risk assessment due to a lack of habitat to support wildlife (Problem Formulation For Screening Ecological Risk Assessment, URS, June 26, 2002).

- At Area B of Unit F, TPH was not detected at a concentration above 10 mg/kg; therefore, a sample was not analyzed for modified Skinner List constituents. Cadmium and selenium were detected in surface soil at concentrations exceeding EPA Region III Risk-based screening criteria for residential soil. Arsenic was detected in surface soil at a concentration exceeding EPA Region III Risk-based screening criteria for industrial soil. Antimony and arsenic were detected in surface soil at concentrations exceeding EPA Region III Risk-based screening criteria for soil to groundwater migration. Area B of Unit F has been eliminated from the ecological risk assessment due to incomplete pathways to ecological receptors (Problem Formulation For Screening Ecological Risk Assessment, URS, June 26, 2002).

- At Area C of Unit F, TPH was not detected at a concentration above 10 mg/kg; therefore, a sample was not analyzed for modified Skinner List constituents. Arsenic was detected in surface soil at a concentration exceeding EPA Region III Risk-based screening criteria for industrial soil. Antimony and arsenic were detected in surface soil at concentrations exceeding EPA Region III Risk-based screening criteria for soil to groundwater migration. Area C of Unit F has been eliminated from the ecological risk assessment due to a lack of habitat to support wildlife (Problem Formulation For Screening Ecological Risk Assessment, URS, June 26, 2002).

- At Area D of Unit F, TPH was not detected at a concentration above 10 mg/kg; therefore, a sample was not analyzed for modified Skinner List constituents. Arsenic was detected in surface soil at a concentration exceeding EPA Region III Risk-based screening criteria for industrial soil. Antimony and arsenic were detected in surface soil at concentrations exceeding EPA Region III Risk-based screening criteria for soil to groundwater migration.

Area D of Unit F has been eliminated from the ecological risk assessment due to a lack of habitat to support wildlife (Problem Formulation For Screening Ecological Risk Assessment, URS, June 26, 2002).

- At Area E of Unit F, TPH was not detected at a concentration above 10 mg/kg; therefore, a sample was not analyzed for modified Skinner List constituents. Arsenic was detected in surface soil at a concentration exceeding EPA Region III Risk-based screening criteria for industrial soil. Antimony and arsenic were detected in surface soil at concentrations exceeding EPA Region III Risk-based screening criteria for soil to groundwater migration. Area E of Unit F has been eliminated from the ecological risk assessment due to incomplete pathways to ecological receptors (Problem Formulation For Screening Ecological Risk Assessment, URS, June 26, 2002).

- At Area F of Unit F, TPH was not detected at a concentration above 10 mg/kg; therefore, a sample was not analyzed for modified Skinner List constituents. A surface soil sample was not collected because the area is paved. Area F of Unit F has been eliminated from the Ecological Risk Assessment due to a lack of habitat to support wildlife (Problem Formulation For Screening Ecological Risk Assessment, URS, June 26, 2002).

- At Area G of Unit F, TPH was not detected at a concentration above 10 mg/kg; therefore, a sample was not analyzed for modified Skinner List constituents. Arsenic was detected in surface soil at a concentration exceeding EPA Region III Risk-based screening criteria for industrial soil. Antimony and arsenic were detected in surface soil at concentrations exceeding EPA Region III Risk-based screening criteria for soil to groundwater migration. Area G of Unit F has been eliminated from the ecological risk assessment because it provides no habitat for wildlife (Problem Formulation For Screening Ecological Risk Assessment, URS, June 26, 2002).

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TABLE 2
SUMMARY OF SOLID WASTE MANAGEMENT UNITS (SWMUs) REVIEWED BY EPA FOR INCLUSION OF CORRECTIVE ACTION PERMIT

DELAWARE CITY REFINERY
DELAWARE CITY, DELAWARE

SOLID WASTE MANAGEMENT UNIT		STUDY REQUIRED BY CORRECTIVE ACTION PERMIT			RECOMMENDATION OF IPOPRS REPORT
		IPOPRS	VRS	RFI	
1.	Former Coke Storage Area	X			No Further Action
2.	Coke Stack	Deferred to DNREC			—
3.	Neutralization Tanks 1 and 2	X			• Repair concrete pad • Extend concrete curbing • Obtain soil samples
4.	Flyash Piping and Pumping Systems	X			• Repair spill collection trenches • Remove solids from trenches and from spills collection basin
5.	Old Flyash Settling Pond	X			Close under guidance of DNREC
6.	New Flyash Settling Pond	X			Increase monitoring of As, Ba, Cd, Cr, Cu, Pb, and Zn to quarterly
7.	Bulk Acid Tank Leakage	Not a SWMU			—
8.	Railroad Tank Car Loading Area	X			No Further Action
9.	Facility Sewer System	X			VRS
10.	Process Area Washdown	X			No Further Action
11.	Maintenance Shop Temporary Accumulation Area	No Further Action			—
12.	Used Solvent Storage Area		X		—
13.	Old Drum Storage Area		X		—
14.	Accumulation Areas (A-M)	Not included in Permit Covered by a RCRA Section 3007 Information Request from EPA			—
15.	Tank Bottom Weathering Areas	X			VRS
16.	Excavated Material Mounds South of Coke Storage Area	X			No Further Action
17.	Former Pit on Route 9	X			No Further Action
18.	Fire Training Area	X			VRS
19.	Trash Incinerator	No Further Action			—
20.	Wastewater Treatment Plant				
	(a) WWTP	X			VRS
	(b) Guard Basin 4	X			VRS
21.	Guard Basins 5 and 6	X			VRS
22.	Oil Treatment/Reprocessing System	X			No Further Action
23.	RCRA Land Treatment Unit	Deferred to DNREC			—
24a.	Dredge Material Storage Area 1			X	—
24b.	Dredge Material Storage Area 2	X			VRS
24c.	Other Dredge Material Storage Areas	X			No Further Action
25.	RCRA Landfill	Deferred to DNREC			—
26.	Tetraethyl Lead Pit		X		—
27.	Units Which Manage Water Treatment System Wastes or Wastewaters				
	(a) Groundwater Treatment System	X			No Further Action
	(b) River Water Treatment System	X			No Further Action
	(c) Water Desalter System	X			No Further Action

TABLE 2
SUMMARY OF SOLID WASTE MANAGEMENT UNITS (SWMUs) REVIEWED BY EPA FOR INCLUSION OF CORRECTIVE ACTION PERMIT

DELAWARE CITY REFINERY
DELAWARE CITY, DELAWARE

SOLID WASTE MANAGEMENT UNIT	STUDY REQUIRED BY CORRECTIVE ACTION PERMIT			RECOMMENDATION OF IPOPRS REPORT
	IPOPRS	VRS	RFI	
(d) Ballast Water Treatment System	X			No Further Action
(e) Sour Water Treatment System	X			No Further Action
28. Crude/Product Tank Farm Separators	X			No Further Action
SWMUs IDENTIFIED SINCE THE PERMIT ISSUANCE				
29. Sulfur Impoundment				No Further Action
30. Sewer Overflow Area				VRS
31. Slurry Oil Dumpster				VRS
32. Stained Soil Within Oily Sewer Backup Areas				VRS
33. Piers 2 and 3				VRS*

Explanation:

IPOPRS - Identification of Potential for an Occurring or Past Release Study
VRS - Verification of Release Study
RFI - RCRA Facility Investigation
— - No IPOPRS Required by Permit
* - After further evaluation, Motiva will do an RFI at this SWMU

TABLE 10

SUMMARY OF GROUNDWATER ANALYTICAL RESULTS
FACILITY SEWER SYSTEM - SWMU 9
RCRA FACILITY INVESTIGATION
MOTIVA ENTERPRISES LLC - DELAWARE CITY REFINERY

Dames & Moore Sample ID		9MW-5	9MW-5	9MW-6	9MW-6	9MW-7	9MW-7	9MW-8	9MW-8
Laboratory ID		J0414-04	J0729-06	J0414-04	J0730-46	J0414-04	J0723-05	J0414-04	J0723-05
Sample Date		4/13/99	7/28/99	4/12/99	7/29/99	4/7/99	7/22/99	4/13/99	7/22/99
Volatile Organic Compounds	**Units**								
1,1,1,2-Tetrachloroethane	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
1,1,1-Trichloroethane	µg/l	NA	NA	3.3	10 U	NA	NA	NA	NA
1,1,2-Trichloroethane	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
1,1-Dichloroethane	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
1,1-Dichloroethene	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
1,1-Dichloropropene	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
1,2,3-Trichloropropane	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
1,2-Dibromo-3-chloropropane	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
1,2-Dichloroethane	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
1,2-Dichloropropane	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
1,2-Dichlorobenzene	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
1,3-Dichlorobenzene	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
1,4-Dichlorobenzene	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
2,2-Dichloropropane	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
2-Chlorotoluene	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
4-Chlorotoluene	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
Benzene	µg/l	1 U	10 U	1 U	10 U	1 U	10 U	481.7 D	752.8 D
Bromobenzene	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
Bromochloromethane	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
Bromodichloromethane	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
Bromoform	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
Bromomethane	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
Carbon Tetrachloride	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
Chlorobenzene	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
Chlorodibromomethane	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
Chloroethane	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
Chloroform	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
Chloromethane	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
cis-1,2-Dichloroethene	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
cis-1,3-Dichloropropene	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA

TABLE 10

SUMMARY OF GROUNDWATER ANALYTICAL RESULTS
FACILITY SEWER SYSTEM - SWMU 9
RCRA FACILITY INVESTIGATION
MOTIVA ENTERPRISES LLC - DELAWARE CITY REFINERY

Dames & Moore Sample ID		9MW-5	9MW-5	9MW-6	9MW-6	9MW-7	9MW-7	9MW-8	9MW-8
Laboratory ID		J0414-04	J0729-06	J0414-04	J0730-46	J0414-04	J0723-05	J0414-04	J0723-05
Sample Date		4/13/99	7/28/99	4/12/99	7/29/99	4/7/99	7/22/99	4/13/99	7/22/99
Volatile Organic Compounds	**Units**								
Dibromomethane	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
Ethylbenzene	µg/l	1 U	10 U	1 U	10 U	1 U	10 U	75.7 D	106.6 DJ
Ethylene Dibromide	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
Methylene Chloride	µg/l	NA	NA	3 U	30 U	NA	NA	NA	NA
m&p-Xylenes	µg/l	2 U	20 U	1 U	20 U	1 U	10 U	237.9 D	450.2 D
o-Xylene	µg/l	1 U	10 U	1 U	10 U	1 U	10 U	102.4 D	183.6 DJ
Methyl Tertiary Butyl Ether	µg/l	5 U	NA	5 U	NA	2	4.1 J	227.9 D	99.8 DJ
Tetrachloroethene	µg/l	12.2	NA	1 U	10 U	NA	NA	NA	NA
Toluene	µg/l	1 U	10 U	1.1	10 U	1 U	10 U	454.7 D	671.8 D
trans-1,2 Dichloroethene	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
trans-1,3 Dichloropropene	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
Trichloroethene	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
Vinyl Chloride	µg/l	NA	NA	1 U	10 U	NA	NA	NA	NA
Semivolatile Organic Compounds									
Phenols	µg/l	NA	NA	0.1 U	0.05 U	NA	NA	NA	NA
Inorganics									
Chloride	mg/l	NA	NA	60	58.9	NA	NA	NA	NA
Iron, Dissolved	µg/l	NA	NA	42.5 B	290	NA	NA	NA	NA
Iron, Total	µg/l	NA	NA	4165	231.4	NA	NA	NA	NA
Manganese, Dissolved	µg/l	NA	NA	2257	10730	NA	NA	NA	NA
Manganese, Total	µg/l	NA	NA	3003	2755	NA	NA	NA	NA
Sodium	µg/l	NA	NA	22270	27380	NA	NA	NA	NA
Sulfate	mg/l	NA	NA	15	26.5	NA	NA	NA	NA
Total Dissolved Solids	mg/l	NA	NA	212	211	NA	NA	NA	NA

TABLE 10

SUMMARY OF GROUNDWATER ANALYTICAL RESULTS
FACILITY SEWER SYSTEM - SWMU 9
RCRA FACILITY INVESTIGATION
MOTIVA ENTERPRISES LLC - DELAWARE CITY REFINERY

Dames & Moore Sample ID		9MW-9	9MW-9	9MW-10	9MW-10	Trip Blank
Laboratory ID		J0414-04	J0723-05	J0414-04	J0723-05	J0414-04
Sample Date		4/12/99	7/22/99	4/13/99	7/22/99	4/12/99
Volatile Organic Compounds	**Units**					
1,1,1,2-Tetrachloroethane	µg/l	NA	NA	NA	NA	1 U
1,1,1-Trichloroethane	µg/l	NA	NA	NA	NA	1 U
1,1,2-Trichloroethane	µg/l	NA	NA	NA	NA	1 U
1,1-Dichloroethane	µg/l	NA	NA	NA	NA	1 U
1,1-Dichloroethene	µg/l	NA	NA	NA	NA	1 U
1,1-Dichloropropene	µg/l	NA	NA	NA	NA	1 U
1,2,3-Trichloropropane	µg/l	NA	NA	NA	NA	1 U
1,2-Dibromo-3-chloropropane	µg/l	NA	NA	NA	NA	1 U
1,2-Dichloroethane	µg/l	NA	NA	NA	NA	1 U
1,2-Dichloropropane	µg/l	NA	NA	NA	NA	1 U
1,2-Dichlorobenzene	µg/l	NA	NA	NA	NA	1 U
1,3-Dichlorobenzene	µg/l	NA	NA	NA	NA	1 U
1,4-Dichlorobenzene	µg/l	NA	NA	NA	NA	1 U
2,2-Dichloropropane	µg/l	NA	NA	NA	NA	1 U
2-Chlorotoluene	µg/l	NA	NA	NA	NA	1 U
4-Chlorotoluene	µg/l	NA	NA	NA	NA	1 U
Benzene	µg/l	7802.5 D	12494 D	4.8	7.5 J	1 U
Bromobenzene	µg/l	NA	NA	NA	NA	1 U
Bromochloromethane	µg/l	NA	NA	NA	NA	1 U
Bromodichloromethane	µg/l	NA	NA	NA	NA	1 U
Bromoform	µg/l	NA	NA	NA	NA	1 U
Bromomethane	µg/l	NA	NA	NA	NA	1 U
Carbon Tetrachloride	µg/l	NA	NA	NA	NA	1 U
Chlorobenzene	µg/l	NA	NA	NA	NA	1 U
Chlorodibromomethane	µg/l	NA	NA	NA	NA	1 U
Chloroethane	µg/l	NA	NA	NA	NA	1 U
Chloroform	µg/l	NA	NA	NA	NA	1 U
Chloromethane	µg/l	NA	NA	NA	NA	1 U
cis-1,2-Dichloroethene	µg/l	NA	NA	NA	NA	1 U
cis-1,3-Dichloropropene	µg/l	NA	NA	NA	NA	1 U

TABLE 10

SUMMARY OF GROUNDWATER ANALYTICAL RESULTS
FACILITY SEWER SYSTEM - SWMU 9
RCRA FACILITY INVESTIGATION
MOTIVA ENTERPRISES LLC - DELAWARE CITY REFINERY

Dames & Moore Sample ID		9MW-9	9MW-9	9MW-10	9MW-10	Trip Blank
Laboratory ID		J0414-04	J0723-05	J0414-04	J0723-05	J0414-04
Sample Date		4/12/99	7/22/99	4/13/99	7/22/99	4/12/99
Volatile Organic Compounds	**Units**					
Dibromomethane	µg/l	NA	NA	NA	NA	1 U
Ethylbenzene	µg/l	624.5 D	758 DJ	1.1	1.4 J	1 U
Ethylene Dibromide	µg/l	NA	NA	NA	NA	1 U
Methylene Chloride	µg/l	NA	NA	NA	NA	3 U
m&p-Xylenes	µg/l	1834 D	2122 D	3.3	3.9 J	2 U
o-Xylene	µg/l	625 D	744 DJ	1 U	10 U	1 U
Methyl Tertiary Butyl Ether	µg/l	250 UD	2000 UD	5 U	10 U	5 U
Tetrachloroethene	µg/l	NA	NA	NA	NA	1 U
Toluene	µg/l	7510.5 D	10604 D	3.4	6.9 J	1 U
trans-1,2 Dichloroethene	µg/l	NA	NA	NA	NA	1 U
trans-1,3 Dichloropropene	µg/l	NA	NA	NA	NA	1 U
Trichloroethene	µg/l	NA	NA	NA	NA	1 U
Vinyl Chloride	µg/l	NA	NA	NA	NA	1 U
Semivolatile Organic Compounds						
Phenols	µg/l	NA	NA	NA	NA	NA
Inorganics						
Chloride	mg/l	NA	NA	NA	NA	NA
Iron, Dissolved	µg/l	NA	NA	NA	NA	NA
Iron, Total	µg/l	NA	NA	NA	NA	NA
Manganese, Dissolved	µg/l	NA	NA	NA	NA	NA
Manganese, Total	µg/l	NA	NA	NA	NA	NA
Sodium	µg/l	NA	NA	NA	NA	NA
Sulfate	mg/l	NA	NA	NA	NA	NA
Total Dissolved Solids	mg/l	NA	NA	NA	NA	NA

TABLE 42

SUMMARY OF SOIL ANALYTICAL RESULTS
SOLID WASTE MANAGEMENT UNIT 24a - DREDGED MATERIAL STORAGE AREA No. 1
RCRA FACILITY INVESTIGATION
MOTIVA ENTERPRISES LLC - DELAWARE CITY REFINERY

	URS Sample ID	24a B-3	24a B-3 DL	24a B-3	24a B-5	24a B-5	24a B-6	24a B-6
	Sample Depth	0 - 2	0 - 2	26 - 28	2 - 4	26 - 28	0 - 2	10 - 12
	Laboratory ID	J1223-11	J1223-11	J1223-11	J1223-11	J1223-11	J1223-11	J1223-11
	Sample Date	12/22/99	12/22/99	12/22/99	12/21/99	12/21/99	12/21/99	12/21/99
Volatile Organic Compounds	**Units**							
1,1,1-Trichloroethane	µg/kg	1.3 U	NA	1.5 U	1.2 U	1.8 U	1.7 U	1.1 U
1,2-Dichloroethane	µg/kg	1.3 U	NA	1.5 U	1.2 U	1.8 U	1.7 U	1.1 U
1,2-Dichloropropane	µg/kg	1.3 U	NA	1.5 U	1.2 U	1.8 U	1.7 U	1.1 U
1,4-Dioxane	µg/kg	130 R,c	NA	150 R,c	120 R,c	180 R,c	170 R,c	110 R,c
2-Butanone	µg/kg	30 L,c	NA	1.5 R,c	52 L,c	85 L,c	95 L,c	1.1 R,c
Benzene	µg/kg	1.3 U	NA	1.5 U	1.2 U	1.8 U	1.7 U	1.1 U
Carbon Disulfide	µg/kg	11	NA	11	12	6.8	21	1.1 U
Chlorobenzene	µg/kg	1.3 U	NA	1.5 U	1.2 U	1.8 U	1.7 U	1.1 U
Chloroform	µg/kg	1.3 U	NA	1.5 U	1.2 U	1.8 U	1.7 U	1.1 U
Ethylbenzene	µg/kg	1.3 U	NA	1.5 U	1.2 U	1.8 U	1.7 U	1.1 U
Ethylene dibromide	µg/kg	1.3 U	NA	1.5 U	1.2 U	1.8 U	1.7 U	1.1 U
m&p-Xylene	µg/kg	2.5 U	NA	3 U	2.4 U	3.6 U	3.3 U	2.1 U
o-Xylene	µg/kg	1.3 U	NA	1.5 U	1.2 U	1.8 U	1.7 U	1.1 U
Styrene	µg/kg	1.3 U	NA	1.5 U	1.2 U	1.8 U	1.7 U	1.1 U
Tetrachloroethene	µg/kg	1.3 U	NA	1.5 U	1.2 U	1.8 U	1.7 U	1.1 U
Toluene	µg/kg	13	NA	14	7.3	21	9.5	3.5
Semivolatile Organic Compounds	**Units**							
1,2-Dichlorobenzene	µg/kg	66 U	330 UL,s	74 U	82 U	85 U	77 U	62 U
1,3-Dichlorobenzene	µg/kg	66 U	330 UL,s	74 U	82 U	85 U	77 U	62 U
1,4-Dichlorobenzene	µg/kg	66 U	330 UL,s	74 U	82 U	85 U	77 U	62 U
2,4,5-Trichlorophenol	µg/kg	160 U	820 R,s	190 U	210 U	210 U	190 U	160 U
2,4,6-Trichlorophenol	µg/kg	66 U	330 R,s	74 U	82 U	85 U	77 U	62 U
2,4-Dimethylphenol	µg/kg	66 U	330 R,s	74 U	82 U	85 U	77 U	62 U
2,4-Dinitrophenol	µg/kg	160 J,c	820 R,s	190 J,c	210 U	210 J,c	190 J,c	160 J,c
2,4-Dinitrotoluene	µg/kg	160 U	820 UL,s	190 U	210 U	210 U	190 U	160 U
2-Chlorophenol	µg/kg	66 U	330 R,s	74 U	82 U	85 U	77 U	62 U
2-Methylphenol	µg/kg	66 U	330 R,s	74 U	82 U	85 U	77 U	62 U
4,6-Dinitro-2-methylphenol	µg/kg	160 U	820 R,s	190 U	210 U	210 U	190 U	160 U
4-Methylphenol	µg/kg	66 U	330 R,s	74 U	82 U	85 U	77 U	62 U
4-Nitrophenol	µg/kg	160 U	820 R,s	190 U	210 U	210 U	190 U	160 U

TABLE 42

SUMMARY OF SOIL ANALYTICAL RESULTS
SOLID WASTE MANAGEMENT UNIT 24a - DREDGED MATERIAL STORAGE AREA No. 1
RCRA FACILITY INVESTIGATION
MOTIVA ENTERPRISES LLC - DELAWARE CITY REFINERY

URS Sample ID		24a B-3	24a B-3 DL	24a B-3	24a B-5	24a B-5	24a B-6	24a B-6
Sample Depth		0 - 2	0 - 2	26 - 28	2 - 4	26 - 28	0 - 2	10 - 12
Laboratory ID		J1223-11	J1223-11	J1223-11	J1223-11	J1223-11	J1223-11	J1223-11
Sample Date		12/22/99	12/22/99	12/22/99	12/21/99	12/21/99	12/21/99	12/21/99
7,12-Dimethylbenzo[a]anthracene	µg/kg	200 U	990 UL,s	220 U	250 U	260 U	230 U	190 U
Aniline	µg/kg	160 U	820 UDL,s	190 U	210 U	210 U	190 U	160 U
Anthracene	µg/kg	66 U	330 UDL,s	74 U	82 U	85 U	77 U	62 U
Benzo(a)anthracene	µg/kg	66 U	330 UDL,s	74 U	82 U	85 U	77 U	62 U
Benzo(a)pyrene	µg/kg	66 U	330 UDL,s	74 U	82 U	85 U	77 U	62 U
Benzo(b)fluoranthene	µg/kg	66 U	330 UDL,s	74 U	82 U	85 U	77 U	62 U
Benzo(k)fluoranthene	µg/kg	66 U	330 UDL,s	74 U	82 U	85 U	77 U	62 U
Bis(2-ethylhexyl)phthalate	µg/kg	310 B*,z	340 DB*,z	210 B*,z	250 B*,z	260 B*,z	240 B*,z	120 B*,z
Butyl benzyl phthalate	µg/kg	66 U	330 UDL,s	74 U	82 U	85 U	77 U	62 U
Chrysene	µg/kg	66 U	330 UDL,s	74 U	82 U	85 U	77 U	62 U
Di-n-butyl phthalate	µg/kg	11,000 E	11,000 DB*,z	630 B*,z	4,300 B*,z	680 B*,z	230 B*,z	180 B*,z
Di-n-octyl phthalate	µg/kg	66 U	330 UDL,s	74 U	82 U	85 U	77 U	62 U
Dibenzo(a,h)anthracene	µg/kg	66 U	330 UDL,s	74 U	82 U	85 U	77 U	62 U
Diethyl phthalate	µg/kg	66 U	330 UDL,s	74 U	82 U	85 U	77 U	62 U
Dimethyl phthalate	µg/kg	66 U	330 UDL,s	74 U	82 U	85 U	77 U	62 U
Fluoranthene	µg/kg	87	330 UDL,s	74 U	82 U	85 U	77 U	62 U
Indeno(1,2,3-cd)pyrene	µg/kg	66 U	330 UDL,s	74 U	82 U	85 U	77 U	62 U
Naphthalene	µg/kg	66 U	330 UDL,s	74 U	82 U	85 U	77 U	62 U
Nitrobenzene	µg/kg	66 U	330 UDL,s	74 U	82 U	85 U	77 U	62 U
Phenanthrene	µg/kg	66 U	330 UDL,s	74 U	82 U	85 U	77 U	62 U
Phenol	µg/kg	66 U	330 DR,s	74 U	82 U	85 U	77 U	62 U
Pyrene	µg/kg	100	330 UDL,s	74 U	82 U	85 U	77 U	62 U
Pyridine	µg/kg	160 J,c	820 DJ,c	190 J,c	210 J,c	210 J,c	190 J,c	160 J,c
Inorganics	**Units**							
Antimony	mg/kg	10.1 UL,c	NA	11 UL,c	12.3 UL,c	12.8 UL,c	11.3 K,c	9.6 UL,c
Arsenic	mg/kg	5.6 L,m	NA	6.5 L,m	10.4 L,m	14 L,m	12.1 L,m	2.8 L,m
Barium	mg/kg	35.1 B+K,l	NA	43.8 B+K,l	66.7 B+K,l	72.7 B+K,l	90.5 K,l	13.2 B+K,l
Cadmium	mg/kg	0.78	NA	0.68 B+	1.34 B+	1.9 B+	2.8	0.56 B+
Chromium	mg/kg	26.2 B+K,c	NA	33.6 K,c	44.6 K,c	62.1 K,c	58.9 K,c	14.9 K,c
Lead	mg/kg	16.2 K,c	NA	19.2 K,c	37.2 K,c	107.8 K,c	54.8 K,c	9.8 K,c
Mercury	mg/kg	0.08 L,c	NA	1.31 L,c	0.22 L,h	0.28 L,h	0.24 L,h	0.02 L,h

TABLE 42

SUMMARY OF SOIL ANALYTICAL RESULTS
SOLID WASTE MANAGEMENT UNIT 24a - DREDGED MATERIAL STORAGE AREA No. 1
RCRA FACILITY INVESTIGATION
MOTIVA ENTERPRISES LLC - DELAWARE CITY REFINERY

	URS Sample ID	24a B-3	24a B-3 DL	24a B-3	24a B-5	24a B-5	24a B-6	24a B-6
	Sample Depth	0 - 2	0 - 2	26 - 28	2 - 4	26 - 28	0 - 2	10 - 12
	Laboratory ID	J1223-11	J1223-11	J1223-11	J1223-11	J1223-11	J1223-11	J1223-11
	Sample Date	12/22/99	12/22/99	12/22/99	12/21/99	12/21/99	12/21/99	12/21/99
Nickel	mg/kg	12.3 B^+	NA	16.6	23.6	26.7	33.3	5.5 B^+
Selenium	mg/kg	0.43 U	NA	0.48 U	0.71 B^+	1.3	0.83 J,r	0.4 U
Silver	mg/kg	1.3 B^+	NA	1.24 B^+	1.4 B^+	2 B^+	2.12 B^+	0.57 U

Notes:

1) µg/kg - micrograms per kilogram.
2) mg/kg - milligrams per kilogram.
3) U - not detected above method detection limit.
4) J - analyte present. Reported value may not be accurate or precise.
5) E - concentration exceeded calibration run of instrument. Sample was re-analyzed.
6) D - sample was diluted prior to re-analysis.
7) NA - diluted sample was not re-analyzed for these constituents.
8) $B^\bullet$ - not detected substantially above the level reported in laboratory blank.
9) B^+ - constituent detected detected below the contract required detection limit but above the instrument detection limit.
10) R - Unreliable result. Analyte may or may not be present in the sample. Supporting data necessary to confirm result.
11) L - Analyte present. Reported value may be biased low. Actual value is expected to be higher.
12) K - Analyte present. Reported value may be biased high. Actual value is expected to be lower.
13) c - Calibration failure. Poor or unstable response.
14) z - Method blank contamination.
15) m - Matrix spike/matrix spike duplicate recovery failure.
16) l - LCS failure.
17) h - Holding time violation.
18) r - linearity failure in calibration or MSA.
19) s - surrogate recovery failure.
20) Samples analyzed by New England Testing Laboratory, Inc. of North Providence, Rhode Island.
21) Samples analyzed for volatile organic compounds by Method 8260B.
22) Samples analyzed for semivolatile organic compounds by Method 8270C.
23) Samples analyzed for inorganics by the following methods:

Barium, Chromium, Nickel, and Vanadium - 6010B

Arsenic - 7060A	Antimony - 7041	Cadmium - 7131A
Lead - 7421	Mercury - 7470A	Selenium - 7740
Silver - 7761		

TABLE 66

SUMMARY OF GROUNDWATER ANALYTICAL RESULTS
SOLID WASTE MANAGEMENT UNIT 33
PIERS 2 & 3
RCRA FACILITY INVESTIGATION
MOTIVA ENTERPRISES LLC - DELAWARE CITY REFINERY

	URS Sample ID	33MW-1	33MW-1 Duplicate	33MW-1
	Laboratory ID	J0408-10	J0408-10	J0730-04
	Sample Date	4/7/99	4/7/99	7/29/99
Volatile Organic Compounds	**Units**			
Benzene	µg/l	1 U	1 U	10 U
Ethylbenzene	µg/l	1 U	1 U	10 U
m&p-Xylenes	µg/l	1 J	2 U	10 U
o-Xylene	µg/l	1 U	1 U	10 U
Methyl Tertiary Butyl Ether	µg/l	97.3	96.6	88.7
Toluene	µg/l	1.3	1 U	10 U
Total Petroleum Hydrocarbons				
Diesel Range Organics	µg/l	1458	2039	2205
Gasoline Range Organics	µg/l	779	675	335
Inorganics				
Tetraethyl Lead	µg/l	1 U	1 U	10 U

Notes:

1) SWMU - Solid Waste Management Unit
2) µg/l - micrograms per liter.
3) U - not detected above the method detection limit.
4) J - detected below the method detection limit. Reported concentration is estimated.
5) Sample analyzed for volatile organic compounds by method 8260B.
6) Samples analyzed for diesel range organics by method 8015 modified.
7) Samples analyzed for gasoline range organics by method 8260 modified.
8) Samples analyzed for tetraethyl lead by method 8270C.
9) Samples analyzed by New England Testing Laboratory, Inc. of N. Providence, R.I.

TABLE 67

SUMMARY OF SOIL ANALYTICAL RESULTS
TOTAL PETROLEUM HYDROCARBONS ANALYSES
RCRA FACILITY INVESTIGATION
MOTIVA ENTERPRISES LLC - DELAWARE CITY REFINERY

Unit F - Used Drum Storage Areas					
URS Sample ID	Laboratory Case No.	Date Sampled	TPH DRO Result in mg/kg	TPH GRO Result in mg/kg	Sample Depth (feet below ground surface)
rfab1d0-2	J0521-06	5/20/99	89.9	11.4	0 - 2 Feet
rfab1d8-10	J0521-06	5/20/99	7.9	8.2	8 - 10 Feet
rfab2d0-2	J0521-06	5/20/99	14.9	24	0 - 2 Feet
rfab2d8-10	J0521-06	5/20/99	14.2	12.2	8 - 10 Feet
rfab3d0-2	J0521-06	5/20/99	245.9	12.3	0 - 2 Feet
rfab3d2-4	J0521-06	5/20/99	269.8	7.6	2 - 4 Feet
rfbb1d0-2	J0527-06	5/26/99	2.7 U	6.6	0 - 2 Feet
rfbb1d8-10	J0527-06	5/26/99	2.6 U	5.7 U	8 - 10 Feet
rfbb2d0-2	J0527-06	5/26/99	2.7 U	6.7 U	0 - 2 Feet
rfbb2d8-10	J0527-06	5/26/99	2.8 U	6.4 U	8 - 10 Feet
rfbb3d0-2	J0527-06	5/26/99	2.7 U	6 U	0 - 2 Feet
rfbb3d8-10	J0527-06	5/26/99	3.1 U	6.7 U	8 - 10 Feet
rfbb4d0-2	J0527-06	5/26/99	2.8 U	6.9 U	0 - 2 Feet
rfbb4d8-10	J0527-06	5/26/99	2.6 U	5.7 U	8 - 10 Feet
rfbb5d0-2	J0527-06	5/26/99	2.9 U	6.8 U	0 - 2 Feet
rfbb5d8-10	J0527-06	5/26/99	2.7 U	6 U	8 - 10 Feet
rfcb1d0-2	J0527-06	5/26/99	2.8 U	6.3 U	0 - 2 Feet
rfcb1d8-10	J0527-06	5/26/99	2.7 U	5.6 U	8 - 10 Feet
rfcb2d0-2	J0527-06	5/26/99	2.9 U	6.9 U	0 - 2 Feet
rfcb2d8-10	J0527-06	5/26/99	2.8 U	5.7 U	8 - 10 Feet
rfcb3d0-2	J0617-08	6/15/99	3.3	6.5 U	0 - 2 Feet
rfcb3d8-10	J0617-08	6/15/99	2.9 U	6.9 U	8 - 10 Feet
rfdb1d0-2	J0526-01	5/25/99	2.8 U	5.8 U	0 - 2 Feet
rfdb1d8-10	J0526-01	5/25/99	2.9 U	7.3 U	8 - 10 Feet
rfdb2d0-2	J0527-06	5/26/99	2.8 U	2.8 U	0 - 2 Feet
rfdb2d0-2 Duplicate	J0527-06	5/26/99	6.8	5.3 U	0 - 2 Feet
rfdb2d2-4	J0527-06	5/26/99	3 U	3 U	2 - 4 Feet
rfdb3d0-2	J0527-06	5/26/99	2.9 U	2.9 U	0 - 2 Feet
rfdb3d8-10	J0527-06	5/26/99	2.9 U	2.9 U	8 - 10 Feet
rfeb1d2-4	J0526-01	5/25/99	1.1 U	6.8 U	2 - 4 Feet
rfeb1d8-10	J0526-01	5/25/99	2.6 U	5.6 U	8 - 10 Feet
rfeb2d2-4	J0526-01	5/25/99	2.9 U	6.1 U	2 - 4 Feet
rfeb2d8-10	J0526-01	5/25/99	2.6 U	5.9 U	8 - 10 Feet
rfeb3d4-6	J0526-01	5/25/99	2.9 U	6.8 U	4 - 6 Feet
rfeb3d8-10	J0526-01	5/25/99	2.6 U	5.6 U	8 - 10 Feet
rfeb4d6-8	J0526-01	5/25/99	2.8 U	5.8 U	6 - 8 Feet

TABLE 67

SUMMARY OF SOIL ANALYTICAL RESULTS
TOTAL PETROLEUM HYDROCARBONS ANALYSES
RCRA FACILITY INVESTIGATION
MOTIVA ENTERPRISES LLC - DELAWARE CITY REFINERY

Unit F - Used Drum Storage Areas					
URS Sample ID	Laboratory Case No.	Date Sampled	TPH DRO Result in mg/kg	TPH GRO Result in mg/kg	Sample Depth (feet below ground surface)
rffb1d8-10	J0521-06	5/20/99	2.7 U	7.1	8 - 10 Feet
rffb2d8-10	J0521-06	5/20/99	2.6 U	7.2	8 - 10 Feet
rffb3d2-4	J0521-06	5/20/99	5	6.5 U	2 - 4 Feet
rffb3d8-10	J0521-06	5/20/99	2.8 U	6 U	8 - 10 Feet
rfgb1d0-2	J0528-06	5/27/99	3 U	7.1 U	0 - 2 Feet
rfgb1d8-10	J0528-06	5/27/99	4.3	6.7 U	8 - 10 Feet
rfgb2d0-2	J0528-06	5/27/99	4.2	6.9 U	0 - 2 Feet
rfgb2d8-10	J0528-06	5/27/99	3 U	6.5 U	8 - 10 Feet
rfgb3d2-4	J0528-06	5/27/99	3.1 U	6.1 U	2 - 4 Feet
rfgb3d8-10	J0528-06	5/27/99	3.1 U	6.3 U	8 - 10 Feet

Notes:

1) TPH DRO - total petroleum hydrocarbons - diesel range organics.
2) TPH GRO - total petroleum hydrocarbons - gasoline range organics.
3) mg/kg - milligrams per kilogram.
4) U - not detected above the method detection limit.
5) Samples submitted for DRO analyzed by modified Method 8100.
6) Samples submitted for GRO analyzed by modified Method 8260.
7) Samples analyzed by New England Testing Laboratory, Inc. of N. Providence, R.I.
8) NA - Not applicable. Aqueous equipment blank sample.

TABLE 68

SUMMARY OF SOIL ANALYTICAL RESULTS
VOLATILE ORGANIC COMPOUNDS
UNIT F
RCRA FACILITY INVESTIGATION
MOTIVA ENTERPRISES LLC - DELAWARE CITY REFINERY

	URS Sample ID	rfab3d2-4
	Sample Depth	2-4
	Laboratory ID	J0521-06
	Sample Date	06/09/99
Volatile Organic Compound	**Units**	
1,1,1 Trichloroethane	µg/kg	0.9 U
1,2 Dichloroethane	µg/kg	0.9 U
1,2 Dichloropropane	µg/kg	0.9 U
1,4 Dioxane	µg/kg	0.9 U
2 Butanone	µg/kg	37.3
Benzene	µg/kg	0.9 U
Carbon Disulfide	µg/kg	35.2
Chlorobenzene	µg/kg	15.5
Chloroform	µg/kg	0.9 U
Ethylbenzene	µg/kg	0.9 U
Ethylene dibromide	µg/kg	0.9 U
m&p Xylene	µg/kg	1.9 U
o Xylene	µg/kg	1.3
Styrene	µg/kg	0.9 U
t Butyl methyl ether	µg/kg	0.9 U
Tetrachloroethene	µg/kg	0.9 U
Toluene	µg/kg	14.0

Notes:
1) µg/kg - micrograms per kilogram.
2) U - not detected above method detection limit.
3) Samples analyzed for volatile organic compounds by method 8260B.
4) Samples analyzed by New England Testing Laboratory, Inc. of North Providence, Rhode Island.

TABLE 69

SUMMARY OF SOIL ANALYTICAL RESULTS
SEMIVOLATILE ORGANIC COMPOUNDS
UNIT F
RCRA FACILITY INVESTIGATION
MOTIVA ENTERPRISES LLC - DELAWARE CITY REFINERY

URS Sample ID		rfab3d2-4
Sample Depth		2-4
Laboratory ID		J0521-06
Sample Date		05/20/99
Semivolatile Organic Compound	**Units**	
1,2 Dichlorobenzene	µg/kg	583.6 UD
1,3 Dichlorobenzene	µg/kg	583.6 UD
1,4 Dichlorobenzene	µg/kg	583.6 UD
2 Chlorophenol	µg/kg	583.6 UD
2 Methylphenol	µg/kg	583.6 UD
2,4 Dimethylphenol	µg/kg	583.6 UD
2,4 Dinitrophenol	µg/kg	1459.0 UD
2,4 Dinitrotoluene	µg/kg	1459.0 UD
2,4,5 Trichlorophenol	µg/kg	583.6 UD
2,4,6 Trichlorophenol	µg/kg	583.6 UD
4 Nitrophenol	µg/kg	1459.0 UD
4 Methylphenol	µg/kg	583.6 UD
4,6 Dinitro 2 Methylphenol	µg/kg	1459.0 UD
7,12 Dimethylbenz[a]anthracene	µg/kg	1750.8 UD
Aniline	µg/kg	1459.0 UD
Anthracene	µg/kg	2,842.2 D
Benzo(a)anthracene	µg/kg	869.6 D
Benzo(a)pyrene	µg/kg	583.6 UD
Benzo(b)fluoranthene	µg/kg	770.4 D
Benzo(k)fluoranthene	µg/kg	583.6 UD
Bis(2 ethylhexyl)phthalate	µg/kg	583.6 UD
Butyl benzyl phthalate	µg/kg	583.6 UD
Chrysene	µg/kg	729.5 D
Di n butyl phthalate	µg/kg	583.6 UD
Di n octyl phthalate	µg/kg	583.6 UD
Dibenz(a,h)anthracene	µg/kg	583.6 UD
Diethyl phthalate	µg/kg	583.6 UD
Dimethyl phthalate	µg/kg	583.6 UD
Fluoranthene	µg/kg	4365.4 D
Indeno(1,2,3 cd)pyrene	µg/kg	583.6 UD
Naphthalene	µg/kg	57,225.0 D
Nitrobenzene	µg/kg	583.6 UD
Phenanthrene	µg/kg	6,828.2 D
Phenol	µg/kg	583.6 UD
Pyrene	µg/kg	3,320.7 D
Pyridine	µg/kg	1459.0 UD

Notes:
1) µg/kg - micrograms per kilogram.
2) U - not detected above method detection limit.
3) D -sample diluted.
4) Samples analyzed for semivolatile organic compounds by method 8270C.
5) Samples analyzed by New England Testing Laboratory, Inc. of North Providence, Rhode Island.

TABLE 70

SUMMARY OF SOIL ANALYTICAL RESULTS
INORGANICS
UNIT F
RCRA FACILITY INVESTIGATION
MOTIVA ENTERPRISES LLC - DELAWARE CITY REFINERY

	URS Sample ID	rfab1ss	rfbb5ss	rfcb1ss	rfdb2ss	rfeb2ss	rfgb2ss	rfab3d2-4
	Sample Depth	Surface	Surface	Surface	Surface	Surface	Surface	2-4
	Laboratory ID	J0602-05	J0602-05	J0602-05	J0602-05	J0602-05	J0602-05	J0521-06
	Sample Date	05/28/99	05/28/99	05/28/99	05/28/99	05/28/99	05/28/99	05/20/99
Inorganics	**Units**							
Antimony	mg/kg	9.56 U	8.38 U	8.86 U	8.88 U	7.75 U	8.2 U	8.6 U
Arsenic	mg/kg	2.9	4.21	1.08 B	2.26	1.44	1.69	5.5
Barium	mg/kg	51.7	77.3	30.9	63.6	39.8	36.9	50.2
Cadmium	mg/kg	1.13	3.21	1.28	1.32	0.88	0.68 U	1.4
Chromium	mg/kg	219.3	66.3	19.3	51.6	28.5	15.1	33.9
Cyanide	mg/kg	NA	NA	NA	NA	NA	NA	0.3 U
Lead	mg/kg	42.6	139.1	286.8	204.1	9.09	55.4	40.9
Mercury	mg/kg	0.41	0.28	0.03	0.08	0.14	0.47	0.4
Nickel	mg/kg	59.7	126.5	53.4	75.96	83.9	25.9	83.9
Selenium	mg/kg	0.42 B	1.01	0.74 U	0.73 U	0.66 U	0.68 U	0.7 U
Silver	mg/kg	0.73 B	1.31 B	1.48 U	0.98 B	0.8 B	1.37 U	1.4 U
Vanadium	mg/kg	168.1	66.9	214.0	55.7	22.3	415	NA

Notes:

1) mg/kg - milligrams per kilogram.
2) U - not detected above method detection limit.
3) B - constituent detected below the contract required detection limit but above the instrument detection limit. Concentration is estimated.
4) MSL - modified Skinner List.
5) Analysis of inorganics performed by the following methods:
   Aluminum, Barium, Chromium, Nickel, and Vandium - 6010B
   Arsenic - 7060A
   Antimony - 7041
   Cadmium - 7131A
   Lead - 7421
   Mercury - 7470A
   Selenium - 7740
   Silver - 7761
6) Samples analyzed by New England Testing Laboratory, Inc. of N. Providence, Rhode Island.

TABLE 71

SUMMARY OF GROUNDWATER ANALYTICAL RESULTS
WELLS SOUTH OF DELAWARE CITY REFINERY
RCRA FACILITY INVESTIGATION
MOTIVA ENTERPRISES LLC - DELAWARE CITY REFINERY

URS Sample ID		D27	D27	D27 Duplicate	D28	D28
Laboratory ID		J0402-09	J0730-04	J0730-04	J0402-09	J0730-04
Sample Date		4/1/99	7/29/99	7/29/99	4/1/99	7/29/99
Volatile Organic Compounds	**Units**					
Benzene	µg/l	1 U	10 U	NA	1 U	10 U
Ethylbenzene	µg/l	1 U	10 U	NA	1 U	10 U
m&p-Xylene	µg/l	2 U	20 U	NA	1 J	20 U
o-Xylene	µg/l	1 U	10 U	NA	1 U	10 U
Toluene	µg/l	1 U	10 U	NA	1 U	10 U
Total Petroleum Hydrocarbons						
Diesel Range Organics	µg/l	50 U	535	180	50 U	226
Gasoline Range Organics	µg/l	130 U	92.1 J	83.6 J	130 U	121

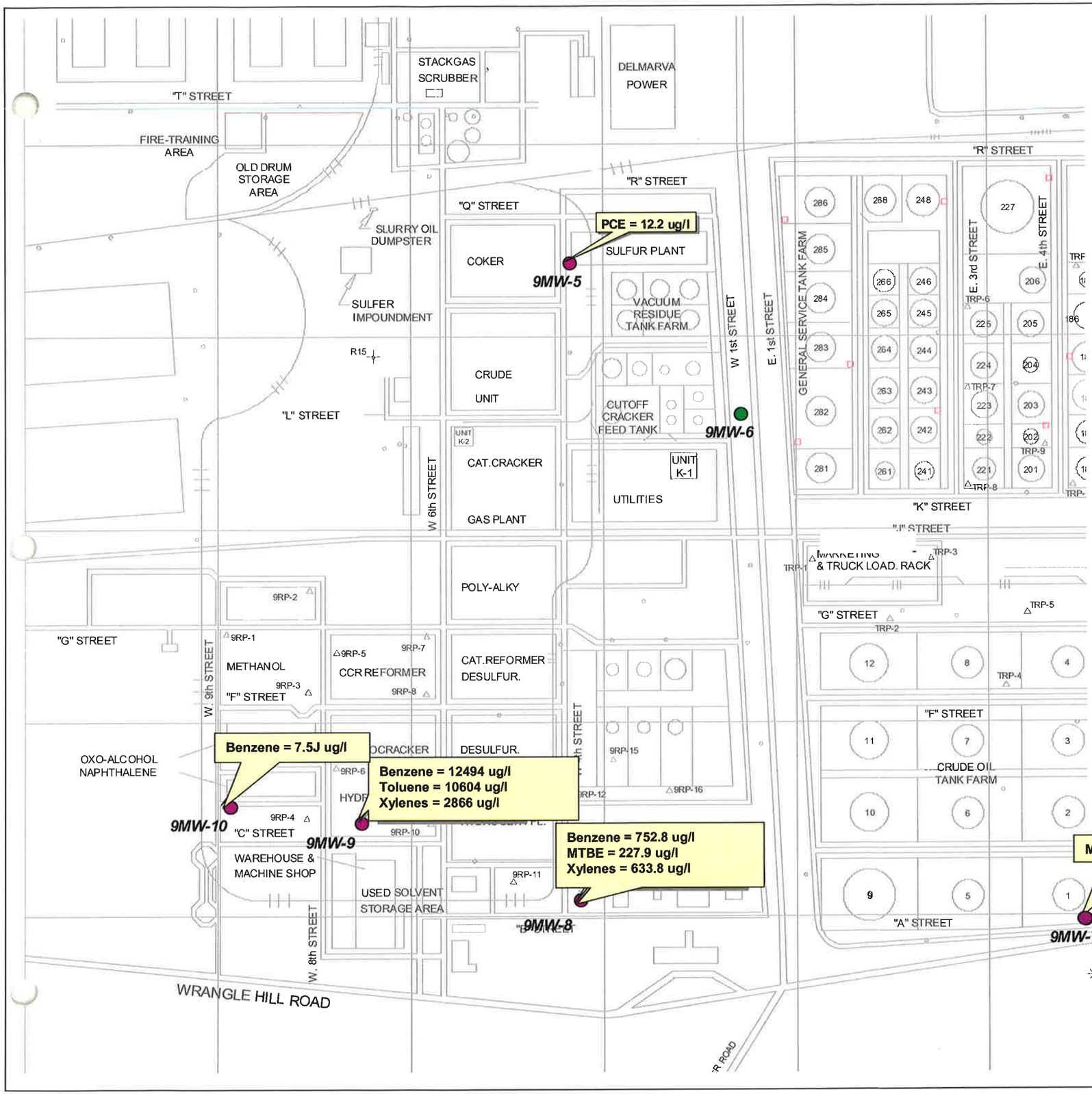
Notes:
1) µg/l - micrograms per liter.
2) U - not detected above the method detection limit.
3) NA - not analyzed for this constituent.
4) J - detected below the method detection limit. Concentration is an estimate.
5) Samples for volatile organic compounds analyzed by method 8260B.
6) Samples for diesel range organics analyzed by method 8100 modified.
7) Samples for gasoline range organics analyzed by method 8260 modified.
8) Samples analyzed by New England Testing Laboratory, Inc. of North Providence, R.I.

TABLE 72

SUMMARY OF GROUNDWATER ANALYTICAL RESULTS
METHYL TERTIARY BUTYL ETHER
MOTIVA ENTERPRISES LLC - DELAWARE CITY REFINERY
NOVEMBER 1999

URS Sample ID	Sample Date	MTBE Result (µg/l)	Reporting Limit (µg/l)
D11	11/23/99	16.3	1
D16	11/23/99	1 U	1
D18	11/23/99	3.67	1
D19	11/23/99	1 U	1
D21	11/23/99	103,500	500
D23	11/23/99	1 U	1
F4	11/24/99	5.65	1
F7	11/24/99	500	5
PC-1	11/24/99	1 U	1
PC-2	11/24/99	1 U	1
9MW-8	11/24/99	92.2	1
Trip Blank	--	1 U	1

Notes:
1) MTBE - methyl tertiary butyl ether.
2) µg/l - micrograms per liter.
3) U - not detected above the method detection limit.
4) Samples analyzed by New England Testing Laboratory, Inc., of N. Providence, Rhode Island.
5) Samples analyzed by method 8260B.



Method Detection Limits that Exceed EPA Region III Tap Water Screening Criteria Dated 4/2003

Chemical Name	Unit	9MW-10	9MW-5	9MW-6	9MW-7	9MW-8	9MW-9
1,2-DIBROMOETHANE	ug/l		1	1			
1,2-DICHLOROETHANE	ug/l		1	1			
1,2-DICHLOROPROPANE	ug/l		1	1			
1,4-DICHLOROBENZENE	ug/l		1	1			
BENZENE	ug/l		1	1	1		
CHLOROFORM	ug/l		1	1			
TETRACHLOROETHYLENE(PCE)	ug/l			1			
tert Butyl methyl ether	ug/l	5	5	5			250
TRICHLOROETHYLENE (TCE)	ug/l			1			

Notes:

1) Blank cells indicate that the method detection limit did not exceed EPA Region III tap water screening criteria dated 4/2003.

2) Tap Limit - EPA Region III risk-based screening criteria for tap water dated 4/2003.

3) (T) = Total, (D) = Dissolved

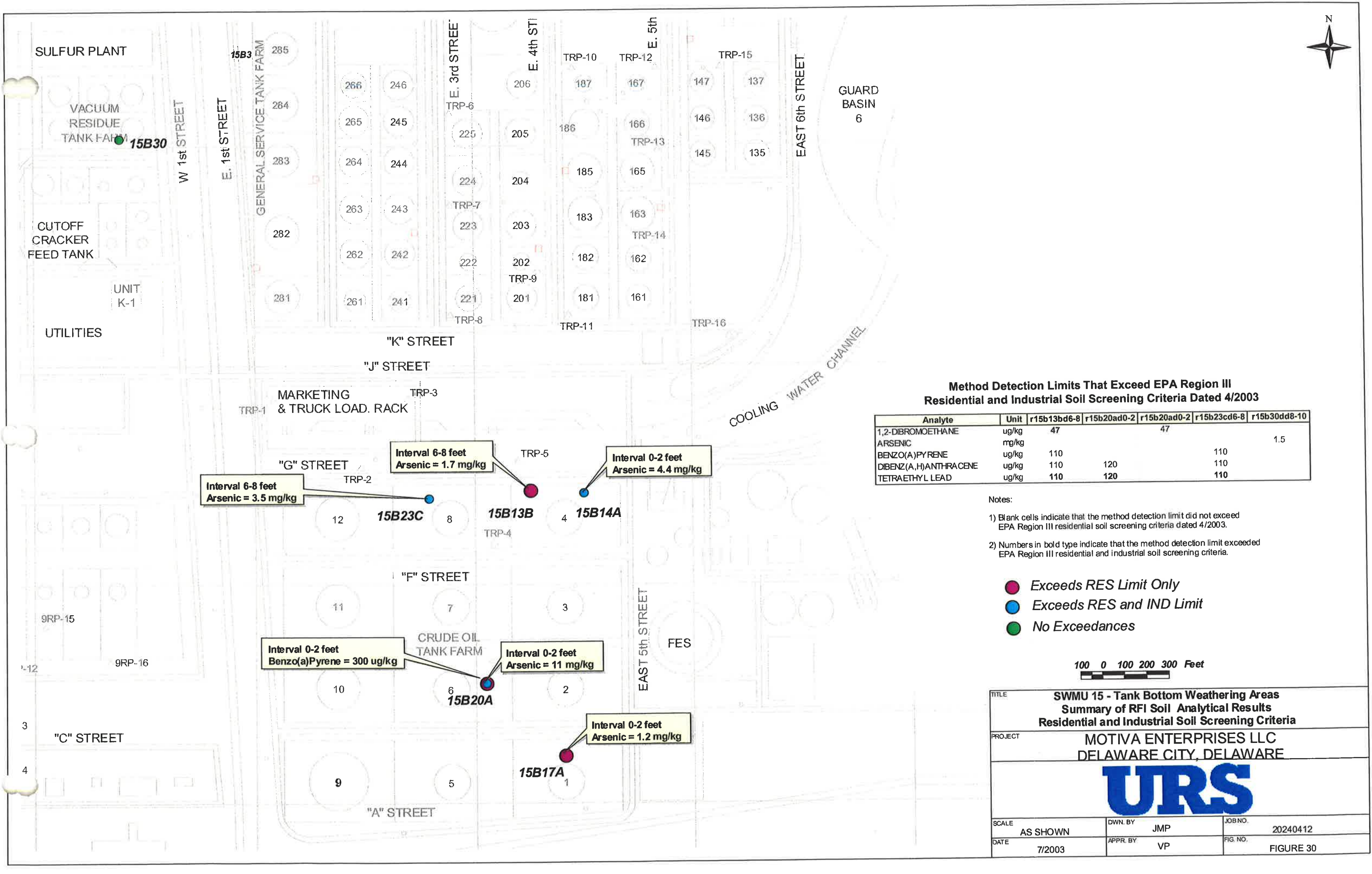
Exceeds Tap Limit

No Exceedances

500 0 500 Feet

TITLE	**SWMU 9 Refinery Sewer System** **Summary of RFI Groundwater Analytical Data** **Tap Water Screening Criteria**
PROJECT	MOTIVA ENTERPRISES LLC DELAWARE CITY, DELAWARE
	URS

SCALE: AS SHOWN	DWN. BY: JMP	JOB NO.: 20240412
DATE: 7/2003	APPR. BY: VP	FIG. NO.: FIGURE 18



Method Detection Limits That Exceed EPA Region III Residential and Industrial Soil Screening Criteria Dated 4/2003

Analyte	Unit	r15b13bd6-8	r15b20ad0-2	r15b20ad0-2	r15b23cd6-8	r15b30dd8-10
1,2-DIBROMOETHANE	ug/kg	47		47		
ARSENIC	mg/kg					1.5
BENZO(A)PYRENE	ug/kg	110			110	
DIBENZ(A,H)ANTHRACENE	ug/kg	110	120		110	
TETRAETHYL LEAD	ug/kg	**110**	**120**		**110**	

Notes:

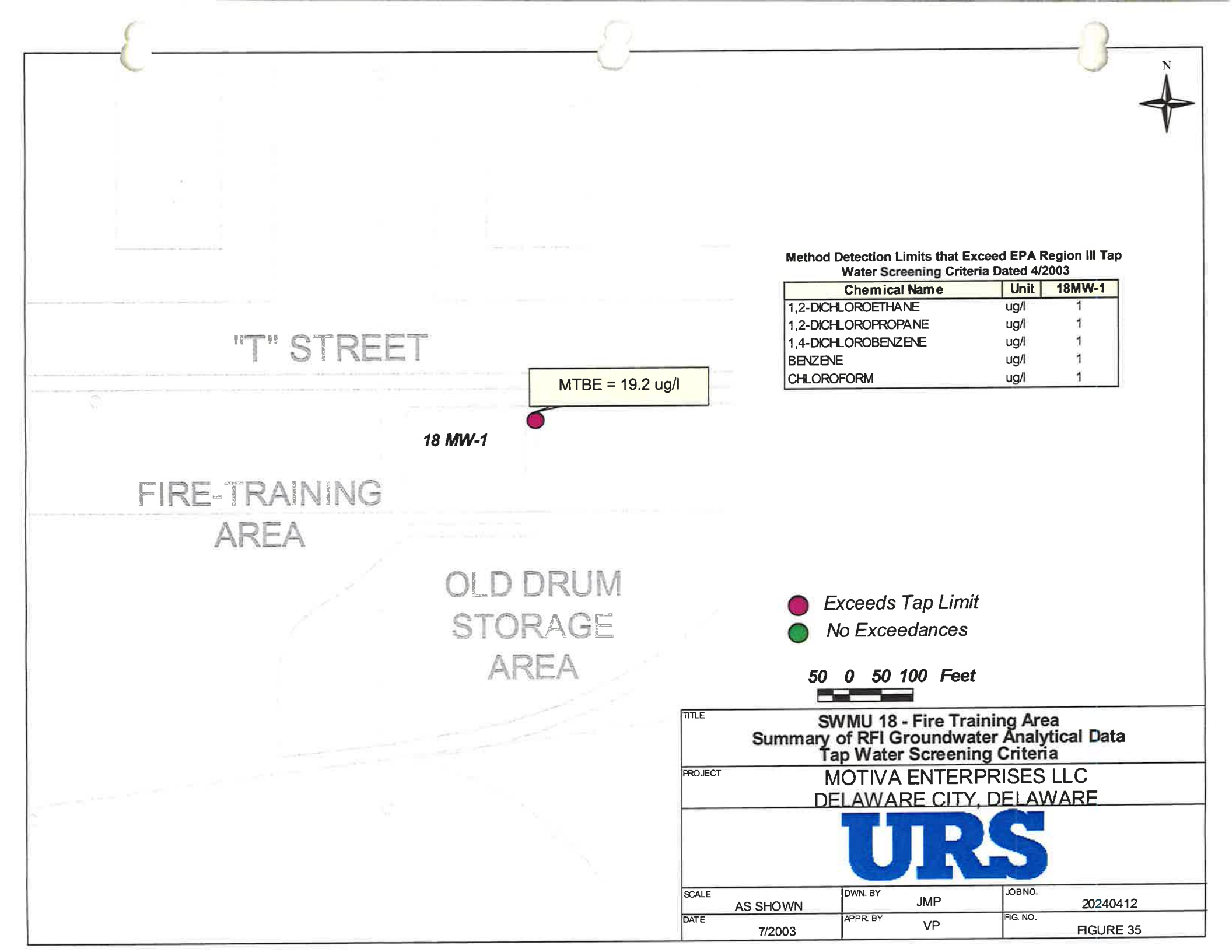
1) Blank cells indicate that the method detection limit did not exceed EPA Region III residential soil screening criteria dated 4/2003.

2) Numbers in bold type indicate that the method detection limit exceeded EPA Region III residential and industrial soil screening criteria.

- *Exceeds RES Limit Only*
- *Exceeds RES and IND Limit*
- *No Exceedances*

100 0 100 200 300 Feet

TITLE	**SWMU 15 - Tank Bottom Weathering Areas Summary of RFI Soil Analytical Results Residential and Industrial Soil Screening Criteria**
PROJECT	MOTIVA ENTERPRISES LLC DELAWARE CITY, DELAWARE
	URS
SCALE: AS SHOWN	DWN. BY: JMP — JOB NO.: 20240412
DATE: 7/2003	APPR. BY: VP — FIG. NO.: FIGURE 30

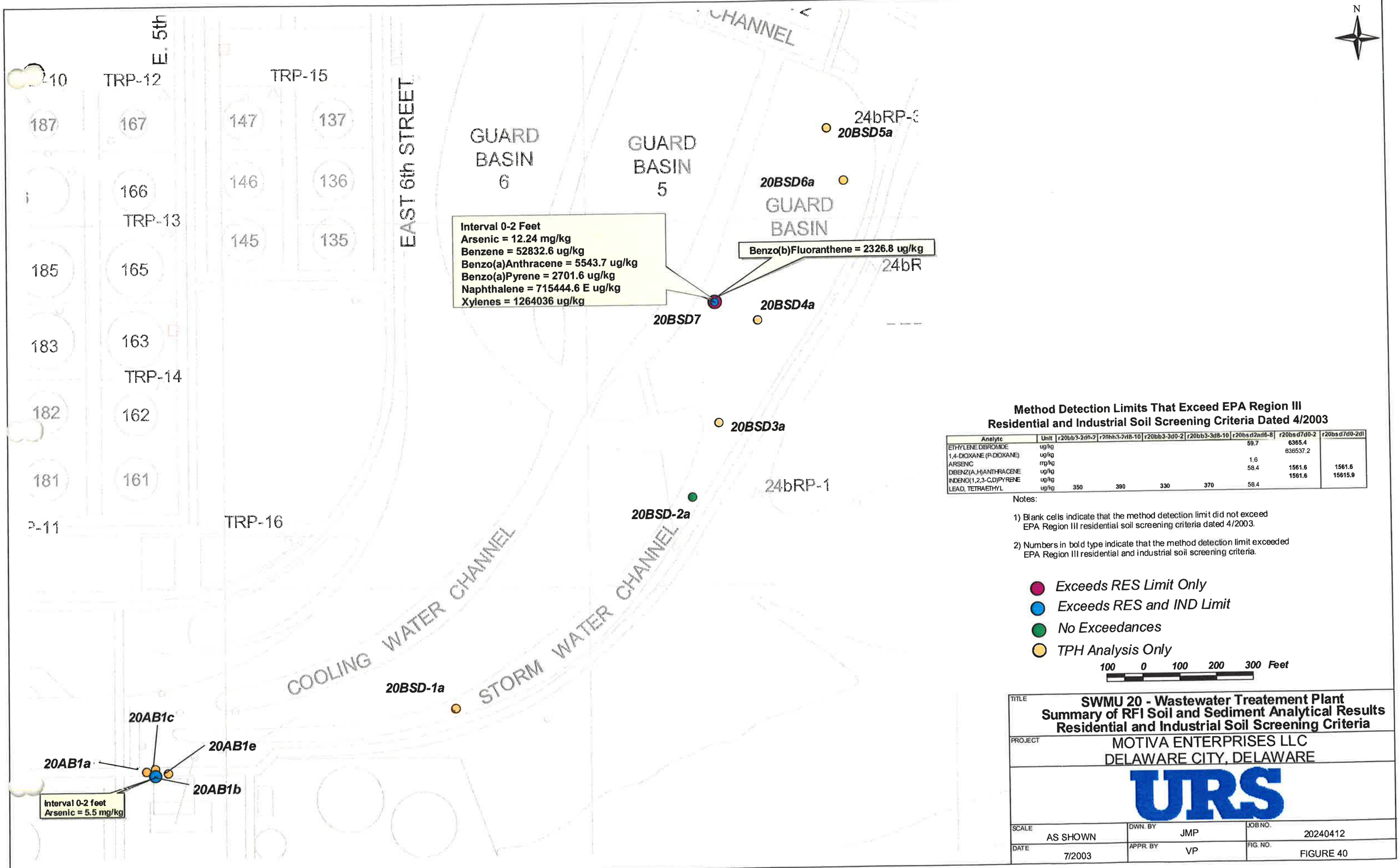


Method Detection Limits that Exceed EPA Region III Tap Water Screening Criteria Dated 4/2003

Chemical Name	Unit	18MW-1
1,2-DICHLOROETHANE	ug/l	1
1,2-DICHLOROPROPANE	ug/l	1
1,4-DICHLOROBENZENE	ug/l	1
BENZENE	ug/l	1
CHLOROFORM	ug/l	1

TITLE	SWMU 18 - Fire Training Area Summary of RFI Groundwater Analytical Data Tap Water Screening Criteria
PROJECT	MOTIVA ENTERPRISES LLC DELAWARE CITY, DELAWARE
	URS

SCALE: AS SHOWN	DWN. BY: JMP	JOB NO.: 20240412
DATE: 7/2003	APPR. BY: VP	FIG. NO.: FIGURE 35



Method Detection Limits That Exceed EPA Region III Residential and Industrial Soil Screening Criteria Dated 4/2003

Analyte	Unit	r20bb3-2d0-2	r20bb3-2d8-10	r20bb3-3d0-2	r20bb3-3d8-10	r20bsd2ad6-8	r20bsd7d0-2	r20bsd7d0-2dl
ETHYLENE DIBROMIDE	ug/kg					59.7	6365.4	
1,4-DIOXANE (P-DIOXANE)	ug/kg						636537.2	
ARSENIC	mg/kg					1.6		
DIBENZ(A,H)ANTHRACENE	ug/kg					58.4	1561.6	1561.6
INDENO(1,2,3-C,D)PYRENE	ug/kg						1561.6	15615.9
LEAD, TETRAETHYL	ug/kg	350	390	330	370	58.4		

Notes:

1) Blank cells indicate that the method detection limit did not exceed EPA Region III residential soil screening criteria dated 4/2003.

2) Numbers in bold type indicate that the method detection limit exceeded EPA Region III residential and industrial soil screening criteria.

- *Exceeds RES Limit Only*
- *Exceeds RES and IND Limit*
- *No Exceedances*
- *TPH Analysis Only*

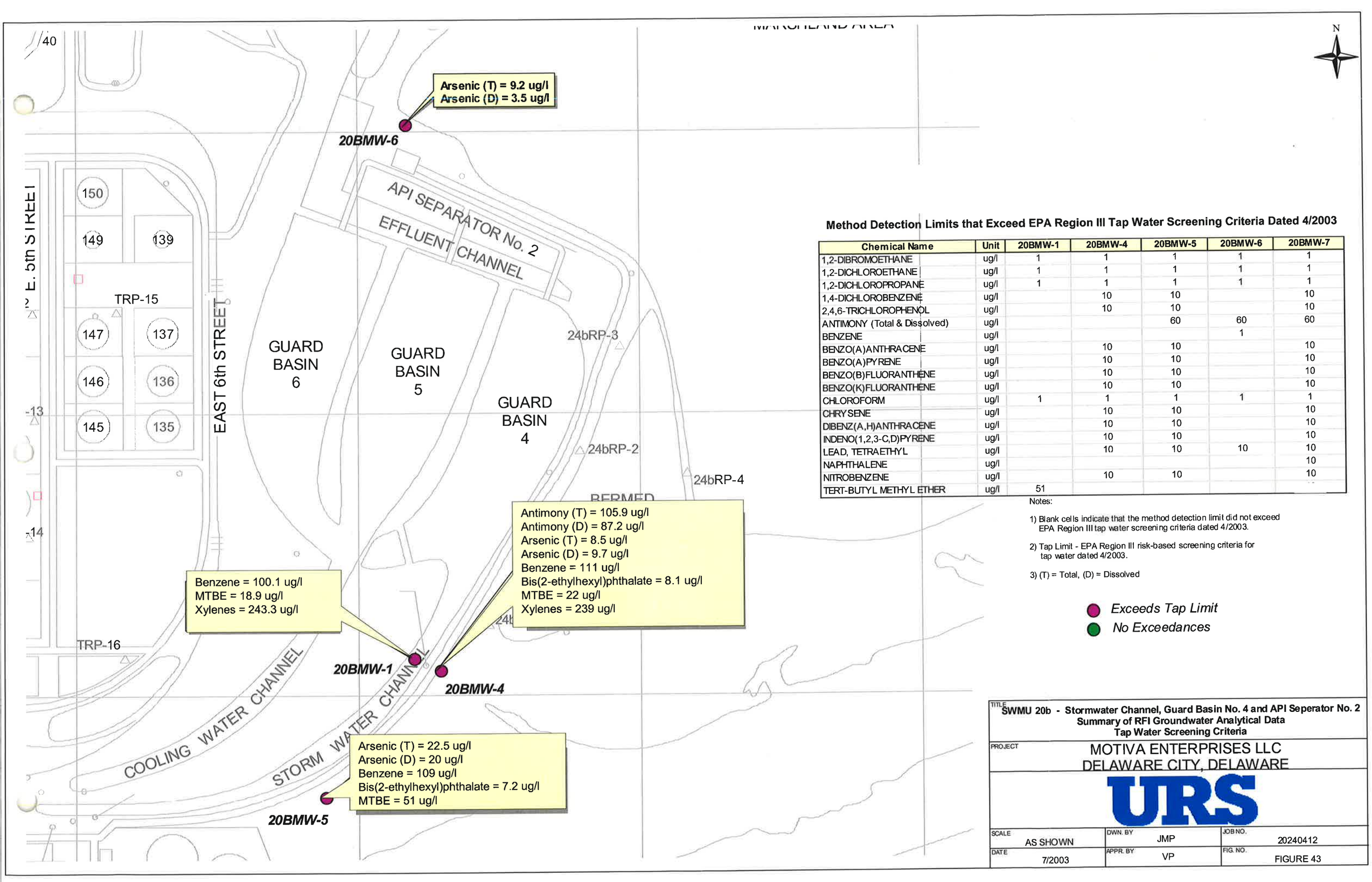
100 0 100 200 300 Feet

TITLE: **SWMU 20 - Wastewater Treatement Plant Summary of RFI Soil and Sediment Analytical Results Residential and Industrial Soil Screening Criteria**

PROJECT: MOTIVA ENTERPRISES LLC
DELAWARE CITY, DELAWARE

URS

SCALE	DWN. BY	JOB NO.
AS SHOWN	JMP	20240412
DATE	APPR. BY	FIG. NO.
7/2003	VP	FIGURE 40



Method Detection Limits that Exceed EPA Region III Tap Water Screening Criteria Dated 4/2003

Chemical Name	Unit	20BMW-1	20BMW-4	20BMW-5	20BMW-6	20BMW-7
1,2-DIBROMOETHANE	ug/l	1	1	1	1	1
1,2-DICHLOROETHANE	ug/l	1	1	1	1	1
1,2-DICHLOROPROPANE	ug/l	1	1	1	1	1
1,4-DICHLOROBENZENE	ug/l		10	10		10
2,4,6-TRICHLOROPHENOL	ug/l		10	10		10
ANTIMONY (Total & Dissolved)	ug/l			60	60	60
BENZENE	ug/l				1	
BENZO(A)ANTHRACENE	ug/l		10	10		10
BENZO(A)PYRENE	ug/l		10	10		10
BENZO(B)FLUORANTHENE	ug/l		10	10		10
BENZO(K)FLUORANTHENE	ug/l		10	10		10
CHLOROFORM	ug/l	1	1	1	1	1
CHRYSENE	ug/l		10	10		10
DIBENZ(A,H)ANTHRACENE	ug/l		10	10		10
INDENO(1,2,3-C,D)PYRENE	ug/l		10	10		10
LEAD, TETRAETHYL	ug/l		10	10	10	10
NAPHTHALENE	ug/l					10
NITROBENZENE	ug/l		10	10		10
TERT-BUTYL METHYL ETHER	ug/l	51				

Notes:

1) Blank cells indicate that the method detection limit did not exceed EPA Region III tap water screening criteria dated 4/2003.

2) Tap Limit - EPA Region III risk-based screening criteria for tap water dated 4/2003.

3) (T) = Total, (D) = Dissolved

Exceeds Tap Limit

No Exceedances

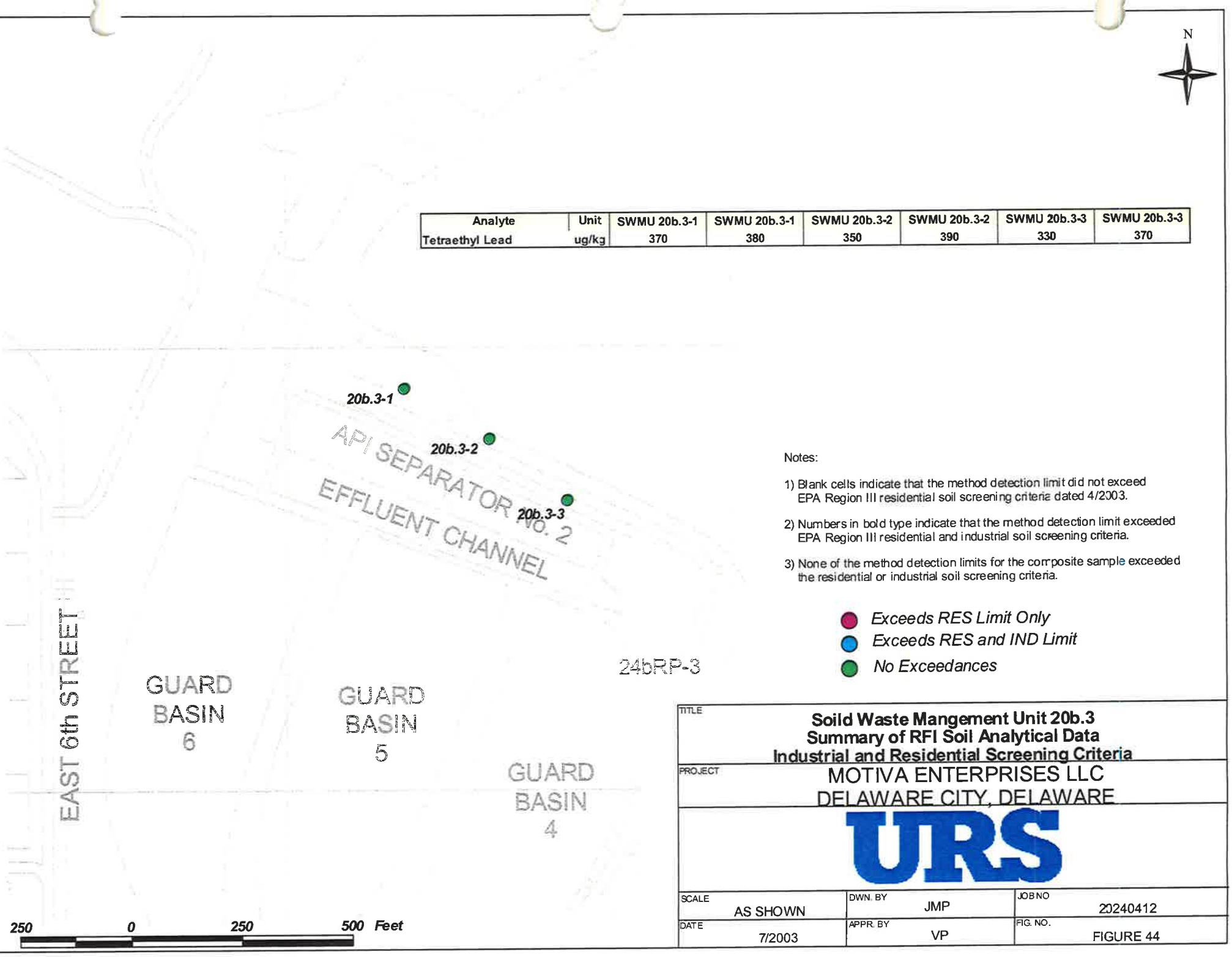
TITLE: **SWMU 20b - Stormwater Channel, Guard Basin No. 4 and API Seperator No. 2**
Summary of RFI Groundwater Analytical Data
Tap Water Screening Criteria

PROJECT: MOTIVA ENTERPRISES LLC
DELAWARE CITY, DELAWARE

URS

SCALE	DWN. BY	JOB NO.
AS SHOWN	JMP	20240412
DATE	APPR. BY	FIG. NO.
7/2003	VP	FIGURE 43

Analyte	Unit	SWMU 20b.3-1	SWMU 20b.3-1	SWMU 20b.3-2	SWMU 20b.3-2	SWMU 20b.3-3	SWMU 20b.3-3
Tetraethyl Lead	ug/kg	370	380	350	390	330	370



Notes:

1) Blank cells indicate that the method detection limit did not exceed EPA Region III residential soil screening criteria dated 4/2003.

2) Numbers in bold type indicate that the method detection limit exceeded EPA Region III residential and industrial soil screening criteria.

3) None of the method detection limits for the composite sample exceeded the residential or industrial soil screening criteria.

- *Exceeds RES Limit Only*
- *Exceeds RES and IND Limit*
- *No Exceedances*

TITLE	**Soild Waste Mangement Unit 20b.3 Summary of RFI Soil Analytical Data Industrial and Residential Screening Criteria**		
PROJECT	MOTIVA ENTERPRISES LLC DELAWARE CITY, DELAWARE		
SCALE: AS SHOWN	DWN. BY: JMP	JOB NO: 20240412	
DATE: 7/2003	APPR. BY: VP	FIG. NO.: FIGURE 44	

MARSHLAND AREA

DREDGED MATERIAL
STORAGE AREA No. 2

SEPARATOR No. 2

UENT CHANNEL

GUARD
BASIN
4

Interval 14-16 feet
Arsenic = 13.72 mg/kg
24BB6

Interval 15-17 feet
Arsenic = 19.67 mg/kg
24BB11

Interval 15-17 feet
Arsenic = 12.77 mg/kg
24BB10

Surface Sample
Arsenic = 12.79 mg/kg
24bRP-3
24BB5

Interval 8-10 feet
Indeno(1,2,3-C,D)Pyrene = 1020.9 ug/kg
Benzon(B)Fluoranthrene = 1868.2 ug/kg
Benzo(A)Pyrene = 1704.9 ug/kg
Benzo(K)Fluoranthrene = 16100 ug/kg
Benzo(A)Anthracene = 11400 ug/kg
Arsenic = 22 mg/kg
24BB4

Interval 15-17 feet
Arsenic = 21.22 mg/kg
24BB9

Interval 11-13 feet
Arsenic = 18.84 mg/kg
24BB7

Interval 11-13 feet
Arsenic = 16.36 mg/kg
24BB8

24bRP-2

24bRP-4

Interval 0-2 feet
Arsenic = 22 mg/kg
Benzo(a)Anthracene = 11400 ug/kg
Benzo(b)Fluoranthene = 16100 ug/kg
24BB1

WELLS IN THIS AREA THAT ARE SCREENED
IN SANDY RE NOT SHOWN.

Interval 0-2 feet
Benzo(k)Fluoranthene = 8880 ug/kg

24bRP-5

24bRP-1

COOLING WATER INTAKE

N

Method Detection Limits That Exceed EPA Region III Residential and Industrial Soil Screening Criteria Dated 4/2003

Analyte	Unit	24BB1	r24bb4d8-10
1,2-DIBROMOETHANE	ug/kg	10	**212.9**
BENZO(A)PYRENE	ug/kg	**4950**	
DIBENZ(A,H)ANTHRACENE	ug/kg	**9900**	
INDENO(1,2,3-C,D)PYRENE	ug/kg	**9900**	1020.9

Notes:

1) Blank cells indicate that the method detection limit did not exceed EPA Region III residential and industrial soil screening criteria dated 4/2003.

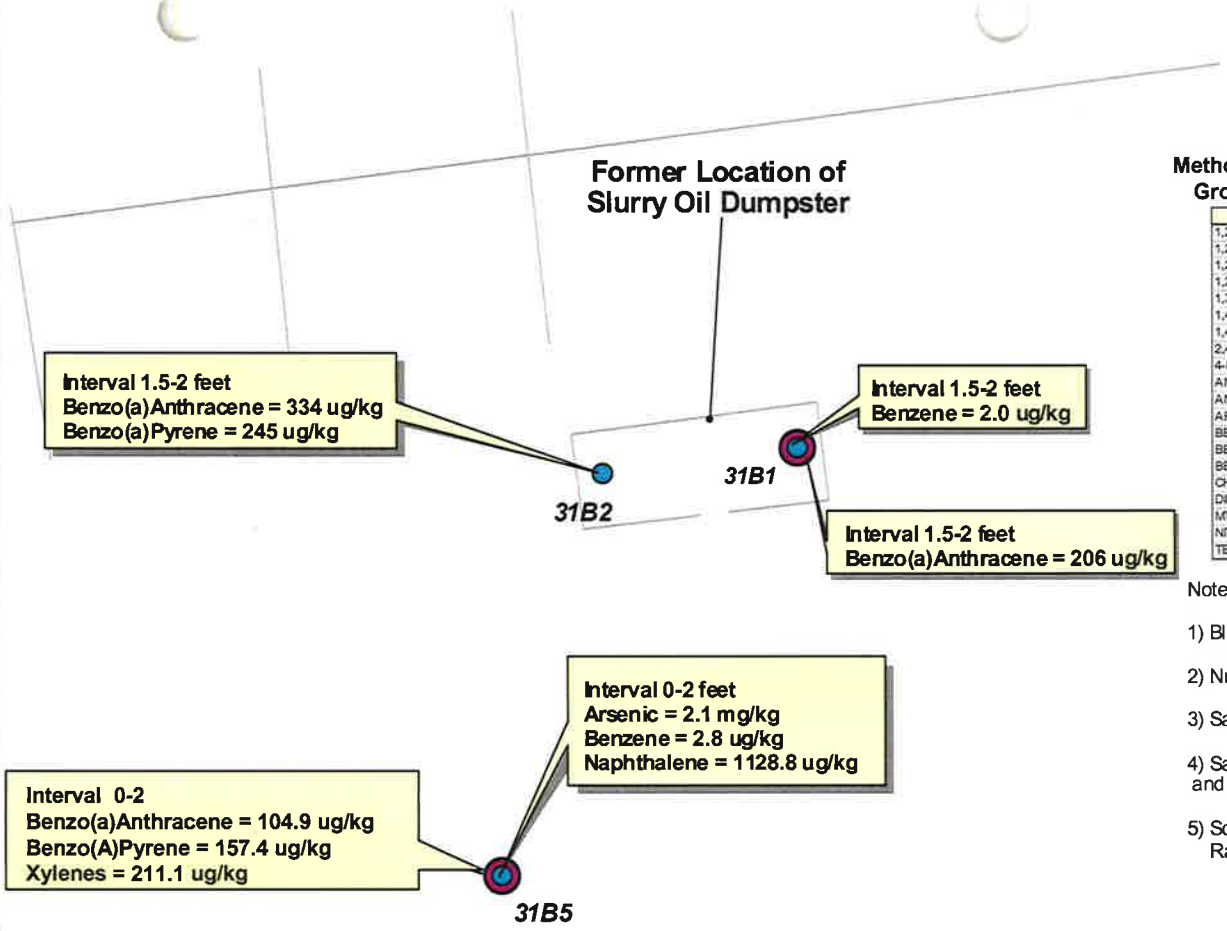
2) Numbers in bold type indicate that the method detection limit exceeded EPA Region III residential and industrial soil screening criteria.

Exceeds RES Limit Only
Exceeds RES and IND Limit
No Exceedances

200 0 200 Feet

TITLE	**SWMU 24b - Dredged Material Storage Area No 2 Summary of RFI and VRS Soil Analytical Results Residential and Industrial Soil Screening Criteria**
PROJECT	MOTIVA ENTERPRISES LLC DELAWARE CITY, DELAWARE
	URS

SCALE: AS SHOWN	DWN. BY: JMP	JOB NO.: 20240412
DATE: 7/2003	APPR. BY: VP	FIG. NO.: FIGURE 54



Method Detection Limits That Exceed EPA Region III Soil to Groundwater Migration Screening Criteria Dated 4/2003

Chemical Name	Unit	31B1	31B2	31SS1	31SS2	r31b5d0-2
1,2-DIBROMOETHANE	ug/kg	10	10			0.9
1,2-DICHLOROBENZENE	ug/kg	330	330			
1,2-DICHLOROETHANE	ug/kg	10	10			0.9
1,2-DICHLOROPROPANE	ug/kg	10	10			0.9
1,3-DICHLOROBENZENE	ug/kg	330	330			
1,4-DICHLOROBENZENE	ug/kg	330	330			60.3
1,4-DIOXANE (P-DIOXANE)	ug/kg	1000	1000			88.5
2,4-DINITROTOLUENE	ug/kg					150.7
4-NITROPHENOL	ug/kg					150.7
ANILINE	ug/kg	660	660			
ANTIMONY	mg/kg			10	10	8.6
ARSENIC	mg/kg			2	2	
BENZENE	ug/kg		10			
BENZO(A)PYRENE	ug/kg	330				
BENZO(B)FLUORANTHENE	ug/kg	330	330			
CHLOROFORM	ug/kg	10	10			0.9
DIBENZ(A,H)ANTHRACENE	ug/kg	660	660			
MTBE	ug/kg					0.9
NITROBENZENE	ug/kg					60.3
TETRACHLOROETHYLENE(PCE)	ug/kg	10	10			

Notes:

1) Blank cells indicate that the method detection limit did not exceed a DAF of 1.

2) Numbers in bold type indicate that the method detection limit exceeded a DAF of 1 and 20.

3) Sample 31B-2 was a duplicate of Sample 31B-1 collected during the VRS.

4) Sample 31SS-1 was a Surface Sample collected from Boring location 31B-1, and Sample 31SS-2 was a duplicate of sample 31SS-1 collected during the VRS.

5) Soil Samples 31B-2, 31B-3 and 31B-4 were only screened for TPH during the RFI. Ranges of detected TPH concentrations are presented on Figures 23 and 24.

Exceeds DAF1 Limit Only

Exceeds DAF1 and DAF20 Limit

No Exceedances

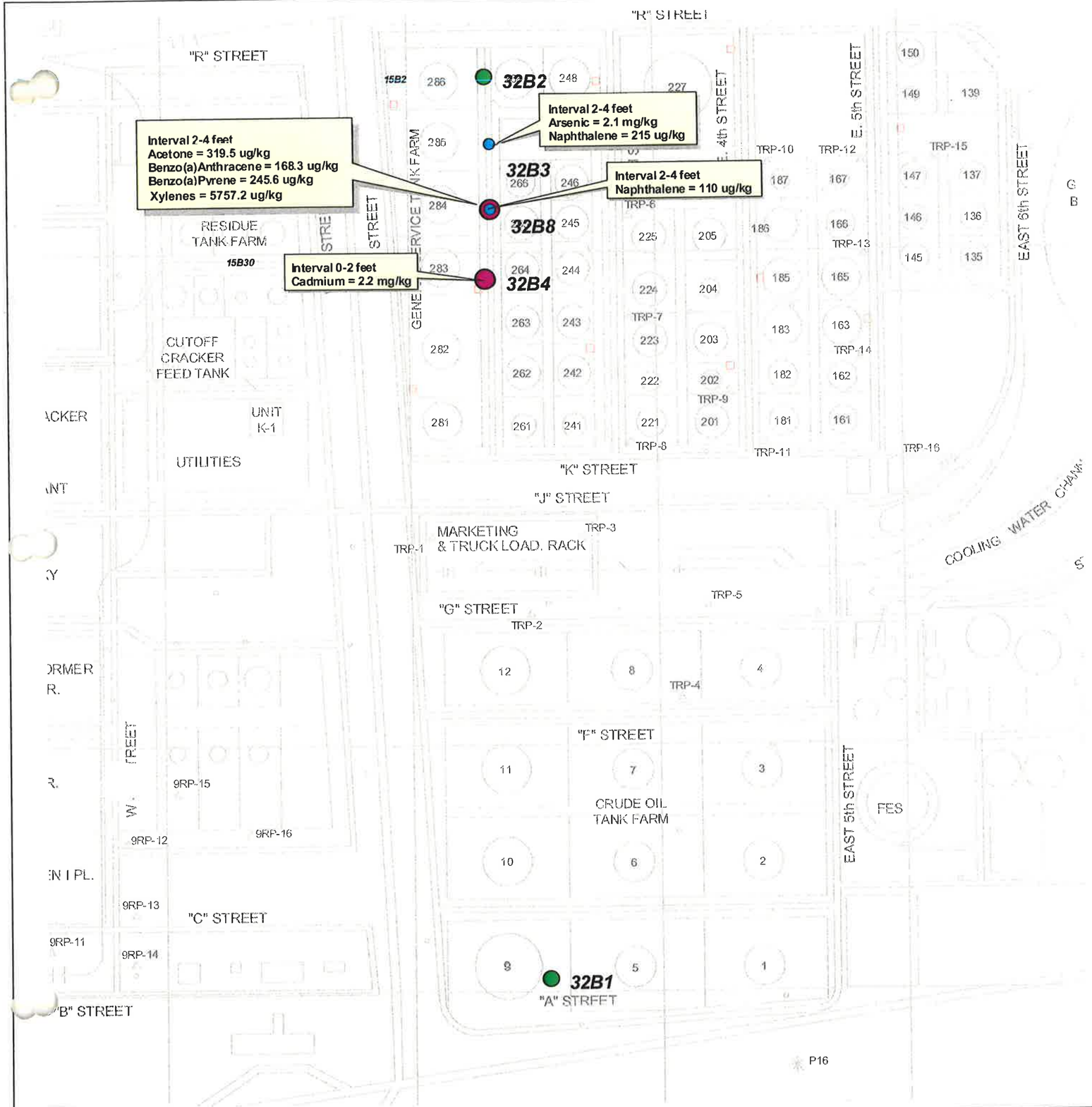
0 *50 Feet*

TITLE
SWMU 31- Former Slurry Oil Dumpster
Summary of RFI and VRS Soil Analytical Data
Soil to Groundwater Migration Screening Criteria

PROJECT
MOTIVA ENTERPRISES LLC
DELAWARE CITY, DELAWARE

URS

SCALE	DWN. BY	JOB NO.
AS SHOWN	JMP	20240412
DATE	APPR. BY	FIG. NO.
7/2003	VP	FIGURE 59



Method Detection Limits That Exceed EPA Region III Soil to Groundwater Migration Screening Criteria Soil Screening Criteria Dated 4/2003

Chemical Name	Unit	32B1	32B2	32B3	32B4	r32b8d2-4
1,2-DIBROMOETHANE	ug/kg	**10**	**10**	**10**	**10**	**0.9**
1,2-DICHLOROBENZENE	ug/kg	330	330	330	330	
1,2-DICHLOROETHANE	ug/kg	**10**	**10**	**10**	**10**	0.9
1,2-DICHLOROPROPANE	ug/kg	**10**	**10**	**10**	**10**	0.9
1,3-DICHLOROBENZENE	ug/kg	330	330	330	330	
1,4-DICHLOROBENZENE	ug/kg	**330**	**330**	**330**	**330**	**56.9**
1,4-DIOXANE (P-DIOXANE)	ug/kg	**1000**	**1000**	**1000**	**1000**	**85.9**
2,4-DINITROTOLUENE	ug/kg	330	330	330	330	142.1
4-NITROPHENOL	ug/kg	660	660	660	660	142.1
ANILINE	ug/kg	**660**	**660**	**660**	**660**	
ANTIMONY	mg/kg	10	10	10	10	9.1
ARSENIC	mg/kg	**0.5**	**2**		**2**	**1.5**
BENZENE	ug/kg	**10**	**10**	**10**	**10**	0.9
BENZO(A)ANTHRACENE	ug/kg	330	330	330	330	
BENZO(A)PYRENE	ug/kg	330	330	330	330	
BENZO(B)FLUORANTHENE	ug/kg	330	330	330	330	
CHLOROFORM	ug/kg	**10**	**10**	**10**	**10**	**0.9**
DIBENZ(A,H)ANTHRACENE	ug/kg	660	660	660	660	
INDENO(1,2,3-C,D)PYRENE	ug/kg	660	660	660	660	
MTBE	ug/kg					**0.9**
NAPHTHALENE	ug/kg	**330**	**330**		**330**	
NITROBENZENE	ug/kg	**330**	**330**	**330**	**330**	**56.9**
TETRACHLOROETHYLENE(PCE)	ug/kg	10	10	10	10	

Notes:

1) Blank cells indicate that the method detection limit did not exceed a DAF of 1.

2) Numbers in bold type indicate that the method detection limit exceeded a DAF of 1 and 20.

Exceeds DAF1 Limit Only

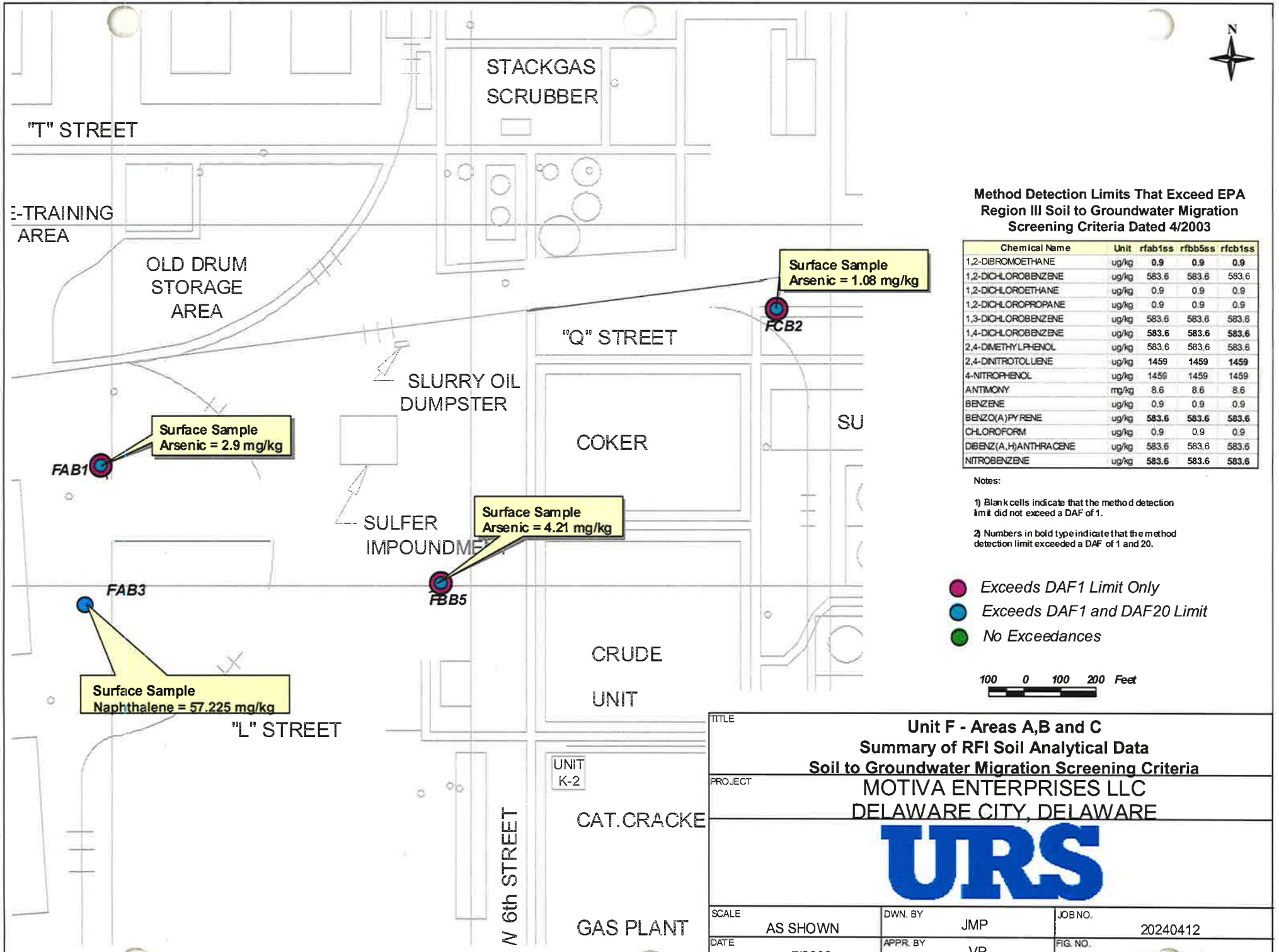
Exceeds DAF1 and DAF20 Limit

No Exceedances

200 0 200 Feet

TITLE	**SWMU 32 - Oily Sewer Backup Areas** **Summary of RFI and VRS Soil Analytical Results** **Soil to Groundwater Migration Screening Criteria**
PROJECT	MOTIVA ENTERPRISES LLC DELAWARE CITY, DELAWARE
	URS

SCALE: AS SHOWN	DWN. BY: JMP	JOB NO.: 20240412
DATE: 7/2003	APPR. BY: VP	FIG. NO.: FIGURE 61



Method Detection Limits That Exceed EPA Region III Soil to Groundwater Migration Screening Criteria Dated 4/2003

Chemical Name	Unit	rfab1ss	rfbb5ss	rfcb1ss
1,2-DIBROMOETHANE	ug/kg	**0.9**	**0.9**	**0.9**
1,2-DICHLOROBENZENE	ug/kg	583.6	583.6	583.6
1,2-DICHLOROETHANE	ug/kg	0.9	0.9	0.9
1,2-DICHLOROPROPANE	ug/kg	0.9	0.9	0.9
1,3-DICHLOROBENZENE	ug/kg	583.6	583.6	583.6
1,4-DICHLOROBENZENE	ug/kg	**583.6**	**583.6**	**583.6**
2,4-DIMETHYLPHENOL	ug/kg	583.6	583.6	583.6
2,4-DINITROTOLUENE	ug/kg	**1459**	**1459**	**1459**
4-NITROPHENOL	ug/kg	1459	1459	1459
ANTIMONY	mg/kg	8.6	8.6	8.6
BENZENE	ug/kg	0.9	0.9	0.9
BENZO(A)PYRENE	ug/kg	**583.6**	**583.6**	**583.6**
CHLOROFORM	ug/kg	0.9	0.9	0.9
DIBENZ(A,H)ANTHRACENE	ug/kg	583.6	583.6	583.6
NITROBENZENE	ug/kg	**583.6**	**583.6**	**583.6**

Notes:

1) Blank cells indicate that the method detection limit did not exceed a DAF of 1.

2) Numbers in bold type indicate that the method detection limit exceeded a DAF of 1 and 20.

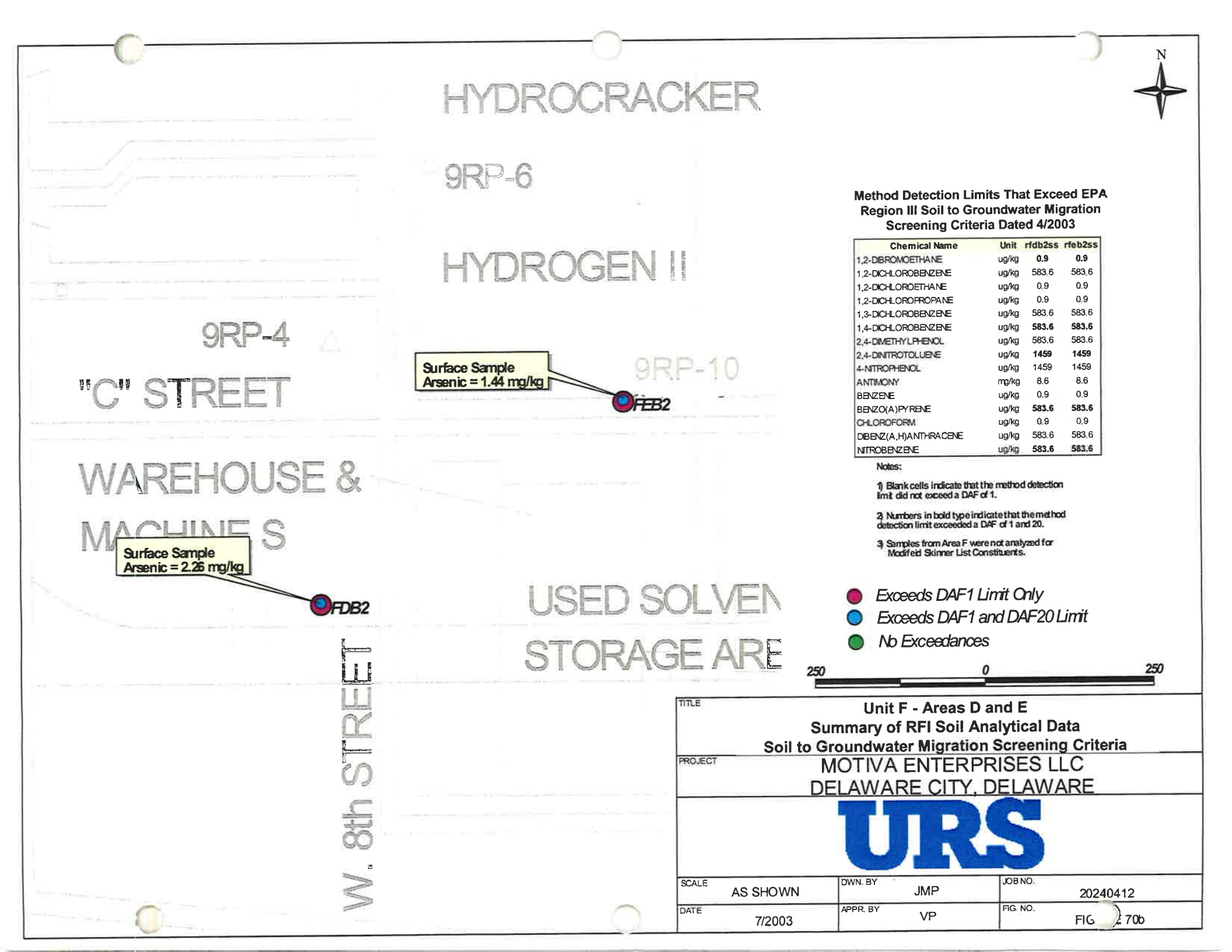
Exceeds DAF1 Limit Only
Exceeds DAF1 and DAF20 Limit
No Exceedances

TITLE
Unit F - Areas A,B and C
Summary of RFI Soil Analytical Data
Soil to Groundwater Migration Screening Criteria

PROJECT
MOTIVA ENTERPRISES LLC
DELAWARE CITY, DELAWARE

URS

SCALE	DWN. BY	JOB NO.
AS SHOWN	JMP	20240412
DATE	APPR. BY	FIG. NO.
7/2003	VP	FIG 70a



Method Detection Limits That Exceed EPA Region III Soil to Groundwater Migration Screening Criteria Dated 4/2003

Chemical Name	Unit	rfdb2ss	rfeb2ss
1,2-DIBROMOETHANE	ug/kg	**0.9**	**0.9**
1,2-DICHLOROBENZENE	ug/kg	583.6	583.6
1,2-DICHLOROETHANE	ug/kg	0.9	0.9
1,2-DICHLOROPROPANE	ug/kg	0.9	0.9
1,3-DICHLOROBENZENE	ug/kg	583.6	583.6
1,4-DICHLOROBENZENE	ug/kg	**583.6**	**583.6**
2,4-DIMETHYLPHENOL	ug/kg	583.6	583.6
2,4-DINITROTOLUENE	ug/kg	**1459**	**1459**
4-NITROPHENOL	ug/kg	1459	1459
ANTIMONY	mg/kg	8.6	8.6
BENZENE	ug/kg	0.9	0.9
BENZO(A)PYRENE	ug/kg	**583.6**	**583.6**
CHLOROFORM	ug/kg	0.9	0.9
DIBENZ(A,H)ANTHRACENE	ug/kg	583.6	583.6
NITROBENZENE	ug/kg	**583.6**	**583.6**

Notes:

1) Blank cells indicate that the method detection limit did not exceed a DAF of 1.

2) Numbers in bold type indicate that the method detection limit exceeded a DAF of 1 and 20.

3) Samples from Area F were not analyzed for Modified Skinner List Constituents.

- *Exceeds DAF1 Limit Only*
- *Exceeds DAF1 and DAF20 Limit*
- *No Exceedances*

TITLE: **Unit F - Areas D and E**
Summary of RFI Soil Analytical Data
Soil to Groundwater Migration Screening Criteria

PROJECT: MOTIVA ENTERPRISES LLC
DELAWARE CITY, DELAWARE

URS

SCALE	DWN. BY	JOB NO.
AS SHOWN	JMP	20240412
DATE	APPR. BY	FIG. NO.
7/2003	VP	FIG 70b

EXPLANATION:

- MW2S ● COLUMBIA FORMATION (WATER TABLE AQUIFER) WELL LOCATION
- 2 ⌖ UPPER POTOMAC FORMATION WELL LOCATION
- R15 ⌖ MIDDLE POTOMAC FORMATION WELL LOCATION
- P16 ✳ LOWER POTOMAC FORMATION WELL LOCATION
- H8 ■ HYDROPUNCH LOCATION
- 9RP-1 ▲ ROST PROBE LOCATION
- 2,366 BENZENE CONCENTRATION IN GROUNDWATER (ppb)
- BENZENE ≥10,000 ppb
- BENZENE ≥1,000 ppb
- BENZENE ≥100 ppb
- BENZENE ≥10 ppb
- BENZENE ≥1 ppb

NOTES:

1. THIS DRAWING WAS PRODUCED BY MODIFYING AN ORIGINAL DELAWARE CITY REFINERY DRAWING. THE LOCATION OF SOME ROADS AND OTHER FEATURES ARE KNOWN TO BE INACCURATELY PLOTTED. HOWEVER, THE POSITIONS OF THE WELLS ARE ACCURATE WITH RESPECT TO THE DELAWARE COORDINATE SYSTEM.
2. WELL L6 IS INTERPRETED AS BEING SCREENED IN THE UPPER POTOMAC FORMATION WHICH AT THE WELL'S LOCATION IS CONSIDERED TO BE IN DIRECT HYDRAULIC CONTACT WITH THE COLUMBIA FORMATION.

0 250 500 750 1000 FEET

GRAPHIC SCALE

TITLE	ISOCONCENTRATION CONTOUR MAP BENZENE IN GROUNDWATER RECENT RFI DATA
PROJECT	MOTIVA ENTERPRISES LLC DELAWARE CITY, DELAWARE

URS

SCALE	AS SHOWN	DWN. BY	R.G.B.	JOB NO.	20240412
DATE	3/13/00	APPR. BY	V.P.	FIG. NO.	14

URS

N

0.03-D mg/L
0.06-T mg/L

0.025-D mg/L
0.011-T mg/L

0.0405-D mg/L
0.242-T mg/L

24AMW-4

0.049-D mg/L
0.0788-T mg/L

24AMW-3

0.05-D mg/L
0.02-D mg/L

0.02-D mg/L
0.04-T mg/L

0.0568-D mg/L
0.0474-T mg/L

24AMW-1

0.0320-D mg/L
0.0519-T mg/L

24AMW-2

0.01-D mg/L

0.02-D mg/L
0.02-D mg/L

0.03-D mg/L
0.02-T mg/L

0.1-D mg/L
0.07-T mg/L

0.02-D mg/L
0.02-D mg/L

0.03-D mg/L
0.05-T mg/L

0.01-D mg/L
0.06-T mg/L

0.01-D mg/L
0.01-T mg/L

0.05-D mg/L
0.04-T mg/L

0.011-D mg/L
0.02-T mg/L

0.0035-D mg/L
0.0092-T mg/L

20BMW-6

0.05-D mg/L

0.03-D mg/L

0.03-D mg/L

0.01-D mg/L
0.01-T mg/L

0.02-T mg/L

0.04-T mg/L

0.05-T mg/L

0.05-D mg/L
0.02-D mg/L

0.03-D mg/L
0.008-T mg/L

0.01-D mg/L
0.011-T mg/L

0.02-D mg/L
0.01-T mg/L

0.0126-D mg/L
0.0203-T mg/L

24BMW-5

20BMW-4

0.006-D mg/L
0.0115-T mg/L

0.02-D mg/L
0.0225-T mg/L

20BMW-5

i33b4e1

4
24
39
19D
18D
41
26
37
2
10
38A
3B
13
29
42D
36D
43D
40
30S
11S
2S
3S
10S
9S
4S

Scale

1000 0 1000 2000 Feet

Job #: 20240412.W1000	SITE WIDE ARSENIC CONCENTRATIONS IN GROUNDWATER DELAWARE CITY REFINERY DELAWARE CITY, DELAWARE
Prepared by: RRM III	
Checked by: BC	
Date: 5/10/2005	FIGURE 72

URS

N

0.5 mg/kg
2.1 mg/kg
11.3 mg/kg S
12.9 mg/kg D
r26b5
r26b3
r26b4
10.4 mg/kg S
14 mg/kg D
12.1 mg/kg S
2.8 mg/kg D
24aB-5
24aB-6
24aB-3
5.6 mg/kg S
6.5 mg/kg D
3 mg/kg
1.3 B mg/kg
2.7 mg/kg
r13b3
r13b2
r13b1
2.19 mg/kg
R15b1
FCB1
1.08B mg/kg
1.45 mg/kg
R15b10
r31b5
2.9 mg/kg
1.38 mg/kg
R15b3
R15b12
rfab1
rfab3d
2.31 mg/kg
3.32 mg/kg
32b8
R15b31
R15b32
1.64 mg/kg
2.1 mg/kg
FBB5
4.54 mg/kg
R15b30
0.59 B mg/kg
5.5 mg/kg
R15b7
2.67 mg/kg
4.21 mg/kg
3.50 mg/kg
R15b9
4.4 mg/kg
5.5 mg/kg
r15b13b
3.5 mg/kg
20ab1b
r15b14a
1.71 mg/kg
R15b25
r15b23c
1.7 mg/kg
r15b15
11 mg/kg
1.92 mg/kg
1.69 mg/kg
r15b20a
FGB2
1.44 mg/kg
EEB2
R15b19
FDB2
r15b17a
3.50 mg/kg
1.2B mg/kg
3.92 mg/kg
R15b18
2.26 mg/kg
17.97 mg/kg
24BB6
19.67 mg/kg
24BB11
5.29 mg/kg
20b3-3
12.79 mg/kg
21SD8
12.77 mg/kg
24BB10
13.72 mg/kg
21.22 mg/kg
9.24 mg/kg
21SD7
r24bb5
24BB9
21SD4
r24bb4
11.8 mg/kg
r24bb7
16.36 mg/kg
20BSD7
10.03 mg/kg
18.84 mg/kg
24BB8
21SD6
21SD3
12.21 mg/kg
17.9 mg/kg
20BSD2
ND
4.8 mg/kg
33mw2
23.1 mg/kg
r33b2

Scale

1000 0 1000 2000 Feet

Job #: 20240412.W1000	SITE WIDE ARSENIC CONCENTRATIONS IN SOIL DELAWARE CITY REFINERY DELAWARE CITY, DELAWARE
Prepared by: RRM III	
Checked by: BC	
Date: 5/10/2005	FIGURE 73