SITE CHARACTERIZATION/REMEDIAL INVESTIGATION REPORT/CLEANUP PLAN AOI 5

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1.0 INTRODUCTION

Sunoco Inc. (R&M) (Sunoco) and the Pennsylvania Department of Environmental Protection (PADEP) entered into a Consent Order & Agreement (CO&A) in December 2003 with respect to Sunoco's Philadelphia Refinery (refinery). Sunoco's Phase I Remedial Plan (Phase I Plan), dated November 2003, was included as an attachment to the CO&A. In accordance with the CO&A and Phase I Plan, a Current Conditions Report and Comprehensive Remedial Plan (CCR) was prepared by Sunoco in June 2004. The Phase I Plan and the CCR divided the facility into 11 Areas of Interest (AOIs), and presented a prioritization of the AOIs based on specific risk factors. The AOIs are shown in Figures 1 and 2 of this report. The CCR also presented the Phase II remedial approach and schedule to characterize each of the 11 AOIs, and to conduct Phase I and II corrective action activities in accordance with the 2003 CO&A and the Phase I Plan. Since 2003, Sunoco has completed site characterization activities at eleven AOIs (AOIs 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 11). For each AOI that has been characterized, Sunoco has prepared and submitted a corresponding Site Characterization Report (SCR) in accordance with the Revised Phase II Corrective Action Activities schedule that was included in the CCR.

Sunoco submitted a Site Characterization Work Plan (Work Plan) for AOI 5 on June 15, 2007 to the PADEP and United States Environmental Protection Agency (EPA). This Work Plan summarized proposed activities to be completed to characterize AOI 5 in accordance with the objectives of the CCR. The Work Plan also included proposed activities to characterize the Resource, Conservation and Recovery Act (RCRA) Solid Waste Management Units (SWMUs) in AOI 5. The Work Plan was implemented between February and August 2007 and the results were summarized in a SCR submitted to PADEP and EPA on August 24, 2007. Based on the findings of the SCR, additional site characterization activities were completed in April and July 2009 to further characterize groundwater and soil samples that were above their respective screening criteria in 2007.

This report is a combined Site Characterization/Remedial Investigation Report (SCR/RIR)/ Cleanup Plan which summarizes the site characterization work completed in 2005 and 2007 as well as proposed remedial activities for AOI 5 based on the characterization. This SCR/RIR/Cleanup Plan will be submitted to the PADEP and the EPA and will be submitted in accordance with the provisions of Pennsylvania's Land Recycling and Environmental Remediation Standards Act (Act 2).

In accordance with Act 2, Langan, on behalf of Sunoco, has prepared the required public and municipal notices as part of this report submittal. The notices and their proof of receipt/publication are included in Appendix A of this report.

1.1 Site Description

The Sunoco Philadelphia Refinery is located in Southwest Philadelphia. AOI 5 is located in the southern most portion of the Facility and is known as the Girard Point South Tank Field Area (Figures 1 and 2). AOI 5 is bordered to the north and northwest by Penrose Avenue and the George Platt (formerly Penrose Avenue) Bridge, an industrial facility to the east, and the Schuylkill River to the south and southwest. AOI 5 encompasses approximately 107 acres. Sunoco purchased the area currently known as Girard Point (AOI 5 through AOI 7) from Chevron USA, Inc. (Chevron) who acquired the facility from the Gulf Oil Company merger.

1.2 Site History

The facility has a long history of petroleum transportation, storage, and processing. The oldest portion of the facility started petroleum related activities in the 1860s, when the Atlantic Refining Company established an oil distribution center. In the 1900s, crude oil processing began followed by full-scale gasoline production during World War II. In addition to refining crude oil, various chemicals, such as acids and ammonia, were also produced at the Facility for a time.

In 1993, a Remedial Action Plan (RAP) was implemented in response to the September 4, 1992 and January 19, 1993 letters forwarded to Chevron from the Pennsylvania Department of Environmental Resources (PADER) requesting that Chevron address the removal of free-phase hydrocarbon from the water table in "affected areas" of the Facility. The results of this investigation/remedial measures evaluation are presented in *Remedial Action Plan Implementation*, dated September 30, 1993, prepared by Chevron's consultant, Dames & Moore. In addition, Chevron also conducted remedial investigation work as part of EPA's corrective action program.

Dames & Moore performed a RCRA Facility Investigation (RFI) and results of that investigation are presented in a report titled *RCRA Facility Investigation* dated November 23, 1993. The purpose of the RFI was to assess the degree and extent of hazardous waste compounds present and to evaluate whether further investigation was

warranted at 10 solid waste management units (SWMUs). Three of these SWMUs are located within AOI 5 and required further characterization. They include SWMU 93 (Storage Tank Areas: Buried Lead Sludge Area 7), SWMU 94 (Storage Tank Areas: Buried Lead Sludge Area 9) and SWMU 101 (Bulkhead Seepage Area).

1.3 Selection of Compounds of Concern and Applicable Standards

The COCs for soil and groundwater are listed in Table 1 of this report. The COCs for the ongoing and proposed investigation activities include the current constituents from the Pennsylvania Corrective Action Process (CAP) Regulation Amendments effective December 1, 2001; provided in Chapter VI, Section E of PADEP's Closure Requirements for Underground Storage Tank Systems. These COCs are the same as those listed in the CCR. In May 2009, Sunoco included two additional COCs 1,2,4-trimethylbenezene and 1,3,5-trimethylbenzene. These two compounds were added to the list of COCs by Sunoco based on the PADEP's revisions to the petroleum short list of compounds and at the request of the PADEP, but are not part of the COC lists for soil and groundwater in AOI 5 because the site characterization work in AOI 5 was performed in 2007 prior to these chemicals being added to the list. Sunoco will not pursue a release of liability under Act 2 for these compounds in AOI 5.

Media of Concern

The media of concern for AOI 5 include groundwater and soil. The potential indoor air quality and off-site vapor migration exposure pathways were evaluated using the PADEP's applicable vapor intrusion guidance. Surface water was evaluated as a receptor in relation to facility activities.

Act 2 Remediation Standards

The approach for attaining Act 2 remediation standards for the media of concern is described below by media.

Groundwater

Groundwater sample results were screened against the PADEP non-residential, used-aquifer (TDS<2,500) statewide health groundwater medium-specific concentrations (groundwater MSCs). As summarized in the CCR, where constituent concentrations are above these statewide health MSCs, Sunoco evaluated application of the site-specific

remediation standard using either the pathway elimination or calculated risk-based standard options.

Shallow Soil – 0 to 2 Feet Interval

Shallow (0-2 feet) soil samples were collected at each soil boring/monitoring well location that represents a potential complete direct contact exposure pathway to site workers (e.g., unpaved areas). These shallow soil results were screened against the PADEP non-residential soil MSCs (soil MSCs). Where compound concentrations are above the PADEP non-residential soil MSCs, Sunoco evaluated application of the site-specific remediation standard using either the pathway elimination or calculated risk-based standard options.

Soil – 2 to 15 Feet Interval

A site-specific remediation standard using the pathway elimination option was applied for soil between 2 and 15 feet beneath the ground surface within the boundaries of AOI 5 based on Sunoco's existing permit program governing excavations. This permit program serves as an institutional control that prevents potential exposure to impacted soils greater than two feet beneath the ground surface. Soil at this depth is evaluated through the groundwater data.

Vapor Intrusion into Indoor Air

For the current occupied buildings in AOI 5 as depicted on Figure 2, groundwater is less than five feet below the ground surface; therefore, the PA DEP USEPA-PA Default Non-Residential Permissible Exposure Limit (PEL) for Volatilization to Indoor Air for soil and groundwater screening criteria in the PADEP's guidance could not be used. As part of the Cleanup Plan for AOI 5, further evaluation (i.e., soil gas samples) will be necessary to assess the impact to indoor air. Because the site specific standard is being used for the Facility, groundwater within some portions of AOI 5 is shallower than five feet, underground utilities exist and sampling was not completed below all areas with impervious covers, Sunoco will place a restriction in the Uniform Environmental Covenants Act (UECA covenant) for AOI 5 that will require further vapor site characterization activities and/or installation of a vapor mitigation system to be installed for any new occupied buildings that will be constructed within AOI 5.

1.4 Overview of Investigative Framework and Remedial Approach for AOI 5

The current remediation program for the refinery is performed under the 2003 CO&A between PADEP and Sunoco. Below is a general summary of the regulatory frame work for the refinery:

- In April 2004, the PADEP and EPA signed an agreement entitled "One Cleanup Program Memorandum of Agreement (MOA or One-Cleanup Program)," which clarifies how sites remediated under Pennsylvania's Act 2 program may satisfy RCRA corrective action requirements through characterization and attainment of Act 2 remediation standards pursuant to Pennsylvania's Act 2.
- In 2005, PADEP, EPA, and Sunoco agreed that the One Cleanup Program would benefit the project by merging the remediation obligations under the various programs into one streamlined approach which would be conducted under the existing 2003 CO&A.
- In October 2006, Sunoco submitted a notice of intent to remediate (NIR) to the PADEP for the refinery entering the refinery into the Act 2 program, excluding the Belmont Terminal. A copy of this NIR and the Act 2 report notifications for this SCR/RIR/Cleanup Plan are included in Appendix A.
- In September 2007, Sunoco held a public involvement meeting in South Philadelphia, Pennsylvania.
- On November 8, 2011, the EPA provided an acknowledgment letter to Sunoco formerly accepting the Sunoco Philadelphia Refinery into the One Clean Up Program. EPA acknowledges that Sunoco is currently operating under one EPA ID Number (PAD049791098) for Point Breeze, Girard Point and Schuylkill River Tank Farm. EPA will issue a letter to Sunoco for each characterized SWMU that lists a non-leaded tank bottom designation for which no further action is required.
- On November 30, 2011, Sunoco submitted a revised *Work Plan for Sitewide Approach Under the One Cleanup Program* (Work Plan for Sitewide Approach), to document the Sitewide remedial approach extending beyond the requirements of the 2003 CO&A. DEP and EPA have reviewed and provided input to this report. With this work plan Sunoco submitted a letter of commitment stating Sunoco will remediate the Philadelphia refinery site according to the Work Plan for Sitewide Approach.

2.0 ENVIRONMENTAL SETTING

AOI 5 is located in the southern-most portion of the refinery and is known as the Girard Point South Tank Field Area. AOI 5 is bordered to the north and northwest by Penrose Avenue and the George Platt Bridge, an industrial facility to the east, and the Schuylkill River to the south and southwest. AOI 5 encompasses approximately 107 acres.

2.1 Historic and Current Use

The primary historic usage of AOI 5 consisted of numerous above ground storage tanks (ASTs) containing fuel oil, waste oil, and lube oil, and packaging facilities. Other historic uses include transfer facilities for rail and trucking and a marine unloading/loading facility. AOI 5 is the oldest operating portion of the Girard Point Refinery, dating back to the 1920s (Dames & Moore, 1987).

Currently, AOI 5 consists primarily of light and intermediate product tankage, old warehouses, and docks that consist of three barge-loading areas. A loading rack and scale house are currently operating in the southeastern portion of AOI 5, as well as two pump houses. A wastewater separator and hazardous waste storage area are located in the southwestern portion of the AOI 5. Much of the area is open space due to the removal of several large ASTs. Two ship ballast tanks remain in use as shown in the Current Use figure in Appendix B. A sheet pile bulkhead, keyed into the Middle Clay Unit, extends along the entire southern boundary of AOI 5 along the Schuylkill River. The extent of the sheet pile wall/bulkhead is shown in Figure 2. The majority of the eastern and southern AOI 5 boundaries are covered by impervious surfaces (approximately 40 percent of AOI 5) and the majority of the interior portions of AOI 5 are not covered by impervious surfaces. The current use and impervious surfaces figures from the previous AOI 5 SCR were updated to reflect present day conditions/usage as part of the AOI 5 site characterization activities. These updated figures are provided in Appendix B.

The existing monitoring well network in AOI 5 includes 71 monitoring wells, three piezometers, and four inactive recovery wells. This monitoring well network includes those wells that were installed as part of the 2007 site characterization efforts. The

wells in AOI 5 are summarized in Table 2 and the remedial system in AOI 5 is discussed in detail in Section 6.0. Sunoco samples select monitoring wells for site COCs established in the CCR in AOI 5 on an annual basis. Groundwater gauging of select monitoring wells in AOI 5 occurs on an annual basis during the fourth quarter of each year. Annual gauging activities and groundwater results are reported to the PADEP and EPA in Quarterly Reports prepared by Sunoco.

Institutional controls (i.e. permits governing excavation, Occupation Safety and Health Administration (OSHA) restrictions, etc.) apply to AOI 5. These institutional controls limit exposure to COCs as listed in Table 1. Prior to any work being completed within AOI 5, appropriate work permits, safety and security measures, etc. must be approved by refinery personnel. Operating areas of AOI 5 are located within a secured area to prevent unauthorized access. Direct contact to soils (soils greater than two feet beneath the ground surface) is governed by Sunoco's on-site procedures and personal protective equipment (PPE).

2.2 Geology

To further characterize geology at AOI 5, Sunoco advanced 18 shallow monitoring wells and 67 shallow soil borings in AOI 5. Each monitoring well and soil boring location was continually logged by a field geologist. The CCR included five geologic cross sections through AOI 5: C-J, C-J', K-C-M, C-L, and N-C-J'. A sixth cross section (R-R') was generated using the deep monitoring well borings in AOI 5. The key for this section is provided as Figure 4 and the geologic section is provided as Figure 5.

The following paragraphs describe the primary geologic units beneath AOI 5 beginning with the deepest units to the shallowest units:

Wissahickon Formation – Bedrock beneath the refinery and AOI 5 is identified as the Wissahickon Schist. This formation is a metamorphosed greenish-gray micaceous schist and quartzite. The competent bedrock of the Wissahickon Formation is overlain by weathered bedrock consisting of micaceous clay, which becomes increasingly sandy as the degree of weathering lessens and competent bedrock is encountered. A review of historic boring logs in AOI 5 indicates that the Lower Sand is located above bedrock. The weathered zone of the Wissahickon Schist was encountered 87 feet below the ground surface at A-21D on the western side of AOI 5, as shown in the geologic cross

section presented as Figure 5. Two additional Lower Sand monitoring wells (A-13D and A-19D) did not encounter bedrock at their respective total depths of 69 feet and 60 feet below the ground surface. However based on geologic interpretation from USGS publications, weathered bedrock in the central and northern portions of AOI 5 are at approximately 90 feet below the ground surface.

Lower Sand Unit of the PRM – Throughout the majority of the refinery, the Wissahickon Formation is overlain by the Lower Sand, which is the lowest member of the Potomac-Raritan Magothy (PRM) Aquifer System. As shown in Figures 5, the Lower Sand overlies bedrock throughout AOI 5. The Lower Sand beneath AOI 5 is brown, orange and/or red, fine gravel and course sand that grades upward into medium-to-fine sands and may contain layers of silts and clay. Throughout central and western portions of AOI 5, the Lower Sand is overlain by the Middle/Lower Clay, as indicated by soil borings A-13D, A-19D, and A-21D. Based on available lithologic data, the Lower Sand is approximately 12 feet thick in the southwestern portion of AOI 5 and increases in thickness towards the eastern-northeastern portion of AOI 5 to approximately 40 feet.

Middle/Lower Clay – The Lower Sand is overlain by the Middle/Lower Clay unit in AOI 5. The Middle/Lower Clay is characterized by very low permeability reddish-brown, brown or gray clays and sandy clays. Shelby Tube samples were collected in the Middle/Lower Clay in AOI 5 in 1986 by Dames and Moore. The results of the Atterberg limits for the sample classified the Middle/Lower Clay as low plasticity clay. The Middle/Lower Clay is present beneath AOI 5 at thickness ranging from 65 feet in the southwestern portion of AOI 5 to approximately 30 feet in the northern-eastern portions of AOI 5, thickening towards the Schuylkill River. The southern and western boundary of AOI 5 is bound by a sheet pile wall which is keyed into the middle/lower clay as shown in Figure 5.

Trenton Gravel – Throughout most of the refinery, the Trenton Gravel typically overlies the Middle/Lower Clay and Lower Sand with thicknesses up to 80 feet and a typical thickness of 40 feet. The Trenton Gravel is of Pleistocene Age (Ice Age; less than 2 million years) and is a very heterogeneous unit comprised of a predominant brown to gray sand, gravel and minor amounts of clay (Owens and Minard, 1979). Along the Schuylkill River, most of the Pleistocene formations have been eroded away. Based on soil borings performed in AOI 5, the Trenton Gravel is not present everywhere beneath AOI 5.

Recent Fill/Alluvium - Overlying the Middle Clay in AOI 5 is recent fill/alluvium materials. The alluvium deposits generally consist of dark gray organic clayey mud or silt and fine sand up to 13 feet thick. Fill varies in composition across AOI 5 and includes sands and gravels, brick, wood fragments and cinder ash up to 10 feet thick. As shown in Figure 5, alluvium deposits exist in the eastern and central portions of AOI 5 and to a lesser extent in the western portion. As shown in Figure 5, the alluvium thickens in the eastern portion of AOI 5.

In addition to the above descriptions, the following general observations can be made concerning the geology in AOI 5:

- The fill/alluvium, Middle/Lower Clay, and the Lower Sand units exist beneath AOI 5 where the Trenton Gravel is not present;
- Fill materials are present throughout AOI 5 generally ranging from 10 to 23 feet in thickness;
- The thickness of the Middle/Lower Clay beneath AOI 5 ranges from 30 to 65 feet, with the thickness slightly increasing towards the south, west, and the Schuylkill River; and
- The thickness of the Lower Sand beneath AOI 5 is approximately 12 feet thick near the Schuylkill River and a minimum of 10 feet thick further inland.

2.3 Hydrogeology

2.3.1 Shallow Groundwater Occurrence and Flow

Shallow groundwater at the refinery refers to unconfined groundwater that occurs in either the fill or alluvium (or both). Intermediate groundwater at the refinery refers to unconfined groundwater that occurs in Trenton Gravel; however, the Trenton Gravel is generally not present beneath AOI 5. Groundwater gauging data collected by Stantec in May 2011 was used to generate a groundwater gradient figure for the shallow zone in AOI 5 (Figure 6). This groundwater elevation data is provided in Table 3 and the groundwater gradient figure is provided as Figure 6. The groundwater elevation data from this gauging event is provided in Table 3. Monitoring well construction details for these monitoring wells are provided in Table 2 and boring/monitoring well

construction logs for the newly-installed monitoring wells are provided in Appendix C of this report. Historic boring/well logs for wells installed prior to the site characterization activities are provided in Appendix D of the CCR. Based on the groundwater elevations as shown in Figure 6, the following observations can be made:

- During the May 2011 groundwater gauging event, shallow groundwater flow in the majority of AOI 5 is generally to the south; and
- In the northern portion of AOI 5, there is some shallow groundwater flow to the north.

As a part of the site characterization activities, aquifer testing was performed in AOI 5 in accordance with the Work Plan to determine hydraulic characteristics of the fill/alluvium materials in AOI 5. A series of "falling head" and "rising head" slug tests were performed on shallow monitoring wells A-140, A-147, A-151, and A-154 to calculate the average hydraulic conductivity value in the fill/alluvium. Due to poor aquifer response data for monitoring well A-140, no further calculations were completed for this test. The highest hydraulic conductivity value for these monitoring wells was calculated to be 33.1 feet/day in A-154 and the average hydraulic conductivity for the three monitoring wells was calculated to be 21.9 feet/day. Based on the available historic aquifer testing data, this value is consistent with the values derived for fill/alluvium in AOIs 1, 4, and 6. A detailed summary of the aquifer testing results and data evaluation is presented in Appendix C.

2.3.2 Deep Groundwater Occurrence and Flow

Three deep (Lower Sand) monitoring wells are located in AOI 5; these include A-13D, A-19D, and A-21D. Well construction details for these monitoring wells are provided in Table 2 and the available logs for these monitoring wells are provided in Appendix D of the CCR. The lithology for the three deep monitoring wells is depicted on Figure 5. Groundwater gauging data collected by Stantec in May 2011 were used to generate a groundwater gradient map for the Lower Sand (deep) zone in AOI 5 (Figure 7). The groundwater contour scheme in Figure 7 incorporates groundwater elevations from deep monitoring wells in AOI 5 and surrounding areas. As shown in Figure 7, groundwater flow in the

Lower Sand in AOI 5 is towards the south-southwest. Groundwater elevations in A-13D, A-19D, and A-21D were lower than elevations observed in nearby shallow wells indicating a downward vertical gradient exists between the shallow and the deep monitoring wells. This is consistent with vertical gradients elsewhere in the refinery.

2.4 Surface Water

No surface water features are located in AOI 5. The nearest surface water body to AOI 5 is the Schuylkill River which comprises the southern boundary of AOI 5. A sheet pile wall that is keyed into the Middle Clay exists between AOI 5 and the Schuylkill River as shown in Figures 2 and 5. Shallow groundwater interaction with the Schuylkill River is limited by the sheet pile wall.

3.0 SITE CHARACTERIZATION ACTIVITIES

The following sections summarize the site characterization activities that were completed in AOI 5 in support of this report. Site characterization activities were performed between February and August 2007 and the results were summarized in a SCR submitted to PADEP and EPA on August 24, 2007. Based on the findings of the SCR, additional site characterization activities were completed in April and July 2009. Site characterization activities were completed by Aquaterra Technologies, Inc. (Aquaterra) and Langan in coordination with Sunoco. These activities were executed in accordance with the AOI 5 Work Plan.

3.1 Shallow Soil Borings and Sampling at Non-RCRA SWMU Areas

In 2007, five soil samples (A-139, A-140, A-143, A-151, and A-152) were collected for analysis of Site COCs from areas within AOI 5 that are outside SWMUs 93, 94, and 101. All five soil samples were collected from monitoring well borings which were advanced in areas not covered by impervious surfaces. Five additional soil samples were collected in 2009 to characterize the non-SWMU areas from monitoring well boring locations (A-141, A-144, A-150, A-153, and A-155).

To further delineate benzene detections above the PADEP non-residential soil MSCs at A-150, four soil samples were collected from soil borings BH-43-09, BH-44-09, BH-45-09, and BH-46-09 in 2009. In 2009, six additional soil borings (BH-13-09, BH-14-09, BH-

15-09, BH-16-09, BH-41-09 and BH-42-09) were completed around A-140 to further delineate lead in soil.

The locations of all soil borings are shown on Figures 3 and 8 and the boring logs are provided in Appendix E. The soil samples collected in 2007 were submitted to Pace Analytical Services (Pace) of Pittsburgh, Pennsylvania and the soil samples collected in 2009 were submitted to Lancaster Laboratories, Inc. (LLI) of Lancaster, Pennsylvania for analysis of site COCs. A summary of the soil analytical results is provided in Table 4 and the results are discussed in Section 5.1. The laboratory analytical reports are provided as Appendix D.

3.2 Shallow Soil Borings and Sampling at RCRA SWMU Areas

The 1993 RFI identified three SWMUs in AOI 5 that required further characterization. These SWMUs include SWMU 93 (Storage Tank Areas: Buried Lead Sludge Area 7), SWMU 94 (Storage Tank Areas: Buried Lead Sludge Area 8), and SWMU 101 (Bulkhead Seepage Area).

In November 2005, Sunoco installed a cover over the northern two-thirds of SWMU 93 which currently serves as a parking area. This covered area is shown in the Current and Historic Use Figure included in Appendix B. From bottom to top, this cover consists of approximately 18 inches of No. 4 stone placed atop the former grade, a layer of woven geo-textile fabric, and 6 to 10 inches of crushed concrete. This cover acts as a barrier which eliminates the potential direct contact exposure pathway to soil beneath the cover. Therefore, no soil borings or samples were collected beneath this cover as part of the 2007 and 2009 site characterization activities. The southern one-third of SWMU 93 is not covered by impervious surface and the investigation approach for this area is discussed below.

The remaining SWMU areas were characterized in accordance with the investigative approach outlined in Sections 1.2.2, 1.2.3, and 1.2.4 of the AOI 5 Work Plan. The locations of the soil borings are shown on Figures 3 and 9 and the boring logs are provided in Appendix E. The locations of the completed soil borings are shown on Figures 3 and 9. Utilizing a stainless steel hand auger, soil borings were advanced to a maximum depth of two feet below grade at each location in accordance with the AOI 5 Work Plan. The 2007 soil samples requiring analysis were submitted to PACE and soil

samples collected in 2009 were submitted to LLI for analysis of total lead concentrations as described in section 1.2.2 of the AOI 5 Work Plan. A summary of the soil analytical results is provided in Table 5 and the results are discussed in Section 5.2. The laboratory analytical reports are provided as Appendix D. The site characterization approach is summarized below by SWMU.

SWMU 93 and 94 Areas

SWMUs 93 and 94 were characterized during the 2007 and 2009 site characterization efforts following the investigative approach outlined in Section 1.2.2 of the AOI 5 Work Plan and summarized below.

- If materials were encountered within the leaded tank bottom areas matching the physical description of the leaded tank bottoms, then Sunoco collected samples for lead.
- If the lead results were above 450 parts per million (ppm) (PADEP's non-residential soil MSC for lead) then samples were analyzed for lead via Toxicity Characteristic Leaching Procedure (TCLP), EPA Test Method 1311.
- Delineated areas that had soils that physically resemble leaded tank bottoms and had lead concentrations that were greater than 450 ppm which is hazardous for lead would retain the leaded tank bottom designation. If no soils were encountered that meet all three of the above mentioned criteria, then the area would no longer be classified as a leaded tank bottom area.

To supplement data previously collected as part of the RFI, the following soil borings and samples were completed in SWMUs 93 and 94:

- SWMU 93 – In 2007, 10 shallow soil borings were advanced and five soil samples (BH-04-07, BH-05-07, BH-06-07, BH-07-07, and BH-08-07) were collected in SWMU 93. In 2009, the following sampling was completed to further delineate lead detections above the PADEP non-residential soil MSC and leaded tank bottoms:
    - Four shallow soil borings (BH-05-09, BH-06-09, BH-07-09, and BH-08-09) were advanced and four soil samples were collected for lead analysis around soil boring location BH-07-07 completed in 2007.

- Four shallow soil borings (BH-17-09, BH-18-09, BH-19-09, and BH-20-09) were advanced and four soil samples were collected for lead analysis around soil boring location BH-08-07 completed in 2007.

- SWMU 94 – In 2007, 15 shallow soil borings were advanced and 6 soil samples (BH-13-07, BH-18-07, BH-20-07, BH-21-07, BH-23-07, and BH-24-07) were collected in SWMU 94. In 2009, the following site characterization activities were completed to further delineate lead detections in soil and leaded tank bottoms:
  - Four shallow soil borings (BH-01-09, BH-02-09, BH-03-09, and BH-04-09) were advanced and four soil samples were collected for lead analysis around soil boring location BH-18-07 completed in 2007.
  - Four shallow soil borings (BH-21-09, BH-22-09, BH-23-09, and BH-24-09) were advanced and four soil samples were collected for lead analysis around soil boring location BH-23-07 completed in 2007.
  - Two shallow soil borings (BH-33-09 and BH-34-09) were advanced and two soil samples were collected for lead analysis south of soil boring location BH-02-09 completed in 2009.
  - Two shallow soil borings (BH-35-09 and BH-36-09) were advanced and two soil samples were collected for lead analysis north of soil boring location BH-04-09 completed in 2009.
  - Two shallow soil borings (BH-37-09 and BH-38-09) were advanced and two soil samples were collected for lead analysis south of soil boring location BH-22-09 completed in 2009.

SWMU 101

According to the 1993 Dames and Moore RFI, lead was detected in soil at SWMU 101 at concentrations above the EPA cleanup levels. The RFI recommended that additional investigation of soil within SWMU 101 be conducted for lead only in soil. The RFI further recommended that light non-aqueous phase liquid (LNAPL) in this SWMU be addressed. The extent of LNAPL was characterized during implementation of a Remedial Action Plan (Dames and Moore, 1993). Following the characterization of LNAPL as discussed in the Remedial Action Plan, Chevron installed the 9 Berth Total Fluids Recovery System to address LNAPL in this area. This recovery system is

discussed in more detail in Section 6.0 of this report. LNAPL in AOI 5 was further characterized as part of the site characterization activities as discussed in Section 5.4 of this report.

In 2007, four soil borings (BH-25-07, BH-26-07, BH-27-07 and A-142) were advanced and four shallow soil samples were collected for total lead in SWMU 101. In 2009, four additional soil borings were advanced and four shallow soil samples were collected (BH-09-09, BH-10-09, BH-11-09, and BH-12-09) for total lead analysis around BH-27-07 due to lead detections above the soil MSC in the 2007 sampling. Also in 2009, two additional shallow soil borings (BH-39-09 and BH-40-09) were advanced and two soil samples were collected for lead analysis north of soil boring location BH-09-09 completed in 2009.

3.3 Installation of Groundwater Monitoring Wells

Monitoring well installation activities were performed between February and August 2007 by Total Quality Drilling, L.L.C. (Total Quality Drilling) of Mullica Hills, New Jersey under direct supervision of Aquaterra and Langan, and in coordination with Sunoco. There were no new wells installed during the 2009 site characterization activities. The locations of all monitoring wells installed in 2007 are shown on Figure 3. Monitoring wells were installed to monitor the water table aquifer beneath AOI 5. No deep monitoring wells were installed since adequate characterization data exists from the three existing deep monitoring wells in AOI 5. The monitoring well installation activities are discussed in detail in the following sections.

3.3.1 Fill/Alluvium (Shallow) Groundwater Monitoring Wells

Under the direction of Aquaterra, Total Quality Drilling installed 17 shallow monitoring wells (A-139, A-140, A-141, A-142, A-143, A-144, A-145, A-146, A-147, A-148, A-149, A-150, A-151, A-152, A-153, A-154, and A-155) within the fill/alluvium in AOI 5. All monitoring well borings were advanced utilizing hollow stem augers and split spoon samplers to record lithology. Locations of these monitoring wells are shown on Figures 3 and 6. Boring logs and monitoring well construction details and lithology are provided in Appendix E. Monitoring wells were constructed with a flush mount manhole cover or with a stickup steel casing for protection. Following construction, the monitoring wells were

developed in accordance with the AOI 5 Work Plan. Well construction details are provided in Table 2.

3.3.2 Lower Sand (Deep) Groundwater Monitoring Wells

Three deep groundwater monitoring wells exist in AOI 5. These monitoring wells include A-13D, A-19D, and A-21D. Boring logs and monitoring well construction summaries for these monitoring wells are included in Appendix E and in Table 2, respectively. No additional deep groundwater monitoring wells were installed in AOI 5 since adequate characterization data existed from the three existing deep monitoring wells in AOI 5.

3.4 Groundwater Monitoring

The AOI 5 SCR included groundwater monitoring results from May 2006. In May 2011, Stantec performed monitoring well gauging activities to collect liquid levels from all accessible monitoring points within AOI 5. Monitoring points were gauged for depth-to-water, and if applicable, depth-to-product in accordance with the AOI 5 Work Plan. All monitoring point gauging readings from this event are summarized in Table 3.

The groundwater monitoring data from Table 3 was used to generate shallow groundwater elevation contours provided as Figure 6. Groundwater gauging data from the deep monitoring wells in Table 3 was used to generate a groundwater contour figure for the deep zone in AOI 5 (Figure 7).

3.5 Groundwater Sampling

Aquaterra performed a round of groundwater sampling from all accessible wells in AOI 5 in May 2007. All groundwater sampling activities were completed in accordance with the AOI 5 Work Plan. The monitoring well sampling summary data sheets are provided as Appendix F.

Following well purging activities, groundwater samples were collected by lowering a disposable bailer slowly into the monitoring well to minimize excess agitation. The bailer was filled with water from the top of the water table and retrieved. Samples were then collected in laboratory-prepared bottleware and immediately placed on ice. Samples were submitted to Pace for analysis of site COCs. Once the sample was

collected, the bailer, bailer cord, and nitrile gloves used to obtain the sample were discarded. Sample date, time, number, and site name were recorded on the chain-of-custody and in field books. For groundwater samples analyzed for lead, PACE Labs filtered the samples to analyze for dissolved lead concentrations.

The groundwater analytical results for the monitoring wells were screened against the PADEP non-residential groundwater MSCs. The results from the shallow monitoring wells are presented in Table 6 and groundwater analytical results for the deep monitoring wells are presented in Table 7. The laboratory analytical reports are included as Appendix D.

3.6 LNAPL Sampling

LNAPL samples for select wells in AOI 5 were previously characterized as described in the CCR. As part of the 2007 characterization activities, Aquaterra collected LNAPL samples from ten monitoring wells (A-4, A-5, A-7, A-20, A-24, A-48, SW-1, SW-4, A-144 and A-155). LNAPL samples were collected using a direct sampling or swabbing method in accordance with Appendix C of the AOI 5 Work Plan. LNAPL samples were packaged in certified hazardous material shipping boxes and shipped to Torkelson Laboratories (Torkelson) of Tulsa, Oklahoma for LNAPL characterization. LNAPL characterization data included product types, density, proportions of product, degree of weathering, and similarities to other LNAPL samples collected at the refinery.

3.7 Surveying Activities

Following completion of monitoring well installation and soil boring activities, the newly-installed monitoring wells and soil boring locations were surveyed by Langan to establish the location and elevation of the inner and outer casing and ground surface at each point. All well elevations were determined to the nearest 0.01 foot relative to mean sea level. All survey activities were performed by a Pennsylvania-licensed surveyor and tied to the NAVD 88 datum. The new survey data for the monitoring wells is presented in Table 2. This new survey data was used to update the Geographic Information System (GIS) and site wide database for the refinery.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

The following sections outline the field and laboratory quality assurance/quality control measures that were incorporated into the site characterization activities. All groundwater gauging and sampling activities were completed in accordance with the field sampling procedures presented in the AOI 5 Work Plan. The complete laboratory analytical data packages for the soil and groundwater sampling events are included in Appendix D.

4.1 Equipment Decontamination

All sampling equipment was decontaminated in accordance with the field sampling procedures to prevent cross-contamination. Prior to sampling, the equipment was decontaminated with successive rinses of detergent and potable water and distilled deionized water. All down-hole equipment used in monitoring well purging, such as submersible pumps, was cleaned with an external non-phosphate detergent wash and tap water rinse. This cleaning process was followed by a flush of potable water.

4.2 Equipment Calibration

Prior to each use, the Horiba instrument was calibrated by measuring the parameters using manufacturer-provided buffer solutions, deionized water and zero oxygen solution.

4.3 Sample Preservation

Samples were preserved, where necessary, with the addition of chemical preservatives, and by cooling the samples at 4°C before and during shipment to the laboratory. Chemical additives necessary for sample preservation were added to the sample containers by the analytical laboratory prior to releasing them to sampling personnel.

4.4 Laboratory Quality Assurance/Quality Control

For the purposes of this investigation, sample results were summarized in 17 sample delivery groups, provided by LLI and Pace Analytical Laboratories, and were evaluated for usability. Lancaster Laboratories performed quality assurance and quality control (QA/QC) analyses, including laboratory control spikes and laboratory control spike duplicates, matrix spikes and matrix spike duplicates, surrogate spikes, method blanks and QA/QC checks such as GC/MS instrument tuning and mass calibration, as appropriate. Laboratory QA/QC summaries were completed by the laboratory and

provided in each data package provided by LLI, attached. All laboratory reports provided by Pace Analytical Laboratories with the exception of one, contained results and notes regarding surrogate recoveries only, no laboratory QA/QC information or QAQC results were provided. As available, the analytical data, data qualifiers, and QC results were evaluated to determine the confidence with which this soil and groundwater data could be used in the decision-making process. Copies of the usability assessment and laboratory reports are provided in Appendix D.

Data quality indicators (DQIs) are qualitative and quantitative measures of data quality "attributes," which are descriptors used to express various properties of analytical data. Thus, DQIs are the various measures of the individual data characteristics that collectively comprise the general, all-encompassing term "data quality." Quality attributes used to assess the data usability include:

- Method selectivity/specificity;
- Accuracy (bias);
- Precision;
- Representativeness;
- Comparability; and
- Completeness.

Based on the evaluation of these indicators, summarized in Appendix D, the soil and groundwater data collected during this investigation is considered usable. As further detailed in Appendix D, few concentrations for groundwater samples: AOI-5 A-143, AOI-5 A-8, AOI-5 A-9, AOI-5 WP-D, AOI-5 A-25, and soil samples; BH-07-07_1-2, BH-08-07_0.75-2, BH-04-07_1-2, A-139-071207_1.5-2, A-140-071207_1.5-2, A-143-071207_0.5-1, A-150, A-155, BH-26-09, BH-25-09, BH-19-09, BH-20-09, A-153, BH-43-09, BH-22-09, BH-23-09, BH21-09 and BH-24-09 should be considered as biased because samples were received at temperatures above 6°C and/or LCS/LCSD, MS/MSD and/or surrogate recoveries were beyond acceptable control limits. The data for these biased samples are considered usable but, based on the source of bias, should be considered slightly higher or lower in concentration than soil or groundwater representative of the site and time collected.

4.5 Documentation

Chain-of-custody forms were maintained throughout the sampling program to document sample acquisition, possession and analysis. Chain-of-custody documentation accompanied all samples from the field to the laboratory. Each sample was assigned a unique number that was recorded on permanent field sheet.

5.0 SITE CHARACTERIZATION ANALYTICAL RESULTS

The following sections discuss the analytical results of the site characterization activities performed in AOI 5.

5.1 Soil Analytical Results at Non-SWMU Areas

The results of the soil samples collected outside of the SWMUs are provided in Table 4. All of the soil samples were collected between the ground surface and two feet below the ground surface and no saturated soils were observed at these depths. In accordance with Section IV of the PADEP's Technical Guidance Manual (TGM) (dated June 8, 2002), lead and benzene were further screened against the EPA Region III Risk-Based Concentrations RBCs (which have been revised and are now called the EPA Regional Screening Levels (RSLs)) for industrial soil to potentially reduce the list of compounds carried through the risk assessment as described in Section 9.0 below. Concentrations of benzene were below the EPA RSL (5.4 mg/kg) and therefore the proposed site-specific standard for benzene will be the benzene RSL. Based on this approach, no cumulative risk assessment was completed for benzene. Concentrations of lead were above the EPA Region 3 RSL (800 mg/kg) and therefore site-specific criterion was developed, as further described in Section 9.0. Soil sample locations with results above their respective PADEP non-residential soil MSCs and the developed site-specific standards are shown in Figure 8.

Below is a general summary of the soil screening results:

- Two soil boring locations (A-150 and A-155) completed in 2007 had detections of benzene above the PADEP non-residential soil MSC (4.9 mg/kg and 0.52 mg/kg, respectively), but the detected benzene concentration in soil was not above the EPA Region 3 RSL at either location.

- Ethylbenzene, ethylene dibromide, 1,2-dichloroethane, toluene, total xylenes, methyl tertiary-butyl ether (MTBE), cumene, anthracene, pyrene, benzo(g,h,i)perylene, benzo(b)fluoranthene, chrysene, benzo(a)anthracene, phenanthrene, flourene and naphthalene were not detected in AOI 5 soil at concentrations above their respective PADEP non-residential soil MSCs.
- One shallow soil sample collected in the eastern portion of AOI 5 (A-140 with a lead concentration of 2,460 mg/kg) was above the site specific criteria (1,708 mg/kg) for total lead based on the 2007 data. In April 2009, Sunoco delineated the lead concentrations in A-140 by collecting six samples from soil borings BH-13-09, BH-14-09, BH-15-09, BH-16-09, BH-41-09, and BH-42-09. Soil samples BH-13-09, BH-14-09, BH-15-09, BH-41-09 and BH-42-09 exhibited concentrations below the PADEP non-residential soil MSC. Only one of the delineation soil samples (BH-16-09) had a detection of lead above the PADEP non-residential soil MSC and also the site-specific criterion, but the location was further delineated to the north by soil samples BH-41-09 and BH-42-09. These areas are further addressed in the Cleanup Plan (see Section 11.0 below).

5.2 Soil Results at SWMU Areas

5.2.1 SWMU 93 and SWMU 94

As stated in Sections 1.2.2 and 1.2.3 of the AOI 5 Work Plan, if materials were encountered in shallow soil (0-2 feet) within SWMUs 93 and 94 (leaded tank bottom areas) during site characterization activities matching the physical description of the leaded tank bottom materials, then samples were collected for total lead. If the total lead results were above 450 ppm (the PADEP non-residential soil MSC for lead) then samples were analyzed for lead via TCLP, EPA Test Method 1311.

SWMU 93

In SWMU 93 during the 2007 sampling event, five soil samples (BH-04-07, BH-05-07, BH-06-07, BH-07-07, and BH-08-07) exhibited characteristics resembling the physical description of leaded tank bottoms and were sampled accordingly. The results of the sample analyses are summarized in Table 5, illustrated on Figure 9 and the logs for these soil borings are provided in Appendix E.

Soil samples BH-04-07, BH-05-07, and BH-06-07 exhibited total lead concentrations below the PADEP non-residential MSC for lead and were not submitted for further analysis. Soil samples BH-07-07 and BH-08-07 were above the PADEP non-residential soil MSC for total lead (1,250 mg/kg and 506 mg/kg, respectively) and were submitted for analysis of TCLP lead using EPA Method 1311. The lead concentration in soil sample BH-07-07 of 9.42 mg/L was above the EPA maximum concentration of lead for toxicity characteristic of 5 mg/L, while the lead concentration in soil sample BH-08-07 (0.653 mg/L) was below the EPA maximum concentration. Therefore the area around BH-07-07 will retain the leaded tank bottom SWMU designation and is addressed in the Cleanup Plan.

Four shallow soil borings/samples, BH-05-09, BH-06-09, BH-07-09, and BH-08-09 were completed around BH-07-07 for delineation of leaded tank bottoms and total lead. Leaded tank bottoms were not observed at BH-05-09 and BH-06-09 and soil samples from these two locations did not have total lead detections above the PADEP non-residential soil MSC. Leaded tank bottoms were observed in BH-07-09 and BH-08-09. Total lead concentrations in BH-07-09 and BH-08-09 were above the PADEP non-residential soil MSC for lead (748 mg/kg and 563 mg/kg respectively), but were not above the site specific criteria.

Four shallow soil borings/samples BH-17-09, BH-18-09, BH-19-09, and BH-20-09 were completed around BH-08-09 for delineation and sampled for total lead. BH-17-09 and BH-20-09 had total lead detections above the PADEP non-residential soil MSC (790 mg/kg and 453 mg/kg, respectively), but were not above site specific criteria. BH-18-09 and BH-19-09 did not have total lead detections above the soil MSC.

SWMU 94

In SWMU 94 during the 2007 sampling event, six soil sample locations (BH-13-07, BH-18-07, BH-20-07, BH-21-07, BH-23-07, and BH-24-07) exhibited characteristics resembling the physical description of leaded tank bottoms and were sampled accordingly. The total lead concentrations from soil samples BH-13-07, BH-20-07, BH-21-07, and BH-24-207 were not above the PADEP non-residential soil MSC for lead and were not submitted for further analysis. The samples collected from soil borings BH-18-07 and BH-23-07 had detections

above the PADEP non-residential soil MSC for total lead (3,190 mg/kg and 1,920 mg/kg, respectively). These samples were submitted for analysis of TCLP lead using EPA Method 1311. The TCLP lead concentration in BH-18-07 (21.8 mg/L) was above the EPA maximum concentration of lead for toxicity characteristic, while the lead concentration in BH-23-07 was below the EPA maximum concentration of lead for toxicity characteristic. Therefore the area around BH-18-07 will retain the leaded tank bottom SWMU designation and is addressed in the Cleanup Plan.

Four shallow soil borings BH-01-09, BH-02-09, BH-03-09, and BH-04-09 were completed around BH-18-07 for delineation of leaded tank bottoms and to collect soil samples for total lead. BH-01-09 total lead concentration was above the PADEP non-residential soil MSC (494 mg/kg), but was not above site specific criteria and did not exhibit evidence of leaded tank bottoms. BH-02-09 exhibited possible leaded tank bottom material and total lead concentrations above the site specific criteria (17,900 mg/kg. A TCLP analysis for lead was run and the result (172 mg/L) also was above the US EPA maximum concentration of lead for toxicity characteristic. BH-03-09 did not have a lead detection above the PADEP non-residential soil MSC nor did it have evidence of leaded tank bottoms. BH-04-09 total lead concentration was above the site specific criteria (1,810 mg/kg), but did not exhibit evidence of leaded tank bottoms. To complete the delineation two additional soil borings (BH-33-09 and BH-34-09) were advanced to the south of BH-02-09 and another two additional soil borings (BH-35-09 and BH-36-09) were advanced to the north of BH-04-09. All four of these soil samples had total lead concentrations below the site-specific criteria but BH-33-09, BH-34-09, and BH-35-09 exhibited concentrations above the PADEP non-residential soil MSC (790 mg/kg, 485 mg/kg, and 772 mg/kg respectively).

Four shallow soil borings (BH-21-09, BH-22-09, BH-23-09, and BH-24-09) were completed around BH-23-07 for delineation of leaded tank bottoms and total lead. BH-21-09, BH-23-09 and BH-24-09 had total lead detections above the PADEP non-residential soil MSC, 1,210 mg/kg, 1,220 mg/kg and 1,100 mg/kg respectively) but were not above the site specific criteria. BH-22-09 had a total lead detection (1,780 mg/kg) above the site specific criteria. Two additional soil borings (BH-37-09 and BH-38-09) were completed to delineate total lead to the south of BH-22-09. The concentrations in these two additional borings were not

above the site specific criteria; however, the total lead concentration in BH-37-09 of 1,310 mg/kg was above the PADEP non-residential soil MSC.

In addition, one soil boring was advanced in SWMU 93 (BH-25-09) and another one in SWMU 94 (BH-26-09) at locations that were inaccessible during site characterization activities (previously identified as BH-09-07 and BH-01-07 in the Work Plan). BH-25-09 had total lead detections above the soil MSC (1,100 mg/kg), but was not above the site specific criteria. BH-25-09 had no lead detections above the soil MSC.

5.2.2 SWMU 101

Shallow soil samples were collected at four soil boring locations (BH-25-07, BH-26-07, BH-27-07, and A-142) within SWMU 101 and analyzed for total lead. The samples collected from soil borings BH-25-07, BH-26-07, and A-142 had total lead concentrations below the PADEP non-residential soil MSC for total lead; and one sample collected from soil boring BH-27-07 had a lead detection of 3,700 mg/kg above the soil MSC and the site specific standard.

Four shallow soil borings and soil samples (BH-09-09, BH-10-09, BH-11-09, and BH-12-09) were completed around BH-27-07 for delineation. BH-09-09 had a total lead concentration of 2,430 mg/kg which was above the site specific criteria. BH-10-09 concentration was not above the PADEP non-residential soil MSC for lead, while BH-11-09 and BH-12-09 had total lead detections above the PADEP non-residential soil MSC (613 mg/kg and 806 mg/kg respectively), but the concentrations were not above site specific criteria. Two additional soil borings (BH-39-09 and BH-40-09) were completed to delineate total lead to the north of BH-09-09. BH-39-09 exhibited a concentration of 1,050 mg/kg, which is above the PADEP non-residential soil MSC but below the site-specific criterion, while the BH-40-09 concentration was below the PADEP non-residential soil MSC.

5.3 Groundwater Results

The results of the groundwater samples collected from monitoring wells in the shallow and deep groundwater units are provided in Table 6. The results were screened against the PADEP non-residential used aquifer (TDS<2,500) groundwater MSCs. Locations

with concentrations above the groundwater MSCs are illustrated in Figure 10. A summary of the COC concentrations that were above their respective PADEP non-residential groundwater MSCs are presented below.

Shallow Wells

A summary of the COC concentrations that exceeded the PADEP used aquifer non-residential groundwater MSCs in Fill/Alluvium wells is below:

- COCs detected in shallow groundwater at concentrations exceeding their respective PADEP non-residential groundwater MSCs include benzene, lead, and chrysene.
- Ethylbenzene, ethylene dibromide, 1,2-dichoroethane, toluene, xylenes, MTBE, pyrene, phenanthrene, fluorene, cumene and naphthalene were not detected in AOI 5 groundwater above their respective PADEP non-residential groundwater MSCs.

Sunoco re-sampled well A-138 in 2009, located in the eastern portion of AOI 5 to further assess the elevated cumene concentration (17,000 ug/L) detected during the July 2007 sampling event. Cumene was detected at 420 ug/L during the 2009 sampling event which is below the PADEP non-residential groundwater MSC of 2,300 ug/L.

Deep (Lower Sand) Wells

A MTBE concentration of 34 ug/L was detected in deep monitoring well A-19D located in the northern portion of AOI 5. No other COC concentrations above the PADEP non-residential used aquifer (TDS<2,500) groundwater MSCs were detected in groundwater from monitoring well A-19D or the other two Lower Sand wells in AOI 5.

5.4 LNAPL Characterization Results

As a part of the site characterization, LNAPL samples were collected from 10 monitoring wells (A-4, A-5, A-7, A-20, A-24, A-48, A-144, A-155, SW-1, and SW-4). LNAPL characterization results are presented in Appendix G. This appendix also includes previous LNAPL characterization data for AOI 5 which was obtained as part of the CCR. The extent of LNAPL in AOI 5, as well as the apparent thickness of LNAPL measured during the May 2011 gauging event, is illustrated in Figure 11.

As part of the AOI 5 SCR/RIR, LNAPL modeling was performed using the American Petroleum Institute (API) Model. LNAPL modeling procedures, input parameters, and results are included as Appendix G. LNAPL was identified at 14 wells (A-13, A-136, A-14, A-144, A-155, A-21, A-24, A-46, A-5, A-7, SW-1, SW-4, WP-A, and WP-B) during the May 2011 groundwater gauging activities. LNAPL thicknesses ranged from a sheen (0.01 feet) at A-7, A-21, A-24, A-136 and WP-A to 1.60 feet at A-124.

A total of 16 LNAPL samples were collected in AOI 5 and submitted to Torkelson for LNAPL typing analysis. Six of these LNAPL samples were collected from monitoring wells A-13, A-14, A-22, A-47, A-133, and A-136 as part of the CCR and ten LNAPL samples were collected from monitoring wells A-4, A-5, A-7, A-20, A-24, A-48, A-144, A-155, SW-1, and SW-4 as part of the AOI 5 SCR/RIR. A summary of the LNAPL typing analysis is included in Appendix G.

Based on the LNAPL characterization performed by Torkelson, the LNAPL types present in AOI 5 consist of lube oil, middle distillate and residual oil. All three LNAPL types have a high degree of weathering. The physical properties of these LNAPL types (drawn from literature sources), soil types (from AOI 5 boring logs) and recent LNAPL thickness measurements (May 2011) were entered into the API Model to estimate LNAPL specific volume and seepage velocity. The input and output parameters of the updated API Model and seepage velocity calculations is presented in Appendix G.

The distribution of LNAPL, specific volume and seepage velocities derived from the May 2011 data is similar to what was reported in the CCR. Figures depicting the results of the LNAPL modeling are included in Appendix G, Gas Figure G-1 - LNAPL Specific Volume and Figure G-2 - LNAPL Mobility Value. Based on the LNAPL types, LNAPL modeling results and recent groundwater gauging activities, LNAPL in these wells is stable and generally immobile.

6.0 REMEDIAL SYSTEM UPDATE

The 9 Berth Total Fluids Recovery System is the only remediation system located in AOI-5. This system was shutdown in January 2009 as a result of freezing conditions and due to the lack of LNAPL in the vicinity of the system. The LNAPL evaluation discussed in Section 5.4 confirmed that the LNAPL in the vicinity of the 9 Berth System is generally immobile.

The 9 Berth Total Fluids Recovery System had the capability of pumping total fluids from two wells - RW-BH1 and RW-BH2. Operation and maintenance data for this system, as well as well gauging and sampling data for AOI 5, was reported to the PADEP and EPA in the quarterly Remediation Status reports for the site.

The 9 Berth Total Fluids Recovery System consisted of total fluids (groundwater and LNAPL) recovery from two recovery wells (RW-BH1 and RW-BH2) using electric, submersible pumps. The recovery wells were gauged weekly as part of the recovery system maintenance and monitoring program to ensure the system was operating as designed. The volume of LNAPL recovered from either well could not be determined based on the system discharge configuration. Total fluids were pumped directly into a closed benzene NESHAP compliant sewer, which discharged to the Girard Point Wastewater Treatment Plant. System monitoring activities included an evaluation of the recovery pumps, system equipment and associated level switches, and collection of the appropriate system performance data.

7.0 FATE AND TRANSPORT ANALYSIS

The following sections describe fate and transport modeling activities performed as part of AOI 5 site characterization.

7.1 Soil

No fate and transport modeling was completed for the soil analytical results since the soil-to-groundwater pathway is evaluated through groundwater data. Potential exposure pathways for AOI 5 are discussed in more detail in Sections 9.0 and 10.0 below.

7.2 Groundwater

Fate and transport calculations were completed for groundwater in AOI 5 to further evaluate the site characterization data. A detailed summary of the procedures and calculations of the fate and transport modeling is presented in Appendix H. The results of the modeling are discussed below.

Four COCs (benzene, chrysene, MTBE, and lead) were detected in groundwater during the May 2007 groundwater sampling event at concentrations above their respective used-aquifer, non-residential groundwater MSCs. Cumene was initially detected above

its groundwater MSC in May 2007, but upon resampling in April 2009, it was detected below its screening concentration and therefore was not included in fate and transport assessment. To address the potential future migration of these COCs, a fate and transport analysis was performed. Per the PADEP ACT 2 Guidance, fate and transport analysis was performed using the predictive models recommended in the PADEP ACT 2 Guidance. The Quick Domenico Version 2 (QD) model and the SWLOAD model were used for fate and transport in groundwater. PENTOXSD is used when assessing potential impacts of groundwater on surface water. Site-specific data was used to complete the fate and transport calculations, when available.

Initial Screening and Approach of Fate and Transport Analysis

Benzene was detected above its used-aquifer, non-residential groundwater MSC at five shallow well locations (A-154, A-135, A-134, A-150 and A-119) in AOI 5 ranging in concentrations from 9 ug/L to 50 ug/L. Four of these locations are in the interior of AOI 5 while one monitoring well (A-119) is located along the eastern property boundary. The point of compliance (POC) monitoring wells located down-gradient of A-154, A-135, A-134 and A-150 do not have detections of benzene above its groundwater MSC nor do they have exceedances of the residential groundwater MSCs. Upon review of historic groundwater data summarized in the quarterly reports, the concentration in these POC wells is consistent with the historic groundwater results; therefore, fate and transport analysis of benzene at A-154, A-135, A-134 and A-150 was not completed. Fate and transport analysis of benzene at A-119 was completed because there are no POC monitoring wells between A-119 and the AOI 5 property boundary.

MTBE was detected above its groundwater MSC in the deep (Lower Sand) monitoring well A-19D. Groundwater flow in the Lower Sand is towards the Schuylkill River. Monitoring well A-13D is located hydraulically down-gradient of A-19D and contains no detectable MTBE concentrations. Due to its proximity to the AOI 5 property line, fate and transport analysis was completed for A-19D.

Chrysene was detected above its groundwater MSC at eight monitoring well locations (A-25, A-133, WP-E, WP-B, WP-A, SWR-3, WP-8 and A-5). Fate and transport analysis was competed for the most downgradient wells with chrysene detections above the groundwater MSC which included monitoring wells A-133, WP-B, WP-A, SWR-3, and WP-8. These wells are located along the sheet pile wall bordering the Schuylkill River. Five areas were identified within approximately 300 feet of the sheet pile wall. These

five areas contain monitoring wells with chrysene detections above the groundwater MSC or containing LNAPL sheen. The five areas are identified in Figure H-1 in Appendix H. The five areas were used to define the chrysene plume source widths for the QD modeling. Five SWLOAD models were then constructed to further determine if groundwater might impact surface water requiring the use of PENTOXSD to derive site-specific groundwater screening criteria protective of surface water. The results of the QD and SWLOAD calculations confirmed that no PENTOX modeling was required in AOI 5.

Lead was detected at concentrations above its groundwater MSC of 5 ug/L at PZ-2 (5.8 ug/L) and WP16-3 (12 ug/L). These two monitoring well locations are either upgradient or side gradient of the SWMUs. PZ-2 and WP16-3 are located hydraulically up-gradient of several wells where lead has not been detected above the groundwater MSC (A-134, A-133 and WP-B) as evidenced by historical sampling results from these wells. Because no downgradient wells had lead detections above the groundwater MSC, PZ-2 and WP16-3 were not included as part of the fate and transport evaluation.

Results of QD and SWLOAD Modeling

QD modeling results for well A-19D, which is located in the northeastern corner of AOI 5, indicates that MTBE would need to travel 29 feet to attenuate to the MTBE groundwater MSC of 20 ug/l. The nearest refinery property boundary to A-19D is approximately 50 feet away. At A-119 the predicted distance for benzene to attenuate to its groundwater MSC of 5 ug/l is 40 feet. The shortest distance to the property boundary from A-119 is 255 feet. Neither MTBE nor benzene in groundwater has the potential to reach the AOI 5 property boundary at concentrations exceeding the groundwater MSC based on the QD modeling results.

QD modeling results indicate that chrysene has a very low potential to migrate under observed site conditions. The predicted distance for chrysene to attenuate to its groundwater MSC of 0.0019 mg/l ranged from less than 1 foot to 4 feet. This result is consistent with the low aqueous solubility of chrysene and its strong tendency to sorb to aquifer materials. SWLOAD results using the same initial concentrations and aquifer parameters as the QD models indicated that chrysene will not reach the sheet pile wall and will not potentially discharge to the Schuylkill River above the groundwater MSC; therefore, a PENTOXSD analysis was not required.

7.3 LNAPL

As described in Appendix G, Sunoco evaluated LNAPL mobility across the site using the API LNAPL Model, as a guide for assessing LNAPL volume, mobility, and recoverability across the refinery. Based on the LNAPL types, updated API Model output results, and recent groundwater gauging activities (May 2011), LNAPL in AOI 5 is stable and immobile.

7.4 Vapor Intrusion into Indoor Air

The occupied buildings located in AOI 5 are illustrated on Figure 11 and in Appendix B. All of the buildings are operated by Sunoco and regulated by OSHA and there are no known preferential pathways that exist in the immediate area (less than 100 feet) of the occupied buildings.

LNAPL present in the monitoring and recovery wells in AOI 5 is located more than 100 feet away from the occupied buildings and there are no known preferential flow pathways connecting the LNAPL areas to the buildings. Therefore, no further evaluation of the potential vapor intrusion into indoor air pathway from LNAPL is required.

For the current occupied buildings as depicted on Figure 2, groundwater is less than 5 feet below the ground surface; therefore, the PA DEP USEPA-PA Default Non-Residential PEL for Volatilization to Indoor Air for soil and groundwater screening criteria could not be used. For the occupied buildings, further evaluation will be conducted to assess the impact to indoor air.

Since the site specific standard is being applied, groundwater within some portions of AOI 5 is shallower than 5 feet, underground utilities exist and sampling was not completed below all areas with impervious covers, Sunoco will place a restriction in the UECA covenant for AOI 5 that will require further vapor site characterization activities and/or installation of a vapor mitigation system to be installed for any new occupied buildings that will be constructed within AOI 5.

8.0 SITE CONCEPTUAL MODEL

A preliminary site conceptual model (SCM) for the refinery, including AOI 5, was presented in the CCR. Data collected from the recent site characterization activities performed in AOI 5 were used to refine the SCM for this area. The revised SCM for AOI 5 is described in the following sections:

8.1 Description and Site Use

AOI 5 is comprised of a wedge-shaped section located in the southern most portion of the refinery that encompasses approximately 107 acres. AOI 5 is bordered to the north and northwest by Penrose Avenue and the George Platt Bridge, an industrial facility to the east, and the Schuylkill River to the south and southwest. Prior to August 1994, the area was owned by Chevron who acquired the facility from a merger with Gulf Oil Company. Existing usage within AOI 5 consists primarily of product tankage, old warehouses, and docks, a loading rack and scale house, and two pump houses. A wastewater separator and hazardous waste storage area are located in the southwestern portion of the AOI 5.

AOI 5 is located within a fenced and secured area to prevent unauthorized access. Prior to any work being completed within AOI 5, appropriate work permits, safety and security measures must be approved by Sunoco Refinery personnel. AOI 5 is under the control of Sunoco's health and safety administrative procedures and is regulated by OSHA. Direct contact to site soils (soils greater than two feet beneath the ground surface) is controlled by Sunoco's on-site permit and personal protective equipment (PPE) procedures. The current and future intended use of AOI 5 is non-residential.

8.2 Geology and Hydrogeology

The following summarizes relevant information concerning geology and hydrogeology in AOI 5:

- The fill/alluvium, Middle/Lower Clay, and the Lower Sand all exist beneath AOI 5.
- The Trenton Gravel is absent beneath AOI 5.
- Unconfined groundwater conditions exist in the fill/alluvium at shallow depths (approximately 1.0 to 19 feet beneath the ground surface).

- The sheet pile wall along the western border of AOI 5 and the Schuylkill River is keyed into the Middle/Lower Clay and acts as a boundary between shallow groundwater in AOI 5 and the river.
- Shallow groundwater flow in the majority of AOI 5 is generally towards the south.
- Groundwater elevations in AOI 5 are shallowest near the sheet pile wall.
- Groundwater flow in the Lower Sand in AOI 5 is generally to the south-southwest.
- A downward vertical flow gradient exists between the shallow and deep groundwater zones.

8.3 Compounds of Concern

The following summarizes relevant information concerning COCs in AOI 5:

- Total lead and benzene are the only COCs in surface soil which were above the PADEP non-residential soil MSCs. These compounds have been delineated where above the soil MSC.
- Benzene, chrysene, and lead are the only COCs in shallow groundwater which were above their respective PADEP non-residential groundwater MSCs.
- MTBE is the only COC in deep groundwater which was above the PADEP non-residential groundwater MSC.

8.4 LNAPL Distribution and LNAPL Mobility

The following summarizes relevant information concerning LNAPL distribution in AOI 5:

- There are three different types or mixtures of LNAPL identified in AOI 5; these include middle distillate, lube oil, and residual oil.
- LNAPL in AOI 5 is contained within the boundary of the refinery and does not appear to have to the potential to migrate off-site due to its low mobility.

8.5 Fate and Transport of COCs

- No fate and transport modeling was completed for the soil analytical results. The soil-to-groundwater pathway is evaluated through groundwater data.

- QD modeling results for well A-19D indicated that MTBE would not reach the refinery boundary above the groundwater MSC.
- QD modeling for monitoring well A-119 predicted that neither MTBE nor benzene in groundwater has the potential to reach the refinery property boundary above the groundwater MSC.
- QD and SWLOAD modeling results indicated that chrysene will not reach the downgradient boundary (sheet pile wall) and will not potentially discharge to the Schuylkill River at concentration above the groundwater MSC; therefore, a PENTOXSD analysis was not required.
- The sheet pile wall located between AOI 5 and the Schuylkill River is keyed into the Lower/Middle Clay and acts as a boundary between shallow groundwater in AOI 5 and the Schuylkill River.
- Based on the thickness of the Middle Clay in AOI 5 (ranging between approximately 30 and 65 feet thick), and since COCs detected in shallow groundwater in AOI 5 were not detected in deep groundwater in AOI 5, the Middle Clay in AOI 5 generally appears to act as a barrier to vertical migration of dissolved phase COCs in the shallow groundwater.

8.6 Potential Migration Pathways and Site Receptors

The following summarizes potential migration pathways and site receptors for AOI 5.

- AOI 5 is situated within a fenced and secured area to prevent unauthorized access.
- The potential direct contact pathway to soil greater than two feet is deemed incomplete based on Sunoco's existing permitting procedures which protect against exposure to soil encountered in excavations.
- The potential direct contact pathway to groundwater is deemed incomplete based on Sunoco's existing permitting procedures which prevent exposure to groundwater that may be encountered in excavations.
- Because groundwater is within 5 feet below the ground surface around the existing occupied buildings, as part of the Cleanup Plan, Sunoco will further investigate (i.e. soil gas samples) to determine impacts to indoor air at these locations.

- The need for further vapor site characterization activities and/or the installation of vapor mitigation systems for future occupied buildings will be evaluated on a case by case basis.
- LNAPL and dissolved phase COCs that were above the groundwater MSCs appear to be contained within the boundary of the refinery.
- The areas that have surface soil detections of lead above the site specific criteria developed (as discussed in section 9.0 below) will be remediated by Sunoco as discussed in the Cleanup Plan (Section 11.0) to eliminate the potential exposure pathway.

9.0 HUMAN HEALTH EXPOSURE ASSESSMENT/RISK ASSESSMENT

Based on the current and future intended non-residential site use for AOI 5, an exposure assessment was conducted for compounds that were above the non-residential statewide health standards in AOI 5. Potential human health exposures for the refinery are for an industrial worker scenario. The media evaluated included groundwater, shallow soil, and subsurface soil (greater than two feet below grade).

The potential direct contact pathway for soil (greater than two feet), groundwater and LNAPL under the industrial scenario is eliminated through Sunoco's established excavation procedures, PPE requirements and soil handling procedures described in Appendix K of the CCR. However, because direct contact to shallow soils could occur outside of excavation activities, shallow soil samples were collected in non-paved areas of AOI 5 to assess this potential exposure pathway.

The following table serves as a summary of potential human health exposure pathways that can be reasonably expected under the current and intended future non-residential use for AOI 5. The table lists potentially contaminated media, potential receptors for these media, and a summary of whether any potentially complete exposure pathways exist at AOI 5 from the media to these receptors.

Exposure Pathway Evaluation Summary

Contaminated Media	Residents	Workers	Day Care	Construction	Trespassers	Recreation	Food
Groundwater	NA	No(1)	NA	No (2)	No	NA	NA
Air (indoor)	NA	No (3)	NA	No(3)	No	NA	NA
Soil <2 feet bgs.	NA	Yes	NA	Yes	No	NA	NA
Soil >2 feet bgs.	NA	No(4)	NA	No(4)	No	NA	NA
Surface Water	NA	No(5)	NA	No(5)	Na	NA	NA
Sediment	NA	NA	NA	NA	Na	NA	NA
LNAPL	NA	No(1)	NA	No (2)	Na	NA	NA

Notes:

(1) No complete groundwater or LNAPL pathways exist for workers that are not addressed through on-site permitting procedures and PPE.
(2) No complete groundwater or LNAPL pathway exists for construction workers that are not addressed through on-site permitting procedures and PPE.
(3) No current complete pathway to indoor air exists based on the evaluation.
(4) No complete pathway exists for site soil >2 feet deep that are not addressed through on-site permitting procedures and PPE.
(5) No complete pathway exists for surface water or sediment that is not addressed through on-site permitting procedures and PPE.

Na - Not applicable
No - No potential complete exposure pathway
Yes – Potential complete exposure pathway

A more detailed evaluation of each of these potential human health exposure pathways is presented in the following sections by media.

9.1 Surface Water/Sediment

There is no surface water features located within AOI 5. The nearest surface water body to AOI 5 is the Schuylkill River which borders the southern AOI boundary (Figure 2). A sheet pile wall keyed into the Middle/Lower Clay is located along the entire western boundary of the site. Shallow groundwater interaction with surface water is limited by the sheet pile wall.

9.2 Shallow Soils (0-2 Feet Below Grade)

The soil-to-groundwater pathway is being addressed through the groundwater pathway discussed in Section 9.3.

Direct Contact Exposure

Shallow soil samples collected and analyzed as part of the AOI 5 characterization activities exhibited concentrations of benzene and lead above their respective PADEP non-residential soil MSCs. Based on the current and future intended non-residential site use, an exposure assessment was conducted for all compounds in surficial soil (0-2 feet) which were above the nonresidential direct contact statewide health standards in

AOI 5. Potential human health exposures for the Refinery are evaluated for an industrial worker scenario.

In AOI 5, shallow soil samples were collected from within the three SWMUs and analyzed for total lead. Samples were also collected outside the three SWMU areas and analyzed for the COCs (as specified in the June 15, 2007 AOI 5 Site Characterization Work Plan). To determine if any unacceptable risk to the industrial worker exists due to direct contact to shallow soil, the results of these samples were compared to the non-residential direct contact medium specific concentrations [PA Code Title 25, Chapter 250.305, Appendix A, Tables 3A and 4A]. Within the three SWMU areas, concentrations of total lead were detected above their respective PADEP non-residential soil MSCs. Outside the SWMU areas, concentrations of benzene and total lead were also detected above their respective PADEP non-residential soil MSCs.

In accordance with TGM, lead and benzene were further screened against the EPA Region III Risk-Based Concentrations RBCs (which have been revised and are now called the EPA Regional Screening Levels) for industrial soil to potentially reduce the list of compounds carried through the risk assessment. All soil concentrations of benzene detected in AOI 5 were below the EPA Region III RSL for industrial soil (5.4 mg/kg) and therefore site-specific criterion for benzene are proposed to be the RSL of 5.4 mg/kg. Concentrations of lead were above the EPA Region 3 RSL and therefore site-specific criterion was developed.

Since total lead was above both the non-residential statewide health standard and EPA Region III screening numbers, a site-specific standard was calculated using PADEP default intake parameters for an on-site industrial worker. For calculating a site-specific standard for workers exposed to lead, Sunoco used the Society of Environmental Geochemistry and Health (SEGH) model used by PADEP to develop the non-residential soil MSC. The input parameters used to develop the site-specific standards for total lead are provided in Appendix I as Table I-1 and described below. The calculated site specific standard for total lead is 1,708 mg/kg.

The site-specific screening level for lead was calculated based on ingestion. As presented in 25 Pa. Code § 250.306(e), Appendix A, Table 7, the non-residential soil screening value for lead is based on the method presented in the SEGH report 'The Society for Environmental Geochemistry and Health (SEGH) Task Force Approach to the

Assessment of Lead in Soil' (Wixson, 1991). Based on the SEGH model and PADEP's default parameters, PADEP's non-residential direct contact soil MSC default value for lead in surface soil is 1,000 mg/kg. To develop a site-specific criteria for lead, the values used by PADEP for the target blood lead concentration (T) and geometric mean background blood lead concentration (B) were revised in consideration of site-specific conditions and updated lead data collected by the US Center for Disease Control and Prevention (CDC).

Concentrations of total lead detected in AOI 5 were compared to the calculated site-specific standard (1,708 mg/kg). Lead exposure is dependent on the blood/lead concentration and not risk based; therefore, lead could not be incorporated into the cumulative risk calculation. The following soil boring locations had concentrations of total lead detected above the site-specific standard:

SWMU 94

- BH-23-07_0.0 – 0.5 (1,920 mg/kg)
- BH-04-09_0.0 - 2.0 (1,810 mg/kg)
- BH-18-07_1.0 - 2.0 (3,190 mg/kg)
- BH-02-09_0.0 - 2.0 (17,900 mg/kg)
- BH-22-09_0.0 – 2.0 (1,780 mg/kg)

SWMU 101

- BH-09-09_0.0 – 2.0 (2,430 mg/kg)
- BH-27-07_1.5 – 2.0 (3,700 mg/kg)

Non-SWMU

- A-140_1.5-2.0 (2,460 mg/kg)
- BH-16-09_0.0 – 2.0 (2,030 mg/kg)

The above mentioned soil sample locations that were above the site specific lead standard have been horizontally delineated and have been, or will be, remediated as further described in the Clean-up Plan (see Section 11.0).

9.3 Groundwater

Benzene and chrysene were detected in shallow groundwater in AOI 5 above their respective PADEP non-residential groundwater MSCs. Previous investigations and recent (2011) well searches verified that no monitoring wells located within 1.0 miles of the refinery are used for drinking water or agricultural use. There are no complete direct contact exposure pathways for groundwater within AOI 5 because of on-site procedures and required PPE. If, during episodes of high precipitation, groundwater or LNAPL becomes exposed to the ground surface, then Sunoco will implement additional PPE and site procedures to prevent direct contact by workers to these areas during these episodes.

Results of the groundwater sampling indicated COCs at concentrations above their respective non-residential groundwater MSCs, included benzene, chrysene, lead, and MTBE. Based on the Quick Domenico and SWLOAD concentrations, the above mentioned COCs are not expected to exceed the groundwater MSCs at the site boundary and or affect site receptors (Schuylkill River to the west and/or residential areas to the east).

Excavations in AOI 5 are governed by Sunoco's permitting procedures which protect against potential exposures to groundwater that could be encountered in an excavation. Also, there are no complete direct contact exposure pathways for groundwater within AOI 5 because of on-site refinery safety procedures and required PPE.

9.4 LNAPL

There are no complete direct contact exposure pathways for LNAPL within AOI 5 because of on-site permitting procedures and required PPE.

9.5 Vapor

There is no LNAPL within 100 feet of any occupied building or any preferential migration pathway that is within 100 feet of an occupied building.

For the current occupied buildings, groundwater is less than 5 feet below the ground surface; therefore, the PA DEP USEPA-PA Default Non-Residential PEL for Volatilization to Indoor Air for soil and groundwater screening criteria could not be used. As part of

the Cleanup Plan for the current occupied buildings, further evaluation (i.e. soil gas samples) will be necessary to assess the impact to indoor air.

Future occupied buildings will be required to have a vapor mitigation system installed.

10.0 ECOLOGICAL ASSESSMENT

The majority of AOI 5 is covered with impervious surfaces as shown in Figure A-1 in Appendix A. Some areas are covered by soil and gravel; however, they are not likely to serve as a breeding area, migratory stopover, or primary habitat for wildlife. In November 2011, a survey of endangered, threatened and special concern wildlife was conducted by submitting a request to the Pennsylvania Natural Diversity Inventory (PNDI) data base. The PNDI search identified two potential impacts that require further review. The first potential impact was for an endangered species identified by the PA Game Commission as the Great Egret. The second is a potential conflict of an unidentified threatened species listed by the PA Fish and Boat Commission.

No surface water features are located in AOI 5. The nearest surface water body to AOI 5 is the Schuylkill River which borders the western boundary. A sheet pile wall is present between AOI 5 and the Schuylkill River as illustrated in Figure 2. Groundwater interaction with surface water/sediment is limited by the sheet pile wall.

11.0 CLEAN UP PLAN

11.1 Remedial Alternative Analysis and Pathway Elimination Demonstration

Based on the soil delineation activities performed as part of the SCR/RIR, four areas will require remedial action to eliminate the potentially complete exposure pathway. These areas are identified as Area 1 – SWMU 94, Area 2 – SWMU 94, Area 3 – SWMU 101 and Area 4 – Non SWMU.

The remedial measures that were selected to address each of the current potential exposure pathways are summarized in Sections 11.2 below. The selected remedies include engineering and institutional controls which have been, or will be, implemented

to attain the site-specific standard through pathway elimination. In accordance with §304(l)(2) of Act 2, since the selected remedies can attain the site-specific standard, a baseline risk assessment report is not required.

The remedy selection process was completed in consideration of the remedies' ability to address each potentially complete exposure pathway identified in the SCR/RIR, and summarized in Sections 11.2 and 11.3 below. A Post Remediation Care Plan will be prepared and submitted with the Final Report. The Post Remediation Care Plan will contain materials management, health and safety, and post remediation monitoring requirements for the remedies to ensure their long-term effectiveness.

Consistent with Amended Title 27-Uniform Environmental Covenants, the uses of the subject property will be restricted to non-residential purposes. An environmental covenant will be applied to within AOI 5 in order to maintain institutional control against potential future exposure and will be included in the Final Report for the site. In addition, a notice will be recorded in the land records of Philadelphia that discloses the types of hazardous substances present on the site.

Based on the characterization of groundwater as described in the SCR/RIR and the results of the groundwater exposure assessment and fate and transport modeling, no additional groundwater remediation systems will be installed as part of this Cleanup Plan.

The remainder of this section presents the evaluation and selection of remedies to address of the above mentioned areas. Figure 12 of this report depicts the locations of the selected remedial alternative areas and Figure 13 depicts conceptual construction details of each of the selected remedies.

11.2 Selected Remedies Under Current Site Conditions

This section presents the remedial measures that were selected to address each of the remediation areas under the current use.

Areas 1 and 2 – SWMU 94

Exposure Pathway - Direct contact to surface soil for lead detections above the site specific standard in Areas 1 and 2 located in the northern portion of SWMU 94 (Figure 12).

The selected remedy to eliminate the potential exposure pathway in Areas 1 and 2 is excavation of the surface soil (0 to 2 feet below grade) and off-site disposal of the soil material. Further delineation of the detections above the non-residential soil MSC for lead will be completed as part of the Cleanup Plan. Only the areas that are above the site specific standard for lead will be excavated as part of the Cleanup Plan. Both areas (above non-residential soil MSC and site specific standard) will be documented in the UECA covenant as described in Section 11.5 below. Once the soil has been excavated from the two areas, clean fill will be placed in the excavations and properly compacted. The area will then be restored to current ground surface conditions. Excavation of the surface soil with lead concentrations above the site specific concentrations will eliminate potential exposure pathways. Excavation activities will be completed in accordance with approved Sunoco excavation procedures and permits. The excavation and soil cover sections are illustrated in the conceptual construction details included as Figure 13 of this report.

Post-excavation soil sampling will be completed as part of this Cleanup Plan and will be included in the Final Report.

Area 3 – SWMU 1010

Exposure Pathway - Direct contact to surface soil for lead detections above the site specific standard in Area 3 located in the eastern portion of SWMU 101 (Figure 12).

The selected remedy to eliminate the potential exposure pathway in Area 4 located in the eastern portion of SWMU 101 was the installation of an asphalt cover. In October 2009, Sunoco paved the area with soil detections above the site specific standard for lead in Area 3. The area that has been paved is shown on Figure 12. The pavement section is illustrated in the conceptual construction details included as Figure 13. Further delineation of the soil detections above the non-residential soil MSC for lead will be completed as part of this Cleanup Plan. The area with soil detections above the non-residential soil MSC and site specific standard for lead will be documented in the UECA covenant as discussed in Section 11.5 below.

A detailed discussion of the Post Remediation Care Plan elements is provided in Section 11.5.

Area 4 – Non-SWMU

Exposure Pathway - Direct contact to surface soil for lead above the site specific standard in Area 4 located in the eastern portion of AOI 5 (Figure 12).

The selected remedy to eliminate the potential exposure pathway in Area 4 is the installation of 80 mil high density polyethylene (HDPE) liner or excavation. The HDPE liner will installed on top of the existing ground surface with a minimum of twelve inches of clean crushed stone placed on top. The installation of the HDPE liner will be installed in accordance with Sunoco's construction procedures and permits. Sunoco may also choose to excavate this area rather than installing the HDPE liner. A general detail of the installation of the HDPE liner or excavation is depicted on Figure 13. The installation of the liner or excavation will eliminate the potential direct contact pathway to surface soil in the eastern portion of AOI 5.

Further delineation of the soil detections above the non-residential soil MSC for lead will be completed as part of this Cleanup Plan. The areas with soil detections above the non-residential soil MSC and site specific standard for lead will be documented in the UECA covenant as discussed in Section 11.5 below.

A detailed discussion of the Post Remediation Care Plan elements is provided in Section 11.5.

11.3 Act 2 Section 304(j) Evaluation of Selected Remedies

The effectiveness of the selected remedies was evaluated by considering factors included in §304 (j) of Act 2. The §304 (j) criteria address a few general areas, such as the long-term or short-term effectiveness of the remedy to manage risk, the extent to which the risks are being reduced, the ability to implement the remedy, reduction of toxicity, mobility or volume of regulated substances, reliability and post remediation care, and cost-benefit considerations. The §304 (j) evaluation is discussed in this section with respect to the selected remedies.

All remedy implementation activities involving earthwork are to be governed by Sunoco's excavation procedures and permits. Sunoco's excavation procedures and permits contain special operating procedures that will be implemented to eliminate short-term risks posed to workers during implementation of the remedies. Therefore, the short-term risk evaluation is not discussed further in the sections below.

If the Site use remains unchanged (e.g. redevelopment does not occur) and the selected remedies are implemented, a health benefit to the property will be gained since the remedies will eliminate potential exposure pathways that currently exist.

The remaining §304 (j) factors were considered in selection of each remedy as discussed in the following sections.

11.3.1 Soil Excavation

a) Long-Term Risks and Effectiveness of the Selected Remedy
Soil above the site specific standards for lead in Areas 1 and 2 in SWMU 94 and potentially in Area 4 will be excavated to eliminate potential future exposure pathways at these isolated locations. The excavated material will be properly disposed or treated off-site in accordance with Sunoco's waste disposal procedures.

b) Reduction of the Toxicity, Mobility, or Volume of Regulated Substances
The toxicity, mobility and volume of lead in the surface soil in Areas 1 and 2 in SWMU 94 will be removed from these areas through soil excavation.

c) Ease or Difficulty of Implementing the Selected Remedy
Excavation of surface soil in Areas 1 and 2 can be performed without difficulty based on the limited extent of soil to be removed and the open access to these areas. Excavations will be performed using standard construction equipment in accordance with Sunoco's excavation and permitting procedures.

d) The Cost of the Selected Remedy

The soil excavations in Areas 1 and 2 (Figure 12) are limited in extent and volume and therefore the capital costs to perform these excavations and properly handle the materials are low (less than $10,000).

11.3.2 Installation of Asphalt Cover

a) Long-Term Risks and Effectiveness of the Selected Remedy

At the eastern portion of SWMU 101 where the existing soil cover is less than 2.0 feet, and where lead exists in surface soil at concentrations above the site specific standard criteria for lead, the direct contact pathway has been eliminated through installation of asphalt cover. This remedy will significantly reduce the risks associated with the long-term potential direct contact of impacted surface soil by providing a permanent physical barrier between the impacted material and receptors. The post remediation care requirements in this area will also ensure the long-term effectiveness of the asphalt cover.

b) Reduction of the Toxicity, Mobility, or Volume of Regulated Substances

The asphalt cover will reduce the mobility of the regulated substances in soil by reducing or eliminating the effects of atmospheric and anthropogenic soil disturbances. The toxicity and volume of regulated materials will be reduced over time by natural chemical and biological degradation processes.

c) Ease or Difficulty of Implementing the Selected Remedy

Paving of the surface soil in Area 3 was completed without difficulty based on the limited extent of soil to be covered and the open access to the area. Paving activities were completed using standard construction equipment in accordance with Sunoco's paving and permitting procedures.

d) The Cost of the Selected Remedy

The asphalt cover in Area 3 (Figure 12) was limited in extent and therefore the capital costs to complete the paving activities are estimated to be below $10,000.

11.3.3 Installation of HDPE Liner

a) Long-Term Risks and Effectiveness of the Selected Remedy

Soil above the site specific standards for lead in Areas 4 in along the eastern portion of AOI 5 will be capped with a HDPE liner and stone cover to eliminate potential future exposure pathways at the isolated area. The post remediation care requirements in this area will also ensure the long-term effectiveness of the asphalt cover.

b) Reduction of the Toxicity, Mobility, or Volume of Regulated Substances

Installation of the HDPE liner and stone will reduce the mobility of the regulated substances in soil by reducing or eliminating the effects of atmospheric and anthropogenic soil disturbances. While this remedial measure remains in effect, the toxicity and volume of regulated materials will be reduced over time by natural chemical and biological degradation processes.

c) Ease or Difficulty of Implementing the Selected Remedy

Installation of the HDPE liner in Area 4 can be completed without difficulty based on the limited extent of soil to be covered and the open access to the area. Installation activities will be completed using standard construction equipment in accordance with Sunoco's construction and permitting procedures.

d) The Cost of the Selected Remedy

The HDPE liner installation in Area 4 (Figure 12) is limited in extent and therefore the capital costs to perform the installation activities will be low (less than $10,000).

11.4 Remedial Design Plans and Specifications

The selected remedies for AOI 5 are illustrated in Figures 12 and 13. The selected remedies do not require a Remedial Action Status Plan or an Operations and Maintenance ("O&M") Plan as no active ongoing remediation measures are proposed. Any O&M activities associated with the maintenance and monitoring of the excavation or soil cover areas will be incorporated into the Post Remediation Care Plan to be

included in the Final Report. The components of the Post Remediation Care Plan are discussed below.

11.5 Post Remedial Care Plan

This section documents the post remediation care requirements needed to maintain the site-specific standard at the Site in accordance with 25 Pa. Code Chapter 250 §204(g) under both the current and anticipated future Site use scenarios. A formal Post Remediation Care Plan will be prepared as part of the Final Report. Under the current non-residential industrial use scenario, the engineering and institutional controls requiring post remediation care to maintain the site-specific standard will include soil covers which include asphalt in Area 3 and HDPE liner in Area 4. The proposed excavation activities in Areas 1 and 2 will not require a Post Remediation Care Plan as the surface soil above the site specific lead standards in these areas will be removed.

The soil cover in Areas 3 and 4 will be visually inspected on an annual basis to ensure that the surface soil cover layer is not disturbed. An inspection form will be completed for each inspection, maintained at the Site, and will be provided to PADEP. A copy of the inspection form to be utilized will be included in the Post Remediation Care Plan to be provided with the Final Report.

Future activities at the Site may involve planned excavations which reach or extend beneath the soil covers. For these activities, the materials management and health and safety components of the Post Remediation Care Plan will govern. Any proposed modifications to the soil covers will be required to be presented to PADEP prior to modification.

If the integrity of the soil cover(s) is unintentionally breached, corrective activities will be implemented, and the incident will be reported to PADEP. The incident report will describe the incident and the measures implemented to restore the soil cover to its original condition.

The UECA covenant for the areas of the above-mentioned engineering and institutional controls, and other engineering controls that currently exist in AOI 5 will require compliance with the Post Remediation Care Plan. The annual inspection reports to be

submitted to PADEP for the inspection of the engineering controls will include verification that use restrictions are being complied with.

12.0 COMMUNITY RELATION ACTIVITIES

A Community Relation Plan (CRP) that includes public involvement with local residents to inform them of the anticipated investigations and remediation activities was completed as part of the NIR submittal in 2006. The purpose of this CRP is to provide a mechanism for the community, government officials, and other interested or affected citizens to be informed of on-site activities related to the investigation activities at the Site. This plan incorporates aspects of public involvement under both PADEP's Act 2 program and EPA's RCRA Corrective Action program. This report and future Act 2 reports will include the appropriate municipal and public notices in accordance with the provisions of Act 2. Notices will be published in the Pennsylvania Bulletin and a summary of the notice will appear in a local newspaper. As part of the CRP, Sunoco intends to hold an initial public meeting in the city of Philadelphia to present the strategy and give status updates of the project at the CAP meeting on an annual basis.

A copy of the NIR and the Act 2 report notifications for this SCR/RIR are included in Appendix A.

13.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the completed activities, the following conclusions and recommendations have been developed for AOI 5:

SOIL

Shallow Soil – Non-SWMU

- One non-SWMU location identified as Area 4 in the Cleanup Plan had detected lead concentrations above the site-specific standards for lead in soil. This area will either be covered by an HDPE liner or excavated by Sunoco as part of the Cleanup Plan activities described in Section 11.0 above to eliminate the potential exposure pathway.

With regard to the potential direct-contact pathway to deeper soil (i.e., greater than 2 feet deep) and the soil-to-groundwater pathway, the direct contact pathway to soil greater than 2 feet beneath the ground surface at the refinery is incomplete because of on-site procedures and PPE requirements that protect onsite workers from exposure as will be documented in the UECA covenant. The soil-to-groundwater pathway was evaluated using shallow groundwater data as is discussed below.

Soil Within SWMUs

- Shallow soil sample results for lead were compared to the calculated site-specific standards. Three areas within SWMUs 94, 95, and 101 had soil samples that were above the calculated site-specific standards for lead. Areas 1 and 2, as discussed in the Cleanup Plan Section 11.1 above will be excavated to eliminate the potential exposure pathway. Area 3 located in SWMU 101 has already been paved over with asphalt by Sunoco eliminating the potential exposure pathway. As part of the Cleanup Plan, post excavation and capping soil samples will be collected to show delineation of the detections above the non-residential soil MSCs. The results of the post excavation and capping soil samples will be presented in the Final Report.

GROUNDWATER

- Four COCs (benzene, chrysene, MTBE, and lead) were detected in groundwater during the May 2007 groundwater sampling event at concentrations above their respective used-aquifer, non-residential groundwater MSCs. Based on QD and SWLOAD fate and transport simulations, the presence of the sheet pile wall, and groundwater flow direction, concentrations of the above mentioned COCs are not expected to exceed the groundwater MSCs at the site boundary and or affect site receptors (Schuylkill River to the west and/or residential areas to the east).
- Excavations in AOI 5 are governed by Sunoco's permitting procedures which protect against potential exposures to groundwater that could be encountered in an excavation.

VAPOR

- As part of the Cleanup Plan for the current occupied buildings, further evaluation (i.e. soil gas samples) will be necessary to further assess the impact to indoor air.

- The need for further vapor site characterization activities and/or the installation of vapor mitigation systems for future occupied buildings will be performed per the UECA covenant for any new occupied buildings built within AOI 5.

LNAPL

- The horizontal extent of the LNAPL plumes within AOI 5 relative to the site boundaries, have been delineated. Based on the LNAPL types, LNAPL modeling results and recent groundwater gauging activities LNAPL present in AOI 5 is stable and relatively immobile. LNAPL does not appear to have the potential to migrate off-site.
- There are no complete direct contact exposure pathways for LNAPL within AOI 5 because of on-site permitting procedures and required PPE.

14.0 SCHEDULE

The proposed schedule for future Site activities is:

- Implement remaining Cleanup Plan activities;
- Submittal of Final Report; and
- Continue quarterly monitoring activities and reports.

15.0 LIST OF CONTACTS

Below is the list of contacts associated with the Cleanup Plan:

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Phone #: 215.864.0640

16.0 SIGNATURES

The following parties are participating in the remediation at this time and are seeking relief from liability under Act 2 of 1995:

James Oppenheim
Sunoco Inc. (R&M)

This Act 2 SCR/RIR/Cleanup Plan has been prepared in accordance with the final provisions of Act 2 and the June 8, 2002 Land Recycling Program Technical Guidance Manual.

17.0 REFERENCES

Dames & Moore, February 13, 1987, Draft Phase I and II Site Assessment and Investigation, Chevron Refinery, Philadelphia, Pennsylvania

A.T. Kearney, Inc., January 1989, Phase II RCRA Facility Assessment of the Chevron USA, Inc. (GULF) Facility, Philadelphia, Pennsylvania.

Dames& Moore, April 16, 1990, EPA Submittal, RCRA Facility Investigation Work Plan, Chevron Refinery, Philadelphia.

Dames & Moore, December 30, 1992, RCRA Verification Investigation Report, Chevron Refinery, Philadelphia, Pennsylvania.

Dames & Moore, September 30, 1993, Remedial Action Plan Implementation, Chevron Refinery, Philadelphia, Pennsylvania

Dames & Moore, November 24, 1993, RCRA Facility Investigation, Chevron Refinery, Philadelphia Pennsylvania (all volumes and related documents).

U.S. Department of the Interior, Geohydrology and Ground-Water Resources of Philadelphia, Pennsylvania, U.S. Geological Survey, Water-Supply Paper 2346.

Schreffler, C. L., 2001, U.S. Department of the Interior, Simulation of Ground-Water Flow in the Potomac-Raritan-Magothy Aquifer System Near the Defense Supply Center Philadelphia, and the Point Breeze Refinery, Southern Philadelphia County, Pennsylvania, Water-Resources Investigations Report 01-4218, 20 pp.

URS Corporation, 2002, Act 2 Combined Report, Philadelphia Energy Center, Sunoco Philadelphia Refinery, Girard Point Processing Area.

Moffitt, G. R., Chevron, 1992, RCRA Verification Investigation Final Report.

Sloto, R. A., 1988, Simulation of Ground-Water Flow in the Lower Sand Unit of the Potomac-Raritan-Magothy Aquifer System, Philadelphia, Pennsylvania, U.S. Geological Survey, Water-Resources Investigations Report 86-4055.

Pennsylvania Department of Environmental Protection, 2003, Document Number 253-0300-100, Land Recycling Program Technical Guidance Manual – Section IV.A.4. Vapor Intrusion Into Buildings From Groundwater and Soil Under the Act 2 Statewide Health Standard.

TABLES

Table 1
Compounds of Concern for Soil
AOI 5
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

SOIL	
METALS	**CAS No.**
Lead (total)	7439-92-1
VOLATILE ORGANIC COMPOUNDS	**CAS No.**
1,2-dichloroethane	107-06-2
Benzene	71-43-2
Cumene	98-82-8
Ethylbenzene	100-41-4
Ethylene dibromide	106-93-4
Methyl tertiary butyl ether	1634-04-4
Toluene	108-88-3
Xylenes (total)	1330-20-7
SEMI-VOLATILE ORGANIC COMPOUNDS	**CAS No.**
Anthracene	120-12-7
Benzo(a)anthracene	56-55-3
Benzo (g,h,i) perylene	191-24-2
Benzo(a)pyrene	50-32-8
Benzo(b)fluoranthene	205-99-2
Chrysene	218-01-9
Fluorene	86-73-7
Naphthalene	91-20-3
Phenanthrene	85-01-8
Pyrene	129-00-0

Notes:
1. Constituents are from Pennsylvania Corrective Action Process (CAP) Regulation Amendments effective December 1, 2001; provided in Chapter VI, Section E (pgs. 29-30) of PADEP Document, *Closure Requirements for Underground Storage Tank Systems,* effective April 1, 1998 and the March 18, 2008 revised PADEP Short List.

Table 1 (continued)
Compounds of Concern for Groundwater
AOI 5
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

GROUNDWATER	
METALS	**CAS No.**
Lead (dissolved)	7439-92-1
VOLATILE ORGANIC COMPOUNDS	**CAS No.**
1,2-dichloroethane	107-06-2
Benzene	71-43-2
Cumene	98-82-8
Ethylbenzene	100-41-4
Ethylene dibromide	106-93-4
Methyl tertiary butyl ether	1634-04-4
Toluene	108-88-3
Xylenes (total)	1330-20-7
SEMI-VOLATILE ORGANIC COMPOUNDS	**CAS No.**
Chrysene	218-01-9
Fluorene	86-73-7
Naphthalene	91-20-3
Phenanthrene	85-01-8
Pyrene	129-00-0

Notes:
1. Constituents are from Pennsylvania Corrective Action Process (CAP) Regulation Amendments effective December 1, 2001; provided in Chapter VI, Section E (pgs. 29-30) of PADEP Document, *Closure Requirements for Underground Storage Tank Systems,* effective April 1, 1998.

Table 2
Existing Well Summary
AOI 5
Last Updated September 28, 2011
Sunoco Philadelphia Refinery and Belmont Terminal

Well ID	Former Well ID[3]	Well Status/ Description	Disposition of Well	Northing	Easting	Well Type	Well Classification[4]	Soil Boring Log Available (Y/N)	Construction Detail Available (Y/N)	Date of Well Completion	Well Construction Details[2]								References
											Well Completion Depth (ft. bgs)	Well Diameter (in)	Top of Inner Casing Elevation (ft. msl) (NAVD88)	Ground Surface Elevation (ft.) (NAVD88)	Top of Screen Elevation (ft) (NAVD88)	Bottom of Screen Elevation (ft) (NAVD88)	Depth to Screen (ft. bgs)	Screen Length (ft.)	
A	–			–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	Dames & Moore, 1987
A-1	–			215288.956	2683608.072	Monitoring Well	Shallow	Y	Y	2/24/86	16	4	6.85	5.81	0.81	-9.19	5	10	Dames & Moore, 1990
A-10	–			215427.902	2682406.215	Monitoring Well	Shallow	Y	Y	2/25/86	15	4	8.28	8.67	3.67	-6.33	5	10	Dames & Moore, 1990
A-11	–			215380.325	2682015.508	Monitoring Well	Shallow	Y	Y	2/25/86	14	4	7.77	4.59	1.09	-8.91	3.5	10	Dames & Moore, 1990
A-118	–			217109.272	2683070.537	RFI Monitoring Well	Shallow	–	–	–	17.5	4	8.30	5.79	–	–	–	–	Handex, 1996
A-119	–	Destroyed		216989.269	2683357.325	RFI Monitoring Well	Shallow	–	–	–	12.5	4	10.68	7.09	–	–	–	–	Handex, 1996
A-12	–			215378.884	2682182.748	Monitoring Well	Shallow	Y	Y	2/24/86	14 /15.6	4	7.57	4.88	1.88	-8.12	3	10	Dames & Moore, 1990
A-120	–	Unable to Locate		216016.277	2683147.065	RFI Monitoring Well	Shallow	–	–	–	17.3	4	9.17	6.51	–	–	–	–	Handex, 1996
A-121	–			215917.121	2682857.226	RFI Monitoring Well	Shallow	–	–	–	17.5	4	9.32	6.00	–	–	–	–	Handex, 1996
A-122	–			215929.834	2682277.550	RFI Monitoring Well	Shallow	–	–	–	17.6	4	7.44	6.79	–	–	–	–	Handex, 1996
A-13	–			215611.001	2682674.376	Monitoring Well	Shallow	Y	Y	2/27/86	13	4	8.48	6.93	3.93	-6.07	3	10	Dames & Moore, 1990
A-132	–	Destroyed		–	–	Monitoring Well	Shallow	Y	Y	8/19/92	16	4	–	10.35	5.35	-4.65	5	10	Dames & Moore, 1992
A-133	–			215795.084	2681232.606	VI Monitoring Well	Shallow	Y	Y	8/19/92	15	4	13.19	10.69	5.69	-4.31	5	10	Dames & Moore, 1992
A-134	–			215809.959	2681408.542	RFI Monitoring Well	Shallow	Y	Y	8/19/92	15	4	9.14	7.21	2.21	-7.79	5	10	Dames & Moore, 1992
A-135	–			215822.935	2681633.451	RFI Monitoring Well	Shallow	Y	Y	8/21/92	16	4	10.76	8.36	3.36	-6.64	5	10	Dames & Moore, 1992
A-136	–			215556.216	2681692.562	RFI Monitoring Well	Shallow	Y	Y	8/20/92	16	2	8.70	7.52	1.52	-8.48	6	10	Dames & Moore, 1992
A-137	–			215161.003	2683597.259	VI Monitoring Well	Shallow	Y	Y	8/19/92	15	4	8.63	6.29	4.29	-7.71	2	12	Dames & Moore, 1992
A-138	–			–	–	Monitoring Well	Shallow	Y	Y				6.57	6.82	–	–			–
A-139	–			–	–	Monitoring Well	Shallow	Y	Y	3/1/07	15	4	9.12	6.90	4.90	-8.10	2	13	Aquaterra, 2007
A-13D	–			215608.118	2682677.259	Monitoring Well	Deep	Y	Y	11/13/86	69	4	9.39	7.07	-51.93	-61.93	59	10	Handex, 1996
A-14	–			215554.774	2682948.303	Monitoring Well	Shallow	Y	Y	2/26/86	13	4	10.49	8.00	5.00	-5.00	3	10	Dames & Moore, 1990
A-140	–			215636.991	2683699.414	Monitoring Well	Shallow	Y	Y	3/6/07	17	4	9.89	7.32	5.32	-9.68	2	15	Aquaterra, 2007
A-141	–	Destroyed		215375.014	2683659.534	Monitoring Well	Shallow	Y	Y	3/6/07	17	4	10.22	7.63	5.63	-9.37	2	15	Aquaterra, 2007
A-142	–			214931.260	2683675.641	Monitoring Well	Shallow	Y	Y	3/6/07	15	4	8.56	6.14	4.14	-8.86	2	13	Aquaterra, 2007
A-143	–			215553.453	2683339.643	Monitoring Well	Shallow	Y	Y	3/1/07	10	4	9.50	7.08	5.08	-2.92	2	8	Aquaterra, 2007
A-144	–			215735.556	2682907.264	Monitoring Well	Shallow	Y	Y	3/6/07	17	4	9.44	7.20	5.20	-9.80	2	15	Aquaterra, 2007
A-145	–			216182.184	2683206.283	Monitoring Well	Shallow	Y	Y	3/1/07	15	4	7.45	5.12	3.12	-9.88	2	13	Aquaterra, 2007
A-146	–			216551.974	2682962.216	Monitoring Well	Shallow	Y	Y	3/1/07	17	4	10.88	11.31	9.31	-5.69	2	15	Aquaterra, 2007
A-147	–			216815.030	2682850.343	Monitoring Well	Shallow	Y	Y	3/1/07	14	4	7.51	7.74	5.74	-6.26	2	12	Aquaterra, 2007
A-148	–			216806.086	2682640.918	Monitoring Well	Shallow	Y	Y	3/1/07	12	4	8.01	5.70	3.70	-6.30	2	10	Aquaterra, 2007
A-149	–			216327.389	2682442.660	Monitoring Well	Shallow	Y	Y	3/1/07	15	4	8.49	5.59	3.59	-8.41	2	12	Aquaterra, 2007
A-15	–			216313.742	2682689.425	Monitoring Well	Shallow	Y	Y	2/25/86	15	4	5.11	4.79	-0.21	-10.21	5	10	Dames & Moore, 1990
A-150	–			215611.769	2682502.234	Monitoring Well	Shallow	Y	Y	3/6/07	17	4	9.64	7.17	5.17	-9.83	2	15	Aquaterra, 2007
A-151	–			215824.421	2682128.585	Monitoring Well	Shallow	Y	Y	3/1/07	15	4	7.49	5.10	3.10	-9.90	2	13	Aquaterra, 2007
A-152	–			216072.848	2681986.798	Monitoring Well	Shallow	Y	Y	3/6/07	17	4	4.85	2.43	0.43	-14.57	2	15	Aquaterra, 2007
A-153	–	Unable to Locate		217566.468	2683573.476	Monitoring Well	Shallow	Y	Y	3/1/07	17	4	9.22	9.56	7.56	-7.44	2	15	Aquaterra, 2007
A-154	–	Unable to Locate		–	–	Monitoring Well	Shallow	Y	Y	3/6/07	17	4	–	–	–	–	2	15	Aquaterra, 2007
A-155	–			216208.292	2681449.430	Monitoring Well	Shallow	Y	Y	3/1/07	15	4	8.39	5.90	3.90	-9.10	2	13	Aquaterra, 2007
A-16	–			216996.268	2682671.491	Monitoring Well	Shallow	Y	Y	2/25/86	14	4	9.02	6.20	4.70	-5.30	1.5	10	Dames & Moore, 1990
A-17	–	Destroyed		216877.402	2683572.924	Monitoring Well	Shallow	Y	Y	2/27/86	14	4	8.40	8.37	6.37	-3.63	2	10	Dames & Moore, 1990
A-18	–	Destroyed		217223.174	2683607.501	Monitoring Well	Shallow	Y	Y	2/27/86	12	4	8.47	8.61	6.61	-3.39	2	10	Dames & Moore, 1990
A-19	–	Destroyed		217570.980	2683558.686	Monitoring Well	Shallow	Y	Y	2/27/86	11.5	4	9.52	8.47	6.97	-3.03	1.5	10	Dames & Moore, 1990
A-19D	–			217562.844	2683562.754	Monitoring Well	Deep	Y	Y	10/30/86	60	4	10.64	–	–	–	50	10	Dames & Moore, 1990
A-2	–	Destroyed		–	–	Monitoring Well	Shallow	Y	Y	2/27/86	13	4	7.84	–	–	–	3	10	Dames & Moore, 1990
A-20	–	Destroyed		215307.608	2681972.433	Monitoring Well	Shallow	Y	Y	2/24/86	14	4	8.81	–	–	–	4	10	Dames & Moore, 1990
A-21	–			215629.744	2681388.358	Monitoring Well	Shallow	Y	Y	2/25/86	13	4	8.16	7.77	4.77	-5.23	3	10	Dames & Moore, 1990
A-21D	–			215629.744	2681388.358	Monitoring Well	Deep	Y	Y	10/28/86	85	4	11.25	7.94	-67.06	-77.06	75	10	Dames & Moore, 1990
A-22	–			216031.531	2680996.159	Monitoring Well	Shallow	Y	Y	2/2/86	15	4	7.95	7.76	2.76	-7.24	5	10	Dames & Moore, 1990
A-23	–			216384.931	2682142.800	Monitoring Well	Shallow	Y	Y	2/27/86	13	4	6.31	3.79	0.79	-9.21	3	10	Dames & Moore, 1990
A-24	–			215977.199	2681515.230	Monitoring Well	Shallow	Y	Y	2/24/86	14.5	4	5.53	5.56	3.56	-6.44	2	10	Dames & Moore, 1990
A-25	–			216982.319	2682468.225	Monitoring Well	Shallow	Y	Y	2/27/86	13	4	8.80	8.82	5.82	-4.18	3	10	Dames & Moore, 1990
A-26	–			216793.002	2682167.311	Monitoring Well	Shallow	Y	Y	2/27/86	15	4	8.65	9.00	5.50	-4.50	3.5	10	Dames & Moore, 1990
A-27	–			216591.729	2681846.470	Monitoring Well	Shallow	Y	Y	2/27/86	15	4	10.01	9.50	4.50	-5.50	5	10	Dames & Moore, 1990
A-28	–	Destroyed		–	–	Monitoring Well	–	–	–	–	–	–	–	–	–	–	–	–	Dames & Moore, 1987
A-29	–	Destroyed		–	–	Monitoring Well	–	–	–	–	–	–	–	–	–	–	–	–	Dames & Moore, 1987
A-3	–			215784.549	2683411.637	Monitoring Well	Shallow	Y	Y	2/24/86	15	4	8.24	7.66	4.66	-5.34	3	10	Dames & Moore, 1990
A-30	–	Destroyed		–	–	Monitoring Well	–	–	–	–	–	–	–	–	–	–	–	–	Dames & Moore, 1987
A-39	–			215042.061	2683669.345	Monitoring Well	Shallow	Y	Y	7/18/88	13	4	7.68	5.96	2.96	-7.04	3	10	Dames & Moore, 1992

NOTES:

1. Elevation datum for wells within AOI 5 were suryved to NAVD 88 as a part of this report. Survey completed by Langan as part of Work Plan and Site Characterization Activities.
2. Well construction details were taken directly from well boring logs provided by Handex, Stantec (formerly Secor), Aquaterra or collected from available historic reports. Where no well boring logs exist, no well construction data is listed.
3. Former well IDs were derived from handwritten notes on the logs themselves or the referenced report.
4. Well classification based on the formation in which the well was screened in. Wells screened within the Middle Clay or the Farrington Sand were classified as deep wells.
   Well classification for wells screened above the Lower/Middle Clay were based on the following: screened in Fill/Alluvium - Shallow, screened in Trenton Gravel - Intermediate, screened in Fill/Alluvium & Trenton Gravel - Shallow/Intermediate

AOI - Area of Interest
ft. - feet
bgs - below ground surface
in. - inches
msl - elevation relative to mean sea level
g/cc - grams per cubic centimeter
NA - Data not available
Destroyed Wells
– Data could not be located or determined based on available reports

Table 2
Existing Well Summary
AOI 5
Last Updated September 28, 2011
Sunoco Philadelphia Refinery and Belmont Terminal

Well ID	Former Well ID[3]	Well Status/ Description	Disposition of Well	Northing	Easting	Well Type	Well Classification[4]	Soil Boring Log Available (Y/N)	Construction Detail Available (Y/N)	Date of Well Completion	Well Construction Details[2]								References
											Well Completion Depth (ft. bgs)	Well Diameter (in)	Top of Inner Casing Elevation (ft. msl) (NAVD88)	Ground Surface Elevation (ft.) (NAVD88)	Top of Screen Elevation (ft) (NAVD88)	Bottom of Screen Elevation (ft) (NAVD88)	Depth to Screen (ft. bgs)	Screen Length (ft.)	
A-4	–			215000.611	2683519.767	Monitoring Well	Shallow	Y	Y	2/24/86	15	4	6.04	5.85	0.85	-9.15	5	10	Dames & Moore, 1990
A-40	–			215200.651	2683591.853	Monitoring Well	Shallow	Y	Y	7/18/88	13	4	8.63	6.02	3.02	-6.98	3	10	Dames & Moore, 1992
A-41	–			215130.366	2683523.371	Monitoring Well	Shallow	Y	Y	7/18/88	13	4	8.33	5.29	2.29	-7.71	3	10	Dames & Moore, 1992
A-42	–	Destroyed		–	–	Monitoring Well	Shallow	Y	Y	7/19/88	13	4	8.58	7.53	4.53	-5.47	3	10	Dames & Moore, 1992
A-43	–			215588.114	2683119.688	Monitoring Well	Shallow	Y	Y	7/19/88	13	4	10.43	7.89	4.89	-5.11	3	10	Dames & Moore, 1992
A-44	–			215461.963	2683121.490	Monitoring Well	Shallow	Y	Y	7/19/88	13	4	10.01	7.61	4.61	-5.39	3	10	Dames & Moore, 1992
A-45	–			215239.036	2682742.137	Monitoring Well	Shallow	Y	Y	7/19/88	13	4	4.72	4.87	1.87	-8.13	3	10	Dames & Moore, 1992
A-46	–			215347.166	2682463.884	Monitoring Well	Shallow	Y	Y	7/19/88	12	4	10.82	8.56	6.56	-3.44	2	10	Dames & Moore, 1992
A-47	–			215249.128	2682432.166	Monitoring Well	Shallow	Y	Y	7/19/88	12	4	7.42	5.55	3.55	-6.45	2	10	Dames & Moore, 1992
A-48	–			215156.858	2682295.202	Monitoring Well	Shallow	Y	Y	7/20/88	12.5	4	6.45	4.63	2.13	-7.87	2.5	10	Dames & Moore, 1992
A-49	–			215647.044	2682249.067	Monitoring Well	Shallow	Y	Y	7/20/88	13	4	7.20	6.80	3.80	-6.20	3	10	Dames & Moore, 1992
A-5	–			215250.570	2682619.590	Monitoring Well	Shallow	Y	Y	2/25/86	18	4	5.01	5.15	1.15	-11.85	4	13	Dames & Moore, 1990
A-50	–	Destroyed		–	–	Monitoring Well	Shallow	Y	Y	7/20/88	13	4	9.72	–	–	–	3	10	Dames & Moore, 1992
A-51	–	Destroyed		–	–	Monitoring Well	Shallow	Y	Y	7/20/88	12.5	4	11.24	–	–	–	2.5	10	Dames & Moore, 1992
A-6	–			215267.871	2682954.070	Monitoring Well	Shallow	Y	Y	2/24/86	15	4	6.74	7.01	4.01	-7.99	3	12	Dames & Moore, 1990
A-7	–			215287.154	2683087.249	Monitoring Well	Shallow	Y	Y	2/24/86	15	4	6.91	6.87	3.87	-6.13	3	10	Dames & Moore, 1990
A-8	–	Destroyed		215079.005	2682870.450	Monitoring Well	Shallow	Y	Y	2/24/86	15	4	6.29	5.24	0.24	-9.76	5	10	Dames & Moore, 1990
A-9	–			215096.126	2683089.052	Monitoring Well	Shallow	Y	Y	2/24/86	15	4	5.80	5.95	2.95	-7.05	3	10	Dames & Moore, 1990
A-91	–			216549.935	2683363.427	Monitoring Well	Shallow	Y	Y	10/21/86	13	4	9.88	7.40	4.40	-5.60	3	10	Dames & Moore, 1990
B	–	Destroyed		–	–	Monitoring Well	–	–	–	–	–	–	–	–	–	–	–	–	Dames & Moore, 1987
C	–	Destroyed		–	–	Monitoring Well	–	–	–	–	–	–	–	–	–	–	–	–	Dames & Moore, 1987
PZ-1	–	Damaged	Blocked at ~2.5 ft bgs	215883.487	2681473.420	RFI Well Point Loc.	Shallow	–	–	–	–	–	7.76	4.84	–	–	–	–	Handex, 1996
PZ-2	–			215938.273	2681495.046	RFI Well Point Loc.	Shallow	–	–	–	–	–	10.88	5.12	–	–	–	–	Handex, 1996
PZ-3	–			215958.457	2681510.905	RFI Well Point Loc.	Shallow	–	–	–	–	–	10.53	5.74	–	–	–	–	Handex, 1996
RW-6S	RW-6			215947.481	2681519.677	Recovery Well	Shallow	–	–	–	14.6	4	8.22	5.22	–	–	–	–	–
RW16-2	–	Destroyed		–	–	Monitoring Well	Shallow	–	–	–	–	–	–	–	–	–	–	–	Handex, 1996
RWBH-1	–			215219.405	2682069.647	Recovery Well - Active	Shallow	Y	–	3/19/96	11.5	4	5.33	5.36	3.86	-6.14	1.5	10	Handex, 1996
RWBH-2	–			215220.069	2682108.595	Recovery Well - Active	Shallow	Y	–	3/22/96	8	4	4.13	4.33	2.33	-3.67	2	6	Handex, 1996
RWM-8	–	Destroyed		–	–	Monitoring Well	–	–	–	–	–	–	–	–	–	–	–	–	Handex, 1996
RWM-9	–	Destroyed		–	–	Monitoring Well	–	–	–	–	–	–	–	–	–	–	–	–	Handex, 1996
SW-1	–			215437.008	2681673.285	RFI Monitoring Well	Shallow	–	–	–	20	4	9.76	7.19	–	–	–	–	Handex, 1996
SW-2	–			215458.201	2681632.848	RFI Monitoring Well	Shallow	–	–	–	18.6	4	9.94	7.71	–	–	–	–	Handex, 1996
SW-3	–			215491.872	2681564.953	Monitoring Well	Shallow	–	–	–	18	4	9.97	7.85	–	–	–	–	Handex, 1996
SW-4	–			215533.919	2681486.195	RFI Monitoring Well	Shallow	–	–	–	15.6	4	7.15	7.22	–	–	–	–	Handex, 1996
SW-5	–			215654.599	2681321.800	RFI Monitoring Well	Shallow	–	–	–	14.6	4	10.49	7.84	–	–	–	–	Handex, 1996
SWR-1				215697.370	2681283.470	Recovery Well - Inactive	Shallow						8.28						
SWR-2	–			215397.239	2681737.115	Recovery Well - Inactive	Shallow	–	–	–	15	4	10.06	8.41	–	–	–	–	Handex, 1996
SWR-3	–			215359.059	2681810.735	Recovery Well - Inactive	Shallow	–	–	–	11.6	4	10.61	–	–	–	–	–	Handex, 1996
WP1-1	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	6/4/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP1-2	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	6/4/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP1-3	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	6/4/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP1-4	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	6/3/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP1-5	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	6/3/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP1-6	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	6/8/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP1-7	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/26/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP1-8	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/26/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP1-9	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	6/3/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP1-10	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/26/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP1-11	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/26/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP1-12	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	6/3/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP1-13	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	6/15/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP1-14	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	6/15/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP1-15	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	6/24/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP2-1	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/28/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP2-2	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/28/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP2-3	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/28/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP2-4	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/28/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP2-5	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/28/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993

NOTES:

1. Elevation datum for wells within AOI 5 were suryved to NAVD 88 as a part of this report. Survey completed by Langan as part of Work Plan and Site Characterization Activities.
2. Well construction details were taken directly from well boring logs provided by Handex, Stantec (formerly Secor), Aquaterra or collected from available historic reports. Where no well boring logs exist, no well construction data is listed.
3. Former well IDs were derived from handwritten notes on the logs themselves or the referenced report.
4. Well classification based on the formation in which the well was screened in. Wells screened within the Middle Clay or the Farrington Sand were classified as deep wells.
   Well classification for wells screened above the Lower/Middle Clay were based on the following: screened in Fill/Alluvium - Shallow, screened in Trenton Gravel - Intermediate, screened in Fill/Alluvium & Trenton Gravel - Shallow/Intermediate

AOI - Area of Interest
ft. - feet
bgs - below ground surface
in. - inches
msl - elevation relative to mean sea level
g/cc - grams per cubic centimeter
NA - Data not available
Destroyed Wells
– Data could not be located or determined based on available reports

Table 2
Existing Well Summary
AOI 5
Last Updated September 28, 2011
Sunoco Philadelphia Refinery and Belmont Terminal

Well ID	Former Well ID[3]	Well Status/ Description	Disposition of Well	Northing	Easting	Well Type	Well Classification[4]	Soil Boring Log Available (Y/N)	Construction Detail Available (Y/N)	Date of Well Completion	Well Construction Details[2]								References
											Well Completion Depth (ft. bgs)	Well Diameter (in)	Top of Inner Casing Elevation (ft. msl) (NAVD88)	Ground Surface Elevation (ft.) (NAVD88)	Top of Screen Elevation (ft) (NAVD88)	Bottom of Screen Elevation (ft) (NAVD88)	Depth to Screen (ft. bgs)	Screen Length (ft.)	
WP2-6	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/28/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP2-7	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/28/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP2-8	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/28/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP2-9	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/28/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP2-10	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/28/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP2-11	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/28/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP2-12	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/28/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP2-13	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/28/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP2-14	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/28/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP3-1	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/28/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP3-2	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/28/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP3-3	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/28/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP3-4	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/28/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP3-5	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/28/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP3-6	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/28/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP3-7	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/28/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP3-8	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/28/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP3-9	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/28/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP3-10	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/28/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP3-11	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/28/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP3-12	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/28/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP4-1	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	6/1/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP4-2	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	6/1/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP4-3	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	6/1/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP4-4	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	6/1/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP4-5	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	6/1/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP5-1	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	6/11/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP5-2	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	6/11/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP5-3	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	6/11/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP6-1	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/25/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP6-2	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/25/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP6-3	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/25/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP6-4	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/25/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP7-1	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/25/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP7-2	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/25/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP7-3	–	Destroyed		–	–	Temporary Well Point	–	Y	Y	5/25/93	10.5	–	–	–	–	–	0.5	10	Dames & Moore, 1993
WP-1	–	Destroyed		–	–	Temporary Well Point	–	–	–	–	4	–	5.74	4.61	–	–	–	–	Handex, 1996
WP-10	–	Destroyed		215290.938	2682063.085	Temporary Well Point	–	–	–	–	–	–	–	10.16	–	–	–	–	Handex, 1996
WP-14	–			215243.362	2682198.607	Temporary Well Point	Shallow	–	–	–	9	2	9.12	4.24	–	–	–	–	Handex, 1996
WP16-1	–	Destroyed		216966.376	2682416.412	Temporary Well Point	–	–	–	–	–	–	–	13.19	–	–	–	–	Handex, 1996
WP16-3	–			216898.621	2682402.462	Temporary Well Point	Shallow	–	–	–	14.5	2	11.07	7.34	–	–	–	–	Handex, 1996
WP16-4	–	Destroyed		216970.362	2682549.930	Temporary Well Point	–	–	–	–	–	–	–	9.27	–	–	–	–	Handex, 1996
WP-1a	–	Destroyed		–	–	Temporary Well Point	–	–	–	–	–	–	–	–	–	–	–	–	Handex, 1996
WP-2	–	Destroyed		215256.247	2682083.943	Temporary Well Point	–	–	–	–	2	–	5.83	4.82	–	–	–	–	Handex, 1996
WP-2a	–	Destroyed				Temporary Well Point	–	–	–	–	–	–	–	–	–	–	–	–	Handex, 1996
WP-3	–	Destroyed		215256.450	2682128.553	Temporary Well Point	Shallow	–	–	–	4	–	5.11	5.12	–	–	–	–	Handex, 1996
WP-3a	–	Destroyed		–	–	Temporary Well Point	–	–	–	–	–	–	–	–	–	–	–	–	Handex, 1996
WP-4a	–	Destroyed		215009.622	2683231.422	Temporary Well Point	Shallow	–	–	–	9.5	2	6.70	–	–	–	–	–	Handex, 1996
WP-5	–	Destroyed		–	–	Temporary Well Point	Shallow	–	–	–	–	–	6.50	4.60	–	–	–	–	Handex, 1996
WP-5a	–	Destroyed		–	–	Temporary Well Point	–	–	–	–	–	–	–	–	–	–	–	–	Handex, 1996
WP-7	–	Destroyed		–	–	Temporary Well Point	Shallow	–	–	–	–	–	–	8.84	–	–	–	–	Handex, 1996
WP-8	–			215136.674	2682440.816	Temporary Well Point	Shallow	–	–	–	9	2	6.99	3.98	–	–	–	–	Handex, 1996
WP-9	–			215223.177	2682225.999	Temporary Well Point	Shallow	–	–	–	13	2	8.57	5.75	–	–	–	–	Handex, 1996
WP9-7	–	Destroyed		216462.196	2681507.693	Temporary Well Point	–	–	–	–	–	–	–	8.25	–	–	–	–	Handex, 1996
WP9-8	–			216376.530	2681391.260	Temporary Well Point	–	–	–	–	–	–	8.87	6.17	–	–	–	–	Handex, 1996
WP-A	–			215593.701	2681386.916	Temporary Well Point	Shallow	–	–	–	13	2	9.60	7.35	–	–	–	–	Handex, 1996
WP-B	–			215667.228	2681310.505	Temporary Well Point	Shallow	–	–	–	12	2	10.08	7.12	–	–	–	–	Handex, 1996
WP-C	–			215696.063	2681466.211	Temporary Well Point	Shallow	–	–	–	12.6	2	9.98	7.38	–	–	–	–	Handex, 1996
WP-D	–			215913.763	2681483.512	Temporary Well Point	Shallow	–	–	–	11.6	2	8.26	5.36	–	–	–	–	Handex, 1996
WP-E	–			215985.849	2681621.917	Temporary Well Point	Shallow	–	–	–	10.5	2	7.35	5.08	–	–	–	–	Handex, 1996

NOTES:

1. Elevation datum for wells within AOI 5 were suryved to NAVD 88 as a part of this report. Survey completed by Langan as part of Work Plan and Site Characterization Activities.
2. Well construction details were taken directly from well boring logs provided by Handex, Stantec (formerly Secor), Aquaterra or collected from available historic reports. Where no well boring logs exist, no well construction data is listed.
3. Former well IDs were derived from handwritten notes on the logs themselves or the referenced report.
4. Well classification based on the formation in which the well was screened in. Wells screened within the Middle Clay or the Farrington Sand were classified as deep wells.
   Well classification for wells screened above the Lower/Middle Clay were based on the following: screened in Fill/Alluvium - Shallow, screened in Trenton Gravel - Intermediate, screened in Fill/Alluvium & Trenton Gravel - Shallow/Intermediate

AOI - Area of Interest
ft. - feet
bgs - below ground surface
in. - inches
msl - elevation relative to mean sea level
g/cc - grams per cubic centimeter
NA - Data not available
Destroyed Wells
– Data could not be located or determined based on available reports

Table 3
Summary of Groundwater and LNAPL Elevations
AOI 5
May 2011
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Monitoring Point ID	Northing	Easting	Well Type	Well Classification[4]	Specific Gravity (g/cc) Used for GW Correction		Depth to Product (ft btic)	Depth to GW[5] (ft btic)	Apparent LNAPL Thickness (ft)	LNAPL Elevation[6] (ft amsl)	Groundwater Elevation (ft amsl)	Corrected GW Elevation (ft amsl)	TIC Elevation (ft. msl)	Notes
					S.G.[2]	Source[3]								
A	–	–												
A-1	215288.956	2683608.072	Monitoring Well	Shallow			–	4.00	–	–	2.85	2.85	6.85	
A-10	215427.902	2682406.215	Monitoring Well	Shallow			–	3.70	–	–	4.58	4.58	8.28	
A-11	215380.325	2682015.508	Monitoring Well	Shallow			–	4.58	–	–	3.19	3.19	7.77	
A-118	217109.272	2683070.537	RFI Monitoring Well	Shallow			–	3.71	–	–	4.59	4.59	8.30	
A-119	216989.269	2683357.325	RFI Monitoring Well	Shallow										Destroyed during PECO Construction
A-12	215378.884	2682182.748	Monitoring Well	Shallow			–	5.00	–	–	2.57	2.57	7.57	
A-120	216016.277	2683147.065	RFI Monitoring Well	Shallow			–		–	–		–	9.17	
A-121	215917.121	2682857.226	RFI Monitoring Well	Shallow			–	5.82	–	–	3.50	3.50	9.32	
A-122	215929.834	2682277.550	RFI Monitoring Well	Shallow			–	4.73	–	–	2.71	2.71	7.44	
A-13	215611.001	2682674.376	Monitoring Well	Shallow	0.9015	A-13	5.25	5.80	**0.55**	3.23	2.68	3.18	8.48	
A-132	–	–	Monitoring Well	Shallow										
A-133	215795.084	2681232.606	VI Monitoring Well	Shallow			–	7.90	–	–	5.29	5.29	13.19	
A-134	215809.959	2681408.542	RFI Monitoring Well	Shallow			–	6.86	–	–	2.28	2.28	9.14	
A-135	215822.935	2681633.451	RFI Monitoring Well	Shallow			–	7.85	–	–	2.91	2.91	10.76	
A-136	215556.216	2681692.562	RFI Monitoring Well	Shallow	0.9767	A-136	6.60	6.61	**0.01**	2.10	2.09	2.10	8.70	
A-137	215161.003	2683597.259	VI Monitoring Well	Shallow			–	5.89	–	–	2.74	2.74	8.63	
A-138	–	–	Monitoring Well	Shallow			–	2.78	–	–	3.79	3.79	6.57	
A-139	–	–	Monitoring Well	Shallow			–	4.39	–	–	4.73	4.73	9.12	
A-13D	215608.118	2682677.259	Monitoring Well	Deep			–	11.30	–	–	-1.91	-1.91	9.39	
A-14	215554.774	2682948.303	Monitoring Well	Shallow	0.9143	A-14	7.00	7.20	**0.20**	3.49	3.29	3.47	10.49	
A-140	215636.991	2683699.414	Monitoring Well	Shallow			–	4.33	–	–	5.56	5.56	9.89	
A-141	215375.014	2683659.534	Monitoring Well	Shallow										
A-142	214931.260	2683675.641	Monitoring Well	Shallow			–	6.90	–	–	1.66	1.66	8.56	
A-143	215553.453	2683339.643	Monitoring Well	Shallow			–	6.00	–	–	3.50	3.50	9.50	
A-144	215735.556	2682907.264	Monitoring Well	Shallow	0.8753	A-144	5.20	6.80	**1.60**	4.24	2.64	4.04	9.44	
A-145	216182.184	2683206.283	Monitoring Well	Shallow			–	3.08	–	–	4.37	4.37	7.45	
A-146	216551.974	2682962.216	Monitoring Well	Shallow			–	4.50	–	–	6.38	6.38	10.88	
A-147	216815.030	2682850.343	Monitoring Well	Shallow			–	1.73	–	–	5.78	5.78	7.51	
A-148	216806.086	2682640.918	Monitoring Well	Shallow			–	2.63	–	–	5.38	5.38	8.01	
A-149	216327.389	2682442.660	Monitoring Well	Shallow			–	3.20	–	–	5.29	5.29	8.49	
A-15	216313.742	2682689.425	Monitoring Well	Shallow			–	1.10	–	–	4.01	4.01	5.11	
A-150	215611.769	2682502.234	Monitoring Well	Shallow	0.9015	A-13	–	5.23	–	–	4.41	4.41	9.64	
A-151	215824.421	2682128.585	Monitoring Well	Shallow			–	4.25	–	–	3.24	3.24	7.49	
A-152	216072.848	2681986.798	Monitoring Well	Shallow			–	3.00	–	–	1.85	1.85	4.85	
A-153	217566.468	2683573.476	Monitoring Well	Shallow			–		–	–		–	9.22	
A-154	–	–	Monitoring Well	Shallow			–		–	–		–	–	
A-155	216208.292	2681449.430	Monitoring Well	Shallow	0.8777	A-155	5.18	6.33	**1.15**	3.21	2.06	3.07	8.39	
A-16	216996.268	2682671.491	Monitoring Well	Shallow			–	4.76	–	–	4.26	4.26	9.02	
A-17	216877.402	2683572.924	Monitoring Well	Shallow			–	NM	–	–	-	-	8.40	Well destroyed;redrilled and destroyed again
A-18	217223.174	2683607.501	Monitoring Well	Shallow										
A-19	217570.980	2683558.686	Monitoring Well	Shallow										
A-19D	217562.844	2683562.754	Monitoring Well	Deep			–	5.18	–	–	5.46	5.46	10.64	

NOTES:

1. Elevation datum for wells within AOI 5 were surveyed to NAVD 88 as a part of this report. Survey completed by Langan as part of Work Plan and Site Characterization Activities.
2. Specific gravity (S.G.) values were determined from LNAPL samples collected by Aquaterra/Stantec as part of CCR and/or SCR/RIR.
3. For wells with no direct LNAPL density values, the density value in the nearest well with LNAPL data was used.
4. Well classification based on the formation in which the well was screened in. Wells screened within the Middle Clay or the Farrington Sand were classified as deep wells.
   Well classification for wells screened above the Lower/Middle Clay were based on the following: screened in Fill/Alluvium - Shallow, screened in Trenton Gravel - Intermediate, screened in Fill/Alluvium & Trenton Gravel - Shallow/Intermediate
5. Depth to water and depth to LNAPL provided by Stantec/Aquaterra. All wells gauged in May 2011 unless otherwise noted.

0.01 foot Apparent LNAPL Thickness = Sheen or Film of Product on Groundwater.
AOI - Area of Interest
LNAPL - Light Non-Aqueous Phase Liquid
GW - Groundwater
ft - Feet
bgs - Below Ground Surface
tic - Top of Inner Casing
in - Inches
msl - Elevation Relative to Mean Sea Level
g/cc - Grams Per cubic centimeter
NA - Data Not Available
Destroyed Wells

Table 3
Summary of Groundwater and LNAPL Elevations
AOI 5
May 2011
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Monitoring Point ID	Northing	Easting	Well Type	Well Classification[4]	Specific Gravity (g/cc) Used for GW Correction		Depth to Product (ft btic)	Depth to GW[5] (ft btic)	Apparent LNAPL Thickness (ft)	LNAPL Elevation[6] (ft amsl)	Groundwater Elevation (ft amsl)	Corrected GW Elevation (ft amsl)	TIC Elevation (ft. msl)	Notes
					S.G.[2]	Source[3]								
A-2	--	--	Monitoring Well	Shallow										
A-20	215307.608	2681972.433	Monitoring Well	Shallow										
A-21	215629.744	2681388.358	Monitoring Well	Shallow	0.9100	SW-4	1.90	1.90	**0.01**	6.26	6.26	6.27	8.16	
A-21D	215629.744	2681388.358	Monitoring Well	Deep			--	16.28	--	--	-5.03	-5.03	11.25	
A-22	216031.531	2680996.159	Monitoring Well	Shallow	0.9356	A-22	--	4.50	--	--	3.45	3.45	7.95	
A-23	216384.931	2682142.800	Monitoring Well	Shallow			--	3.55	--	--	2.76	2.76	6.31	
A-24	215977.199	2681515.230	Monitoring Well	Shallow	0.8953	A-24	1.60	1.60	**0.01**	3.93	3.93	3.94	5.53	
A-25	216982.319	2682468.225	Monitoring Well	Shallow			--	3.24	--	--	5.56	5.56	8.80	
A-26	216793.002	2682167.311	Monitoring Well	Shallow			--	4.95	--	--	3.70	3.70	8.65	
A-27	216591.729	2681846.470	Monitoring Well	Shallow			--	5.95	--	--	4.06	4.06	10.01	
A-28	--	--	Monitoring Well	--										
A-29	--	--	Monitoring Well	--										
A-3	215784.549	2683411.637	Monitoring Well	Shallow			--	4.85	--	--	3.39	3.39	8.24	
A-30	--	--	Monitoring Well	--										
A-39	215042.061	2683669.345	Monitoring Well	Shallow			--	2.63	--	--	5.05	5.05	7.68	
A-4	215000.611	2683519.767	Monitoring Well	Shallow	0.9100	A-4	--	4.06	--	--	1.98	1.98	6.04	
A-40	215200.651	2683591.853	Monitoring Well	Shallow			--	5.92	--	--	2.71	2.71	8.63	
A-41	215130.366	2683523.371	Monitoring Well	Shallow			--	5.69	--	--	2.64	2.64	8.33	
A-42	--	--	Monitoring Well	Shallow										
A-43	215588.114	2683119.688	Monitoring Well	Shallow			--	6.18	--	--	4.25	4.25	10.43	
A-44	215461.963	2683121.490	Monitoring Well	Shallow			--	6.63	--	--	3.38	3.38	10.01	
A-45	215239.036	2682742.137	Monitoring Well	Shallow	0.9124	A-5	--	3.31	--	--	1.41	1.41	4.72	
A-46	215347.166	2682463.884	Monitoring Well	Shallow	0.8926	A-47	7.30	7.34	**0.04**	3.52	3.48	3.52	10.82	
A-47	215249.128	2682432.166	Monitoring Well	Shallow			--	5.25	--	--	2.17	2.17	7.42	
A-48	215156.858	2682295.202	Monitoring Well	Shallow	0.9100	A-48	--	3.78	--	--	2.67	2.67	6.45	
A-49	215647.044	2682249.067	Monitoring Well	Shallow			--	3.45	--	--	3.75	3.75	7.20	
A-5	215250.570	2682619.590	Monitoring Well	Shallow	0.9124	A-5	4.30	4.40	**0.10**	0.71	0.61	0.70	5.01	
A-50	--	--	Monitoring Well	Shallow										
A-51	--	--	Monitoring Well	Shallow										
A-6	215267.871	2682954.070	Monitoring Well	Shallow			--	3.30	--	--	3.44	3.44	6.74	
A-7	215287.154	2683087.249	Monitoring Well	Shallow	0.8905	A-7	2.95	2.95	**0.01**	3.96	3.96	3.97	6.91	
A-8	215079.005	2682870.450	Monitoring Well	Shallow										
A-9	215096.126	2683089.052	Monitoring Well	Shallow			--	3.16	--	--	2.64	2.64	5.80	
A-91	216549.935	2683363.427	Monitoring Well	Shallow			--	4.93	--	--	4.95	4.95	9.88	
B	--	--	Monitoring Well	--										
C	--	--	Monitoring Well	--										
PZ-1	215883.487	2681473.420	RFI Well Point Loc.	Shallow			--	NM	--	--		--	7.76	Dry or Blocked at 2.40 ft bgs
PZ-2	215938.273	2681495.046	RFI Well Point Loc.	Shallow			--	7.75	--	--	3.13	3.13	10.88	
PZ-3	215958.457	2681510.905	RFI Well Point Loc.	Shallow			--	6.30	--	--	4.23	4.23	10.53	
RW-6S	215947.481	2681519.677	Recovery Well	Shallow			--	4.74	--	--	3.48	3.48	8.22	
RW16-2	--	--	Monitoring Well	Shallow										
RWBH-1	215219.405	2682069.647	Recovery Well - Active	Shallow	0.9100	A-48	--	3.21	--	--	2.12	2.12	5.33	
RWBH-2	215220.069	2682108.595	Recovery Well - Active	Shallow	0.9100	A-48	--	3.53	--	--	0.60	0.60	4.13	
RWM-8	--	--	Monitoring Well	--										
RWM-9	--	--	Monitoring Well	--										

NOTES:

1. Elevation datum for wells within AOI 5 were surveyed to NAVD 88 as a part of this report. Survey completed by Langan as part of Work Plan and Site Characterization Activities.
2. Specific gravity (S.G.) values were determined from LNAPL samples collected by Aquaterra/Stantec as part of CCR and/or SCR/RIR.
3. For wells with no direct LNAPL density values, the density value in the nearest well with LNAPL data was used.
4. Well classification based on the formation in which the well was screened in. Wells screened within the Middle Clay or the Farrington Sand were classified as deep wells.
   Well classification for wells screened above the Lower/Middle Clay were based on the following: screened in Fill/Alluvium - Shallow, screened in Trenton Gravel - Intermediate, screened in Fill/Alluvium & Trenton Gravel - Shallow/Intermediate
5. Depth to water and depth to LNAPL provided by Stantec/Aquaterra. All wells gauged in May 2011 unless otherwise noted.

<0.01 - Sheen or Film of Product on Groundwater.
AOI - Area of Interest
LNAPL - Light Non-Aqueous Phase Liquid
GW - Groundwater
ft - Feet
bgs - Below Ground Surface
tic - Top of Inner Casing
in - Inches
msl - Elevation Relative to Mean Sea Level
g/cc - Grams Per cubic centimeter
NA - Data Not Available
[ ] Destroyed Wells

Table 3
Summary of Groundwater and LNAPL Elevations
AOI 5
May 2011
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Monitoring Point ID	Northing	Easting	Well Type	Well Classification[4]	Specific Gravity (g/cc) Used for GW Correction		Depth to Product (ft btic)	Depth to GW[5] (ft btic)	Apparent LNAPL Thickness (ft)	LNAPL Elevation[6] (ft amsl)	Groundwater Elevation (ft amsl)	Corrected GW Elevation (ft amsl)	TIC Elevation (ft. msl)	Notes
					S.G.[2]	Source[3]								
SW-1	215437.008	2681673.285	RFI Monitoring Well	Shallow	0.9100	SW-1	7.91	8.53	0.62	1.85	1.23	1.79	9.76	
SW-2	215458.201	2681632.848	RFI Monitoring Well	Shallow			--	7.21	--	--	2.73	2.73	9.94	
SW-3	215491.872	2681564.953	Monitoring Well	Shallow			--	8.10	--	--	1.87	1.87	9.97	
SW-4	215533.919	2681486.195	RFI Monitoring Well	Shallow	0.9100	SW-4	4.98	5.05	0.07	2.17	2.10	2.16	7.15	
SW-5	215654.599	2681321.800	RFI Monitoring Well	Shallow	0.9356	A-22	5.47	5.49	NA	--	5.00	5.00	10.49	Product is viscous
SWR-1	215697.370	2681283.470	Recovery Well - Inactive	Shallow			--	5.05	--	--	3.23	3.23	8.28	
SWR-2	215397.239	2681737.115	Recovery Well - Inactive	Shallow			--	8.64	--	--	1.42	1.42	10.06	
SWR-3	215359.059	2681810.735	Recovery Well - Inactive	Shallow			--	9.52	--	--	1.09	1.09	10.61	
WP7-2	--	--	Temporary Well Point	--										
WP7-3	--	--	Temporary Well Point	--										
WP-1	--	--	Temporary Well Point	--										
WP-10	215290.938	2682063.085	Temporary Well Point	--										
WP-14	215243.362	2682198.607	Temporary Well Point	Shallow			--	5.79	--	--	3.33	3.33	9.12	
WP16-1	216966.376	2682416.412	Temporary Well Point	--									--	
WP16-3	216898.621	2682402.462	Temporary Well Point	Shallow			--	4.95	--	--	6.12	6.12	11.07	
WP16-4	216970.362	2682549.930	Temporary Well Point	--										
WP-1a	--	--	Temporary Well Point	--										
WP-2	215256.247	2682083.943	Temporary Well Point	--										
WP-2a			Temporary Well Point	--										
WP-3	215256.450	2682128.553	Temporary Well Point	Shallow										
WP-3a	--	--	Temporary Well Point	--										
WP-4a	215009.622	2683231.422	Temporary Well Point	Shallow										
WP-5	--	--	Temporary Well Point	Shallow										
WP-5a	--	--	Temporary Well Point	--										
WP-7	--	--	Temporary Well Point	Shallow										
WP-8	215136.674	2682440.816	Temporary Well Point	Shallow			--	3.83	--	--	3.16	3.16	6.99	
WP-9	215223.177	2682225.999	Temporary Well Point	Shallow			--	4.90	--	--	3.67	3.67	8.57	
WP9-7	216462.196	2681507.693	Temporary Well Point	--										
WP9-8	216376.530	2681391.260	Temporary Well Point	--			--		--	--	--	--	8.87	
WP-A	215593.701	2681386.916	Temporary Well Point	Shallow	0.9356	A-22	4.87	4.87	0.01	4.73	4.73	4.74	9.60	
WP-B	215667.228	2681310.505	Temporary Well Point	Shallow	0.9356	A-22	6.82	7.34	0.52	3.26	2.74	3.23	10.08	
WP-C	215696.063	2681466.211	Temporary Well Point	Shallow			--	7.52	--	--	2.46	2.46	9.98	
WP-D	215913.763	2681483.512	Temporary Well Point	Shallow			--	5.13	--	--	3.13	3.13	8.26	
WP-E	215985.849	2681621.917	Temporary Well Point	Shallow			--	4.37	--	--	2.98	2.98	7.35	

NOTES:

1. Elevation datum for wells within AOI 5 were surveyed to NAVD 88 as a part of this report. Survey completed by Langan as part of Work Plan and Site Characterization Activities.
2. Specific gravity (S.G.) values were determined from LNAPL samples collected by Aquaterra/Stantec as part of CCR and/or SCR/RIR.
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Table 4
Summary of Soil Sample Analytical Results: Outside SWMU Areas
AOI 5
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Chemical Name	CAS No	PADEP Non-Residential Soil to Groundwater MSC for Unsaturated Soils Used Aquifer, (TDS<2,500)	PADEP Non-Residential Direct Contact (0 - 2 ft bgs)	PADEP Non-Residential Used Aquifer Unsaturated Soil MSCs (TDS<2,500)	Location ID	A-139				A-140				A-143				A-151				A_152				A-140			
					Sample ID	A-139_071207_1.5-2.0				A-140_071207_1.5-2.0				A-143_0712_1.5-2.0				A-151_071207_1.5-2.0				A-152_071207_1.5-2.0				A-140			
					Sample Matrix	Soil				Soil				Soil				Soil				Soil				Soil			
					Sample Depth	1.5-2.0				1.5-2.0				1.5-2.0				1.5-2.0				1.5-2.0				1.5-2.0			
					Sample Date	7/12/2007				7/12/2007				7/12/2007				7/12/2007				7/12/2007				4/6/2009			
					Unit	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF
Volatile Organic Compounds																													
1,2-Dichloroethane	107-06-2	0.5	86	0.5	mg/kg	ND	U	0.0053	--	ND	U	0.0038	--	ND	U	0.0035	--	ND	U	0.0035	--	ND	U	0.0031	--	ND	U	0.24	42.81
Benzene	71-43-2	0.5	290	0.5	mg/kg	ND	U	0.0053	--	ND	U	0.0038	--	ND	U	0.0035	--	0.036	0	0.0035	--	ND	U	0.0031	--	ND	U	0.24	42.81
Cumene	98-82-8	2500	10000	2500	mg/kg	ND	U	0.0053	--	ND	U	0.0038	--	ND	U	0.0035	--	ND	U	0.0035	--	ND	U	0.0031	--	ND	U	0.24	42.81
Ethylbenzene	100-41-4	70	10000	70	mg/kg	ND	U	0.0053	--	ND	U	0.0038	--	ND	U	0.0035	--	ND	U	0.0035	--	ND	U	0.0031	--	ND	U	0.24	42.81
Ethylene Dibromide (EDB)	106-93-4	0.005	3.7	0.005	mg/kg	ND	U	**0.0053**	--	ND	U	0.0038	--	ND	U	0.0035	--	ND	U	0.0035	--	ND	U	0.0031	--	ND	U	**0.24**	42.81
Methyl Tertiary Butyl Ether	1634-04-4	2	3200	2	mg/kg	ND	U	0.0053	--	ND	U	0.0038	--	ND	U	0.0035	--	ND	U	0.0035	--	ND	U	0.0031	--	ND	U	0.24	42.81
Toluene	108-88-3	100	10000	100	mg/kg	ND	U	0.0053	--	ND	U	0.0038	--	ND	U	0.0035	--	0.0056	0	0.0035	--	ND	U	0.0031	--	ND	U	0.24	42.81
Xylene (Total)	1330-20-7	1000	8000	1000	mg/kg	ND	U	0.0053	--	ND	U	0.0075	--	ND	U	0.0071	--	0.0086	0	0.0070	--	ND	U	0.0063	--	ND	U	0.24	42.81
Semi-Volatile Organic Compounds																													
Anthracene	120-12-7	350	190000	350	mg/kg	ND	U	0.85	--	2.2		2	--	ND	U	0.38	--	ND	U	1.9	--	ND	U	1.9	--	0.87		0.19	1
Benzo(a)anthracene	56-55-3	320	110	320	mg/kg	ND	U	0.85	--	5.1		2	--	ND	U	0.38	--	ND	U	1.9	--	ND	U	1.9	--	2.3		0.19	1
Benzo(a)pyrene	50-32-8	46	11	46	mg/kg	ND	U	0.85	--	6.1		2	--	ND	U	0.38	--	ND	U	1.9	--	ND	U	1.9	--	1.9		0.19	1
Benzo(b)fluoranthene	205-99-2	170	110	170	mg/kg	0.93		0.85	--	6.1		2	--	ND		0.38	--	ND		1.9	--	ND		1.9	--	2.6		0.19	1
Benzo(g,h,i)perylene	191-24-2	180	170000	180	mg/kg	ND	U	0.85	--	ND	U	2	--	ND	U	0.38	--	ND	U	1.9	--	ND	U	1.9	--	1.1		0.19	1
Chrysene	218-01-9	230	11000	230	mg/kg	ND	U	0.85	--	5.2		2	--	ND	U	0.38	--	ND	U	1.9	--	ND	U	1.9	--	2.2		0.19	1
Fluorene	86-73-7	3800	110000	3800	mg/kg	ND	U	0.85	--	ND	U	2	--	ND	U	0.38	--	ND	U	1.9	--	ND	U	1.9	--	0.42		0.19	1
Naphthalene	91-20-3	25	56000	25	mg/kg	ND	U	0.85	--	ND	U	2	--	ND	U	0.38	--	ND	U	1.9	--	ND	U	1.9	--	ND	U	0.19	1
Phenanthrene	85-01-8	10000	190000	10000	mg/kg	ND	U	0.85	--	7.2		2	--	ND	U	0.38	--	ND	U	1.9	--	ND	U	1.9	--	3.8		0.19	1
Pyrene	129-00-0	2200	84000	2200	mg/kg	0.92		0.85	--	11		2	--	ND		0.38	--	ND		1.9	--	ND		1.9	--	3.9		0.19	1
Metals																													
Lead (Total)	7439-92-1	450	1000	450	mg/kg	191		0.61	--	**2460**		0.64	--	446		0.58	--	112		0.65	--	110		0.57	--	316		1.14	10

Notes:
PADEP - Pennsylvania Department of Environmental Protection
mg/kg - milligram per kilogram
MSC - PADEP's Medium Specific Concentration for Soil
RL - Reporting Limit
ND - Not Detected
DF - Dilution Factor

All soil samples collected and analyzed were unsaturated.

Qualifiers:
Q - Qualifier
U - The analyte was analyzed but not detected

Exceedance Summary:
10 - RL exceeds the PADEP Non-Residential Soil MSC
10 - Concentration exceeds the PADEP Non-Residential Soil MSC
10 - Concentration exceeds the PADEP Non-Residential Direct Contact Standard

Table 4
Summary of Soil Sample Analytical Results: Outside SWMU Areas
AOI 5
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Chemical Name	CAS No	PADEP Non-Residential Soil to Groundwater MSC for Unsaturated Soils Used Aquifer, (TDS<2,500)	PADEP Non-Residential Direct Contact (0 - 2 ft bgs)	PADEP Non-Residential Used Aquifer Unsaturated Soil MSCs (TDS<2,500)	Location ID	A-141				A-144				A-150				A-153				A-155			
					Sample ID	A-141				A-144				A-150				A-153				A-155			
					Sample Matrix	Soil				Soil				Soil				Soil				Soil			
					Sample Depth	0.5-2.0				0.5-2.0				0.0-2.0				0.0-2.0				0.0-2.0			
					Sample Date	4/6/2009				4/6/2009				4/7/2009				4/8/2009				4/7/2009			
					Unit	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF
Volatile Organic Compounds																									
1,2-Dichloroethane	107-06-2	0.5	86	0.5	mg/kg	ND	U	0.28	46.82	ND	U	0.27	40.72	ND	U	0.33	54.23	ND	U	0.38	64.43	ND	U	0.26	43.71
Benzene	71-43-2	0.5	290	0.5	mg/kg	ND	U	0.28	46.82	ND	U	0.27	40.72	4.9		0.33	54.23	ND	U	0.38	64.43	0.52		0.26	43.71
Cumene	98-82-8	2500	10000	2500	mg/kg	ND	U	0.28	46.82	ND	U	0.27	40.72	1.2		0.33	54.23	ND	U	0.38	64.43	7.2		0.26	43.71
Ethylbenzene	100-41-4	70	10000	70	mg/kg	ND	U	0.28	46.82	ND	U	0.27	40.72	3.3		0.33	54.23	ND	U	0.38	64.43	0.71		0.26	43.71
Ethylene Dibromide (EDB)	106-93-4	0.005	3.7	0.005	mg/kg	ND	U	**0.28**	46.82	ND	U	**0.27**	40.72	ND	U	**0.33**	54.23	ND	U	**0.38**	64.43	ND	U	**0.26**	43.71
Methyl Tertiary Butyl Ether	1634-04-4	2	3200	2	mg/kg	ND	U	0.28	46.82	ND	U	0.27	40.72	ND	U	0.33	54.23	ND	U	0.38	64.43	ND	U	0.26	43.71
Toluene	108-88-3	100	10000	100	mg/kg	ND	U	0.28	46.82	ND	U	0.27	40.72	6.9		0.33	54.23	ND	U	0.38	64.43	1		0.26	43.71
Xylene (Total)	1330-20-7	1000	8000	1000	mg/kg	ND	U	0.28	46.82	ND	U	0.27	40.72	12		0.33	54.23	0.43		0.38	64.43	2.3		0.26	43.71
Semi-Volatile Organic Compounds																									
Anthracene	120-12-7	350	190000	350	mg/kg	0.38		0.20	1	ND	U	0.22	1	0.28		0.20	1	0.28		0.2	1	5.7		2.0	10
Benzo(a)anthracene	56-55-3	320	110	320	mg/kg	1		0.20	1	0.43		0.22	1	ND	U	0.20	1	0.75		0.2	1	3.5		2.0	10
Benzo(a)pyrene	50-32-8	46	11	46	mg/kg	0.95		0.20	1	0.56		0.22	1	ND	U	0.20	1	0.65		0.2	1	3.1		2.0	10
Benzo(b)fluoranthene	205-99-2	170	110	170	mg/kg	1.2		0.20	1	0.75		0.22	1	ND	U	0.20	1	0.99		0.2	1	3.2		2.0	10
Benzo(g,h,i)perylene	191-24-2	180	170000	180	mg/kg	0.66		0.20	1	0.45		0.22	1	ND	U	0.20	1	0.43		0.2	1	ND	U	2.0	10
Chrysene	218-01-9	230	11000	230	mg/kg	1.1		0.20	1	0.49		0.22	1	ND	U	0.20	1	0.77		0.2	1	4.8		2.0	10
Fluorene	86-73-7	3800	110000	3800	mg/kg	ND	U	0.20	1	ND	U	0.22	1	0.34		0.20	1	ND	U	0.2	1	19		2.0	10
Naphthalene	91-20-3	25	56000	25	mg/kg	ND	U	0.20	1	ND	U	0.22	1	ND	U	0.20	1	0.28		0.2	1	ND	U	2.0	10
Phenanthrene	85-01-8	10000	190000	10000	mg/kg	1.5		0.20	1	0.53		0.22	1	0.33		0.20	1	1.3		0.2	1	31		2.0	10
Pyrene	129-00-0	2200	84000	2200	mg/kg	1.8		0.20	1	0.52		0.22	1	0.33		0.20	1	1.1		0.2	1	6.5		2.0	10
Metals																									
Lead (Total)	7439-92-1	450	1000	450	mg/kg	660		2.4	20	156		1.28	10	190		1.19	10	37.4		1.14	10	446		1.19	10

Notes:
PADEP - Pennsylvania Department of Environmental Protection
mg/kg - milligram per kilogram
MSC - PADEP's Medium Specific Concentration for Soil
RL - Reporting Limit
ND - Not Detected
DF - Dilution Factor

All soil samples collected and analyzed were unsaturated.

Qualifiers:
Q - Qualifier
U - The analyte was analyzed but not detected

Exceedance Summary:
10 - RL exceeds the PADEP Non-Residential Soil MSC
10 - Concentration exceeds the PADEP Non-Residential Soil MSC
10 - Concentration exceeds the PADEP Non-Residential Direct Contact Standard

Table 4
Summary of Soil Sample Analytical Results: Outside SWMU Areas
AOI 5
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Chemical Name	CAS No	PADEP Non-Residential Soil to Groundwater MSC for Unsaturated Soils Used Aquifer, (TDS<2,500)	PADEP Non-Residential Direct Contact (0 - 2 ft bgs)	PADEP Non-Residential Used Aquifer Unsaturated Soil MSCs (TDS<2,500)	Location ID	BH-13-09				BH-14-09				BH-15-09				BH-16-09				BH-41-09				BH-42-09			
					Sample ID	BH-13-09				BH-14-09				BH-15-09				BH-16-09				BH-41-09				BH-42-09			
					Sample Matrix	Soil				Soil				Soil				Soil				Soil				Soil			
					Sample Depth	1.0-2.0				1.0-2.0				0.5-2.0				0.0-2.0				0.0-2.0				0.0-2.0			
					Sample Date	4/6/2009				4/6/2009				4/6/2009				4/6/2009				7/9/2009				7/9/2009			
					Unit	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF
Metals																													
Lead (Total)	7439-92-1	450	1000	450	mg/kg	298		1.11	10	285		1.2	10	323		1.13	10	**2030**		6.13	50	387		1.08	10	183		1.1	10

Chemical Name	CAS No	PADEP Non-Residential Soil to Groundwater MSC for Unsaturated Soils Used Aquifer, (TDS<2,500)	PADEP Non-Residential Direct Contact (0 - 2 ft bgs)	PADEP Non-Residential Used Aquifer Unsaturated Soil MSCs (TDS<2,500)	Location ID	BH-43-09				BH-44-09				BH-45-09				BH-46-09			
					Sample ID	BH-43-09				BH-44-09				BH-45-09				BH-46-09			
					Sample Matrix	Soil				Soil				Soil				Soil			
					Sample Depth	0.0-2.0				0.0-2.0				0.0-2.0				0.0-2.0			
					Sample Date	7/9/2009				7/9/2009				7/9/2009				7/9/2009			
					Unit	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF
Volatile Organic Compounds																					
Benzene	71-43-2	0.5	290	0.5	mg/kg	ND	U	0.0060	0.99	ND	U	0.29	51.55	ND	U	0.30	51.65	ND	U	0.0060	0.96

Notes:
PADEP - Pennsylvania Department of Environmental Protection
mg/kg - milligram per kilogram
MSC - PADEP's Medium Specific Concentration for Soil
RL - Reporting Limit
ND - Not Detected
DF - Dilution Factor

All soil samples collected and analyzed were unsaturated.

Qualifiers:
Q - Qualifier
U - The analyte was analyzed but not detected

Exceedance Summary:
10 - RL exceeds the PADEP Non-Residential Soil MSC
10 - Concentration cxceeds the PADEP Non-Residential Soil MSC
10 - Concentration exceeds the PADEP Non-Residential Direct Contact Standard

Table 5
Summary of Shallow Soil Sample Analytical Results: SWMU Areas
AOI 5
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Chemical Name	CAS No	PADEP Non-Residential Soil to Groundwater MSCs Used Aquifer, (TDS<2,500)	PADEP Non-Residential Direct Contact (0 - 2 ft bgs)	PADEP Non-Residential Used Aquifer Unsaturated Soil MSCs (TDS<2,500)	SWMU No.	93				93				93				93				93			
					Location ID	BH-04-07				BH-05-07				BH-06-07				BH-07-07				BH-08-07			
					Sample ID	BH-04-07_1-2				BH-05-07_1-2				BH-06-07_1.0-2.0				BH-07-07_1-2				BH-08-07_.75-2			
					Sample Matrix	Soil				Soil				Soil				Soil				Soil			
					Sample Depth	1.0-2.0				1.0-2.0				0.5-1.0				1.0-2.0				0.75-2.0			
					Sample Date	7/13/2007				7/12/2007				4/4/2007				7/13/2007				7/13/2007			
					Unit	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF
Metals																									
Lead (Total)	7439-92-1	450	1000	450	mg/kg	203		0.58	-	316		0.78	-	373		0.63	-	**1250**		0.71	-	506		0.64	-
TCLP Metals																									
Lead (Total) ***	7439-92-1			5	mg/L	NA				NA				NA				**9.42**		0.05		0.653		0.05	

Chemical Name	CAS No	PADEP Non-Residential Soil to Groundwater MSCs Used Aquifer, (TDS<2,500)	PADEP Non-Residential Direct Contact (0 - 2 ft bgs)	PADEP Non-Residential Used Aquifer Unsaturated Soil MSCs (TDS<2,500)	SWMU No.	93				93				93				93				93			
					Location ID	BH-05-09				BH-06-09				BH-07-09				BH-08-09_AOI5				BH-17-09			
					Sample ID	BH-05-09				BH-06-09				BH-07-09				BH-08-09_AOI5_0.0-2.0				BH-17-09			
					Sample Matrix	Soil				Soil				Soil				Soil				Soil			
					Sample Depth	0.0-2.0				0.0-2.0				0.0-2.0				0.0-2.0				0.0-2.0			
					Sample Date	4/8/2009				4/8/2009				4/7/2009				4/7/2009				4/8/2009			
					Unit	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF
Metals																									
Lead (Total)	7439-92-1	450	1000	450	mg/kg	449		1.38	10	407		1.32	10	748		2.43	20	563		1.23	10	790		2.45	20
TCLP Metals																									
Lead (Total) ***	7439-92-1			5	mg/L	NA				NA				NA				NA				NA			

Chemical Name	CAS No	PADEP Non-Residential Soil to Groundwater MSCs Used Aquifer, (TDS<2,500)	PADEP Non-Residential Direct Contact (0 - 2 ft bgs)	PADEP Non-Residential Used Aquifer Unsaturated Soil MSCs (TDS<2,500)	SWMU No.	94				94				94				94				94			
					Location ID	BH-24-09				BH-33-09				BH-34-09				BH-35-09				BH-36-09			
					Sample ID	BH-24-09				BH-33-09				BH-34-09				BH-35-09				BH-36-09			
					Sample Matrix	Soil				Soil				Soil				Soil				Soil			
					Sample Depth	0.0-2.0				0.0-2.0				0.0-2.0				0.0-2.0				0.0-2.0			
					Sample Date	6/8/2009				7/9/2009				7/9/2009				7/9/2009				7/9/2009			
					Unit	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF
Metals																									
Lead (Total)	7439-92-1	450	1000	450	mg/kg	**1100**		6.17	50	790		2.75	20	485		1.4	10	772		2.62	20	374		1.46	10
TCLP Metals																									
Lead (Total) ***	7439-92-1			5	mg/L	NA				1.04		0.015		NA				NA				NA			

Notes:
*** Criteria for TCLP Total Lead Samples is the EPA Maximum Concentration of Contaminants for Toxicity Characteristic
TCLP - Toxicity Characteristic Leachning Procedure
PADEP - Pennsylvania Department of Environmental Protection
mg/kg - milligram per kilogram
mg/L - milligram per liter
MSC - PADEP's Medium Specific Concentration for Soil
RL - Reporting Limit
ND - Not Detected
DF - Dilution Factor

All soil samples collected and analyzed were unsaturated.

Qualifiers:
Q - Qualifier
U - The analyte was analyzed but not detected

Exceedance Summary:
10 - RL exceeds the PADEP Non-Residential Soil MSC
10 - Concentration exceeds the PADEP Non-Residential Soil MSC
10 - Concentration exceeds the PADEP Non-Residential Direct Contact Standard
10 - Concentration exceeds the EPA Maximum Concentration of Contaminants for Toxicity Characteristic

Table 5
Summary of Shallow Soil Sample Analytical Results: SWMU Areas
AOI 5
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Chemical Name	CAS No	PADEP Non-Residential Soil to Groundwater MSCs Used Aquifer, (TDS<2,500)	PADEP Non-Residential Direct Contact (0 - 2 ft bgs)	PADEP Non-Residential Used Aquifer Unsaturated Soil MSCs (TDS<2,500)	SWMU No.	94				94				94				94				94			
					Location ID	BH-13-07				BH-18-07				BH-20-07				BH-21-07				BH-23-07			
					Sample ID	BH-13-07_0.5-0.75				BH-18-07_1.0-2.0				BH-20-07_0.75-2.0				BH-21-07_1.75-2				BH-23-07_0-0.5			
					Sample Matrix	Soil				Soil				Soil				Soil				Soil			
					Sample Depth	0.5-1.0				1.0-2.0				0.75-2.0				1.75-2.0				0-0.5			
					Sample Date	4/4/2007				4/4/2007				7/11/2007				4/4/2007				7/11/2007			
					Unit	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF
Metals																									
Lead (Total)	7439-92-1	450	1000	450	mg/kg	310		0.62	-	**3190**		0.99	-	21.7		0.58	10	26.7		0.59	-	**1920**		0.69	-
TCLP Metals																									
Lead (Total) ***	7439-92-1			5	mg/L	NA				**21.8**		0.05		NA				NA				0.78		0.05	

Chemical Name	CAS No	PADEP Non-Residential Soil to Groundwater MSCs Used Aquifer, (TDS<2,500)	PADEP Non-Residential Direct Contact (0 - 2 ft bgs)	PADEP Non-Residential Used Aquifer Unsaturated Soil MSCs (TDS<2,500)	SWMU No.	93				93				93				94				94			
					Location ID	BH-18-09				BH-19-09				BH-20-09				BH-01-09				BH-02-09			
					Sample ID	BH-18-09				BH-19-09				BH-20-09				BH-01-09				BH-02-09			
					Sample Matrix	Soil				Soil				Soil				Soil				Soil			
					Sample Depth	0.0-2.0				0.0-2.0				0.0-2.0				0.0-2.0				0.0-2.0			
					Sample Date	4/8/2009				4/8/2009				4/8/2009				4/7/2009				4/7/2009			
					Unit	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF
Metals																									
Lead (Total)	7439-92-1	450	1000	450	mg/kg	327		1.46	10	228		1.28	10	453		1.35	10	494		1.58	10	**17900**		68.7	500
TCLP Metals																									
Lead (Total) ***	7439-92-1			5	mg/L	NA				NA				NA				NA				**172**		0.3	

Chemical Name	CAS No	PADEP Non-Residential Soil to Groundwater MSCs Used Aquifer, (TDS<2,500)	PADEP Non-Residential Direct Contact (0 - 2 ft bgs)	PADEP Non-Residential Used Aquifer Unsaturated Soil MSCs (TDS<2,500)	SWMU No.	94				94				101				101				101			
					Location ID	BH-37-09				BH-38-09				BH-09-09				BH-10-09				BH-11-09			
					Sample ID	BH-37-09				BH-38-09				BH-09-09				BH-10-09				BH-11-09			
					Sample Matrix	Soil				Soil				Soil				Soil				Soil			
					Sample Depth	0.0-2.0				0.0-2.0				0.0-2.0				0.0-2.0				0.0-2.0			
					Sample Date	7/9/2009				7/9/2009				4/7/2009				4/6/2009				4/7/2009			
					Unit	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF
Metals																									
Lead (Total)	7439-92-1	450	1000	450	mg/kg	**1310**		2.97	25	36.8		2.35	20	**2430**		13.7	100	441		1.16	10	613		2.36	20
TCLP Metals																									
Lead (Total) ***	7439-92-1			5	mg/L	NA				NA				NA				NA				NA			

Notes:
*** Criteria for TCLP Total Lead Samples is the EPA Maximum Concentration of Contaminants for Toxicity Characteristic
TCLP - Toxicity Characteristic Leachning Procedure
PADEP - Pennsylvania Department of Environmental Protection
mg/kg - milligram per kilogram
mg/L - milligram per liter
MSC - PADEP's Medium Specific Concentration for Soil
RL - Reporting Limit
ND - Not Detected
DF - Dilution Factor

All soil samples collected and analyzed were unsaturated.

Qualifiers:
Q - Qualifier
U - The analyte was analyzed but not detected

Exceedance Summary:
10 - RL exceeds the PADEP Non-Residential Soil MSC
10 - Concentration exceeds the PADEP Non-Residential Soil MSC
10 - Concentration exceeds the PADEP Non-Residential Direct Contact Standard
10 - Concentration exceeds the EPA Maximum Concentration of Contaminants for Toxicity Characteristic

Table 5
Summary of Shallow Soil Sample Analytical Results: SWMU Areas
AOI 5
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Chemical Name	CAS No	PADEP Non-Residential Soil to Groundwater MSCs Used Aquifer, (TDS<2,500)	PADEP Non-Residential Direct Contact (0 - 2 ft bgs)	PADEP Non-Residential Used Aquifer Unsaturated Soil MSCs (TDS<2,500)	SWMU No.	94				101				101				101				101			
					Location ID	BH-24-07				BH-25-07				BH-26-07				BH-27-07				A-142			
					Sample ID	BH-24-07_1.5-2				BH-25-07_1-2				BH-25-07_1-2				BH-27-07_1.5-2.0				A-142_1.5-2.0			
					Sample Matrix	Soil				Soil				Soil				Soil				Soil			
					Sample Depth	1.5-2.0				1.0-2.0				1.0-2.0				1.5-2.0				1.5-2.0			
					Sample Date	4/4/2007				7/11/2007				7/11/2007				7/12/2007				7/12/2007			
					Unit	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF
Metals																									
Lead (Total)	7439-92-1	450	1000	450	mg/kg	152		0.64	-	103		0.6	-	41.7		0.56	-	**3700**		0.59	-	377		0.57	-
TCLP Metals																									
Lead (Total) ***	7439-92-1			5	mg/L	NA				NA				NA				NA				NA			

Chemical Name	CAS No	PADEP Non-Residential Soil to Groundwater MSCs Used Aquifer, (TDS<2,500)	PADEP Non-Residential Direct Contact (0 - 2 ft bgs)	PADEP Non-Residential Used Aquifer Unsaturated Soil MSCs (TDS<2,500)	SWMU No.	94				94				94				94				94			
					Location ID	BH-03-09				BH-04-09				BH-21-09				BH-22-09				BH-23-09			
					Sample ID	BH-03-09				BH-04-09				BH-21-09				BH-22-09				BH-23-09			
					Sample Matrix	Soil				Soil				Soil				Soil				Soil			
					Sample Depth	0.0-2.0				0.0-2.0				0.0-2.0				0.0-2.0				0.0-2.0			
					Sample Date	4/7/2009				4/7/2009				6/8/2009				6/8/2009				6/8/2009			
					Unit	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF
Metals																									
Lead (Total)	7439-92-1	450	1000	450	mg/kg	316		1.79	10	**1810**		8.17	50	**1210**		6.57	50	**1780**		13	100	**1220**		7.5	50
TCLP Metals																									
Lead (Total) ***	7439-92-1			5	mg/L	NA				NA				NA				NA				NA			

Chemical Name	CAS No	PADEP Non-Residential Soil to Groundwater MSCs Used Aquifer, (TDS<2,500)	PADEP Non-Residential Direct Contact (0 - 2 ft bgs)	PADEP Non-Residential Used Aquifer Unsaturated Soil MSCs (TDS<2,500)	SWMU No.	101				101				101			
					Location ID	BH-12-09				BH-39-09				BH-40-09			
					Sample ID	BH-12-09				BH-39-09				BH-40-09			
					Sample Matrix	Soil				Soil				Soil			
					Sample Depth	0.0-2.0				0.0-2.0				0.0-2.0			
					Sample Date	4/6/2009				7/9/2009				7/9/2009			
					Unit	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF
Metals																	
Lead (Total)	7439-92-1	450	1000	450	mg/kg	806		2.46	20	**1050**		2.29	20	219		1.06	10
TCLP Metals																	
Lead (Total) ***	7439-92-1			5	mg/L	NA				NA				NA			

Notes:
*** Criteria for TCLP Total Lead Samples is the EPA Maximum Concentration of Contaminants for Toxicity Characteristic
TCLP - Toxicity Characteristic Leachning Procedure
PADEP - Pennsylvania Department of Environmental Protection
mg/kg - milligram per kilogram
mg/L - milligram per liter
MSC - PADEP's Medium Specific Concentration for Soil
RL - Reporting Limit
ND - Not Detected
DF - Dilution Factor

All soil samples collected and analyzed were unsaturated.

Qualifiers:
Q - Qualifier
U - The analyte was analyzed but not detected

Exceedance Summary:
10 - RL exceeds the PADEP Non-Residential Soil MSC
10 - Concentration exceeds the PADEP Non-Residential Soil MSC
10 - Concentration exceeds the PADEP Non-Residential Direct Contact Standard
10 - Concentration exceeds the EPA Maximum Concentration of Contaminants for Toxicity Characteristic

Table 5
Summary of Shallow Soil Sample Analytical Results: SWMU Areas
AOI 5
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Chemical Name	CAS No	PADEP Non-Residential Soil to Groundwater MSCs Used Aquifer, (TDS<2,500)	PADEP Non-Residential Direct Contact (0 - 2 ft bgs)	PADEP Non-Residential Used Aquifer Unsaturated Soil MSCs (TDS<2,500)	SWMU No.	93				94			
					Location ID	BH-25-09				BH-26-09			
					Sample ID	BH-25-09				BH-26-09			
					Sample Matrix	Soil				Soil			
					Sample Depth	4/7/2009				4/7/2009			
					Sample Date	SO				SO			
					Unit	Result	Q	RL	DF	Result	Q	RL	DF
Volatile Organic Compounds													
1,2-Dichloroethane	107-06-2	0.5	86	0.5	mg/kg	ND	U	0.36	51.23	ND	U	0.29	47.35
Benzene	71-43-2	0.5	290	0.5	mg/kg	ND	U	0.36	51.23	ND	U	0.29	47.35
Cumene	98-82-8	2500	10000	2500	mg/kg	ND	U	0.36	51.23	ND	U	0.29	47.35
Ethylbenzene	100-41-4	70	10000	70	mg/kg	ND	U	0.36	51.23	ND	U	0.29	47.35
Ethylene Dibromide (EDB)	106-93-4	0.005	3.7	0.005	mg/kg	ND	U	**0.36**	51.23	ND	U	**0.29**	47.35
Methyl Tertiary Butyl Ether	1634-04-4	2	3200	2	mg/kg	ND	U	0.36	51.23	ND	U	0.29	47.35
Toluene	108-88-3	100	10000	100	mg/kg	ND	U	0.36	51.23	ND	U	0.29	47.35
Xylene (Total)	1330-20-7	1000	8000	1000	mg/kg	ND	U	0.36	51.23	ND	U	0.29	47.35
Semi-Volatile Organic Compounds													
Anthracene	120-12-7	350	190000	350	mg/kg	0.42		0.23	1	ND	U	0.20	1
Benzo(a)anthracene	56-55-3	320	110	110	mg/kg	0.79		0.23	1	ND	U	0.20	1
Benzo(a)pyrene	50-32-8	46	11	11	mg/kg	0.81		0.23	1	ND	U	0.20	1
Benzo(b)fluoranthene	205-99-2	170	110	110	mg/kg	1		0.23	1	ND	U	0.20	1
Benzo(g,h,i)perylene	191-24-2	180	170000	180	mg/kg	0.53		0.23	1	ND	U	0.20	1
Chrysene	218-01-9	230	11000	230	mg/kg	0.85		0.23	1	0.25		0.20	1
Fluorene	86-73-7	3800	110000	3800	mg/kg	0.34		0.23	1	ND	U	0.20	1
Naphthalene	91-20-3	25	56000	25	mg/kg	0.25		0.23	1	ND	U	0.20	1
Phenanthrene	85-01-8	10000	190000	10000	mg/kg	1.1		0.23	1	0.44		0.20	1
Pyrene	129-00-0	2200	84000	2200	mg/kg	1.3		0.23	1	0.27		0.20	1
Metals													
Lead (Total)	7439-92-1	450	1000	450	mg/kg	**1100**		2.76	20	102		1.17	10

Notes:
PADEP - Pennsylvania Department of Environmental Protection
mg/kg - milligram per kilogram
MSC - PADEP's Medium Specific Concentration for Soil
RL - Reporting Limit
ND - Not Detected
DF - Dilution Factor

All soil samples collected and analyzed were unsaturated.

Qualifiers:
Q - Qualifier
U - The analyte was analyzed but not detected

Exceedance Summary:
10 - RL exceeds the PADEP Non-Residential Soil MSC
10 - Concentration exceeds the PADEP Non-Residential Soil MSC
10 - Concentration exceeds the PADEP Non-Residential Direct Contact Standard

Table 6
Summary of Groundwater Analytical Results
AOI 5
Philadelphia Refinery
Philadlephia, Pennsylvania

Chemical Name	CAS No	PADEP Non-Residential Used Aquifer Groundwater Criteria, TDS<2,500 mg/l	Location ID	A-133				A-134				A-135				A-143				A-145				A-1				A-10			
			Sample ID	A-133_050307				A-134_050307				A-135_050307				A-143_050307				A-145_050307				A-1_050707				A-10_050807			
			Sample Date	5/3/2007				5/3/2007				5/3/2007				5/3/2007				5/3/2007				5/7/2007				5/8/2007			
			Sample Matrix	Groundwater				Groundwater				Groundwater				Groundwater				Groundwater				Groundwater				Groundwater			
			Unit	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF
Volatile Organic Compounds																															
1,2-Dichloroethane	107-06-2	5	ug/l	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Benzene	71-43-2	5	ug/l	1.2	J	5	1	50		5	1	18		5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Cumene	98-82-8	3,500	ug/l	12		5	1	83		5	1	47		5	1	26		5	1	ND	U	5	1	ND	U	5	1	0.7	J	5	1
Ethylbenzene	100-41-4	700	ug/l	ND	U	5	1	1.5	J	5	1	3.1	J	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Ethylene Dibromide (EDB)	106-93-4	0.05	ug/l	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1
Methyl Tertiary Butyl Ether	1634-04-4	20	ug/l	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Toluene	108-88-3	1,000	ug/l	ND	U	5	1	13		5	1	20		5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Xylene (Total)	1330-20-7	10,000	ug/l	ND	U	5	1	28		5	1	14		5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Semi-Volatile Organic Compounds																															
Chrysene	218-01-9	1.9	ug/l	130	D	**10**	10	ND	U	1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1
Fluorene	86-73-7	1,900	ug/l	170	D	10	10	9		1	1	ND	U	1	1	ND	U	1	1	1.4		1	1	ND	U	1	1	ND	U	1	1
Naphthalene	91-20-3	100	ug/l	ND	UD	10	10	ND	U	1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1
Phenanthrene	85-01-8	1,100	ug/l	200	D	10	10	3.7		1	1	ND	U	1	1	ND	U	1	1	1.4		1	1	ND	U	1	1	ND	U	1	1
Pyrene	129-00-0	130	ug/l	110	D	10	10	ND	U	1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1
Metals																															
Lead (Total)	7439-92-1	5	ug/l	ND	U	0.8	1	ND	U	0.8	1	ND	U	0.8	1	ND	U	0.8	1	ND	U	0.8	1	ND	U	0.8	1	ND	U	0.8	1

Notes:
PADEP - Pennsylvania Department of Environmental Protection
ug/l - micrograms per liter
mg/L - milligram per liter
RL - Reporting Limit
ND - Not Detected
DF - Dilution Factor
NA - Not Analyzed

Qualifiers:
Q - Qualifier
U - The analyte was analyzed but not detected
J - The analyte was detected below the RL. The result should be considered an estimate.
D - The sample was diluted.

Exceedance Summary:
10 - RL exceeds the PADEP Non-Residential Used Aquifer Groundwater Criteria TDS<2,500 mg/l
10 - Result exceeds the PADEP Non-Residential Used Aquifer Groundwater Criteria TDS<2,500 mg/l

Table 6
Summary of Groundwater Analytical Results
AOI 5
Philadelphia Refinery
Philadlephia, Pennsylvania

Chemical Name	CAS No	PADEP Non-Residential Used Aquifer Groundwater Criteria, TDS<2,500 mg/l	Location ID	A-11				A-118				A-119				A-12				A-120				A-121				A-122			
			Sample ID	A-11_050707				A-118_050907				A-119_050907				A-12_050707				A-120_050907				A-121_050907				A-122_050807			
			Sample Date	5/7/2007				5/9/2007				5/9/2007				5/7/2007				5/9/2007				5/9/2007				5/8/2007			
			Sample Matrix	Groundwater				Groundwater				Groundwater				Groundwater				Groundwater				Groundwater				Groundwater			
			Unit	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF
Volatile Organic Compounds																															
1,2-Dichloroethane	107-06-2	5	ug/l	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Benzene	71-43-2	5	ug/l	ND	U	5	1	ND	U	5	1	15		5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Cumene	98-82-8	3,500	ug/l	ND	U	5	1	0.61	J	5	1	160		5	1	ND	U	5	1	8.6		5	1	ND	U	5	1	ND	U	5	1
Ethylbenzene	100-41-4	700	ug/l	ND	U	5	1	ND	U	5	1	3.8	J	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Ethylene Dibromide (EDB)	106-93-4	0.05	ug/l	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1
Methyl Tertiary Butyl Ether	1634-04-4	20	ug/l	3.3	J	5	1	ND	U	5	1	3	J	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Toluene	108-88-3	1,000	ug/l	ND	U	5	1	ND	U	5	1	4.2	J	5	1	ND	U	5	1	0.64	J	5	1	0.6	J	5	1	ND	U	5	1
Xylene (Total)	1330-20-7	10,000	ug/l	ND	U	5	1	ND	U	5	1	8.2		5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Semi-Volatile Organic Compounds																															
Chrysene	218-01-9	1.9	ug/l	ND	U	1	1	ND	U	**3.2**	1	ND	U	**3**	1	ND	U	1	1	ND	U	**3**	1	ND	U	**3**	1	ND	U	1	1
Fluorene	86-73-7	1,900	ug/l	ND	U	1	1	ND	U	3.2	1	5.4		3	1	24	D	9.9	10	12		3	1	ND	U	3	1	ND	U	1	1
Naphthalene	91-20-3	100	ug/l	ND	U	1	1	ND	U	3.2	1	ND	U	3	1	ND	U	1	1	ND	U	3	1	ND	U	3	1	ND	U	1	1
Phenanthrene	85-01-8	1,100	ug/l	ND	U	1	1	ND	U	3.2	1	6.7		3	1	4.2		1	1	6		3	1	ND	U	3	1	ND	U	1	1
Pyrene	129-00-0	130	ug/l	ND	U	1	1	ND	U	3.2	1	ND	U	3	1	2.6		1	1	ND	U	3	1	ND	U	3	1	ND	U	1	1
Metals																															
Lead (Total)	7439-92-1	5	ug/l	0.81	B	2	1	ND	U	0.8	1	ND	U	0.8	1	ND	U	0.8	1	ND	U	0.8	1	ND	U	0.8	1	ND	U	0.8	1

Notes:
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RL - Reporting Limit
ND - Not Detected
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Qualifiers:
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U - The analyte was analyzed but not detected
J - The analyte was detected below the RL. The result should be considered an estimate.
D - The sample was diluted.

Exceedance Summary:
10 - RL exceeds the PADEP Non-Residential Used Aquifer Groundwater Criteria TDS<2,500 mg/l
10 - Result exceeds the PADEP Non-Residential Used Aquifer Groundwater Criteria TDS<2,500 mg/l

Table 6
Summary of Groundwater Analytical Results
AOI 5
Philadelphia Refinery
Philadlephia, Pennsylvania

Chemical Name	CAS No	PADEP Non-Residential Used Aquifer Groundwater Criteria, TDS<2,500 mg/l	Location ID	A-137				A-138				A-138				A-139				A-140				A-141				A-142			
			Sample ID	A-137_050707				A-138				AOI-5 A-138				A-139_050707				A-140_050707				A-141_050707				A-142_050707			
			Sample Date	5/7/2007				4/24/2009				7/12/2007				5/7/2007				5/7/2007				5/7/2007				5/7/2007			
			Sample Matrix	Groundwater				Groundwater				Groundwater				Groundwater				Groundwater				Groundwater				Groundwater			
			Unit	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF
Volatile Organic Compounds																															
1,2-Dichloroethane	107-06-2	5	ug/l	ND	U	5	1	NA				ND	U	**50**	-	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Benzene	71-43-2	5	ug/l	ND	U	5	1	NA				ND	U	**50**	-	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Cumene	98-82-8	3,500	ug/l	ND	U	5	1	420		20	10	17000		1000	-	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Ethylbenzene	100-41-4	700	ug/l	ND	U	5	1	NA				62		50	-	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Ethylene Dibromide (EDB)	106-93-4	0.05	ug/l	ND	U	0.05	1	NA				ND	U	0.05	-	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1
Methyl Tertiary Butyl Ether	1634-04-4	20	ug/l	0.6	J	5	1	NA				ND	U	**50**	-	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Toluene	108-88-3	1,000	ug/l	ND	U	5	1	NA				ND	U	50	-	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Xylene (Total)	1330-20-7	10,000	ug/l	ND	U	5	1	NA				280		100	-	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Semi-Volatile Organic Compounds																															
Chrysene	218-01-9	1.9	ug/l	ND	U	1	1	NA				ND	U	0.2	-	ND	U	1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1
Fluorene	86-73-7	1,900	ug/l	ND	U	1	1	NA				ND	U	0.62	-	ND	U	1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1
Naphthalene	91-20-3	100	ug/l	ND	U	1	1	NA				ND	U	3	-	ND	U	1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1
Phenanthrene	85-01-8	1,100	ug/l	ND	U	1	1	NA				0.66		0.4	-	ND	U	1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1
Pyrene	129-00-0	130	ug/l	ND	U	1	1	NA				0.21		0.2	-	ND	U	1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1
Metals																															
Lead (Total)	7439-92-1	5	ug/l	ND	U	0.8	1	NA				ND	U	0.8	-	ND	U	0.8	1	ND	U	0.8	1	ND	U	0.8	1	ND	U	0.8	1

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Exceedance Summary:
10 - RL exceeds the PADEP Non-Residential Used Aquifer Groundwater Criteria TDS<2,500 mg/l
10 - Result exceeds the PADEP Non-Residential Used Aquifer Groundwater Criteria TDS<2,500 mg/l

Table 6
Summary of Groundwater Analytical Results
AOI 5
Philadelphia Refinery
Philadlephia, Pennsylvania

Chemical Name	CAS No	PADEP Non-Residential Used Aquifer Groundwater Criteria, TDS<2,500 mg/l	Location ID	A-145				A-146				A-147				A-148				A-149				A-15				A-150			
			Sample ID	A-145_050307				A-146_050907				A-147_050907				A-148_050807				A-149_050807				A-15_050807				A-150_050807			
			Sample Date	5/3/2007				5/9/2007				5/9/2007				5/8/2007				5/8/2007				5/8/2007				5/8/2007			
			Sample Matrix	Groundwater				Groundwater				Groundwater				Groundwater				Groundwater				Groundwater				Groundwater			
			Unit	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF
Volatile Organic Compounds																															
1,2-Dichloroethane	107-06-2	5	ug/l	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Benzene	71-43-2	5	ug/l	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	27		5	1
Cumene	98-82-8	3,500	ug/l	ND	U	5	1	3.2	J	5	1	1.3	J	5	1	0.98	J	5	1	18		5	1	4.1	J	5	1	27		5	1
Ethylbenzene	100-41-4	700	ug/l	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	0.83	J	5	1
Ethylene Dibromide (EDB)	106-93-4	0.05	ug/l	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1
Methyl Tertiary Butyl Ether	1634-04-4	20	ug/l	ND	U	5	1	1.8	J	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Toluene	108-88-3	1,000	ug/l	ND	U	5	1	0.7	J	5	1	2.3	J	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	3.1	J	5	1
Xylene (Total)	1330-20-7	10,000	ug/l	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	6.5		5	1
Semi-Volatile Organic Compounds																															
Chrysene	218-01-9	1.9	ug/l	ND	U	1	1	ND	U	**3**	1	ND	U	**3**	1	ND	U	1	1	ND	U	1	1	ND	U	1	1	1.6		1	1
Fluorene	86-73-7	1,900	ug/l	1.4		1	1	9.7		3	1	21		3	1	2.2		1	1	ND	U	1	1	18		1	1	20		1	1
Naphthalene	91-20-3	100	ug/l	ND	U	1	1	ND	U	3	1	ND	U	3	1	ND	U	1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1
Phenanthrene	85-01-8	1,100	ug/l	1.4		1	1	5		3	1	19		3	1	4.2		1	1	ND	U	1	1	8.1		1	1	16		1	1
Pyrene	129-00-0	130	ug/l	ND	U	1	1	ND	U	3	1	7.4		3	1	2.2		1	1	ND	U	1	1	1.2		1	1	3.8		1	1
Metals																															
Lead (Total)	7439-92-1	5	ug/l	ND	U	0.8	1	4.5		2	1	ND	U	0.8	1	ND	U	0.8	1	0.96	B	2	1	ND	U	0.8	1	ND	U	0.8	1

Notes:
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Exceedance Summary:
10 - RL exceeds the PADEP Non-Residential Used Aquifer Groundwater Criteria TDS<2,500 mg/l
10 - Result exceeds the PADEP Non-Residential Used Aquifer Groundwater Criteria TDS<2,500 mg/l

Table 6
Summary of Groundwater Analytical Results
AOI 5
Philadelphia Refinery
Philadlephia, Pennsylvania

Chemical Name	CAS No	PADEP Non-Residential Used Aquifer Groundwater Criteria, TDS<2,500 mg/l	Location ID	A-152				A-153				A-154				A-16				A-17				A-23				A-25			
			Sample ID	A-152_050807				A-153_050907				A-154_050807				A-16_050807				AOI-5 A-17				A-23_050807				A-25_050307			
			Sample Date	5/8/2007				5/9/2007				5/8/2007				5/8/2007				7/12/2007				5/8/2007				5/4/2007			
			Sample Matrix	Groundwater				Groundwater				Groundwater				Groundwater				Groundwater				Groundwater				Groundwater			
			Unit	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF
Volatile Organic Compounds																															
1,2-Dichloroethane	107-06-2	5	ug/l	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	-	ND	U	5	1	ND	U	5	1
Benzene	71-43-2	5	ug/l	ND	U	5	1	ND	U	5	1	9		5	1	ND	U	5	1	ND	U	5	-	ND	U	5	1	ND	U	5	1
Cumene	98-82-8	3,500	ug/l	ND	U	5	1	3.2	J	5	1	14		5	1	ND	U	5	1	ND	U	5	-	ND	U	5	1	ND	U	5	1
Ethylbenzene	100-41-4	700	ug/l	ND	U	5	1	ND	U	5	1	0.84	J	5	1	ND	U	5	1	ND	U	5	-	ND	U	5	1	ND	U	5	1
Ethylene Dibromide (EDB)	106-93-4	0.05	ug/l	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	-	ND	U	0.05	1	ND	U	0.05	1
Methyl Tertiary Butyl Ether	1634-04-4	20	ug/l	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	-	ND	U	5	1	ND	U	5	1
Toluene	108-88-3	1,000	ug/l	ND	U	5	1	ND	U	5	1	3.2	J	5	1	ND	U	5	1	ND	U	5	-	ND	U	5	1	ND	U	5	1
Xylene (Total)	1330-20-7	10,000	ug/l	ND	U	5	1	ND	U	5	1	9.6		5	1	ND	U	5	1	ND	U	10	-	ND	U	5	1	ND	U	5	1
Semi-Volatile Organic Compounds																															
Chrysene	218-01-9	1.9	ug/l	ND	U	1	1	ND	U	**3.1**	1	ND	U	1	1	ND	U	1.1	1	ND	U	0.2	-	ND	U	1	1	3.1		1	1
Fluorene	86-73-7	1,900	ug/l	ND	U	1	1	ND	U	3.1	1	ND	U	1	1	ND	U	1.1	1	ND	U	0.62	-	ND	U	1	1	ND	U	1	1
Naphthalene	91-20-3	100	ug/l	ND	U	1	1	ND	U	3.1	1	ND	U	1	1	ND	U	1.1	1	ND	U	3	-	ND	U	1	1	ND	U	1	1
Phenanthrene	85-01-8	1,100	ug/l	ND	U	1	1	ND	U	3.1	1	ND	U	1	1	ND	U	1.1	1	ND	U	0.4	-	ND	U	1	1	2.4		1	1
Pyrene	129-00-0	130	ug/l	ND	U	1	1	ND	U	3.1	1	ND	U	1	1	1.3		1.1	1	ND	U	0.2	-	ND	U	1	1	5.5		1	1
Metals																															
Lead (Total)	7439-92-1	5	ug/l	ND	U	0.8	1	ND	U	0.8	1	ND	U	0.8	1	ND	U	0.8	1	ND	U	0.8	-	ND	U	0.8	1	ND	U	0.8	1

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Exceedance Summary:
10 - RL exceeds the PADEP Non-Residential Used Aquifer Groundwater Criteria TDS<2,500 mg/l
10 - Result exceeds the PADEP Non-Residential Used Aquifer Groundwater Criteria TDS<2,500 mg/l

Table 6
Summary of Groundwater Analytical Results
AOI 5
Philadelphia Refinery
Philadlephia, Pennsylvania

Chemical Name	CAS No	PADEP Non-Residential Used Aquifer Groundwater Criteria, TDS<2,500 mg/l	Location ID	A-26				A-26				A-27				A-3				A-39				A-40				A-41			
			Sample ID	A-26_1262006				A-26_050407				A-27_050807				A-3_050307				A-39_050707				A-40_050707				A-41_050707			
			Sample Date	12/6/2006				5/3/2007				5/8/2007				5/3/2007				5/7/2007				5/7/2007				5/7/2007			
			Sample Matrix	Groundwater				Groundwater				Groundwater				Groundwater				Groundwater				Groundwater				Groundwater			
			Unit	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF
Volatile Organic Compounds																															
1,2-Dichloroethane	107-06-2	5	ug/l	ND	U	1	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Benzene	71-43-2	5	ug/l	ND	U	1	1	ND	U	5	1	1.7	J	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Cumene	98-82-8	3,500	ug/l	ND	U	1	1	ND	U	5	1	26		5	1	6.8		5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Ethylbenzene	100-41-4	700	ug/l	ND	U	1	1	ND	U	5	1	0.51	J	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Ethylene Dibromide (EDB)	106-93-4	0.05	ug/l	NA				ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1
Methyl Tertiary Butyl Ether	1634-04-4	20	ug/l	ND	U	1	1	1.1	J	5	1	1.7	J	5	1	ND	U	5	1	ND	U	5	1	0.57	J	5	1	0.88	J	5	1
Toluene	108-88-3	1,000	ug/l	ND	U	1	1	ND	U	5	1	5.8		5	1	ND	U	5	1	ND	U	5	1	0.59	J	5	1	ND	U	5	1
Xylene (Total)	1330-20-7	10,000	ug/l	ND	U	3	1	ND	U	5	1	8.8		5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Semi-Volatile Organic Compounds																															
Chrysene	218-01-9	1.9	ug/l	ND	U	1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1	1.1		1	1	ND	U	1	1	ND	U	1	1
Fluorene	86-73-7	1,900	ug/l	ND	U	1	1	ND	U	1	1	ND	U	1	1	1.5		1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1
Naphthalene	91-20-3	100	ug/l	ND	U	1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1
Phenanthrene	85-01-8	1,100	ug/l	ND	U	1	1	ND	U	1	1	ND	U	1	1	1.3		1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1
Pyrene	129-00-0	130	ug/l	ND	U	1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1	2.2		1	1	ND	U	1	1	ND	U	1	1
Metals																															
Lead (Total)	7439-92-1	5	ug/l	ND	B	2	1	ND	U	0.8	1	ND	U	0.8	1	ND	U	0.8	1	ND	U	0.8	1	ND	U	0.8	1	ND	U	0.8	1

Notes:
PADEP - Pennsylvania Department of Environmental Protection
ug/l - micrograms per liter
mg/L - milligram per liter
RL - Reporting Limit
ND - Not Detected
DF - Dilution Factor
NA - Not Analyzed

Qualifiers:
Q - Qualifier
U - The analyte was analyzed but not detected
J - The analyte was detected below the RL. The result should be considered an estimate.
D - The sample was diluted.

Exceedance Summary:
10 - RL exceeds the PADEP Non-Residential Used Aquifer Groundwater Criteria TDS<2,500 mg/l
10 - Result exceeds the PADEP Non-Residential Used Aquifer Groundwater Criteria TDS<2,500 mg/l

Table 6
Summary of Groundwater Analytical Results
AOI 5
Philadelphia Refinery
Philadlephia, Pennsylvania

Chemical Name	CAS No	PADEP Non-Residential Used Aquifer Groundwater Criteria, TDS<2,500 mg/l	Location ID	A-43				A-44				A-48				A-49				A-5				A-6				A-8			
			Sample ID	A-43_050307				A-44_050307				A-48_050807				A-49_050807				A-5_050407				A-6_050907				A-8_050407			
			Sample Date	5/3/2007				5/3/2007				5/8/2007				5/8/2007				5/4/2007				5/9/2007				5/4/2007			
			Sample Matrix	Groundwater				Groundwater				Groundwater				Groundwater				Groundwater				Groundwater				Groundwater			
			Unit	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF
Volatile Organic Compounds																															
1,2-Dichloroethane	107-06-2	5	ug/l	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Benzene	71-43-2	5	ug/l	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Cumene	98-82-8	3,500	ug/l	ND	U	5	1	ND	U	5	1	60		5	1	5.5		5	1	ND	U	5	1	0.73	J	5	1	ND	U	5	1
Ethylbenzene	100-41-4	700	ug/l	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Ethylene Dibromide (EDB)	106-93-4	0.05	ug/l	ND	U	0.05	1	ND	U	0.05	1	0.05	J	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1
Methyl Tertiary Butyl Ether	1634-04-4	20	ug/l	ND	U	5	1	ND	U	5	1	2.3	J	5	1	ND	U	5	1	17		5	1	ND	U	5	1	1	J	5	1
Toluene	108-88-3	1,000	ug/l	ND	U	5	1	ND	U	5	1	0.68	J	5	1	ND	U	5	1	0.73	J	5	1	0.82	J	5	1	ND	U	5	1
Xylene (Total)	1330-20-7	10,000	ug/l	ND	U	5	1	ND	U	5	1	2.1	J	5	1	1.4	J	5	1	1.1	J	5	1	0.9	J	5	1	ND	U	5	1
Semi-Volatile Organic Compounds																															
Chrysene	218-01-9	1.9	ug/l	ND	U	1.1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1	2.3		1	1	NA				ND	U	1	1
Fluorene	86-73-7	1,900	ug/l	ND	U	1.1	1	ND	U	1	1	4		1	1	1.4		1	1	8.2		1	1	NA				ND	U	1	1
Naphthalene	91-20-3	100	ug/l	ND	U	1.1	1	ND	U	1	1	ND	U	1	1	1.2		1	1	ND	U	1	1	NA				ND	U	1	1
Phenanthrene	85-01-8	1,100	ug/l	ND	U	1.1	1	ND	U	1	1	2.3		1	1	ND	U	1	1	5.1		1	1	NA				ND	U	1	1
Pyrene	129-00-0	130	ug/l	ND	U	1.1	1	ND	U	1	1	2.1		1	1	ND	U	1	1	9.8		1	1	NA				ND	U	1	1
Metals																															
Lead (Total)	7439-92-1	5	ug/l	1.9	B	2	1	ND	U	0.8	1	1.3	B	2	1	ND	U	0.8	1	ND	U	0.8	1	ND	U	0.8	1	ND	U	0.8	1

Notes:
PADEP - Pennsylvania Department of Environmental Protection
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Exceedance Summary:
10 - RL exceeds the PADEP Non-Residential Used Aquifer Groundwater Criteria TDS<2,500 mg/l
10 - Result exceeds the PADEP Non-Residential Used Aquifer Groundwater Criteria TDS<2,500 mg/l

Table 6
Summary of Groundwater Analytical Results
AOI 5
Philadelphia Refinery
Philadlephia, Pennsylvania

Chemical Name	CAS No	PADEP Non-Residential Used Aquifer Groundwater Criteria, TDS<2,500 mg/l	Location ID	A-9				A-91				PZ-2				PZ-3				RW-6				SW-2				SW-3			
			Sample ID	A-9_050407				A-91_050907				PZ-2_050307				PZ-3_050307				RW-6_050307				SW-2_050707				SW-3_050707			
			Sample Date	5/4/2007				5/9/2007				5/3/2007				5/3/2007				5/3/2007				5/7/2007				5/7/2007			
			Sample Matrix	Groundwater				Groundwater				Groundwater				Groundwater				Groundwater				Groundwater				Groundwater			
			Unit	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF
Volatile Organic Compounds																															
1,2-Dichloroethane	107-06-2	5	ug/l	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Benzene	71-43-2	5	ug/l	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Cumene	98-82-8	3,500	ug/l	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Ethylbenzene	100-41-4	700	ug/l	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Ethylene Dibromide (EDB)	106-93-4	0.05	ug/l	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1
Methyl Tertiary Butyl Ether	1634-04-4	20	ug/l	5.1		5	1	1.2	J	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	1.6	J	5	1
Toluene	108-88-3	1,000	ug/l	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Xylene (Total)	1330-20-7	10,000	ug/l	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Semi-Volatile Organic Compounds																															
Chrysene	218-01-9	1.9	ug/l	ND	U	1	1	ND	U	**3.3**	1	1.9		1	1	ND	U	1.1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1
Fluorene	86-73-7	1,900	ug/l	ND	U	1	1	ND	U	3.3	1	ND	U	1	1	ND	U	1.1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1
Naphthalene	91-20-3	100	ug/l	ND	U	1	1	ND	U	3.3	1	ND	U	1	1	ND	U	1.1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1
Phenanthrene	85-01-8	1,100	ug/l	ND	U	1	1	ND	U	3.3	1	1.5		1	1	ND	U	1.1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1
Pyrene	129-00-0	130	ug/l	ND	U	1	1	ND	U	3.3	1	1.9		1	1	ND	U	1.1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1
Metals																															
Lead (Total)	7439-92-1	5	ug/l	ND	U	0.8	1	ND	U	0.8	1	5.8		2	1	2.7		2	1	ND	U	0.8	1	1.5	B	2	1	ND	U	0.8	1

Notes:
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10 - RL exceeds the PADEP Non-Residential Used Aquifer Groundwater Criteria TDS<2,500 mg/l
10 - Result exceeds the PADEP Non-Residential Used Aquifer Groundwater Criteria TDS<2,500 mg/l

Table 6
Summary of Groundwater Analytical Results
AOI 5
Philadelphia Refinery
Philadlephia, Pennsylvania

Chemical Name	CAS No	PADEP Non-Residential Used Aquifer Groundwater Criteria, TDS<2,500 mg/l	Location ID	SWR-2				SWR-3				WP-14				WP16-3				WP-4A				WP-8				WP-9			
			Sample ID	SWR-2_050707				SWR-3_050707				WP-14_050807				WP16-3_050407				WP-4A_050707				WP-8_050907				WP-9_050807			
			Sample Date	5/7/2007				5/7/2007				5/8/2007				5/4/2007				5/7/2007				5/9/2007				5/8/2007			
			Sample Matrix	Groundwater				Groundwater				Groundwater				Groundwater				Groundwater				Groundwater				Groundwater			
			Unit	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF
Volatile Organic Compounds																															
1,2-Dichloroethane	107-06-2	5	ug/l	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Benzene	71-43-2	5	ug/l	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Cumene	98-82-8	3,500	ug/l	ND	U	5	1	0.55	J	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Ethylbenzene	100-41-4	700	ug/l	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Ethylene Dibromide (EDB)	106-93-4	0.05	ug/l	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1
Methyl Tertiary Butyl Ether	1634-04-4	20	ug/l	ND	U	5	1	ND	U	5	1	0.69	J	5	1	ND	U	5	1	ND	U	5	1	3.3	J	5	1	ND	U	5	1
Toluene	108-88-3	1,000	ug/l	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	0.79	J	5	1	ND	U	5	1
Xylene (Total)	1330-20-7	10,000	ug/l	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	0.91	J	5	1	ND	U	5	1
Semi-Volatile Organic Compounds																															
Chrysene	218-01-9	1.9	ug/l	ND	U	1	1	6.2		1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1	NA				ND	U	1.2	1
Fluorene	86-73-7	1,900	ug/l	0.58	J	1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1	NA				ND	U	1.2	1
Naphthalene	91-20-3	100	ug/l	ND	U	1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1	NA				ND	U	1.2	1
Phenanthrene	85-01-8	1,100	ug/l	ND	U	1	1	2.3		1	1	ND	U	1	1	ND	U	1	1	ND	U	1	1	NA				ND	U	1.2	1
Pyrene	129-00-0	130	ug/l	ND	U	1	1	11		1	1	ND	U	1	1	ND	U	1	1	1.9		1	1	NA				ND	U	1.2	1
Metals																															
Lead (Total)	7439-92-1	5	ug/l	ND	U	0.8	1	2.5		2	1	2.3		2	1	12		2	1	2.9		2	1	ND	U	0.8	1	ND	U	0.8	1

Notes:
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RL - Reporting Limit
ND - Not Detected
DF - Dilution Factor
NA - Not Analyzed

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J - The analyte was detected below the RL. The result should be considered an estimate.
D - The sample was diluted.

Exceedance Summary:
10 - RL exceeds the PADEP Non-Residential Used Aquifer Groundwater Criteria TDS<2,500 mg/l
10 - Result exceeds the PADEP Non-Residential Used Aquifer Groundwater Criteria TDS<2,500 mg/l

Table 6
Summary of Groundwater Analytical Results
AOI 5
Philadelphia Refinery
Philadlephia, Pennsylvania

Chemical Name	CAS No	PADEP Non-Residential Used Aquifer Groundwater Criteria, TDS<2,500 mg/l	Location ID	WP-A				WP-B				WP-C				WP-D				WP-E			
			Sample ID	WP-A_050707				WP-B_050307				WP-C_050307				WP-D_050307				WP-E_050307			
			Sample Date	5/7/2007				5/3/2007				5/3/2007				5/3/2007				5/3/2007			
			Sample Matrix	Groundwater				Groundwater				Groundwater				Groundwater				Groundwater			
			Unit	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF	Result	Q	RL	DF
Volatile Organic Compounds																							
1,2-Dichloroethane	107-06-2	5	ug/l	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Benzene	71-43-2	5	ug/l	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Cumene	98-82-8	3,500	ug/l	ND	U	5	1	1.8	J	5	1	2	J	5	1	ND	U	5	1	1.6	J	5	1
Ethylbenzene	100-41-4	700	ug/l	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Ethylene Dibromide (EDB)	106-93-4	0.05	ug/l	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1	ND	U	0.05	1
Methyl Tertiary Butyl Ether	1634-04-4	20	ug/l	0.62	J	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Toluene	108-88-3	1,000	ug/l	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1	ND	U	5	1
Xylene (Total)	1330-20-7	10,000	ug/l	ND	U	5	1	ND	U	5	1	0.95	J	5	1	ND	U	5	1	ND	U	5	1
Semi-Volatile Organic Compounds																							
Chrysene	218-01-9	1.9	ug/l	3.6		1	1	12	D	**9.9**	10	ND	U	1	1	ND	U	1	1	3.4		1	1
Fluorene	86-73-7	1,900	ug/l	ND	U	1	1	ND	UD	9.9	10	1.1		1	1	ND	U	1	1	ND	U	1	1
Naphthalene	91-20-3	100	ug/l	ND	U	1	1	ND	UD	9.9	10	ND	U	1	1	ND	U	1	1	ND	U	1	1
Phenanthrene	85-01-8	1,100	ug/l	ND	U	1	1	ND	UD	9.9	10	ND	U	1	1	ND	U	1	1	ND	U	1	1
Pyrene	129-00-0	130	ug/l	11		1	1	23	D	9.9	10	ND	U	1	1	ND	U	1	1	7		1	1
Metals																							
Lead (Total)	7439-92-1	5	ug/l	1.5	B	2	1	1.7	B	2	1	ND	U	0.8	1	ND	U	0.8	1	ND	U	0.8	1

Notes:
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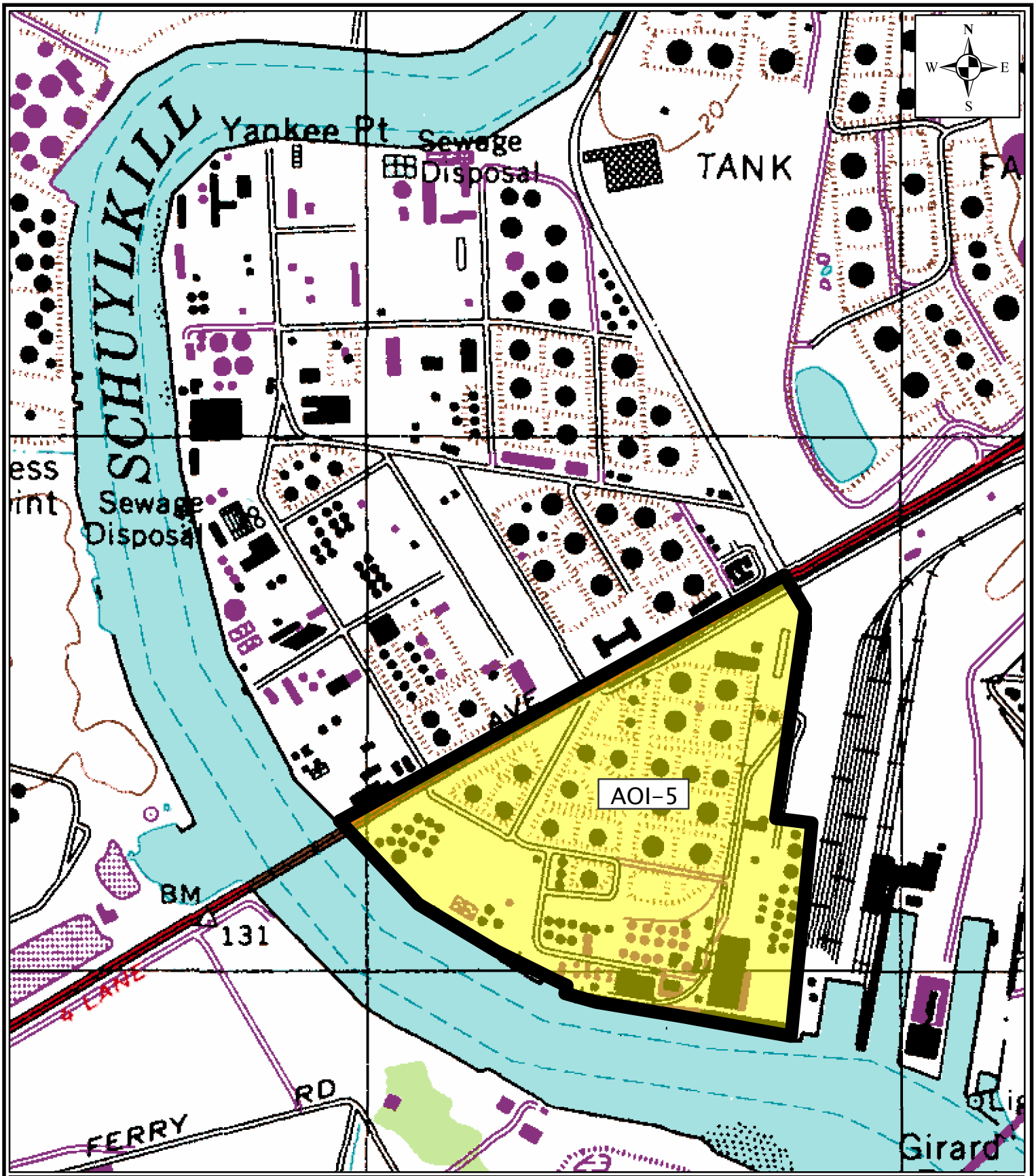
FIGURES



Sunoco, Inc. (R&M)
Philadelphia Refinery
3144 Passyunk Avenue
Philadelphia, PA. 19145

Figure 1: Site Location Map: AOI 5
AOI 5 Site Characterization Report/
Remedial Investigation Report
Sunoco Philadelphia Refinery

Philadelphia Pennsylvania

Job Number	Scale: 1" = 800'	Date
2574601	0 400 800 Feet	November 8, 2011

Q:\Data6\2574601\ArcGIS\MapDocuments\AOI 5 SCR\Figure 1- AOI 5 Boundaries.mxd

N
W E
S

Legend

- Sheet Pile Wall
- Potential Industrial Receptor
- AOI Boundary

Notes:
1. Bing Maps aerial imagery provided by © 2010 Microsoft Corporation and its data suppliers and obtained under the licensing agreement with ESRI.

Figure 2: Site Plan
AOI 5 Site Characterization Report/
Remedial Investigation Report
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Sunoco, Inc. (R&M)
Philadelphia Refinery
3144 Passyunk Avenue
Philadelphia, PA.
19145

0 300 600
Feet

SCALE: 1" = 300'
DATE: Nov. 8, 2011
DRN. BY: MH
CKD. BY: DW
JOB#: 2574601

Path: \\langan.com\data\DT data6\2574601\ArcGIS\MapDocuments\AOI 5 SCRSCR_RIR\Figure 2 - AOI 5 Site Plan_11-4-11.mxd

Legend

- Shallow Soil Boring Locations with Soil Samples
- Shallow Soil Boring Locations without Soil Samples
- New Shallow Monitoring Well with Soil Sample
- New Shallow Monitoring Well without Soil Sample
- New Shallow Monitoring Well with LNAPL Sample
- LNAPL Sample Location From Existing Monitoring Wells
- Existing Monitoring Well
- Existing Recovery Well
- Sheet Pile Wall
- Solid Waste Management Unit (SWMU)
- AOI Boundary

Notes:
1. Bing Maps aerial imagery provided by © 2010 Microsoft Corporation and its data suppliers and obtained under the licensing agreement with ESRI.
2. Boundary of SWMUs referenced from the RCRA Facility Investigation Chevron Refinery Vol 1, Dames and Moore, 11-24-93.

Figure 3: Completed Activities
AOI-5 Site Characterization Report/
Remedial Investigation Report
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Sunoco, Inc. (R&M)
Philadelphia Refinery
3144 Passyunk Avenue
Philadelphia, PA.
19145

0 150 300 Feet

SCALE: 1" = 150'
DATE: November 7, 2011
DRN. BY: MH
CKD. BY: DW
JOB#: 2574601

N
W E
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Legend

- Shallow Monitoring Well Location
- Deep Monitoring Well Location
- Shallow Recovery Well Location
- Piezometer Location
- Damaged/Abandoned/Unable to Locate
- Sheet Pile Wall
- AOI-5 Cross Section Location
- Solid Waste Management Unit (SWMU)
- AOI Boundary

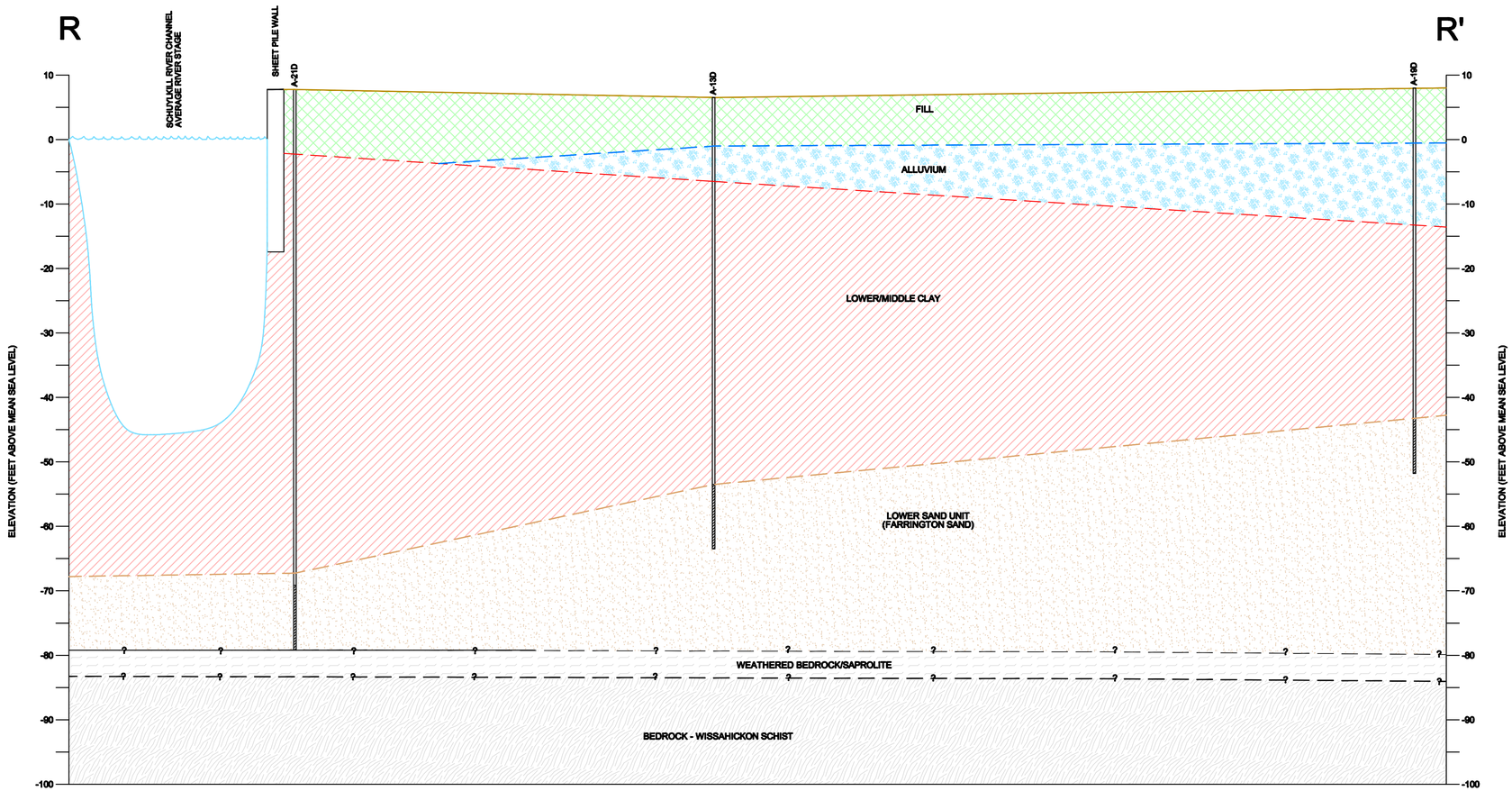
Notes:
1. Bing Maps aerial imagery provided by © 2010 Microsoft Corporation and its data suppliers and obtained under the licensing agreement with ESRI.

Figure 4: Cross Section Location Plan
AOI-5 Site Characterization Report/
Remedial Investigation Report
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

SUNOCO

Sunoco, Inc. (R&M)
Philadelphia Refinery
3144 Passyunk Avenue
Philadelphia, PA.
19145

0 150 300 Feet



LEGEND:

- FILL
- SAND
- ALLUVIUM
- WEATHERED BEDROCK
- CLAY
- WISSAHICKON SCHIST
- B-129 LOCATION ID
- ——?——?—— INFERRED CONTACTS
- WELL CASING
- WELL SCREEN

NOTES:

1. DEPTH OF SCHUYLKILL RIVER FROM SIMULATION OF GROUNDWATER FLOW IN THE POTOMIC-RARITAN-MAGOTHY AQUIFER SYSTEM NEAR THE DEFENSE SUPPLY CENTER PHILADELPHIA, AND THE POINT BREEZE REFINERY, SOUTHERN PHILADELPHIA COUNTY, PENNSYLVANIA BY CURTIS L. SCHREFFLER DATED 2001.
2. DEPTH OF SHEET PILE WALL DETERMINED FROM FIGURE 3-8 GENERALIZED GEOLOGIC CROSS SECTION A-C DATED 13 NOVEMBER 1992 FROM DAMES & MOORE, RCRA VERIFICATION INVESTIGATION REPORT, CHEVRON REFINERY, 1992. CROSS SECTION RENAMED C-J.
3. CONTACT BETWEEN FILL AND ALLUVIUM IS APPROXIMATED BASED ON AVAILABLE HISTORIC WELL LOGS.

10 0 2 4 10
VERTICAL SCALE IN FEET

200 0 100 200
HORIZONTAL SCALE IN FEET

SUNOCO

Project
SUNOCO PHILADELPHIA REFINERY
PHILADELPHIA COUNTY PENNSYLVANIA

Drawing Title
GEOLOGIC CROSS SECTION R-R'

Project No. 2574601	Drawing No. 5
Date 14 AUGUST 2007	
Scale 1"=200' HOR. 1"=10' VER.	
Drn. By DMW/TS	
Last Revised X	Of

Filename: S:\Data6\2574601\CADD Drawings\Geologic Cross-Section R-Rborderedit.dwg Date: 8/24/2007 Time: 9:40 User: scarlisle Style Table: Langan.stb Layout: D Size Sheet (Bottom)

Legend

- A-91 4.95 — Shallow Monitoring Well and Groundwater Elevation (ft.)
- RW-BH-1 2.12 — Shallow Recovery Well and Groundwater Elevation (ft.)
- PZ-2 3.13 — Piezometer and Groundwater Elevation (ft.)
- WP-1 — Abandoned/Damaged/Unable to Locate
- 4 — Groundwater Elevation Contour (ft.)
- 4 — Groundwater Depression (ft.)
- 5 — Inferred Groundwater Elevation Contour (ft.)
- Sheet Pile Wall
- AOIs

Notes:
1. Bing Maps aerial imagery provided by © 2010 Microsoft Corporation and its data suppliers and obtained under the licensing agreement with ESRI.
2. Wells gauged in May 2011, Aquaterra/Stantec.

Figure 6: Shallow Groundwater Elevation Contour Plan
AOI-5 Site Characterization Report/ Remedial Investigation Report
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Sunoco, Inc. (R&M)
Philadelphia Refinery
3144 Passyunk Avenue
Philadelphia, PA.
19145

0 150 300 Feet

SCALE: 1" = 150'
DATE: November 7, 2011
DRN. BY: MH
CKD. BY: DW
JOB# : 2574601

Path: \\langan.com\data\DT\data6\2574601\ArcGIS\MapDocuments\AOI 5 SCR\SCR_RIR\Figure 6 - Shallow Intermediate GW Elev Contours_May2011.mxd

N
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N-4
7.15
N-9
5.68
N-13
4.88
N-38D
0.85
N-21
3.72
N-19
3.18
N-27
2.51
N-30
3.77
N-44D
4.15
N-46D
N-50D
4.25

AOI-8

SCHUYLKILL RIVER

S-294D
2.41
S-72D
2.38
S-80D
1.82
S-302D
1.7
S-305D
0.47
S-46D
1.06
S-59D
S-264
0.53
S-280D
0.51
S-119D
0.41

AOI -10
AOI-2
AOI-1
AOI-4
AOI-3
AOI-7
AOI-6
AOI-5
AOI-9

C-129D
0.13
S-284D
0.37
C-65D
C-144D
-4.16
S-69D
-0.15
BF-108
C-50D
-0.16
S-38D
-0.52
S-38D2
-0.7
BF-90D
-0.44
S-13
S-22
-0.73
S-8
-1.72
S-6
C-134D
-1.43
A-19D
-1.89
B-48D
-1.64
S-76DSRTF
-6.4
B-134D
-2.91
B-133D
-1.59
S-74D2SRTF
-5.03
S-74D1SRTF
-6.6
B-132D
-4.96
A-21D
-5.31
A-13D
-2.15
S-120DSRTF
-7
S-106DSRTF
-7.17

1 2 3 4 5 6 7
0 -1 -2 -3 -4 -5 -6 -7

Notes:
1. Bing Maps aerial imagery provided by © 2010 Microsoft Corporation and its data suppliers and obtained under the licensing agreement with ESRI.
2. Deep groundwater elevations provided by Aquaterra, June/July 2011.

PENNSYLVANIA
Approximate Site Location

Legend

S-119D 0.41 — Deep Groundwater Monitoring Well and Groundwater Elevation

N-46D — Damaged/Abandoned/Unable to Locate

Deep Groundwater Contour

Area of Interest (AOI)

N-30 3.77 — Wells omitted from contouring

Figure 7 - Deep (Lower Sand) Groundwater Elevation Contour Plan - June/July 2011
AOI-5 Site Characterizaton Report/
Remedial Investigation Report
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Sunoco, Inc. (R&M)
Philadelphia Refinery
3144 Passyunk Avenue
Philadelphia, PA.
19145

0 250 500 1,000 Feet

SCALE: 1" = 500'
DATE: November 7, 2011
DRN. BY: MH
CKD. BY: DW
JOB#: 2574601

Path: \\langan.com\data\DT\data6\2574601\ArcGIS\MapDocuments\AOI 5 SCR\SCR_RIR\Figure 7 - Deep GW Contours_11-7-11.mxd

N
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Legend

- A-144_0.5-2.0 — Monitoring Well Location with Shallow Soil Sample Not Exceeding PADEP Non-Res Soil MSCs
- A-140 / A-140_071207_1.5-2.0 / *Lead in mg/kg* / Lead (total) - 2,460 — Shallow Monitoring Well Location with Shallow Soil Sample Exceeding PADEP Non-Res Soil MSCs
- A-138 — Shallow Monitoring Well Location with No Soil Sample
- Existing Monitoring Point
- Existing Recovery Well
- Sheet Pile Wall
- AOI Boundary
- * BH-09-09 * — Shallow Soil Sample with Exceedance of Site Specific Standard for Lead (1,708 mg/kg)

Compounds of Concern for Site Soil and Associated MSCs

Chemical Name	CAS No	PADEP Non-Residential Used Aquifer Unsaturated Soil MSCs (TDS<2,500)
Volatile Organic Compounds		
1,2-Dichloroethane	107-06-2	0.5
Benzene	71-43-2	0.5
Cumene	98-82-8	2500
Ethylbenzene	100-41-4	70
Ethylene Dibromide (EDB)	106-93-4	0.005
Methyl Tertiary Butyl Ether	1634-04-4	2
Toluene	108-88-3	100
Xylene (Total)	1330-20-7	1000
Semi-Volatile Organic Compounds		
Anthracene	120-12-7	350
Benzo(a)anthracene	56-55-3	320
Benzo(a)pyrene	50-32-8	46
Benzo(b)fluoranthene	205-99-2	170
Benzo(g,h,i)perylene	191-24-2	180
Chrysene	218-01-9	230
Fluorene	86-73-7	3800
Naphthalene	91-20-3	25
Phenanthrene	85-01-8	10000
Pyrene	129-00-0	2200
Metals		
Lead (Total)	7439-92-1	450

Notes:
1. Boundary of SWMUs and sheet pile wall referenced from RCRA Facility Investigation Chevron Refinery Vol 1, Dames and Moore, 11-24-93.
2. Site specific criteria for lead is 1,708 mg/kg.
3. Bing Maps aerial imagery provided by © 2010 Microsoft Corporation and its data suppliers and obtained under the licensing agreement with ESRI.

Figure 8: Summary of Soil Sample Exceedances: Non-SWMU Areas
AOI-5 Site Characterization Report/ Remedial Investigation Report
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Sunoco, Inc. (R&M)
Philadelphia Refinery
3144 Passyunk Avenue
Philadelphia, PA.
19145

0 150 300 Feet

SCALE: 1" = 150'
DATE: November 11, 2011
DRN. BY: MH
CKD. BY: DW
JOB#: 2574601

Q:\Data\Ef\2574601\ArcGIS\MapDocuments\AOI 5 SCR\Figure 8 - Summary of Non SWMU Soil Sample Exceedances.mxd

Legend

- BH-08-07 / BH-08-07_0.75-2.0 / *Lead in mg/kg* / Lead (total) - 506 — Shallow Soil Boring Location with Exceedance of PADEP Non-Res Soil MSCs
- BH-04-07_1.0-2.0 — Shallow Soil Boring Location with No Exceedance of PADEP Non-Res Soil MSCs
- BH-01-07 — Shallow Soil Boring Location with No Sample
- A-142 — Shallow Monitoring Well Location with Shallow Soil Sample Not Exceeding PADEP Non-Res Soil MSCs
- A-149 — Shallow Monitoring Well Location with No Soil Sample
- Existing Monitoring Point
- Existing Recovery Well
- Sheet Pile Wall
- Solid Waste Management Unit (SWMU)
- AOI Boundary
- * BH-09-09 * — Shallow Soil Sample with Exceedance of Site Specific Standard for Lead (1,708 mg/kg)

Compound of Concern for SWMU Areas with PADEP MSCs

Chemical Name	CAS No	PADEP Non-Residential Used Aquifer Unsaturated Soil MSCs (TDS<2,500)
Volatile Organic Compounds		
1,2-Dichloroethane	107-06-2	0.5
Benzene	71-43-2	0.5
Cumene	98-82-8	2500
Ethylbenzene	100-41-4	70
Ethylene Dibromide (EDB)	106-93-4	0.005
Methyl Tertiary Butyl Ether	1634-04-4	2
Toluene	108-88-3	100
Xylene (Total)	1330-20-7	1000
Semi-Volatile Organic Compounds		
Anthracene	120-12-7	350
Benzo(a)anthracene	56-55-3	320
Benzo(a)pyrene	50-32-8	46
Benzo(b)fluoranthene	205-99-2	170
Benzo(g,h,i)perylene	191-24-2	180
Chrysene	218-01-9	230
Fluorene	86-73-7	3800
Naphthalene	91-20-3	25
Phenanthrene	85-01-8	10000
Pyrene	129-00-0	2200
Metals		
Lead (Total)	7439-92-1	450

Notes:
1. Boundary of SWMUs and sheet pile wall referenced from RCRA Facility Investigation Chevron Refinery Vol 1, Dames and Moore, 11-24-93.
2. Site specific criteria for lead is 1,708 mg/kg.
3. Bing Maps aerial imagery provided by © 2010 Microsoft Corporation and its data suppliers and obtained under the licensing agreement with ESRI.

Figure 9: Summary of Soil Sample Exceedances: SWMU Areas
AOI-5 Site Characterization Report/ Remedial Investigation Report
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Sunoco, Inc. (R&M)
Philadelphia Refinery
3144 Passyunk Avenue
Philadelphia, PA.
19145

0 150 300 Feet

SCALE: 1" = 150
DATE: November 15, 2011
DRN. BY: MH
CKD. BY: DW
JOB#: 257460

Q:\Data\257460\ArcGIS\Map Documents\AOI 5 SCR\Figure 9 - Summary of SWMU Soil Sample Exceedances.mxd

Legend

- A-152 — Shallow Monitoring Well with No Exceedance of PADEP MSCs
- A-134 — Shallow Monitoring Well with Exceedance of PADEP MSCs
- A-13D — Deep Monitoring Well with No Exceedance of PADEP MSCs
- A-19D — Deep Monitoring Well with Exceedance of PADEP MSCs
- A-136 — Existing Monitoring Point Not Sampled (Contained LNAPL or Not Accessible)
- AOI Boundary

Compounds of Concern for Site Groundwater and Associated MSCs

Chemical Name	CAS No	PADEP Non-Residential Used Aquifer Groundwater Criteria, TDS<2,500 mg/l
Volatile Organic Compounds		
1,2-Dichloroethane	107-06-2	5
Benzene	71-43-2	5
Cumene	98-82-8	3,500
Ethylbenzene	100-41-4	700
Ethylene Dibromide (EDB)	106-93-4	0.05
Methyl Tertiary Butyl Ether	1634-04-4	20
Toluene	108-88-3	1,000
Xylene (Total)	1330-20-7	10,000
Semi-Volatile Organic Compounds		
Chrysene	218-01-9	1.9
Fluorene	86-73-7	1,900
Naphthalene	91-20-3	100
Phenanthrene	85-01-8	1,100
Pyrene	129-00-0	130
Metals		
Lead (Total)	7439-92-1	5

Notes:
1. Bing Maps aerial imagery provided by © 2010 Microsoft Corporation and its data suppliers and obtained under the licensing agreement with ESRI.

Figure 10: Summary of Groundwater Sample Exceedances
AOI-5 Site Characterization Report/
Remedial Investigation Report
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Sunoco, Inc. (R&M)
Philadelphia Refinery
3144 Passyunk Avenue
Philadelphia, PA.
19145

0 150 300 Feet

SCALE: 1" = 150'
DATE: November 10, 2011
DRN. BY: MH
CKD. BY: DW
JOB# : 2574601

Path: \\langan.com\data\DT\data9\2574601\ArcGIS\MapDocuments\AOI 5 SCR\SCR_RIR\Figure10 - Summary of Groundwater Sample Exceedances DH 11-16-11.mxd

N
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Legend

- Shallow Monitoring Well with Apparent LNAPL Thickness (ft.)
- Shallow Monitoring Well with Apparent LNAPL Thickness (ft.)
- Monitoring Well (Unclassified) With No LNAPL
- Monitoring Wells With No LNAPL
- Fill / Alluvium Recovery Well with No LNAPL
- Monitoring Wells With No Gauging
- Occupied Buildings
- AOIs
- Sheet Pile Wall

LNAPL Types

- Middle Distillate
- Lube Oil
- Residual Oil

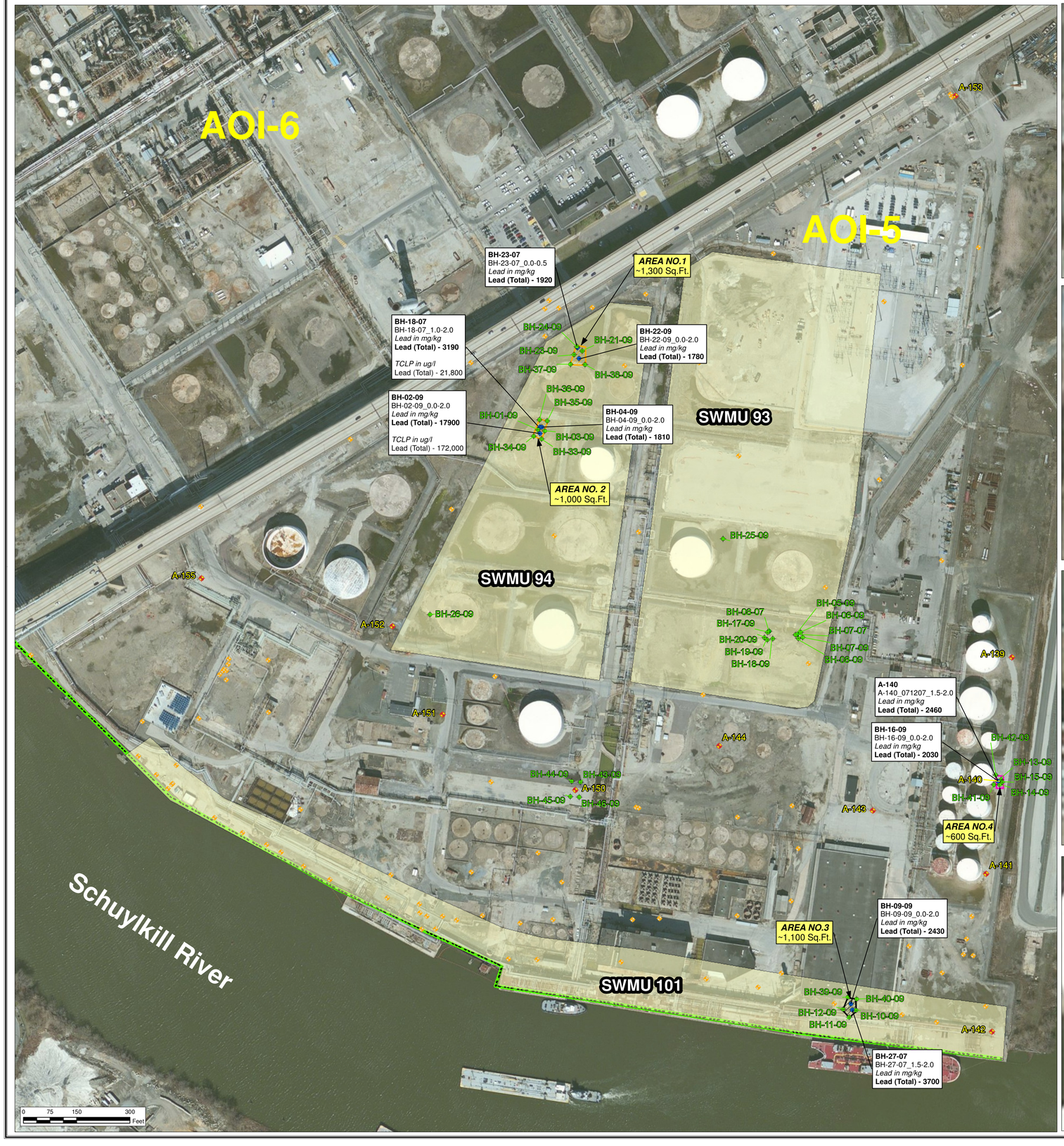
Notes:
1. NM = The actual LNAPL thickness for well SW-5 was unable to be measured due to the products viscosity.
2. Bing Maps aerial imagery provided by © 2010 Microsoft Corporation and its data suppliers and obtained under the licensing agreement with ESRI.

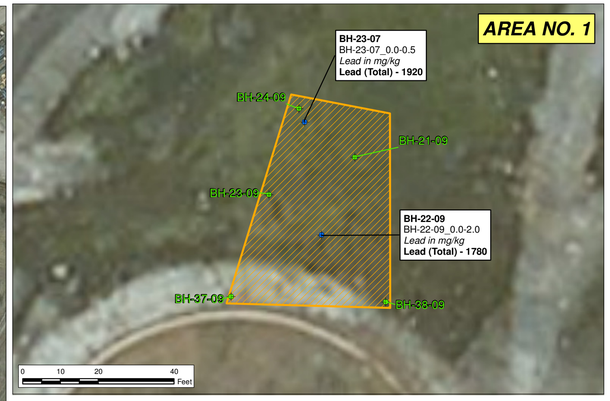
Figure 11: Apparent LNAPL Thickness
AOI-5 Site Characterization Report/
Remedial Investigation Report
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

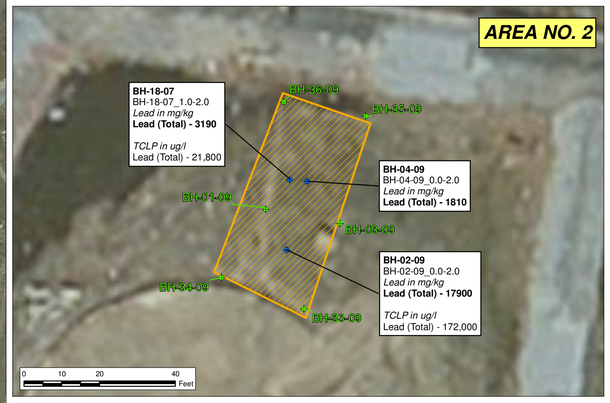
Sunoco, Inc. (R&M)
Philadelphia Refinery
3144 Passyunk Avenue
Philadelphia, PA.
19145

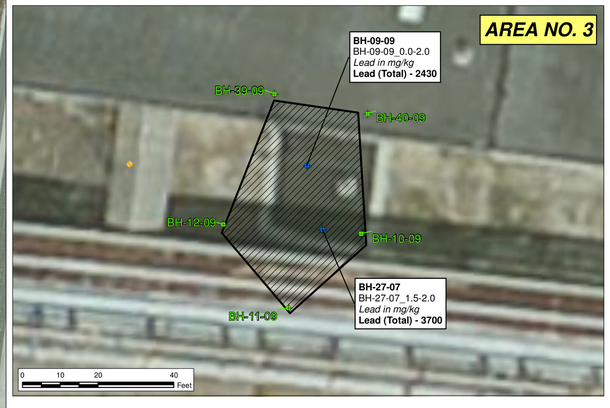
0 150 300 Feet

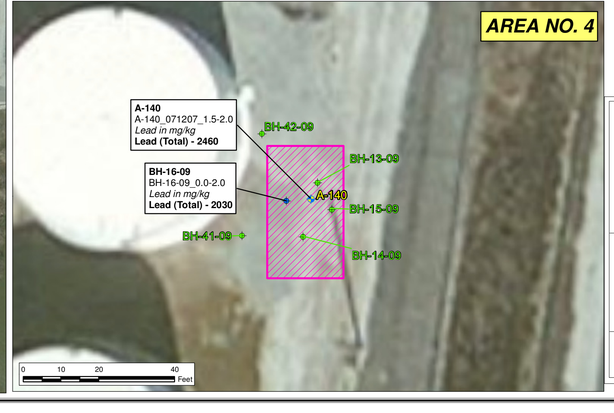
SCALE: 1" = 150'
DATE: November 8, 2011
DRN. BY: MH
CKD. BY: DW
JOB# : 2574601











N
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Legend

- Monitoring Well Locations/Shallow Soil Samples with No Exceedance of Site Specific Criteria for Lead (1,708 mg/kg)
- Monitoring Well Locations/Shallow Soil Samples with Exceedance of Site Specific Criteria for Lead (1,708 mg/kg)
- Shallow Soil Boring with No Exceedance of Site Specific Criteria for Lead (1,708 mg/kg)
- Shallow Soil Boring with Exceedance of Site Specific Criteria for Lead (1,708 mg/kg)
- Existing Monitoring Points
- Existing Recovery Well
- Sheet Pile Wall
- RCRA Solid Waste Management Units (SWMU)
- AOI Boundary

Selected Remedy Key

- Areas 1 and 2 - Excavation Area
- Area 3 - Asphalt Capped Area
- HDPE Liner/Cap or Excavation Area

Notes:
1. Boundary of SWMUs and sheet pile wall referenced from RCRA Facility Investigation Chevron Refinery Vol 1, Dames and Moore, 11-24-93.
2. bgs = below ground surface
3. Site specific criteria for lead is 1,708 mg/kg.
4. Bing Maps aerial imagery provided by © 2010 Microsoft Corporation and its data suppliers and obtained under the licensing agreement with ESRI.

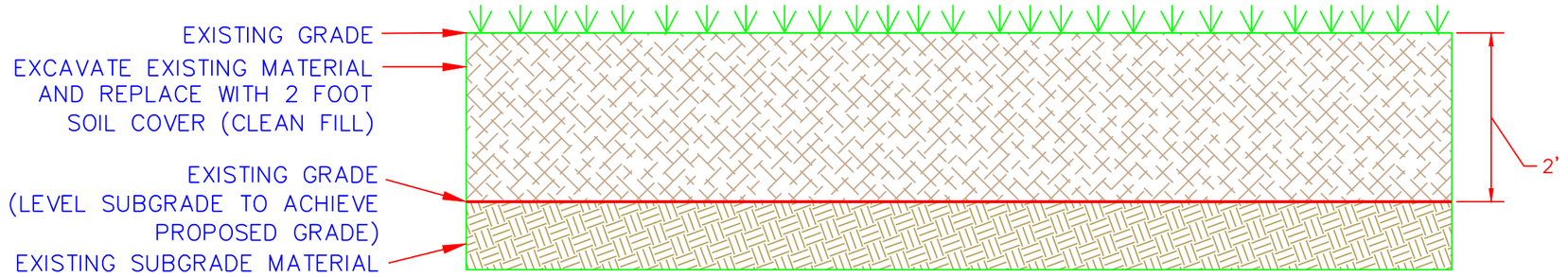
Figure 12: Summary of Selected Remedial Actions: Engineering Controls
AOI-5 Site Characterization Report/
Remedial Investigation Report
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Sunoco, Inc. (R&M)
Philadelphia Refinery
3144 Passyunk Avenue
Philadelphia, PA.
19145

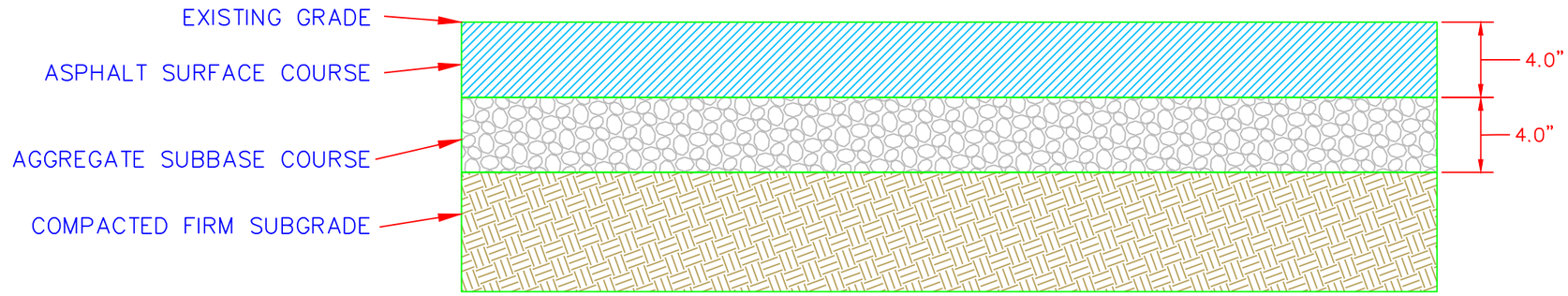
0 150 300 Feet

SCALE: See Insets
DATE: November 9, 2011
DRN. BY: MH
CKD. BY: DW
JOB# : 2574601

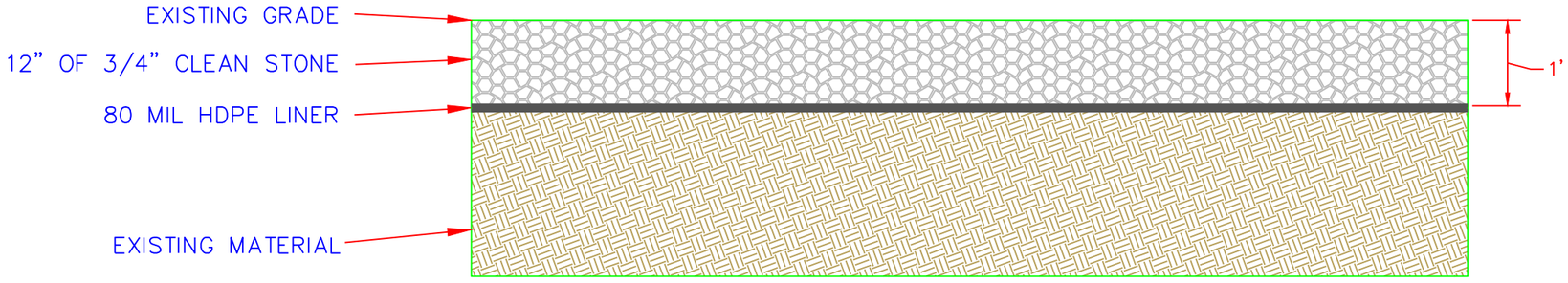
Path: \\langan.com\data\PHI\data\257460\Arc\GIS\MapDocuments\AOI 5 SCHGCR_RIRF\gure 12 - Summary of Selected Remedial Actions_11-15-11.mxd



AREAS 1 AND 2 – EXCAVATION AND SOIL COVER SECTION



AREA 3 – PAVEMENT SECTION



AREA 4 – HDPE LINER AND STONE COVER SECTION

NOTES:
1) ALL WORK TO BE COMPLETED IN ACCORDANCE WITH SUNOCO'S EXCAVATION, PAVING AND PERMITTING REQUIREMENTS.

SUNOCO, INC (R&M)

CONCEPTUAL DETAILS OF REMEDIAL ALTERNATIVES

PHILADELPIC COUNTY PHILADELPHIA PENNSYLVANIA

Project No.	Date	Scale	Dwg. No.
2574601	11/11/11	N.T.S.	FIG 13

Filename: \\langan.com\data\DT\data6\2574601\Cadd Data – 2574601\Dwg\Environmental\Figure 13 – Conceptual Details of Remedial Alternatives.dwg Date: 12/13/2011 Time: 15:01 User: dtaylor Style Table: Autodesk–Color.stb Layout: FIG. 13

APPENDIX A

Notice of Intent to Remediate and
Report Notifications

Sunoco Inc.
3144 Passyunk Avenue
Philadelphia PA 19145-5299
215 339 2000

October 12, 2006

Mr. Robert Day-Lewis
Pennsylvania DEP
2 East Main Street
Norristown, PA 19401

Mr. Steve O'Neil
Pennsylvania DEP
2 East Main Street
Norristown, PA 19401

Re: Sunoco Inc. (R&M) Philadelphia Refinery
Philadelphia, Philadelphia County

Dear Mr. Day-Lewis and Mr. O'Neil:

In accordance with the Land Recycling and Environmental Remediation Standards Act (Act 2), enclosed are two copies of a Notice of Intent to Remediate (NIR) for the Sunoco Inc. (R&M) Philadelphia Refinery. This NIR covers remediation being done as part of the 2003 Consent Order and Agreement (CO&A) at Point Breeze, Girard Point and Schuylkill River Tank Farm. Remediation at Belmont Terminal, which is part of the CO&A, is not part of this NIR since this site is not subject to RCRA Corrective Action. Sunoco is considering submitting a separate NIR for this area under the Act 2 program only.

This NIR is being submitted with the intent to enter the Sunoco Philadelphia Refinery into the One Cleanup Program with PaDEP and the USEPA. All remediation work at the Philadelphia refinery will be completed under the 2003 Consent Order & Agreement (CO&A), however, RCRA Corrective Action measures will be addressed concurrently with work performed under the CO&A and within the Act 2 program.

Please call me at 610-859-1881 or email me at jroppenheim@sunocoinc.com with any questions or comments.

Best Regards,

James Oppenheim, PE
Sr. Environmental Consultant

Cc: Sunoco Legal Dept.
Philadelphia Refinery Environmental Central File
David Burke, PADEP
Walter Payne, PADEP
Hon Lee, USEPA Region III
Colleen Costello, Langan

Will remediation be to a site-specific standard ☒ or as a special industrial area ☐? If so, the municipality or municipalities must be provided 30-day comment period.
Remediator/Property Owner/Consultant. For each of these recipients of the approval of the final report, complete form below.

Remediator
Contact Person: James R. Oppenheim
Relationship to site (e.g. owner, remediator, participating in cleanup, consultant): Remediation Project Manager
Phone Number: (610) 859-1881
Company Name: Sunoco, Inc. (R&M)
Address (street, city, state, zip): 100 Green St., Marcus Hook, PA 19061
Email Address: jroppenheim@sunocoinc.com
Property Owner
Contact Person: Scott Baker
Relationship to site (e.g. owner, remediator, participating in cleanup, consultant): Environmental Manager
Phone Number: (215) 339-2074
Company Name: Sunoco, Inc. (R&M)
Address (street, city, state, zip): 3144 Passyunk Ave. Philadelphia, PA 19145
Email Address: sabaker@sunocoinc.com
Consultant
Contact Person: Colleen Costello
Relationship to site (e.g. owner, remediator, participating in cleanup, consultant): Consultant
Phone Number: (215) 864-0640
Company Name: Langan Engineering and Environmental Services
Address (street, city, state, zip): 30 South 17th St., Suite 1500, Philadelphia, PA 19103
Email Address: ccostello@langan.com

Preparer of Notice of Intent to Remediate:

Name: James Oppenheim

Title: Project Manager

Address: 100 Green Street
Marcus Hook, PA 19061

Telephone: (610) 859-1881

Email Address: jroppenheim@sunocoinc.com

Email Image File of Site Map showing property lines and general area of site(s) to be remediated to: (landrecycling@state.pa.us)

Sunoco Inc.
3144 Passyunk Avenue
Philadelphia PA 19145-5299
215 339 2000

October 12, 2006

Manager
Philadelphia Department of Public Health
Environmental Health Services
321 University Avenue
Philadelphia, PA 19104

Re: Sunoco, Inc. (R&M) Philadelphia Refinery
Philadelphia, Philadelphia County

Dear Sir/Madam:

The Land Recycling and Environmental Remediation Standards Act (Act 2) requires that a Notice of Intent to Remediate (NIR) be provided to the municipality in which the site is located when a site is being remediated to a site-specific Standard. The municipality is afforded a 30-day comment period. In accordance with this provision of the Act, Sunoco, Inc. (R&M) is formally notifying you of its intent to remediate the subject site under Act 2. A copy of the NIR, which will be sent to the Pennsylvania Department of Environmental Protection (PaDEP), is enclosed. This notice will also be published in the Pennsylvania Bulletin, and a summary of the notice appeared in the Philadelphia Daily News on October 16, 2006.

Publication of this notice in the Philadelphia Daily News initiates the 30-day public and municipal comment period. During the next thirty days, your municipality may request to become involved in the development of the remediation plans for the site. If the municipality wishes to become involved in this project, please send your comments to Sunoco to my attention.

Please call me at (610) 859-1881 if you have any questions concerning the proposed remediation.

Best Regards,

James R. Oppenheim, P.E.
Senior Environmental Consultant

Cc: Sunoco Legal Dept.
Philadelphia Refinery Environmental Central File
Steve O'Neil, PaDEP
Colleen Costello, Langan

Will remediation be to a site-specific standard ☒ or as a special industrial area ☐? If so, the municipality or municipalities must be provided 30-day comment period.
Remediator/Property Owner/Consultant. For each of these recipients of the approval of the final report, complete form below.

Remediator
Contact Person: James R. Oppenheim
Relationship to site (e.g. owner, remediator, participating in cleanup, consultant): Remediation Project Manager
Phone Number: (610) 859-1881
Company Name: Sunoco, Inc. (R&M)
Address (street, city, state, zip): 100 Green St., Marcus Hook, PA 19061
Email Address: jroppenheim@sunocoinc.com
Property Owner
Contact Person: Scott Baker
Relationship to site (e.g. owner, remediator, participating in cleanup, consultant): Environmental Manager
Phone Number: (215) 339-2074
Company Name: Sunoco, Inc. (R&M)
Address (street, city, state, zip): 3144 Passyunk Ave. Philadelphia, PA 19145
Email Address: sabaker@sunocoinc.com
Consultant
Contact Person: Colleen Costello
Relationship to site (e.g. owner, remediator, participating in cleanup, consultant): Consultant
Phone Number: (215) 864-0640
Company Name: Langan Engineering and Environmental Services
Address (street, city, state, zip): 30 South 17th St., Suite 1500, Philadelphia, PA 19103
Email Address: ccostello@langan.com

Preparer of Notice of Intent to Remediate:

Name: James Oppenheim
Title: Project Manager
Address: 100 Green Street
Marcus Hook, PA 19061
Telephone: (610) 859-1881
Email Address: jroppenheim@sunocoinc.com

Email Image File of Site Map showing property lines and general area of site(s) to be remediated to: (landrecycling@state.pa.us)

Proof of Publication in The Philadelphia Daily News
Under Act. No 587, Approved May 16, 1929

STATE OF PENNSYLVANIA
COUNTY OF PHILADELPHIA

Anna Dickerson being duly sworn, deposes and says that **The Philadelphia Daily News** is a newspaper published daily, except Sunday, at Philadelphia, Pennsylvania, and was established in said city in 1925, since which date said newspaper has been regularly issued in said County, and that a copy of the printed notice of publication is attached hereto exactly as the same was printed and published in the regular editions and issues of the said newspaper on the following dates:

October 16, 2006

Affiant further deposes and says that he is an employee of the publisher of said newspaper and has been authorized to verify the foregoing statement and that he is not interested in the subject matter of the aforesaid notice of publication, and that all allegations in the foregoing statement as to time, place and character of publication are true.

Anna Dickerson

Sworn to and subscribed before me this 16th day of October 2006

Mary Anne Logan
Notary Public

My Commission Expires:

NOTARIAL SEAL
Mary Anne Logan, Notary Public
City of Philadelphia, Phila. County
My Commission Expires March 30, 2009

Copy of Notice of Publication

Newspaper Notice of Intent to Remediate to an Environmental Standard. (Sections 302(e)(1)(ii), 303(h)(1)(ii), 304(n)(1)(i), and 305(c)(1))

Pursuant to the Land Recycling and Environmental Remediation Standards Act (Act), the act of May 19, 1995, P.L. 4, No. 1995-2, notice is hereby given that Sunoco Inc.(R&M) has submitted to the Pennsylvania Department of Environmental Protection a Notice of Intent to Remediate a site located at 3144 Passyunk Ave., Philadelphia, Philadelphia County, Pennsylvania. This Notice of Intent to Remediate states that the site is a petroleum refinery. It has been determined that petroleum compounds have impacted soil and groundwater at the site. Sunoco, Inc. (R&M) has indicated that proposed remediation measures will include source reduction and engineered boundary controls. The proposed future use of the property is industrial for continued operation as a petroleum refinery.

Sunoco Inc. (R&M) plans to use the site-specific remediation standard at the site. The Act provides for a 30-day public comment period for site-specific standard remediation. The 30-day comment period is initiated with the publication of this notice. Until November 16, 2006, the City of Philadelphia may submit a request to Sunoco Inc. (R&M) to be involved in the development of the remediation and reuse plans for the site. The City of Philadelphia may also submit a request to Sunoco Inc. (R&M) during this 30-day comment period to develop and implement a public involvement plan. Copies of these requests and of any comments should also be submitted to the Department of Environmental Protection at 2 East Main Street, Norristown, PA 19401 to the attention of Mr. Walter Payne. All correspondence with Sunoco Inc. (R&M) should be addressed to the Public Relations Dept., Sunoco Inc. (R&M) at 3144 Passyunk Ave, Philadelphia, PA, 19145.

LEGAL NOTICES

Newspaper Notice of Intent to Remediate
to an Environmental Standard.
(Sections 302(e)(1)(ii), 303(h)(1)(ii),
304(n)(1)(i), and 305(c)(1))

Pursuant to the Land Recycling and Environmental Remediation Standards Act (Act), the act of May 19, 1995, P.L. 4, No. 1995-2., notice is hereby given that Sunoco Inc.(R&M) has submitted to the Pennsylvania Department of Environmental Protection a Notice of Intent to Remediate a site located at 3144 Passyunk Ave., Philadelphia, Philadelphia County, Pennsylvania. This Notice of Intent to Remediate states that the site is a petroleum refinery. It has been determined that petroleum compounds have impacted soil and groundwater at the site. Sunoco Inc. (R&M) has indicated that proposed remediation measures will include source reduction and engineered boundary controls. The proposed future use of the property is industrial for continued operation as a petroleum refinery.

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Appeared in: ***Philadelphia Inquirer & Philadelphia Daily News*** on Monday, 10/16/2006

Back

LANGAN
ENGINEERING & ENVIRONMENTAL SERVICES

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George P. Kelley, P.E.
George E. Derrick, P.E.
Michael A. Semeraro, Jr., P.E.
Nicholas De Rose, P.G.
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Stewart H. Abrams, P.E.
Brian M. Conlon, P.E.
Jeffrey A. Smith, P.G.

November 7, 2011

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

Manager
Philadelphia Department of Public Health
Environmental Health Services
321 University Avenue
Philadelphia, Pennsylvania 19104

RE: Notice of Submittal of Site Characterization/ Remedial Investigation Report/Cleanup Plan
Area of Interest (AOI) 5
Sunoco, Inc. (R&M) Philadelphia Refinery
Philadelphia, Philadelphia County, Pennsylvania
Langan Project No.: 2574601

Dear Sir/Madam:

Notice is hereby given that Sunoco, Inc. (R&M) (Sunoco) is in the process of submitting a Site Characterization/Remedial Investigation Report/Cleanup Plan to the Pennsylvania Department of Environmental Protection for AOI 5 located at the Sunoco Philadelphia Refinery, Philadelphia, Philadelphia County, Pennsylvania. The report indicates that the remediation planned will attain compliance with a combination of site-specific and the statewide health cleanup standards.

This notice is made under the provision of the Land Recycling and Environmental Standards Act, the Act of May 19, 1995, P.L. #4, No. 2.

Sincerely,
Langan Engineering and Environmental Services, Inc.

Colleen Costello

Colleen Costello, P.G.
Senior Principal

cc: Jim Oppenheim, Sunoco
Kevin Dunleavy, Sunoco

\\langan.com\data\DT\data6\2574601\Office Data\Reports\Repackaged SCR_RIR\AOI 5\Appendices\Appendix B\RIR Municipal Notice_110711.doc

7011 1150 0001 9432 0683

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Street, Apt. No.; or PO Box No.: Philadelphia Dept. of Public Health
City, State, ZIP+4: Environmental Health Services
321 University Avenue
Philadelphia, Pennsylvania 19104

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: *COMPLETE THIS SECTION*

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

Manager
Philadelphia Dept. of Public Health
Environmental Health Services
321 University Avenue
Philadelphia, Pennsylvania 19104

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X [signature] ☑ Agent ☐ Addressee

B. Received by (Printed Name) Joaquin Ortiz C. Date of Delivery 11/8/11

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☑ No

3. Service Type
☑ Certified Mail ☐ Express Mail
☐ Registered ☑ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? *(Extra Fee)* ☐ Yes

2. Article Number *(Transfer from service label)* 7011 1150 0001 9432 0683

PS Form 3811, February 2004 — Domestic Return Receipt — 102595-02-M-1540

Notification of Receipt
of Site Characterization/Remedial Investigation Report/Cleanup Plan

Notice is hereby given that Sunoco Inc. (R&M) (Sunoco) is in the process of submitting a Site Characterization/Remedial Investigation Report/Cleanup Plan to the Pennsylvania Department of Environmental Protection (PADEP), Southeast Regional Office for Area of Interest 5 (AOI 5) located at the Sunoco Philadelphia Refinery, Philadelphia, Pennsylvania. Sunoco has indicated in the report that site characterization activities have been completed at AOI 5 in accordance with the Land Recycling and Environmental Remediation Standards Act and the 2004 Memorandum of Agreement between the PADEP and U.S. Environmental Protection Agency (EPA) (a.k.a., the PA One Cleanup Program). This notice is made under the provision of the Land Recycling and Environmental Remediation Standards Act, the Act of May 19, 1995, P.L. #4, No. 2.

Proof of Publication in The Philadelphia Daily News
Under Act. No 587, Approved May 16, 1929

STATE OF PENNSYLVANIA
COUNTY OF PHILADELPHIA

Anna Dickerson being duly sworn, deposes and says that **The Philadelphia Daily News** is a newspaper published daily, except Sunday, at Philadelphia, Pennsylvania, and was established in said city in 1925, since which date said newspaper has been regularly issued in said County, and that a copy of the printed notice of publication is attached hereto exactly as the same was printed and published in the regular editions and issues of the said newspaper on the following dates:

November 14, 2011

Affiant further deposes and says that she is an employee of the publisher of said newspaper and has been authorized to verify the foregoing statement and that she is not interested in the subject matter of the aforesaid notice of publication, and that all allegations in the foregoing statement as to time, place and character of publication are true.

Anna Dickerson

Sworn to and subscribed before me this 14th day of November, 2011.

Mary Anne Logan
Notary Public

My Commission Expires:

NOTARIAL SEAL
Mary Anne Logan, Notary Public
City of Philadelphia, Phila. County
My Commission Expires March 30, 2013

Copy of Notice of Publication

Notification of Receipt of Site Characteriza - tion / Remedial Investigation Report/ Cleanup Plan

Notice is hereby given that Sunoco Inc. (R&M) (Sunoco) is in the process of submitting a Site Characterization/Remedial Investigation Report/Cleanup Plan to the Pennsylvania Department of Environmental Protection (PADEP), Southeast Regional Office for Area of Interest 5 (AOI 5) located at the Sunoco Philadelphia Refinery, Philadelphia, Pennsylvania. Sunoco has indicated in the report that site characterization activities have been completed at AOI 5 in accordance with the Land Recycling and Environmental Remediation Standards Act and the 2004 Memorandum of Agreement between the PADEP and U.S. Environmental Protection Agency (EPA) (a.k.a., the PA One Cleanup Program). This notice is made under the provision of the Land Recycling and Environmental Remediation Standards Act, the Act of May 19, 1995, P.L. #4, No. 2.

APPENDIX B

Current and Historic Use Figure

N
W E
S

Legend

- Current Use Areas
- Historic Use Areas
- Impervious Surfaces
- AOI Boundaries

Notes:
1. Bing Maps aerial imagery provided by © 2010 Microsoft Corporation and its data suppliers and obtained under the licensing agreement with ESRI.

Appendix B - Current and Historic Use
AOI-5 Site Characterization Report/
Remedial Investigation Report
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Sunoco, Inc. (R&M)
Philadelphia Refinery
3144 Passyunk Avenue
Philadelphia, PA.
19145

0 150 300 Feet

SCALE: 1" = 150'
DATE: November 15, 2011
DRN. BY: MH
CKD. BY: DW
JOB#: 2574601

Path: \\angan.com\data\DT\data\2574601\ArcGISMapDocuments\AOI-5 SCR\SCR_RIR-Appendix_A_AOI-5 Current Use and Historic Use_111911.mxd

APPENDIX C

Aquifer Testing Data

Appendix C
Aquifer Testing Data
AOI 5 Site Characterization Report
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

1.0 Introduction

A series of "falling head" and "rising head" slug tests were performed at four monitoring wells located in AOI 5 at the Sunoco Philadelphia Pennsylvania Refinery. These tests were completed on June 15 (MW-151 and MW-154) and June 18 (MW-140 and MW-147), 2007 by Aquaterra. All four wells tested are screened in the unconfined water table aquifer. A pressure transducer/datalogger combination was used to record changes in water level during each test. Each location was tested twice (except at MW-140) using both rising and falling slugs. Observations recorded on several of the monitoring well logs (MW-140 and MW-154) indicate that there is a mixture of soil types adjacent to the screened intervals, principally silty clay, sand, and gravel.

2.0 Analytical Methods

Representative hydraulic conductivities were estimated using the aquifer and slug test analysis software AQTESOLV. The analytical solutions used are the Bouwer Rice and the Hvorslev methods for unconfined aquifers. Prior to AQTESOLV analysis the depth to groundwater data from each test was normalized. Normalization is done to eliminate the ambiguity in matching straight-line solutions (such as the Bouwer Rice and Hvorslev methods) to slug test data (Butler, 1998). To normalize a data set the recorded water table displacement is scaled between one (maximum displacement) and zero (static recovery). The recommended normalized displacement head range for straight line matching of data is 0.15 to 0.25 for the Hvorslev method and 0.20 to 0.30 for the Bouwer Rice method (Butler, 1998). The displacement data was additionally corrected for partial penetration of the well screen into the aquifer and for a partially submerged well screen, where appropriate. The AQTESOLV files can be found in Attachment A.

According to the AQTESOLV User's Guide the following requirements apply to the use of the Bouwer-Rice solution:

- Aquifer has infinite aerial extent
- Aquifer is homogeneous and of uniform thickness
- Aquifer potentiometric surface is initially horizontal
- Test well is fully or partially penetrating

- A volume of water, V, is injected or discharged from the well instantaneously
- Aquifer is confined or unconfined
- Flow is steady

According to the AQTESOLV User's Guide the following requirements apply to the use of the Hvorslev solution:

- Aquifer has infinite aerial extent
- Aquifer is homogeneous and of uniform thickness
- Aquifer potentiometric surface is initially horizontal
- Test well is partially penetrating
- A volume of water, V, is injected or discharged from the well instantaneously
- Aquifer is confined (Bouwer, 1989, demonstrated that the Hvorslev method is equally good at estimating the hydraulic conductivity of an unconfined aquifer, provided that the water table elevation is not too close to the top of the well screen)
- Flow is steady
- The screened interval is saturated throughout the test

3.0 Results

Hydraulic conductivity estimates were derived from MW-147, MW-151 and MW-154. Monitoring well and aquifer input parameters used in the AQTESOLV analysis are summarized in Table 1. Estimated hydraulic conductivities for each monitoring well are summarized in Table 2. The AQTESOLV analysis files can be found in Attachment A. The saturated thickness in this analysis is assumed to be 20 feet.

MW-147

The range of estimated hydraulic conductivities for MW-147 using the Bouwer Rice method is 2.534 ft/d to 19.870 ft/d and using the Hvorslev method is 11.610 ft/d to 23.620 ft/d. The geometric average hydraulic conductivity for both analytical methods is 11.9 ft/d.

MW-151

Using the Bouwer-Rice method the range of estimated hydraulic conductivities for MW-151 is 10.060 ft/d to 56.27 ft/d. The geometric average hydraulic conductivity is 20.8 ft/d.

MW-154

Using the Bouwer-Rice method the range of estimated hydraulic conductivities for MW-154 is 20.140 ft/d to 45.28 ft/d. The geometric average hydraulic conductivity is 33.1 ft/d.

MW-140

The hydraulic response at MW-140 did not produce the gradual rise or fall in water level as observed in slug tests performed at the other monitoring wells in AOI 5. The aquifer response at MW-140 may be due to an extremely high hydraulic conductivity, inadequate slug volume or a combination of both. In the falling head test at MW-140 there is an initial upward displacement of the water level of about 0.25 ft which returns to near static in less than three seconds. In the rising head test at MW-140 there is also observed an initial displacement of approximately 0.25 ft which again returns to static in less than three seconds. The rate of data collection (every three seconds) does not facilitate the analysis this response curve. This may indicate the presence of highly conductive materials such as gravel.

4.0 Summary

The geometric average hydraulic conductivity at MW-147 is 11.9 ft/d, at MW-151 the geometric average hydraulic conductivity is 20.8 ft/d and at MW-154 the geometric average hydraulic conductivity is 33.1 ft/d. The hydraulic conductivity at MW-140 is undetermined due to the quick response of the water level during the testing (return to static in less than three seconds). These hydraulic conductivity estimates are consistent with literature values for the principle soil type present (sand). According to Heath, 1983, the hydraulic conductivity for sand ranges from 1.0 ft/d to 100 ft/d.

5.0 References

Hvorslev, M.J., 1951. Time Lag and Soil Permeability in Ground-Water Observations, Bull. No. 36, Waterways Exper. Sta. Corps of Engrs, U.S. Army, Vicksburg, Mississippi, pp. 1-50.

Bouwer, H. and R.C. Rice, 1976. A slug test method for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells, Water Resources Research, vol. 12, no. 3, pp. 423-428.

Bouwer, H., 1989. The Bouwer and Rice slug test–an update, Ground Water, vol. 27, no. 3, pp. 304-309.

Butler, J.J., Jr., 1998. The Design, Performance, and Analysis of Slug Tests, Lewis Publishers, Boca Raton, 252p.

TABLES

Table 1
Slug Test Analysis Data for AQTESOLV
AOI 5 Site Characterization Report
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Test ID	Initial Depth to Water	Intial Displacement	Saturated Thickness	Length of Well Screen	Length of Sceen Above Static Water Table	Screen Penetration Depth Below Water Table	Inside Radius of Well Casing	Effective Radius of Well Bore	Outer Radius of Well Bore	Effective Porosity of Gravel Pack
	ft	ft	ft	ft	ft	ft	ft	ft	ft	unitless
140 Slug In 1	5.68	No Response	20	15	2	13	0.333	0.687	0.687	0.33
140 Slug Out 1										
147 Slug In 1	1.69	0.892	20	12	-2.31	14.31	0.333	0.687	0.687	0.33
147 Slug In 2		0.788								
147 Slug Out 1		1.387								
147 Slug Out 2		0.924								
151 Slug In 1	4.35	0.774	20	13	2.35	10.65	0.333	0.687	0.687	0.33
151 Slug In 2		0.358								
151 Slug Out 1		0.69								
151 Slug Out 2		0.62								
154 Slug In 1	2.5	0.621	20	15	0.5	14.5	0.333	0.687	0.687	0.33
154 Slug In 2		0.236								
154 Slug Out 1		0.535								
154 Slug Out 2		0.605								

NOTES:

1) Monitoring Well A-147 groundwater elevations during slug testing were above the top of the well screen.

2) Monitoring Wells A-151 and A-154 groundwater elevations duringslug testing were within the well screen.

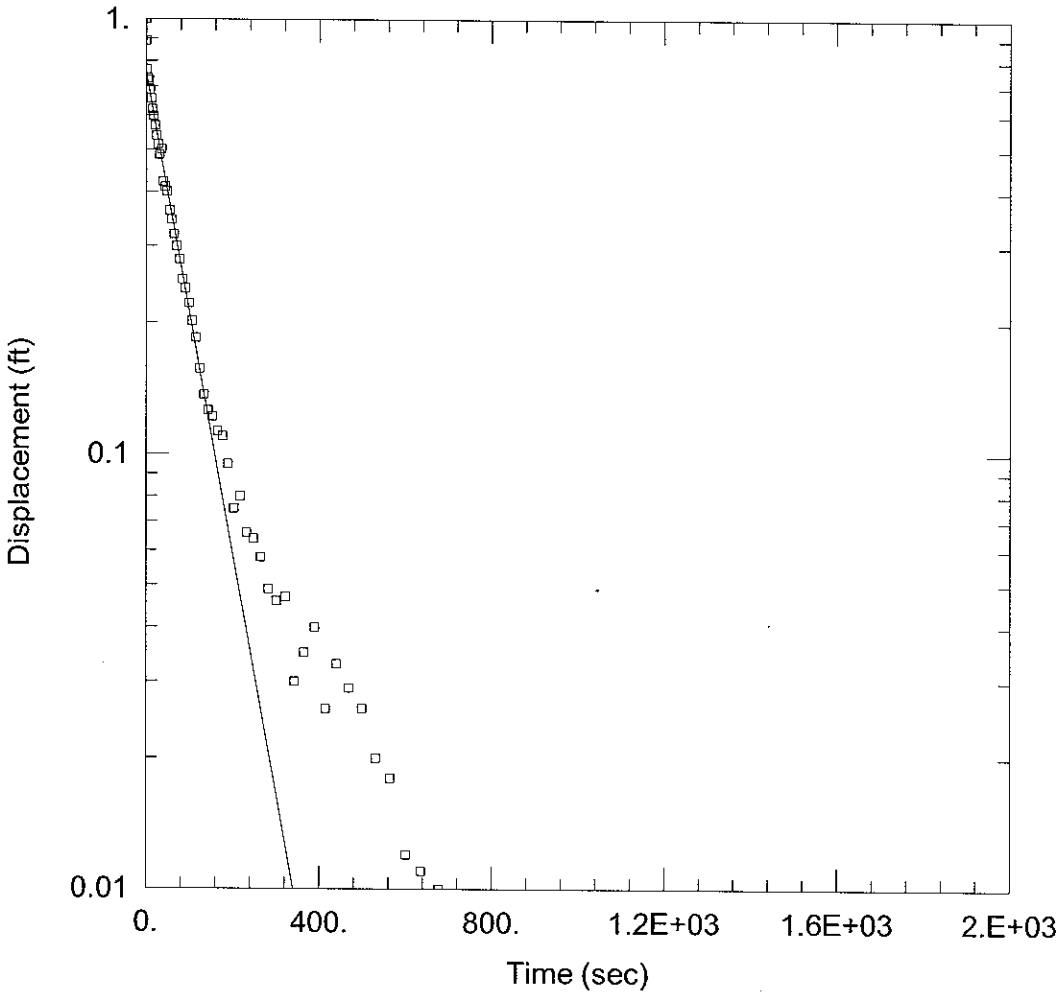
Table 2
Slug Test Analysis Results
AOI 5 Site Characterization Report
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Test ID	Bouwer- Rice	Hvorslev
	ft/d	ft/d
147 Slug In 1	9.751	14.52
147 Slug In 2	12.88	16.2
147 Slug Out 1	2.534	11.61
147 Slug Out 2	19.87	23.62
151 Slug In 1	56.27	NA
151 Slug In 2	10.06	NA
151 Slug Out 1	20.82	NA
151 Slug Out 2	15.82	NA
154 Slug In 1	45.28	NA
154 Slug In 2	20.14	NA
154 Slug Out 1	32.7	NA
154 Slug Out 2	40.28	NA

NOTES:

NA = The Hvorslev method is applicable only if the well screen is completely submerged.

ATTACHMENT A



WELL TEST ANALYSIS

Data Set: S:\...\147 Slug In 1 Bouwer Rice.aqt
Date: 06/29/07 Time: 14:06:50

PROJECT INFORMATION

Company: Langan

AQUIFER DATA

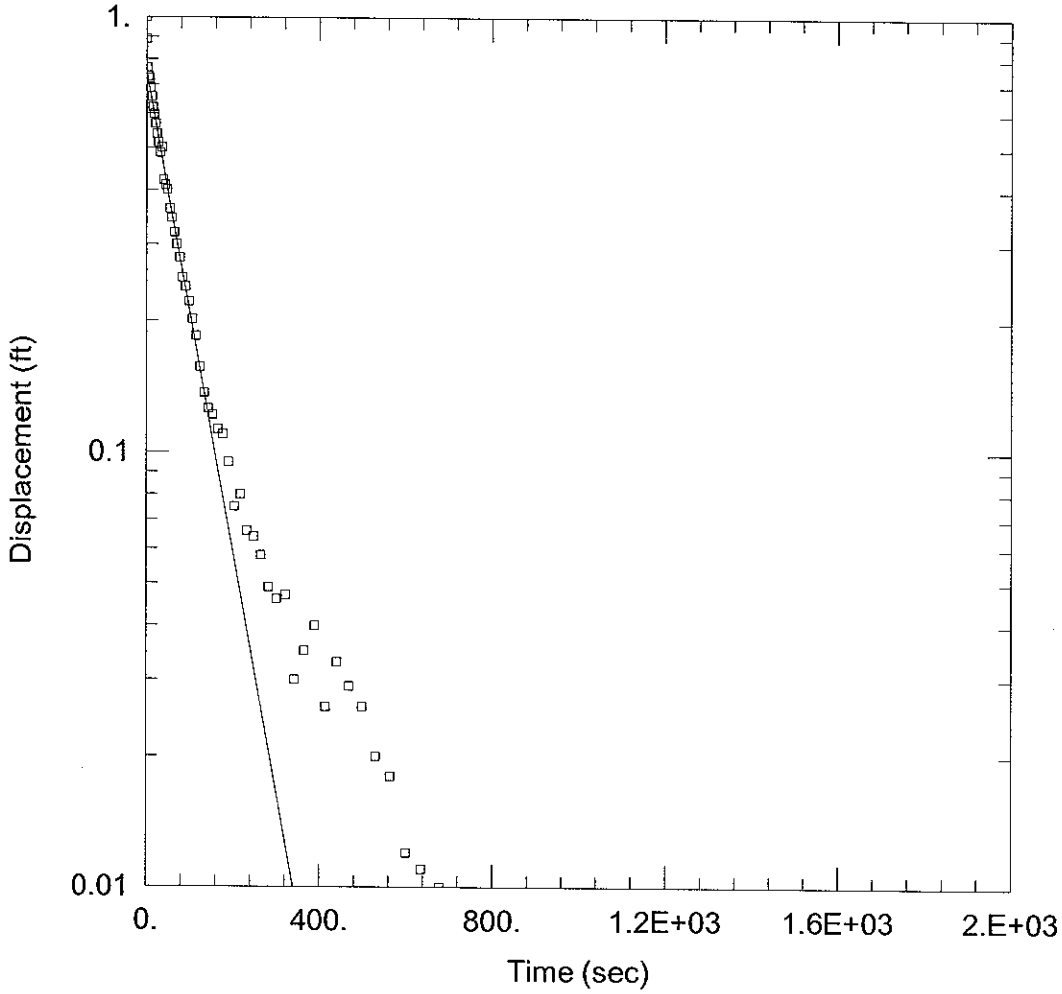
Saturated Thickness: 20. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (OW 1)

Initial Displacement: 0.892 ft
Wellbore Radius: 0.687 ft
Screen Length: 12. ft
Gravel Pack Porosity: 0.333
Casing Radius: 0.333 ft
Well Skin Radius: 0.687 ft
Total Well Penetration Depth: 14.31 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 9.751 ft/day
y0 = 0.7519 ft



WELL TEST ANALYSIS

Data Set: S:\...\147 Slug In 1 Hvorslev.aqt
Date: 06/29/07 Time: 14:06:56

PROJECT INFORMATION

Company: Langan

AQUIFER DATA

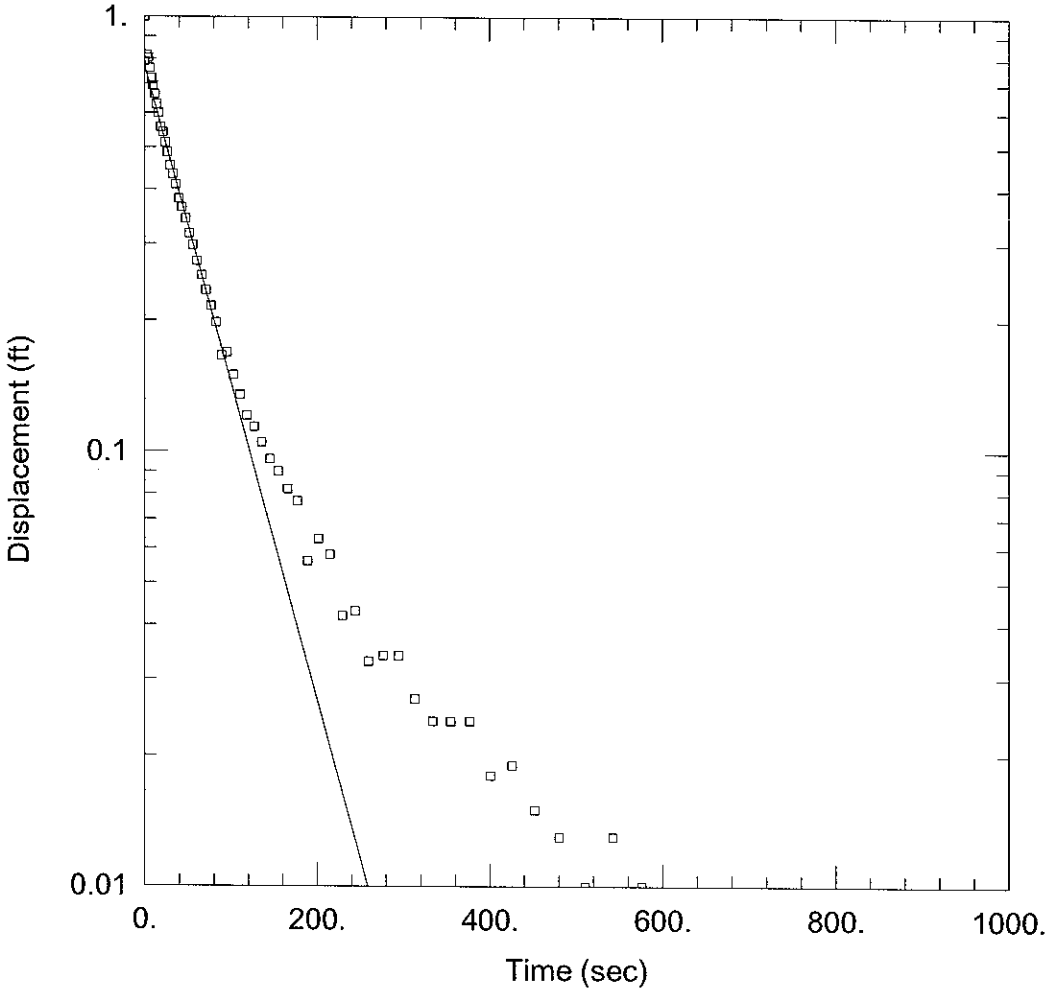
Saturated Thickness: 20. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (OW 1)

Initial Displacement: 0.892 ft
Wellbore Radius: 0.687 ft
Screen Length: 12. ft
Gravel Pack Porosity: 0.333
Casing Radius: 0.333 ft
Well Skin Radius: 0.687 ft
Total Well Penetration Depth: 14.31 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev
K = 14.52 ft/day
y0 = 0.748 ft



WELL TEST ANALYSIS

Data Set: S:\...\147 Slug In 2 Bouwer Rice.aqt
Date: 06/29/07 Time: 14:07:03

PROJECT INFORMATION

Company: Langan

AQUIFER DATA

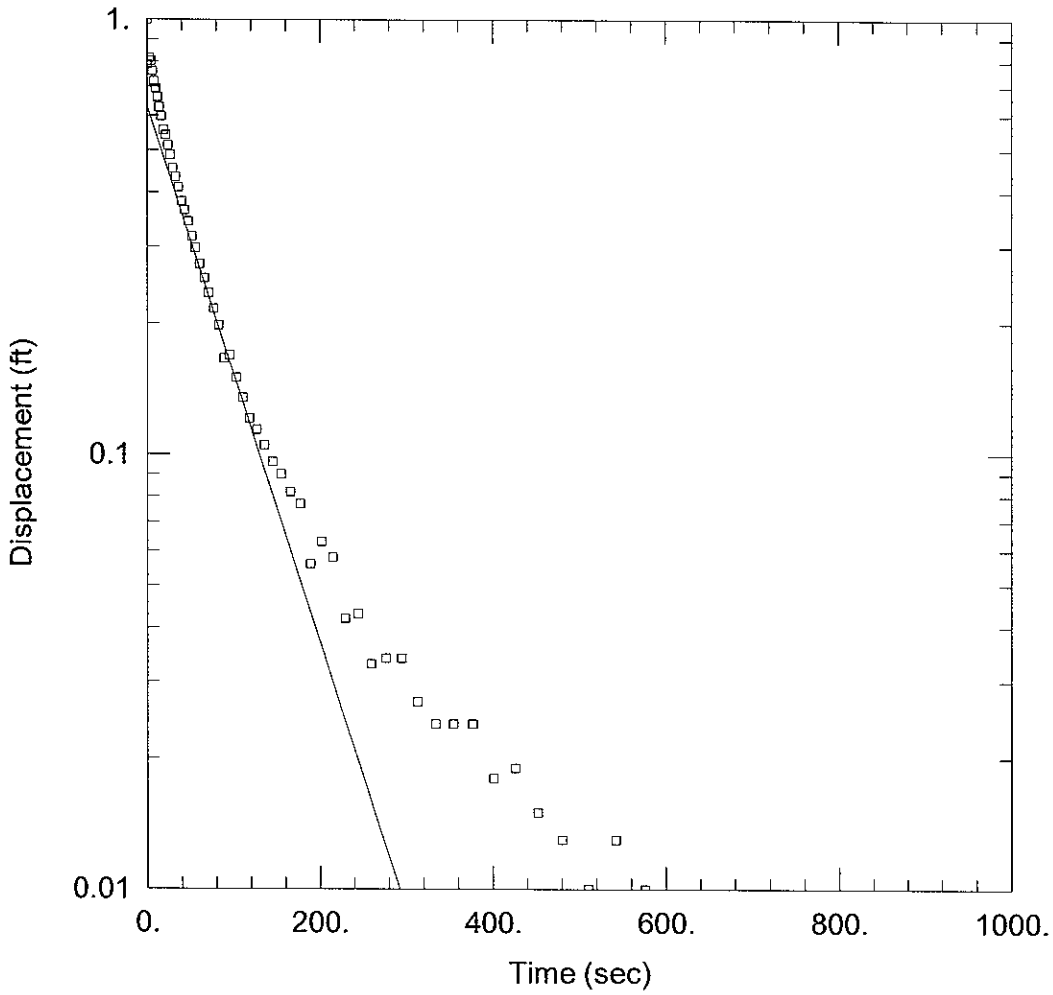
Saturated Thickness: 20. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (OW 1)

Initial Displacement: 0.788 ft
Wellbore Radius: 0.687 ft
Screen Length: 12. ft
Gravel Pack Porosity: 0.333
Casing Radius: 0.333 ft
Well Skin Radius: 0.687 ft
Total Well Penetration Depth: 14.31 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 12.88 ft/day
y0 = 0.7703 ft



WELL TEST ANALYSIS

Data Set: S:\...\147 Slug In 2 Hvorslev.aqt
Date: 06/29/07 Time: 14:07:11

PROJECT INFORMATION

Company: Langan

AQUIFER DATA

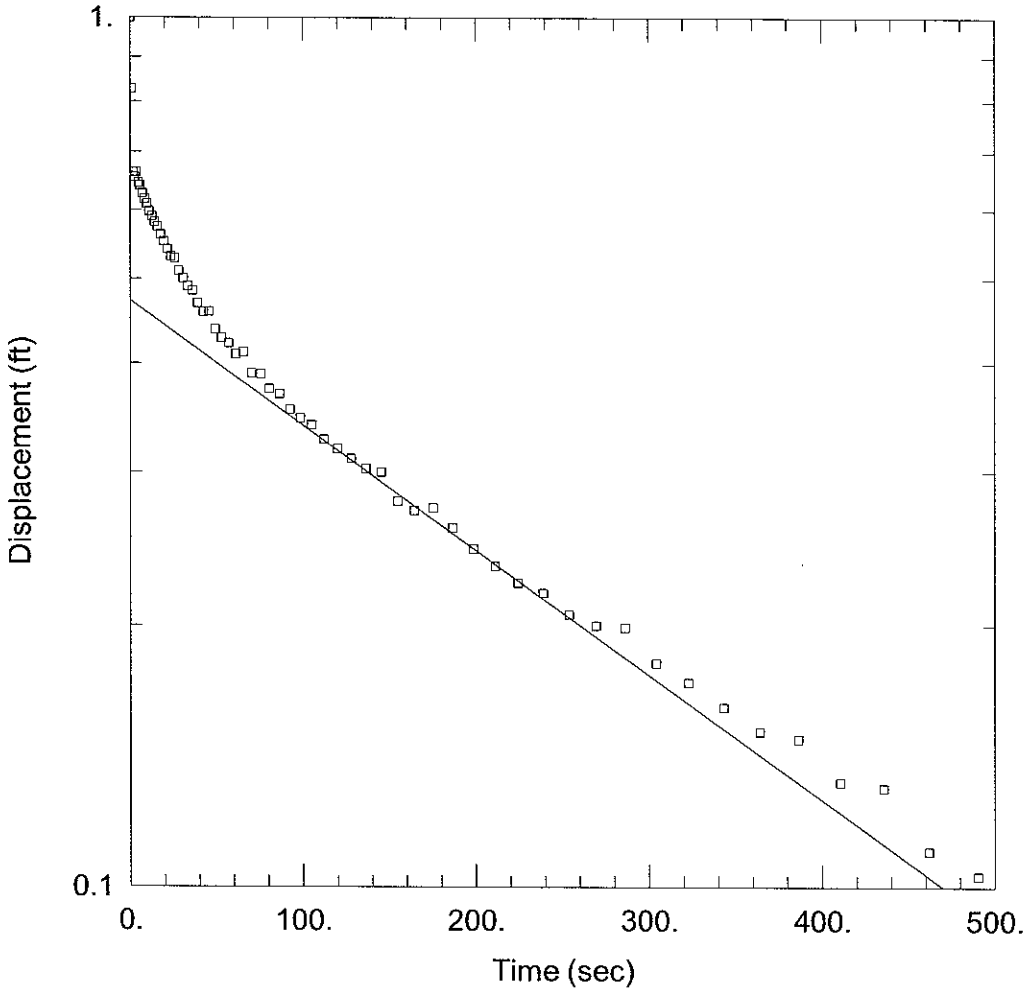
Saturated Thickness: 20. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (OW 1)

Initial Displacement: 0.788 ft
Wellbore Radius: 0.687 ft
Screen Length: 12. ft
Gravel Pack Porosity: 0.333
Casing Radius: 0.333 ft
Well Skin Radius: 0.687 ft
Total Well Penetration Depth: 14.31 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev
K = 16.2 ft/day
y0 = 0.63 ft



WELL TEST ANALYSIS

Data Set: S:\...\147 Slug Out 1 Bouwer Rice.aqt
Date: 06/29/07 Time: 14:07:17

PROJECT INFORMATION

Company: Langan

AQUIFER DATA

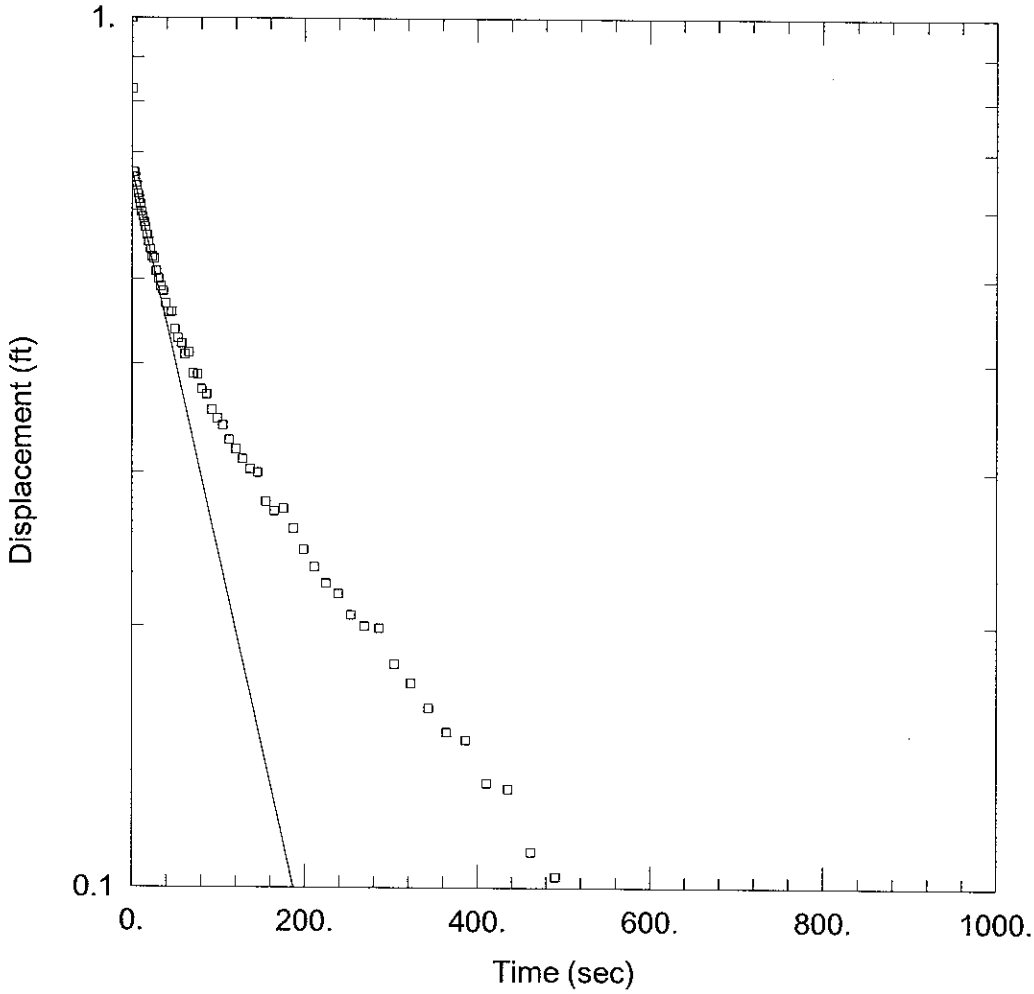
Saturated Thickness: 20. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (OW 1)

Initial Displacement: 1.387 ft
Wellbore Radius: 0.687 ft
Screen Length: 12. ft
Gravel Pack Porosity: 0.333
Casing Radius: 0.333 ft
Well Skin Radius: 0.687 ft
Total Well Penetration Depth: 14.31 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 2.534 ft/day
y0 = 0.4724 ft



WELL TEST ANALYSIS

Data Set: S:\...\147 Slug Out 1 Hvorslev.aqt
Date: 06/29/07 Time: 14:07:25

PROJECT INFORMATION

Company: Langan

AQUIFER DATA

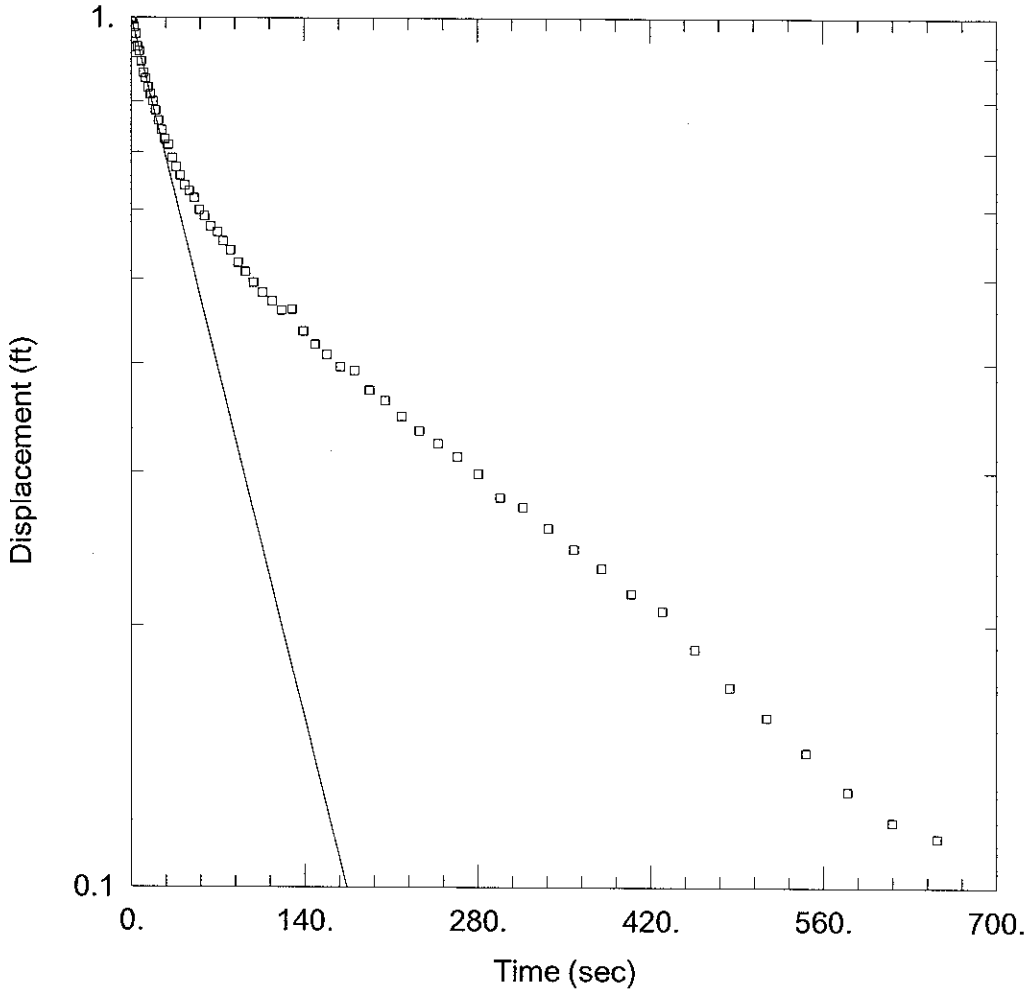
Saturated Thickness: 20. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (OW 1)

Initial Displacement: 1.387 ft
Wellbore Radius: 0.687 ft
Screen Length: 12. ft
Gravel Pack Porosity: 0.333
Casing Radius: 0.333 ft
Well Skin Radius: 0.687 ft
Total Well Penetration Depth: 14.31 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev
K = 11.61 ft/day
y0 = 0.668 ft



WELL TEST ANALYSIS

Data Set: S:\...\147 Slug Out 2 Bouwer Rice.aqt
Date: 06/29/07 Time: 14:07:33

PROJECT INFORMATION

Company: Langan

AQUIFER DATA

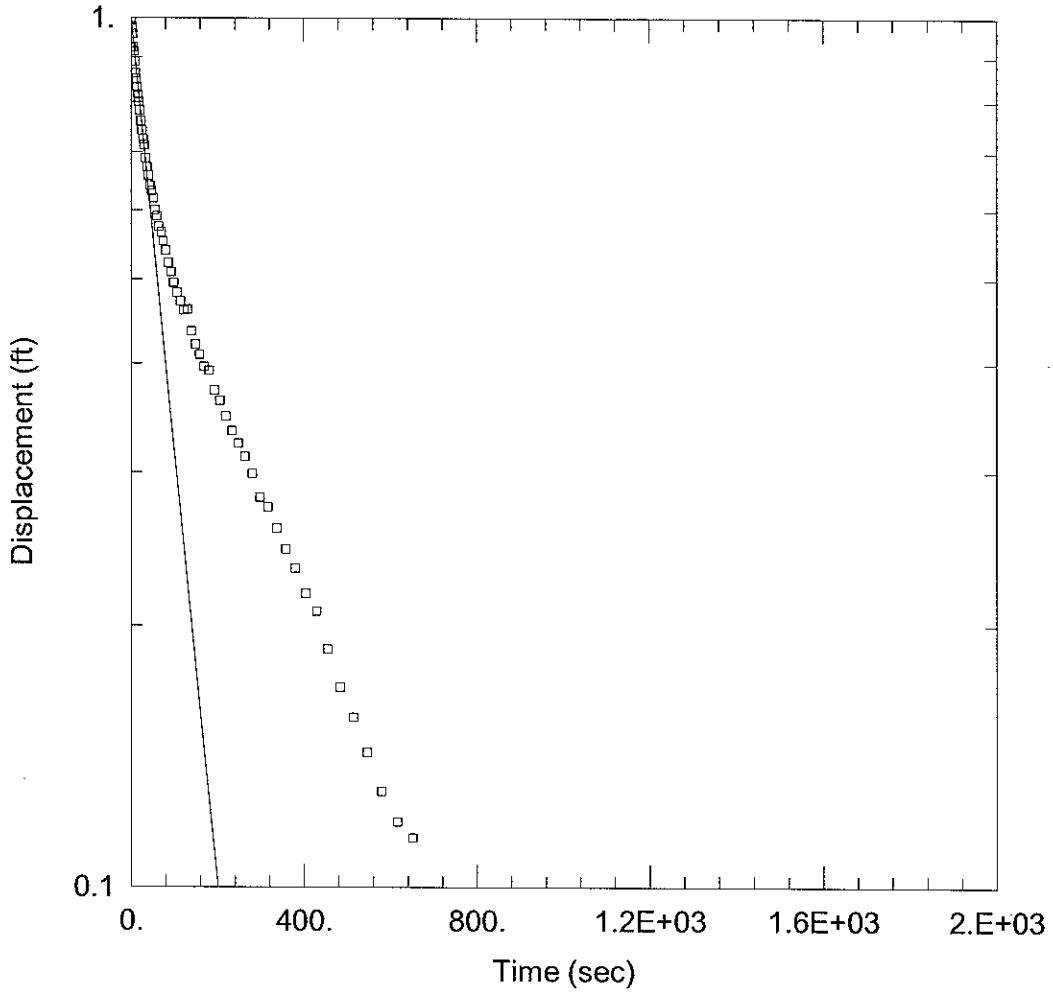
Saturated Thickness: 20. ft
Anisotropy Ratio (Kz/Kr): 0.01

WELL DATA (OW 1)

Initial Displacement: 0.924 ft
Wellbore Radius: 0.687 ft
Screen Length: 12. ft
Gravel Pack Porosity: 0.333
Casing Radius: 0.333 ft
Well Skin Radius: 0.687 ft
Total Well Penetration Depth: 14.31 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 19.87 ft/day
y0 = 1. ft



WELL TEST ANALYSIS

Data Set: S:\...\147 Slug Out 2 Hvorslev.aqt
Date: 06/29/07 Time: 14:07:40

PROJECT INFORMATION

Company: Langan

AQUIFER DATA

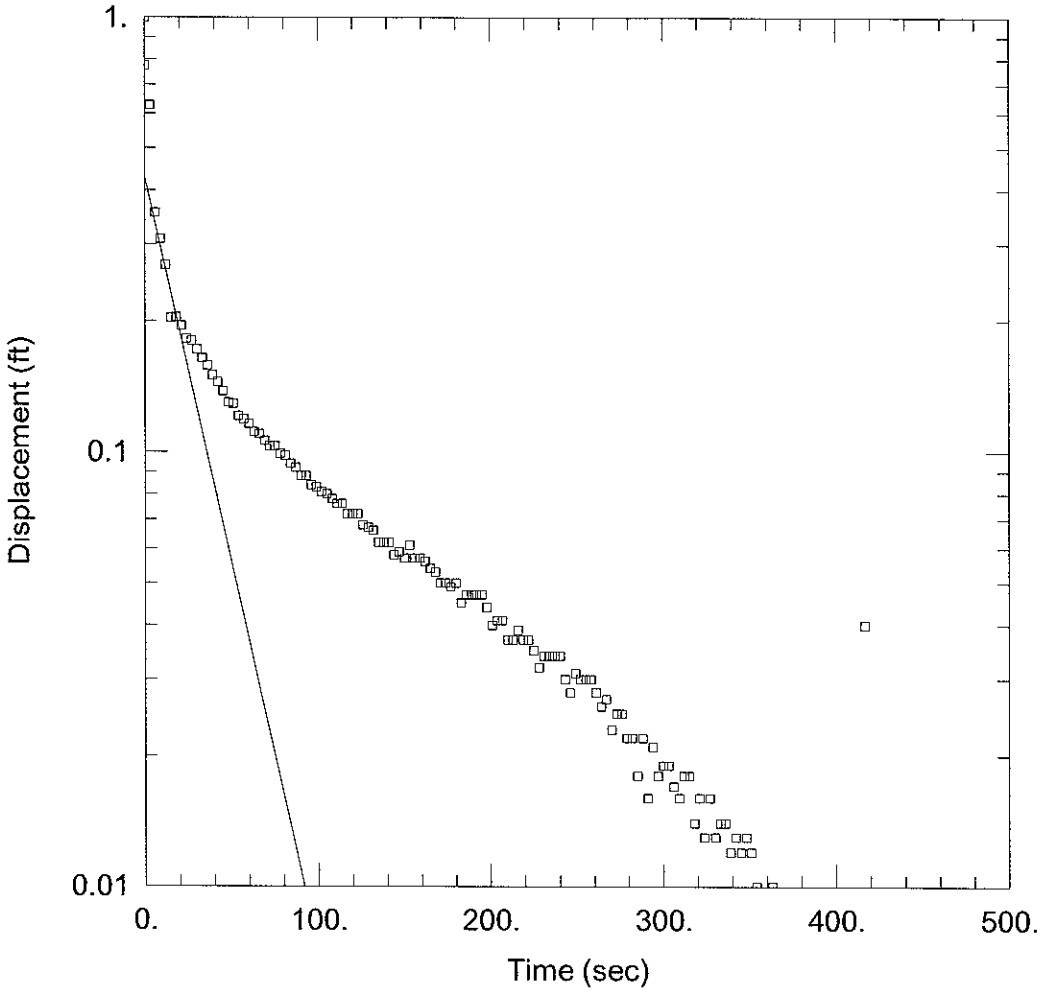
Saturated Thickness: 20. ft
Anisotropy Ratio (Kz/Kr): 0.01

WELL DATA (OW 1)

Initial Displacement: 0.924 ft
Wellbore Radius: 0.687 ft
Screen Length: 12. ft
Gravel Pack Porosity: 0.333
Casing Radius: 0.333 ft
Well Skin Radius: 0.687 ft
Total Well Penetration Depth: 14.13 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev
K = 23.62 ft/day
y0 = 1. ft



WELL TEST ANALYSIS

Data Set: S:\...\151 Slug In 1 Bouwer Rice.aqt
Date: 06/29/07 Time: 14:07:46

PROJECT INFORMATION

Company: Langan

AQUIFER DATA

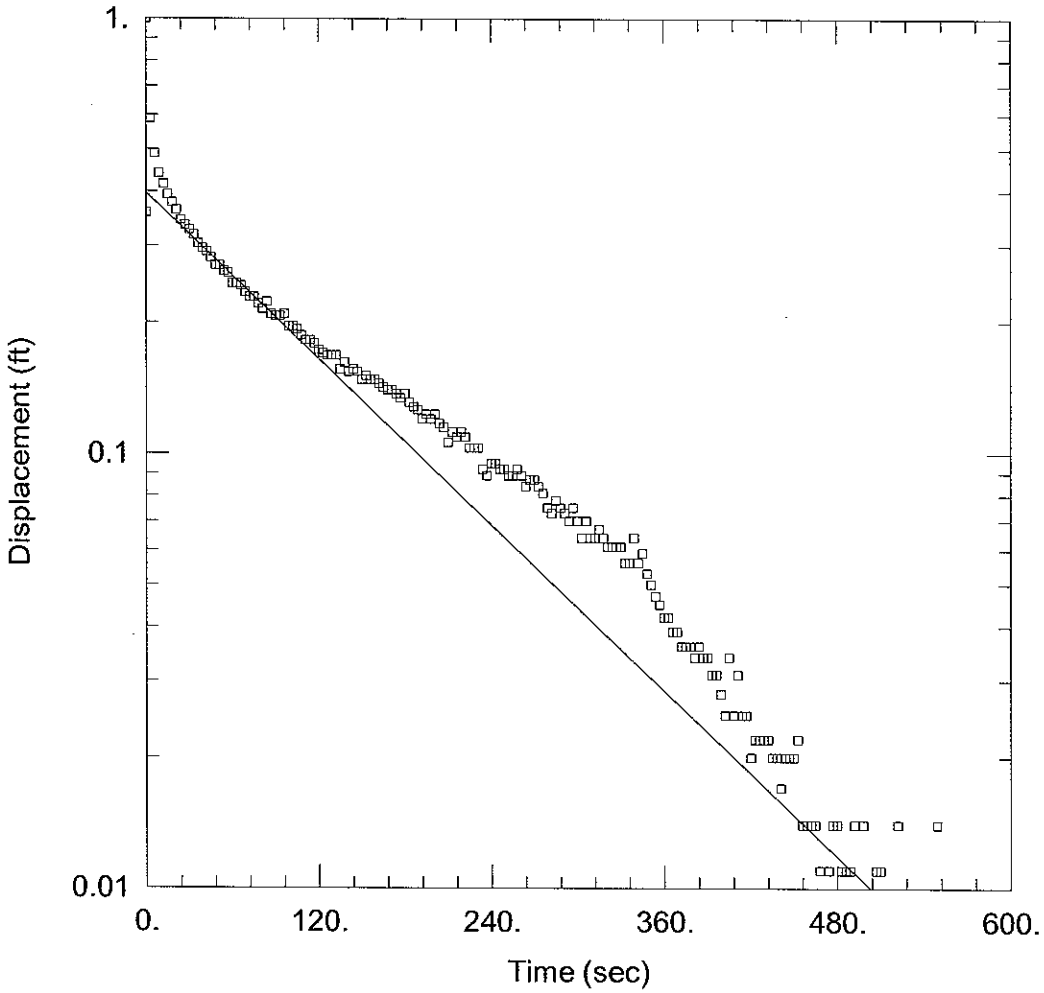
Saturated Thickness: 20. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (151 Slug 1 I)

Initial Displacement: 0.774 ft
Wellbore Radius: 0.687 ft
Screen Length: 13. ft
Gravel Pack Porosity: 0.333
Casing Radius: 0.333 ft
Well Skin Radius: 0.687 ft
Total Well Penetration Depth: 10.65 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 56.27 ft/day
y0 = 0.4294 ft



WELL TEST ANALYSIS

Data Set: S:\...\151 Slug In 2 Bouwer Rice.aqt
Date: 06/29/07 Time: 14:07:55

PROJECT INFORMATION

Company: Langan

AQUIFER DATA

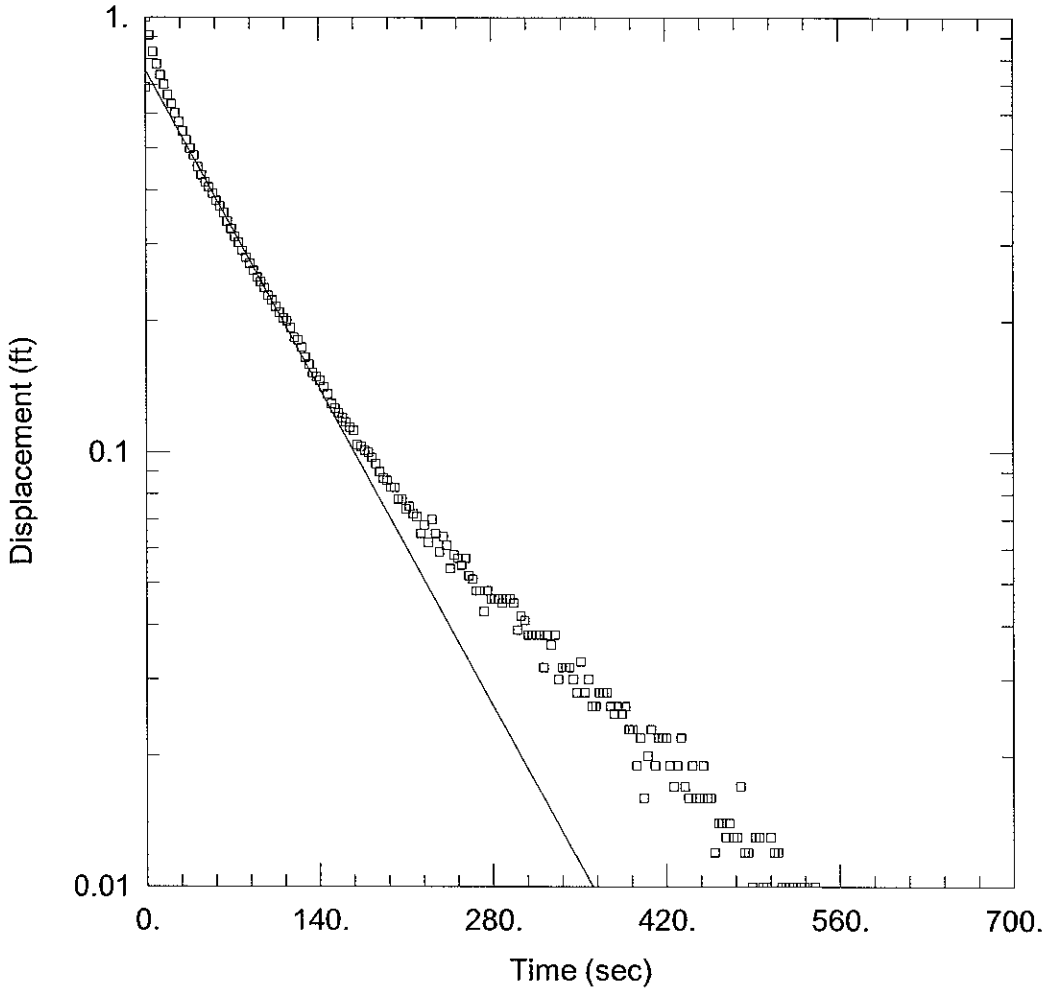
Saturated Thickness: 20. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (151 Slug 1 I)

Initial Displacement: 0.358 ft
Wellbore Radius: 0.687 ft
Screen Length: 13. ft
Gravel Pack Porosity: 0.333
Casing Radius: 0.333 ft
Well Skin Radius: 0.687 ft
Total Well Penetration Depth: 10.65 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 10.06 ft/day
y0 = 0.3971 ft



WELL TEST ANALYSIS

Data Set: S:\...\151 Slug Out 1 Bouwer Rice.aqt
Date: 06/29/07 Time: 14:08:02

PROJECT INFORMATION

Company: Langan

AQUIFER DATA

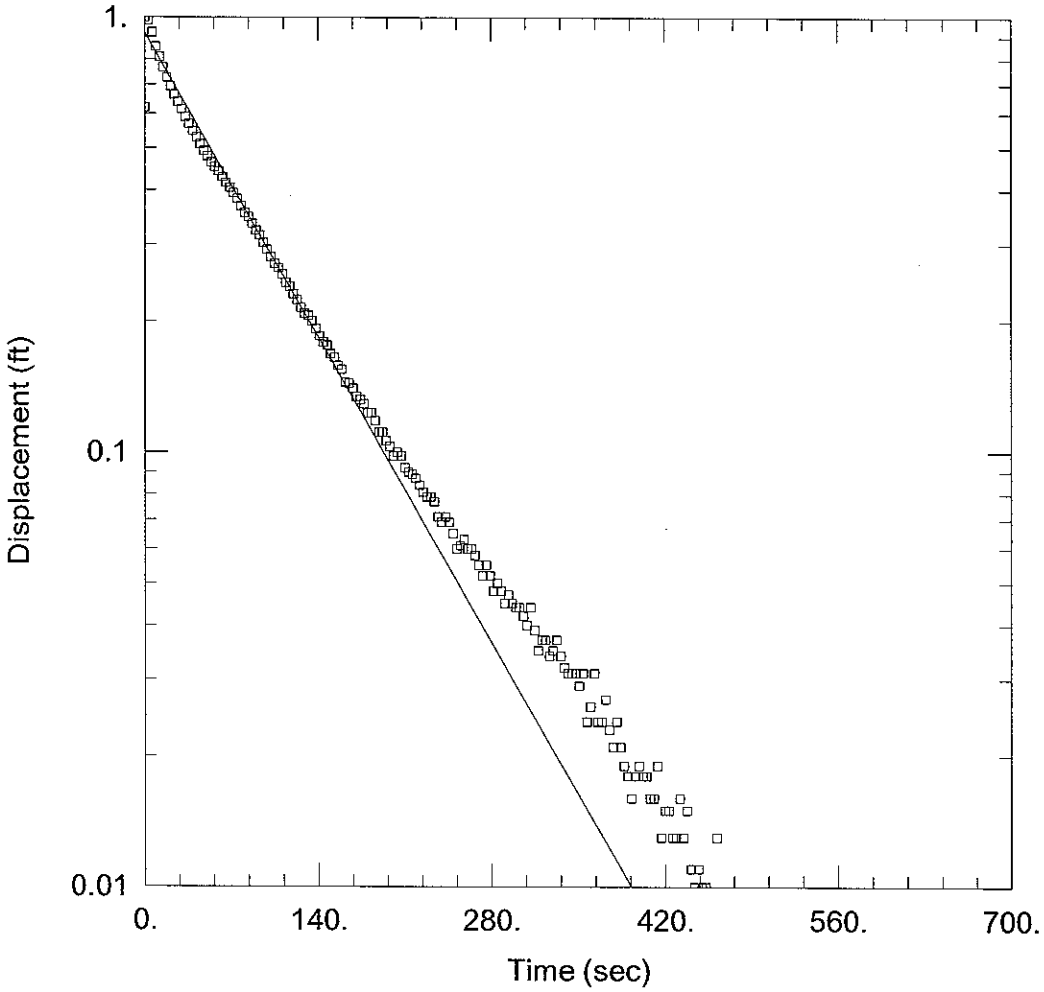
Saturated Thickness: 10.65 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (151)

Initial Displacement: 0.69 ft
Wellbore Radius: 0.687 ft
Screen Length: 13. ft
Gravel Pack Porosity: 0.333
Casing Radius: 0.333 ft
Well Skin Radius: 0.687 ft
Total Well Penetration Depth: 15. ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 20.82 ft/day
y0 = 0.7547 ft



WELL TEST ANALYSIS

Data Set: S:\...\151 Slug Out 2 Bouwer Rice.aqt
Date: 06/29/07 Time: 14:08:08

PROJECT INFORMATION

Company: Langan

AQUIFER DATA

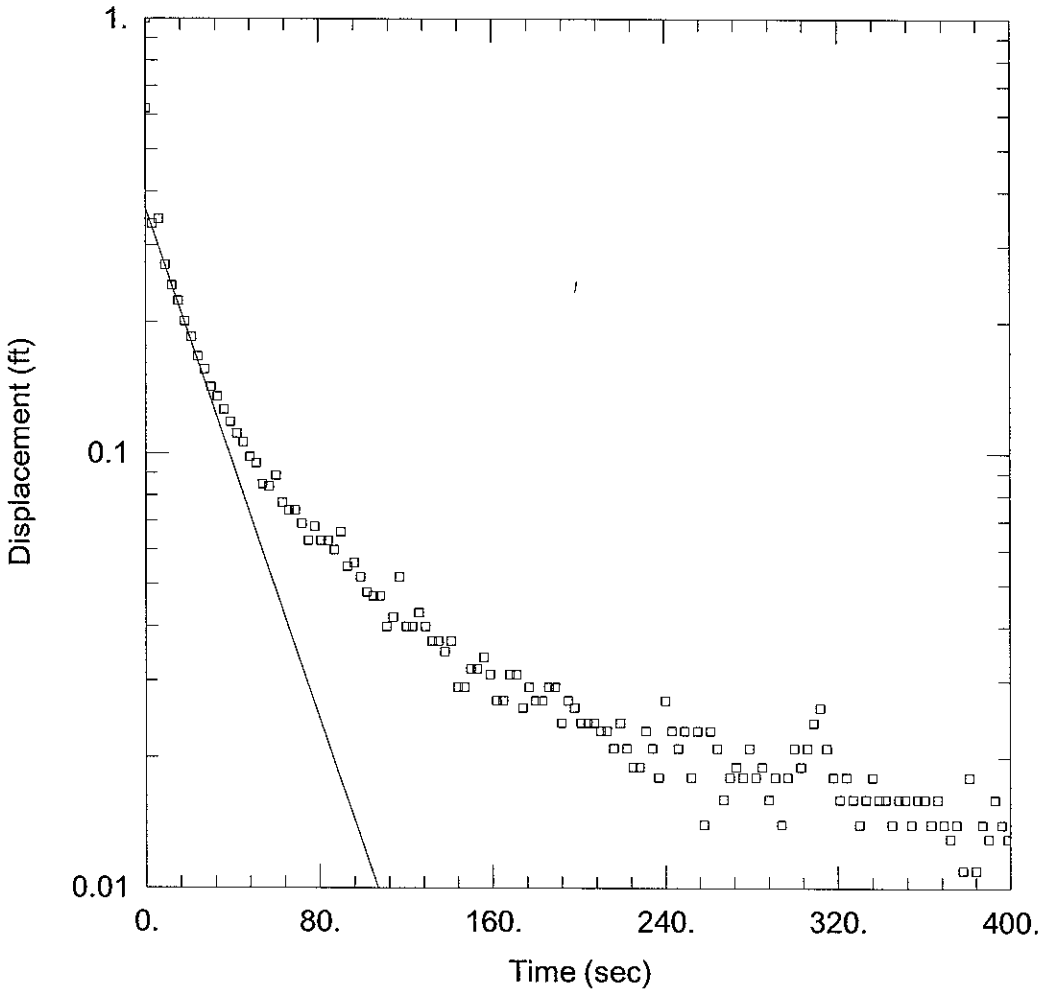
Saturated Thickness: 20. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (151)

Initial Displacement: 0.62 ft
Wellbore Radius: 0.687 ft
Screen Length: 13. ft
Gravel Pack Porosity: 0.333
Casing Radius: 0.333 ft
Well Skin Radius: 0.687 ft
Total Well Penetration Depth: 10.65 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 15.82 ft/day
y0 = 0.9207 ft



WELL TEST ANALYSIS

Data Set: S:\...\154 Slug In 1 Bouwer Rice.aqt
Date: 06/29/07 Time: 14:08:16

PROJECT INFORMATION

Company: Langan

AQUIFER DATA

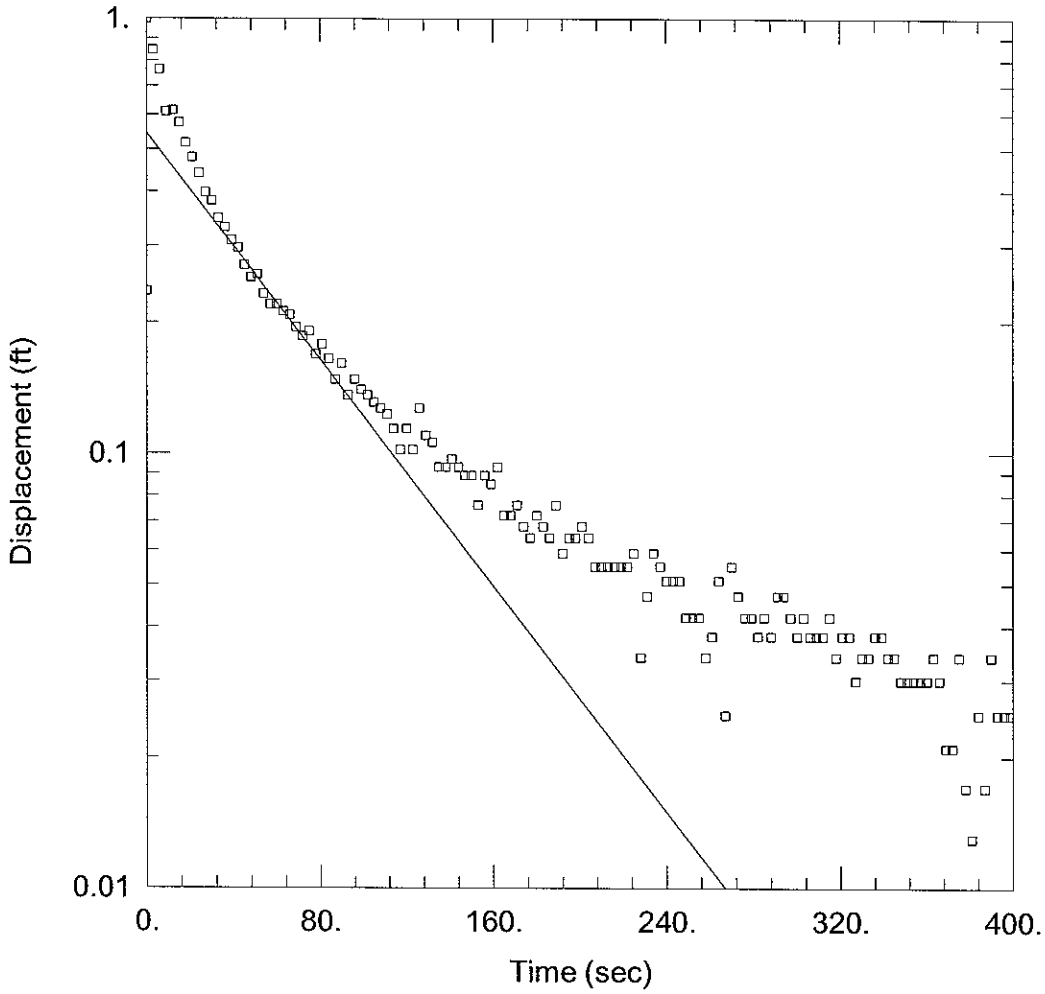
Saturated Thickness: 20. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (154)

Initial Displacement: 0.621 ft
Wellbore Radius: 0.687 ft
Screen Length: 15. ft
Gravel Pack Porosity: 0.333
Casing Radius: 0.333 ft
Well Skin Radius: 0.687 ft
Total Well Penetration Depth: 14.5 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 45.28 ft/day
y0 = 0.3655 ft



WELL TEST ANALYSIS

Data Set: S:\...\154 Slug In 2 Bouwer Rice.aqt
Date: 06/29/07 Time: 14:08:23

PROJECT INFORMATION

Company: Langan

AQUIFER DATA

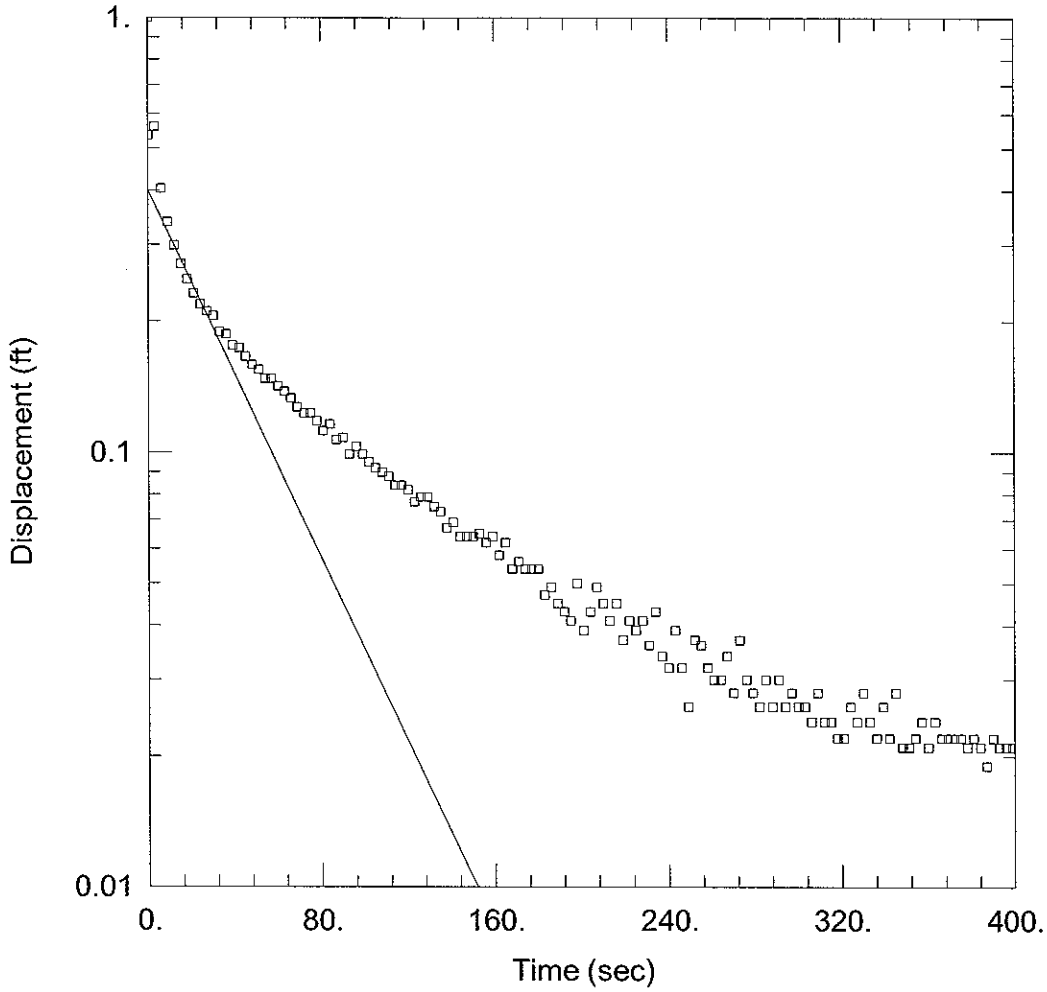
Saturated Thickness: 20. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (154)

Initial Displacement: 0.236 ft
Wellbore Radius: 0.687 ft
Screen Length: 15. ft
Gravel Pack Porosity: 0.333
Casing Radius: 0.333 ft
Well Skin Radius: 0.687 ft
Total Well Penetration Depth: 14.5 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 20.14 ft/day
y0 = 0.5441 ft



WELL TEST ANALYSIS

Data Set: S:\...\154 Slug Out 1 Bouwer Rice.aqt
Date: 06/29/07 Time: 14:08:31

PROJECT INFORMATION

Company: Langan

AQUIFER DATA

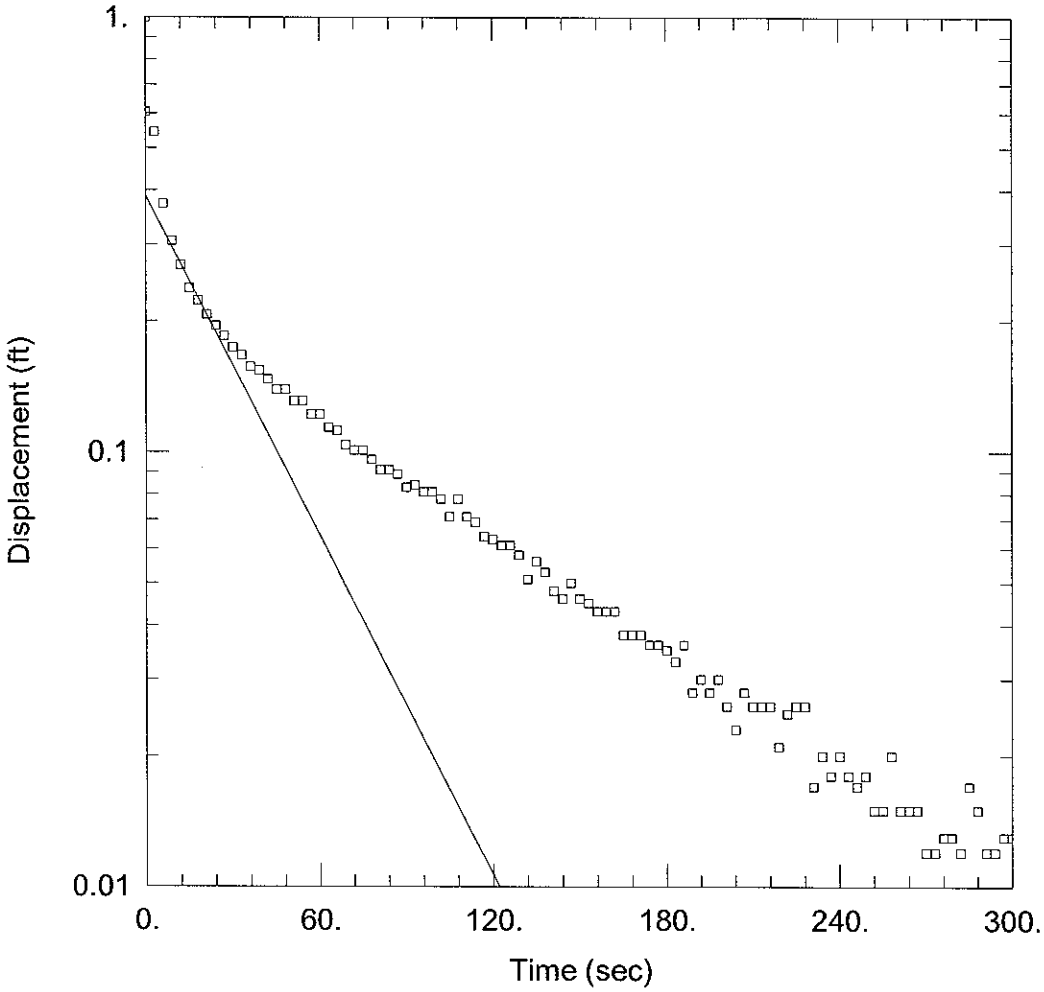
Saturated Thickness: 20. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (154)

Initial Displacement: 0.535 ft
Wellbore Radius: 0.687 ft
Screen Length: 15. ft
Gravel Pack Porosity: 0.333
Casing Radius: 0.333 ft
Well Skin Radius: 0.687 ft
Total Well Penetration Depth: 14.5 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 32.7 ft/day
y0 = 0.3999 ft



WELL TEST ANALYSIS

Data Set: S:\...\154 Slug Out 2 Bouwer Rice.aqt
Date: 06/29/07 Time: 14:08:37

PROJECT INFORMATION

Company: Langan

AQUIFER DATA

Saturated Thickness: 20. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (154)

Initial Displacement: 0.605 ft
Wellbore Radius: 0.687 ft
Screen Length: 15. ft
Gravel Pack Porosity: 0.333
Casing Radius: 0.333 ft
Well Skin Radius: 0.687 ft
Total Well Penetration Depth: 14.5 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 40.28 ft/day
y0 = 0.3879 ft

APPENDIX D

Soil and Groundwater Analytical Reports

APPENDIX E

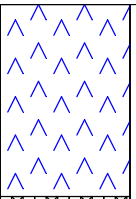
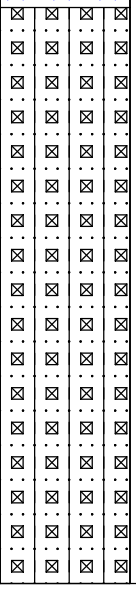
Soil Boring Logs and Monitoring Well Construction Summaries

SUBSURFACE BORING LOGS

SUBSURFACE BORING LOG

BOREHOLE NO. **BH-02-07**

PROJECT:	**Sunoco Refinery**	DRILLING CO.:	**Aquaterra**
SITE LOCATION:	**AOI-5**	DRILLING METHOD	**Hand Auger**
JOB NO.:		SAMPLING METHOD	**Cuttings**
LOGGED BY:	**Brandee Blasi**	TOTAL DEPTH:	**2'**
DATES DRILLED:	**4 April 2007**		

DEPTH (feet)	SAMPLE INTERVAL	PID (ppm)	LITHOLOGY DESCRIPTION	LITH-OLOGY	COMMENTS
0	0-0.5'		Gravel and fill		
	0.5'-2'		Black silty sand with gravel and rock		No Sample Collected
-1					
-2					

SUBSURFACE BORING LOG

BOREHOLE NO. **BH-03-07**

PROJECT:	**Sunoco Refinery**	DRILLING CO.:	**Aquaterra**
SITE LOCATION:	**AOI-5**	DRILLING METHOD	**Hand Auger**
JOB NO.:		SAMPLING METHOD	**Cuttings**
LOGGED BY:	**Brandee Blasi**	TOTAL DEPTH:	**2'**
DATES DRILLED:	**11 July 2007**		

DEPTH (feet)	SAMPLE INTERVAL	PID (ppm)	LITHOLOGY DESCRIPTION	LITH-OLOGY	COMMENTS
0	0-1'		Brown sandy silt		
-1	1'-1.5'		Brown sandy silt and gravel		NO SAMPLE COLLECTED
	1.5'-2'		Black stained sandy silt and gravel		
-2					

SUBSURFACE BORING LOG

BOREHOLE NO. **BH-04-07**

PROJECT:	**Sunoco Refinery**	DRILLING CO.:	**Aquaterra**
SITE LOCATION:	**AOI-5**	DRILLING METHOD	**Hand Auger**
JOB NO.:		SAMPLING METHOD	**Cuttings**
LOGGED BY:	**Brandee Blasi**	TOTAL DEPTH:	**2'**
DATES DRILLED:	**13 July 2007**		

DEPTH (feet)	SAMPLE INTERVAL	PID (ppm)	LITHOLOGY DESCRIPTION	LITH-OLOGY	COMMENTS
0	0-1'		Brown sandy silt and gravel		
-1	1'-2'		Black sandy silt, stained, metallic-like appearance		Sample 1'-2' collected for lead analysis
-2					

SUBSURFACE BORING LOG

BOREHOLE NO. **BH-05-07**

PROJECT: **Sunoco Refinery**
SITE LOCATION: **AOI-5**
JOB NO.:
LOGGED BY: **Brandee Blasi**
DATES DRILLED: **12 July 2007**

DRILLING CO.: **Aquaterra**
DRILLING METHOD **Hand Auger**
SAMPLING METHOD **Cuttings**
TOTAL DEPTH: **2'**

DEPTH (feet)	SAMPLE INTERVAL	PID (ppm)	LITHOLOGY DESCRIPTION	LITH-OLOGY	COMMENTS
0	0-1'		Brown sandy silt and gravel		
-1	1'-2'		Black stained sandy silt, highly plastic, strong petroleum odor, slight metallic-like appearance		Sample 1'-2' collected for lead analysis
-2					

SUBSURFACE BORING LOG

BOREHOLE NO. **BH-06-07**

PROJECT: **Sunoco Refinery**
SITE LOCATION: **AOI-5**
JOB NO.:
LOGGED BY: **Brandee Blasi**
DATES DRILLED: **4 April 2007**

DRILLING CO.: **Aquaterra**
DRILLING METHOD **Hand Auger**
SAMPLING METHOD **Cuttings**
TOTAL DEPTH: **2'**

DEPTH (feet)	SAMPLE INTERVAL	PID (ppm)	LITHOLOGY DESCRIPTION	LITH-OLOGY	COMMENTS
0	0-0.5'		Gravel and fill		
	0.5'-1'		Rocks and silt		
-1	1'-2'		Gray metallic-like sand, silt and gravel		Sample 1'-2' collected for lead analysis
-2					

SUBSURFACE BORING LOG

BOREHOLE NO. **BH-07-07**

PROJECT: **Sunoco Refinery**
SITE LOCATION: **AOI-5**
JOB NO.:
LOGGED BY: **Brandee Blasi**
DATES DRILLED: **13 July 2007**

DRILLING CO.: **Aquaterra**
DRILLING METHOD **Hand Auger**
SAMPLING METHOD **Cuttings**
TOTAL DEPTH: **2'**

DEPTH (feet)	SAMPLE INTERVAL	PID (ppm)	LITHOLOGY DESCRIPTION	LITH-OLOGY	COMMENTS
0	0-0.25'		Brown sandy silt and gravel		
	0.25'-1'		Black sandy silt		
-1	1'-2'		Gray sandy silt and gravel, wet, slight metallic-like appearance		Sample 1'-2' collected for lead analysis
-2					

SUBSURFACE BORING LOG

BOREHOLE NO. **BH-08-07**

PROJECT: **Sunoco Refinery**
SITE LOCATION: **AOI-5**
JOB NO.:
LOGGED BY: **Brandee Blasi**
DATES DRILLED: **13 July 2007**

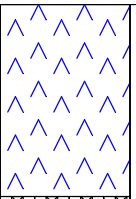
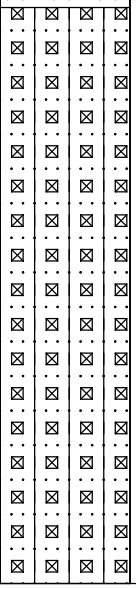
DRILLING CO.: **Aquaterra**
DRILLING METHOD **Hand Auger**
SAMPLING METHOD **Cuttings**
TOTAL DEPTH: **2'**

DEPTH (feet)	SAMPLE INTERVAL	PID (ppm)	LITHOLOGY DESCRIPTION	LITH-OLOGY	COMMENTS
0	0-0.75'		Brown sandy silt and gravel		
	0.75'-2'		Black stained sandy silt, petroleum odor, slight metallic-like appearance		Sample 0.75'-2' collected for lead analysis
-1					
-2					

SUBSURFACE BORING LOG

BOREHOLE NO. **BH-10-07**

PROJECT:	**Sunoco Refinery**	DRILLING CO.:	**Aquaterra**
SITE LOCATION:	**AOI-5**	DRILLING METHOD	**Hand Auger**
JOB NO.:		SAMPLING METHOD	**Cuttings**
LOGGED BY:	**Brandee Blasi**	TOTAL DEPTH:	**2'**
DATES DRILLED:	**4 April 2007**		

DEPTH (feet)	SAMPLE INTERVAL	PID (ppm)	LITHOLOGY DESCRIPTION	LITH-OLOGY	COMMENTS
0	0-0.5'		Gravel and fill		
	0.5'-2'		Black silt with gravel		No Sample Collected
-1					
-2					

SUBSURFACE BORING LOG

BOREHOLE NO. **BH-12-07**

PROJECT: **Sunoco Refinery**
SITE LOCATION: **AOI-5**
JOB NO.:
LOGGED BY: **Brandee Blasi**
DATES DRILLED: **4 April 2007**

DRILLING CO.: **Aquaterra**
DRILLING METHOD **Hand Auger**
SAMPLING METHOD **Cuttings**
TOTAL DEPTH: **2'**

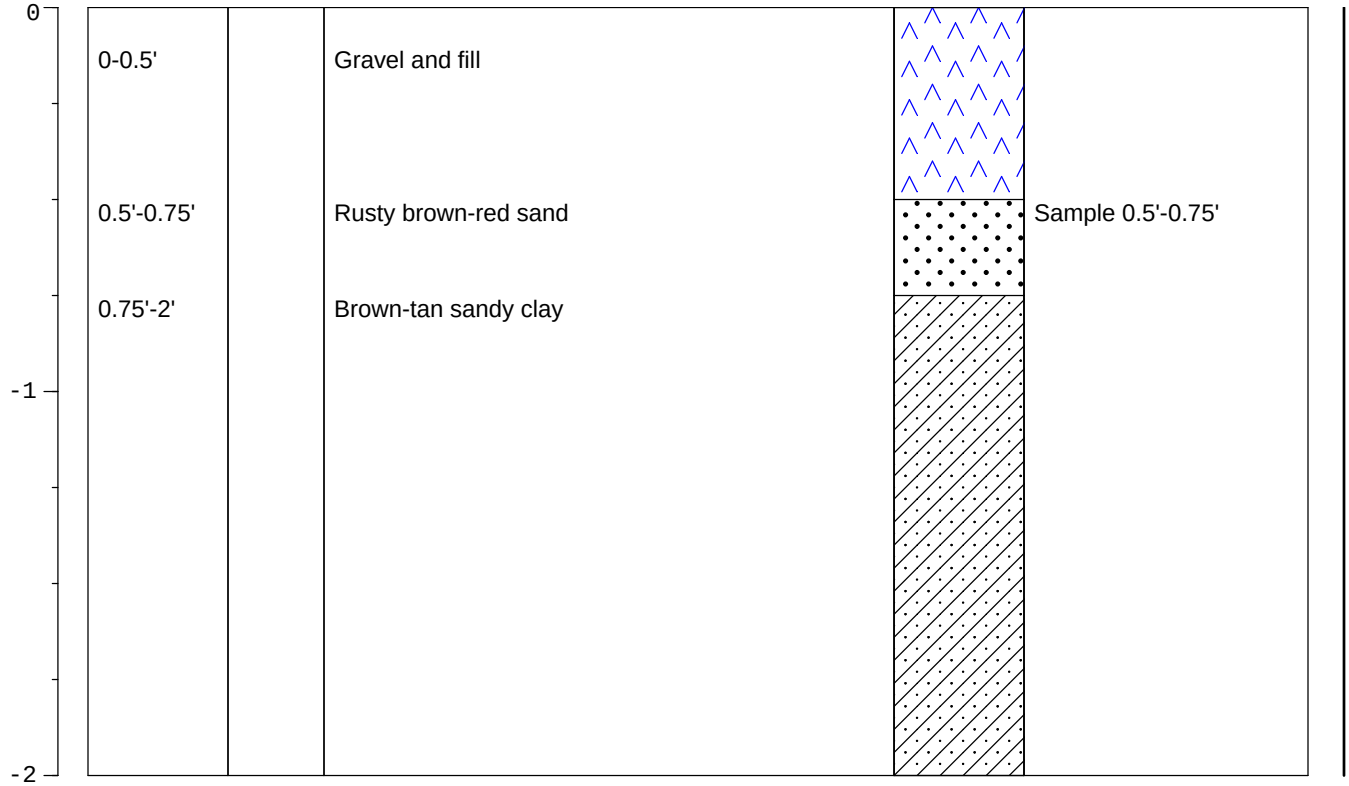
DEPTH (feet)	SAMPLE INTERVAL	PID (ppm)	LITHOLOGY DESCRIPTION	LITH-OLOGY	COMMENTS
0	0-1'		Gravel and fill		
-1	1'-2'		Brown sandy silt clay and gravel		No Sample Collected
-2					

SUBSURFACE BORING LOG

BOREHOLE NO. **BH-13-07**

PROJECT:	**Sunoco Refinery**	DRILLING CO.:	**Aquaterra**
SITE LOCATION:	**AOI-5**	DRILLING METHOD	**Hand Auger**
JOB NO.:		SAMPLING METHOD	**Cuttings**
LOGGED BY:	**Brandee Blasi**	TOTAL DEPTH:	**2'**
DATES DRILLED:	**4 April 2007**		

DEPTH (feet)	SAMPLE INTERVAL	PID (ppm)	LITHOLOGY DESCRIPTION	LITH-OLOGY	COMMENTS
0	0-0.5'		Gravel and fill		
	0.5'-0.75'		Rusty brown-red sand		Sample 0.5'-0.75'
	0.75'-2'		Brown-tan sandy clay		
-1					
-2					



SUBSURFACE BORING LOG

BOREHOLE NO. **BH-14-07**

PROJECT: **Sunoco Refinery**
SITE LOCATION: **AOI-5**
JOB NO.:
LOGGED BY: **Brandee Blasi**
DATES DRILLED: **4 April 2007**

DRILLING CO.: **Aquaterra**
DRILLING METHOD **Hand Auger**
SAMPLING METHOD **Cuttings**
TOTAL DEPTH: **2'**

DEPTH (feet)	SAMPLE INTERVAL	PID (ppm)	LITHOLOGY DESCRIPTION	LITH-OLOGY	COMMENTS
0	0-0.5'		Gravel and fill		
	0.5'-2'		Bricks and rock in sandy silt		No Sample Collected
-1					
-2					

SUBSURFACE BORING LOG

BOREHOLE NO. **BH-15-07**

PROJECT: **Sunoco Refinery**
SITE LOCATION: **AOI-5**
JOB NO.:
LOGGED BY: **Brandee Blasi**
DATES DRILLED: **4 April 2007**

DRILLING CO.: **Aquaterra**
DRILLING METHOD **Hand Auger**
SAMPLING METHOD **Cuttings**
TOTAL DEPTH: **2'**

DEPTH (feet)	SAMPLE INTERVAL	PID (ppm)	LITHOLOGY DESCRIPTION	LITH-OLOGY	COMMENTS
0	0-0.5'		Gravel and fill		
	0.5'-2'		Black-green petroleum stained silty clay		No Sample Collected
-1					
-2					

SUBSURFACE BORING LOG

BOREHOLE NO. **BH-16-07**

PROJECT: **Sunoco Refinery**
SITE LOCATION: **AOI-5**
JOB NO.:
LOGGED BY: **Brandee Blasi**
DATES DRILLED: **11 July 2007**

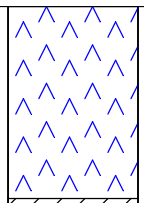
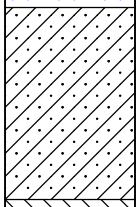
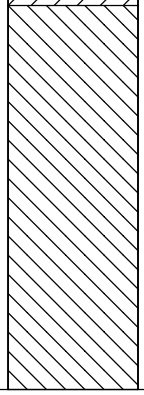
DRILLING CO.: **Aquaterra**
DRILLING METHOD **Hand Auger**
SAMPLING METHOD **Cuttings**
TOTAL DEPTH: **2'**

DEPTH (feet)	SAMPLE INTERVAL	PID (ppm)	LITHOLOGY DESCRIPTION	LITH-OLOGY	COMMENTS
0	0-1'		Brown sandy silt and gravel fill		
-1	1'-2'				NO SAMPLE COLLECTED
-2					

SUBSURFACE BORING LOG

BOREHOLE NO. **BH-18-07**

PROJECT:	**Sunoco Refinery**	DRILLING CO.:	**Aquaterra**
SITE LOCATION:	**AOI-5**	DRILLING METHOD	**Hand Auger**
JOB NO.:		SAMPLING METHOD	**Cuttings**
LOGGED BY:	**Brandee Blasi**	TOTAL DEPTH:	**2'**
DATES DRILLED:	**4 April 2007**		

DEPTH (feet)	SAMPLE INTERVAL	PID (ppm)	LITHOLOGY DESCRIPTION	LITH-OLOGY	COMMENTS
0	0-0.5'		Gravel and fill		
	0.5'-1'		Brown sandy clay with gravel		
-1	1'-2'		Black dense clay with metallic-like appearance (may be from sheen)		Sample 1'-2' collected for lead anaylsis
-2					

SUBSURFACE BORING LOG

BOREHOLE NO. **BH-19-07**

PROJECT: **Sunoco Refinery**
SITE LOCATION: **AOI-5**
JOB NO.:
LOGGED BY: **Brandee Blasi**
DATES DRILLED: **12 April 2007**

DRILLING CO.: **Aquaterra**
DRILLING METHOD **Hand Auger**
SAMPLING METHOD **Cuttings**
TOTAL DEPTH: **0.5'**

DEPTH (feet)	SAMPLE INTERVAL	PID (ppm)	LITHOLOGY DESCRIPTION	LITH-OLOGY	COMMENTS
0	0-0.5'		Silty clay and gravel fill		Consistent refusal at 0.5' after several attempts in differnt locations
					No Sample Collected

SUBSURFACE BORING LOG

BOREHOLE NO. **BH-20-07**

PROJECT: **Sunoco Refinery**
SITE LOCATION: **AOI-5**
JOB NO.:
LOGGED BY: **Brandee Blasi**
DATES DRILLED: **11 July 2007**

DRILLING CO.: **Aquaterra**
DRILLING METHOD **Hand Auger**
SAMPLING METHOD **Cuttings**
TOTAL DEPTH: **2'**

DEPTH (feet)	SAMPLE INTERVAL	PID (ppm)	LITHOLOGY DESCRIPTION	LITH-OLOGY	COMMENTS
0	0-0.75'		Brown/"rust" colored sandy silt, rust from actually metal in ground (localized)		
	0.75-2'		Black-silver metallic-like sandy silt		Sample 0.75'-2 for lead analysis
-1					
-2					

SUBSURFACE BORING LOG

BOREHOLE NO. **BH-21-07**

PROJECT: **Sunoco Refinery**
SITE LOCATION: **AOI-5**
JOB NO.:
LOGGED BY: **Brandee Blasi**
DATES DRILLED: **4 April 2007**

DRILLING CO.: **Aquaterra**
DRILLING METHOD **Hand Auger**
SAMPLING METHOD **Cuttings**
TOTAL DEPTH: **2'**

DEPTH (feet)	SAMPLE INTERVAL	PID (ppm)	LITHOLOGY DESCRIPTION	LITH-OLOGY	COMMENTS
0	0-0.5'		Gravel and fill		
	0.5'-1.75'		Brown sandy silt with gravel		
-1					Sample 1.75'-2' collected for lead anaylsis
	1.75'-2'		Orange-brown plastic clay "waxy" consistency		
-2					

SUBSURFACE BORING LOG

BOREHOLE NO. **BH-22-07**

PROJECT: **Sunoco Refinery**
SITE LOCATION: **AOI-5**
JOB NO.:
LOGGED BY: **Brandee Blasi**
DATES DRILLED: **12 July 2007**

DRILLING CO.: **Aquaterra**
DRILLING METHOD **Hand Auger**
SAMPLING METHOD **Cuttings**
TOTAL DEPTH: **2'**

DEPTH (feet)	SAMPLE INTERVAL	PID (ppm)	LITHOLOGY DESCRIPTION	LITH-OLOGY	COMMENTS
0	0-2'		Brown sandy silt and gravel		NO SAMPLE COLLECTED
-1					
-2					

SUBSURFACE BORING LOG

BOREHOLE NO. **BH-23-07**

PROJECT: **Sunoco Refinery**
SITE LOCATION: **AOI-5**
JOB NO.:
LOGGED BY: **Brandee Blasi**
DATES DRILLED: **11 July 2007**

DRILLING CO.: **Aquaterra**
DRILLING METHOD **Hand Auger**
SAMPLING METHOD **Cuttings**
TOTAL DEPTH: **2'**

DEPTH (feet)	SAMPLE INTERVAL	PID (ppm)	LITHOLOGY DESCRIPTION	LITH-OLOGY	COMMENTS
0	0-0.5'		Brown/"rust" colored sandy silt		Sample 0'-0.5' collected for lead anaylsis
	0.5'-1'		Black stained sandy silt and gravel		
-1	1'-2'		Gray-green silt with petroleum odor		
-2					

SUBSURFACE BORING LOG

BOREHOLE NO. **BH-24-07**

PROJECT:	**Sunoco Refinery**	DRILLING CO.:	**Aquaterra**
SITE LOCATION:	**AOI-5**	DRILLING METHOD	**Hand Auger**
JOB NO.:		SAMPLING METHOD	**Cuttings**
LOGGED BY:	**Brandee Blasi**	TOTAL DEPTH:	**2'**
DATES DRILLED:	**4 April 2007**		

DEPTH (feet)	SAMPLE INTERVAL	PID (ppm)	LITHOLOGY DESCRIPTION	LITH-OLOGY	COMMENTS
0	0-0.5'		Gravel and fill		
	0.5'-1.5'		Brown clay with gravel and sand		
-1	1.5'-2'		Black-green metallic-like gravel and sand		Sample 1.5'-2' collected for lead anaylsis
-2					

SUBSURFACE BORING LOG

BOREHOLE NO. **BH-25-07**

PROJECT: **Sunoco Refinery**
SITE LOCATION: **AOI-5**
JOB NO.:
LOGGED BY: **Brandee Blasi**
DATES DRILLED: **11 July 2007**

DRILLING CO.: **Aquaterra**
DRILLING METHOD **Hand Auger**
SAMPLING METHOD **Cuttings**
TOTAL DEPTH: **2'**

DEPTH (feet)	SAMPLE INTERVAL	PID (ppm)	LITHOLOGY DESCRIPTION	LITH-OLOGY	COMMENTS
0	0-1'		Fill		
-1	1'-2'		Black stained sandy, silt and gravel, wet		Sample 1'-2' collected for lead analysis
-2					

SUBSURFACE BORING LOG

BOREHOLE NO. **BH-26-07**

PROJECT: **Sunoco Refinery**
SITE LOCATION: **AOI-5**
JOB NO.:
LOGGED BY: **Brandee Blasi**
DATES DRILLED: **11 July 2007**

DRILLING CO.: **Aquaterra**
DRILLING METHOD **Hand Auger**
SAMPLING METHOD **Cuttings**
TOTAL DEPTH: **2'**

DEPTH (feet)	SAMPLE INTERVAL	PID (ppm)	LITHOLOGY DESCRIPTION	LITH-OLOGY	COMMENTS
0	0-1'		Fill		
-1	1'-2'		Black stained sandy, silt and gravel, wet		Sample 1'-2' collected for lead analysis
-2					

SUBSURFACE BORING LOG

BOREHOLE NO. **BH-27-07**

PROJECT:	**Sunoco Refinery**	DRILLING CO.:	**Aquaterra**
SITE LOCATION:	**AOI-5**	DRILLING METHOD	**Hand Auger**
JOB NO.:		SAMPLING METHOD	**Cuttings**
LOGGED BY:	**Brandee Blasi**	TOTAL DEPTH:	**2'**
DATES DRILLED:	**12 July 2007**		

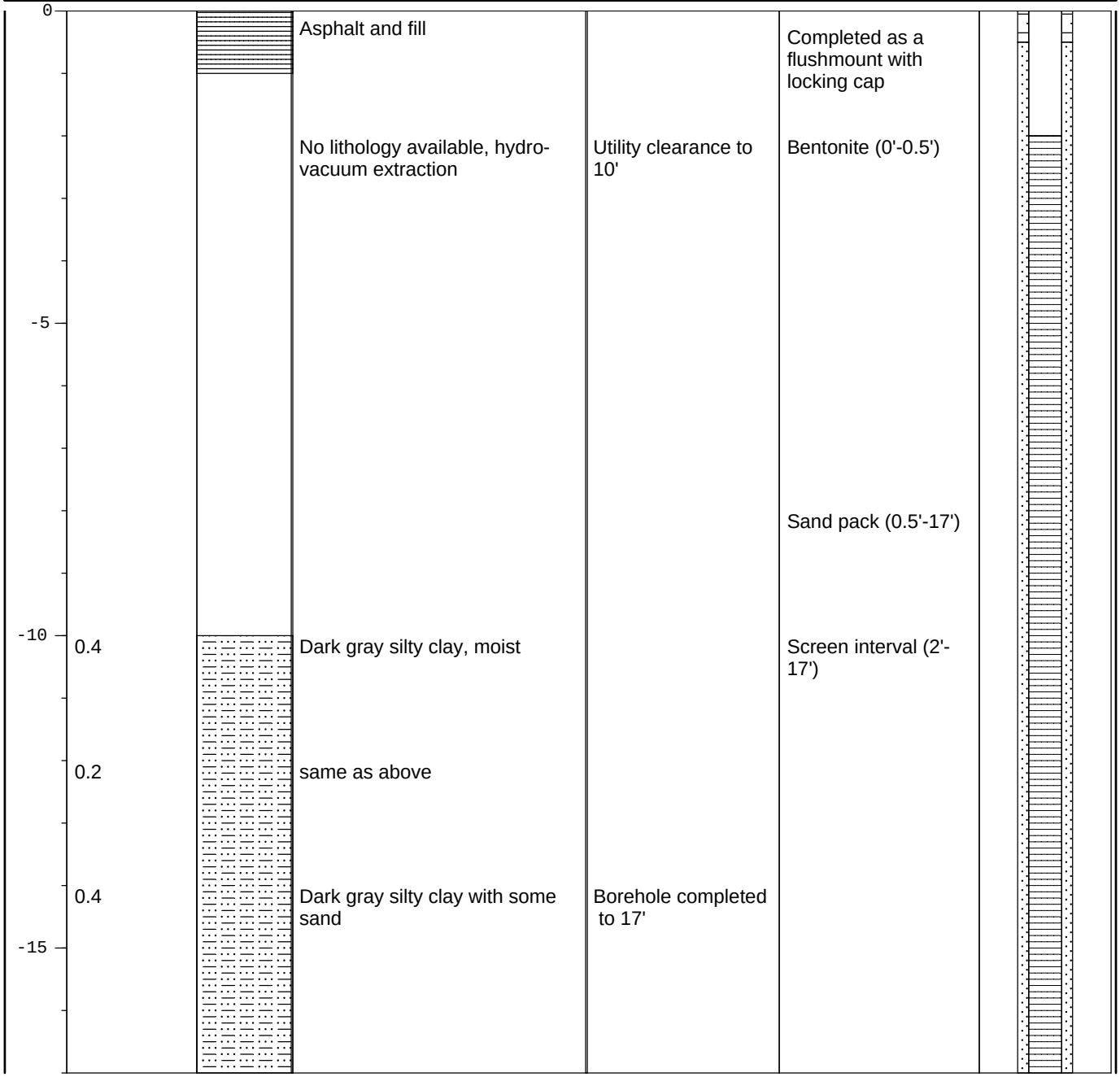
DEPTH (feet)	SAMPLE INTERVAL	PID (ppm)	LITHOLOGY DESCRIPTION	LITH-OLOGY	COMMENTS
0	0-1.5'		Fill-sandy silt with brick and rock		
-1	1.5'-2'		Same as above, less brick content		Sample 1.5'-2' collected for lead analysis
-2					

MONITORING WELL LOGS

MONITORING WELL LOG: A-138

PROJECT:	**Sunoco Refinery**	DRILLING CO.:	**Total Quality Drilling**
SITE LOCATION:	**Philadelphia**	DRILLING METHOD:	**Hollow Stem Auger**
JOB NO.:	**AOI-5**	SAMPLING METHOD:	**Cuttings**
LOGGED BY:	**Kevin Martin**	SCREEN/RISER DIAMETER:	**4-inch**
DATES DRILLED:	**16 March 2007**	WELLBORE DIAMETER:	**8.25"**
TOTAL DEPTH:	**17'**	ELEVATION:	**NA**

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0			Asphalt and fill		Completed as a flushmount with locking cap	
			No lithology available, hydro-vacuum extraction	Utility clearance to 10'	Bentonite (0'-0.5')	
-5						
					Sand pack (0.5'-17')	
-10	0.4		Dark gray silty clay, moist		Screen interval (2'-17')	
	0.2		same as above			
	0.4		Dark gray silty clay with some sand	Borehole completed to 17'		
-15						



MONITORING WELL LOG: A-139

PROJECT:	**Sunoco Refinery**	DRILLING CO.:	**Total Quality Drilling**
SITE LOCATION:	**Philadelphia**	DRILLING METHOD:	**Hollow Stem Auger**
JOB NO.:	**AOI-5**	SAMPLING METHOD:	**Cuttings**
LOGGED BY:	**Kevin Martin**	SCREEN/RISER DIAMETER:	**4-inch**
DATES DRILLED:	**7 March 2007**	WELLBORE DIAMETER:	**8.25"**
TOTAL DEPTH:	**15'**	ELEVATION:	**NA**

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0			Brown silt and sand with gravel.		Completed as a stickup with locking cap	
				Sample A-139_071207_1.5-2		
			No lithology available, hydro-vacuum extraction		Bentonite (0.5'-1')	
				Utility clearance to 8'		
-5						
					Sand pack (1'-15')	
-10	0.4		Dark brown wet, plastic clay	Water encountered	Screen interval (2'-15')	
	0.2		Med brown moist plastic silty clay			
	0.0		Mottled light and dark med sand with some clay	Borehole completed to 15'		
-15						

MONITORING WELL LOG: A-140

PROJECT:	**Sunoco Refinery**	DRILLING CO.:	**Total Quality Drilling**
SITE LOCATION:	**Philadelphia**	DRILLING METHOD:	**Hollow Stem Auger**
JOB NO.:	**AOI-5**	SAMPLING METHOD:	**Cuttings**
LOGGED BY:	**Brandee Blasi**	SCREEN/RISER DIAMETER:	**4-inch**
DATES DRILLED:	**6 March 2007**	WELLBORE DIAMETER:	**8.25"**
TOTAL DEPTH:	**17'**	ELEVATION:	**NA**

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0			Brown silt and gravel		Completed as a stickup with locking cap	
			Brown silt/sand and gravel, moist	Utility clearance to 10'		
			No lithology available, hydro-vacuum extraction	Sample A-140_071207_1.5-2	Bentonite (0'-0.5')	
-5					Sand pack (0.5'-17')	
-10			Stained silty clay, highly plastic, saturated, odor	water encountered	Screen interval (2'-17')	
			sheen present			
-15				Borehole completed to 17'		

MONITORING WELL LOG: A-141

PROJECT:	**Sunoco Refinery**	DRILLING CO.:	**Total Quality Drilling**
SITE LOCATION:	**Philadelphia**	DRILLING METHOD:	**Hollow Stem Auger**
JOB NO.:	**AOI-5**	SAMPLING METHOD:	**Cuttings**
LOGGED BY:	**Brandee Blasi**	SCREEN/RISER DIAMETER:	**4-inch**
DATES DRILLED:	**6 March 2007**	WELLBORE DIAMETER:	**8.25"**
TOTAL DEPTH:	**17'**	ELEVATION:	**NA**

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0			Large stone gravel surface		Completed as a stickup with locking cap	
			No lithology available, hydro-vacuum extraction	Utility clearance to 6'	Bentonite (0'-0.5')	
-5					Sand pack (0.5'-17')	
-10			Green-black silty clay, saturated, odor	water encountered	Screen interval (2'-17')	
				Borehole completed to 17'		
-15						

MONITORING WELL LOG: A-142

PROJECT:	**Sunoco Refinery**	DRILLING CO.:	**Total Quality Drilling**
SITE LOCATION:	**Philadelphia**	DRILLING METHOD:	**Hollow Stem Auger**
JOB NO.:	**AOI-5**	SAMPLING METHOD:	**Cuttings**
LOGGED BY:	**Brandee Blasi**	SCREEN/RISER DIAMETER:	**4-inch**
DATES DRILLED:	**6 March 2007**	WELLBORE DIAMETER:	**8.25"**
TOTAL DEPTH:	**15'**	ELEVATION:	**NA**

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0		⊠ ⊠ ⊠	Brown silt/sand and gravel		Completed as a stickup with locking cap	
			Brown sand with some gravel, moist	Sample A-142_071207_1.5-2		
			No lithology available, hydro-vacuum extraction	Utility clearance to 10'	Bentonite (0'-0.5')	
-5					Sand pack (0.5'-15')	
-10			Black stained coarse grained sandy clay and silt, saturated, odor	water encountered	Screen interval (2'-15')	
-15			Coarse sand and gravel, saturated with sheen, odor	Borehole collapse to 15'		
				Borehole completed to 17'		

MONITORING WELL LOG: A-143

PROJECT:	**Sunoco Refinery**	DRILLING CO.:	**Total Quality Drilling**
SITE LOCATION:	**Philadelphia**	DRILLING METHOD:	**Hydro-vac**
JOB NO.:	**AOI-5**	SAMPLING METHOD:	**none**
LOGGED BY:	**Kevin Martin**	SCREEN/RISER DIAMETER:	**4-inch**
DATES DRILLED:	**7 March 2007**	WELLBORE DIAMETER:	**10"**
TOTAL DEPTH:	**10'**	ELEVATION:	**NA**

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0			Brown silt and fill material	Sample A-143_071207_0.5-1	Completed as a stickup with locking cap	
			Soft dug only due to overhead utilities, no lithology available due to hydro-vacuum extraction	Utility clearance to 10'	Bentonite (0.5'-1')	
-5					Sand pack (1'-10')	
					Screen interval (2'-10')	
-10				Borehole completed to 10'		

MONITORING WELL LOG: A-144

PROJECT:	**Sunoco Refinery**	DRILLING CO.:	**Total Quality Drilling**
SITE LOCATION:	**Philadelphia**	DRILLING METHOD:	**Hollow Stem Auger**
JOB NO.:	**AOI-5**	SAMPLING METHOD:	**Cuttings**
LOGGED BY:	**Brandee Blasi**	SCREEN/RISER DIAMETER:	**4-inch**
DATES DRILLED:	**6 March 2007**	WELLBORE DIAMETER:	**8.25"**
TOTAL DEPTH:	**17'**	ELEVATION:	**NA**

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0			Fill material		Completed as a stickup with locking cap	
			No lithology available, hydro-vacuum extraction	Utility clearance to 10'	Bentonite (0'-0.5')	
-5					Sand pack (0.5'-17')	
-10			Green-gray clay with sheen, highly plastic, saturated, odor	water encountered	Screen interval (2'-17')	
-15				Borehole completed to 17'		

MONITORING WELL LOG: A-145

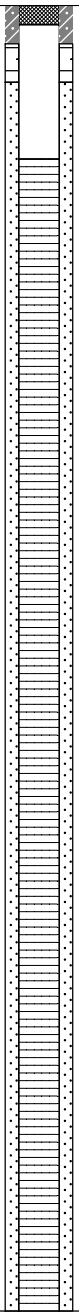
PROJECT:	**Sunoco Refinery**	DRILLING CO.:	**Total Quality Drilling**
SITE LOCATION:	**Philadelphia**	DRILLING METHOD:	**Hollow Stem Auger**
JOB NO.:	**AOI-5**	SAMPLING METHOD:	**Cuttings**
LOGGED BY:	**Kevin Martin**	SCREEN/RISER DIAMETER:	**4-inch**
DATES DRILLED:	**8 March 2007**	WELLBORE DIAMETER:	**8.25"**
TOTAL DEPTH:	**15'**	ELEVATION:	**NA**

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0			Brown silt-sand and gravel		Completed as a stickup with locking cap	
			Gray-green silt, plastic, slight petroleum odor			
			No lithology available, hydro-vacuum extraction	Utility clearance to 10'	Bentonite (0.5'-1')	
-5						
					Sand pack (1'-15')	
-10	0.4		Med brown silty clay, moist		Screen interval (2'-15')	
	0.0		Med brown plastic clay, wet	water encountered		
			Dark brown silty clay with some sand	Borehole completed to 15'		
-15						

MONITORING WELL LOG: A-146

PROJECT:	**Sunoco Refinery**	DRILLING CO.:	**Total Quality Drilling**
SITE LOCATION:	**Philadelphia**	DRILLING METHOD:	**Hollow Stem Auger**
JOB NO.:	**AOI-5**	SAMPLING METHOD:	**Cuttings**
LOGGED BY:	**Kevin Martin**	SCREEN/RISER DIAMETER:	**4-inch**
DATES DRILLED:	**8 March 2007**	WELLBORE DIAMETER:	**8.25"**
TOTAL DEPTH:	**17'**	ELEVATION:	**NA**

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0			Crushed stone fill		Completed as a flushmount with locking cap	
			No lithology available, hydro-vacuum extraction	Utility clearance to 8'	Bentonite (0.5'-1')	
-5					Sand pack (1'-17')	
-10	0.2		Dark brown silty clay, wet, some sand	water encountered	Screen interval (2'-17')	
	0.1		Med brown sandy clay, moist			
	0.0		Med brown fine sand with some clay, moist			
-15				Borehole completed to 17'		



MONITORING WELL LOG: A-147

PROJECT:	**Sunoco Refinery**	DRILLING CO.:	**Total Quality Drilling**
SITE LOCATION:	**Philadelphia**	DRILLING METHOD:	**Hollow Stem Auger**
JOB NO.:	**AOI-5**	SAMPLING METHOD:	**Cuttings**
LOGGED BY:	**Kevin Martin**	SCREEN/RISER DIAMETER:	**4-inch**
DATES DRILLED:	**9 March 2007**	WELLBORE DIAMETER:	**8.25"**
TOTAL DEPTH:	**14'**	ELEVATION:	**NA**

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0			Crushed stone fill		Completed as a flushmount with locking cap	
			No lithology available, hydro-vacuum extraction	Utility clearance to 8'	Bentonite (1'-2')	
-5					Sand pack (2'-14')	
-10	0.7		Med brown plastic clay, moist		Screen interval (2'-14')	
	0.6		Dark brown plastic silty clay, moist			
			Same as above	Well set at 14'		
-15				Borehole completed to 18'		

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MONITORING WELL LOG: A-147

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM

MONITORING WELL LOG: A-148

PROJECT:	**Sunoco Refinery**	DRILLING CO.:	**Total Quality Drilling**
SITE LOCATION:	**Philadelphia**	DRILLING METHOD:	**Hollow Stem Auger**
JOB NO.:	**AOI-5**	SAMPLING METHOD:	**Cuttings**
LOGGED BY:	**Kevin Martin**	SCREEN/RISER DIAMETER:	**4-inch**
DATES DRILLED:	**9 March 2007**	WELLBORE DIAMETER:	**8.25"**
TOTAL DEPTH:	**12'**	ELEVATION:	**NA**

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0			Dark brown sandy silt and gravel		Completed as a stickup with locking cap	
			No lithology available, hydro-vacuum extraction	Utility clearance to 8'	Bentonite (0.5'-1')	
-5					Sand pack (1'-12')	
-10	0.9		Dark brown silty clay, moist		Screen interval (2'-12')	
	0.7		Dark brown silty clay with some sand, moist	Well set at 12'		
			Same as above			
-15				Borehole completed to 16'		

MONITORING WELL LOG: A-149

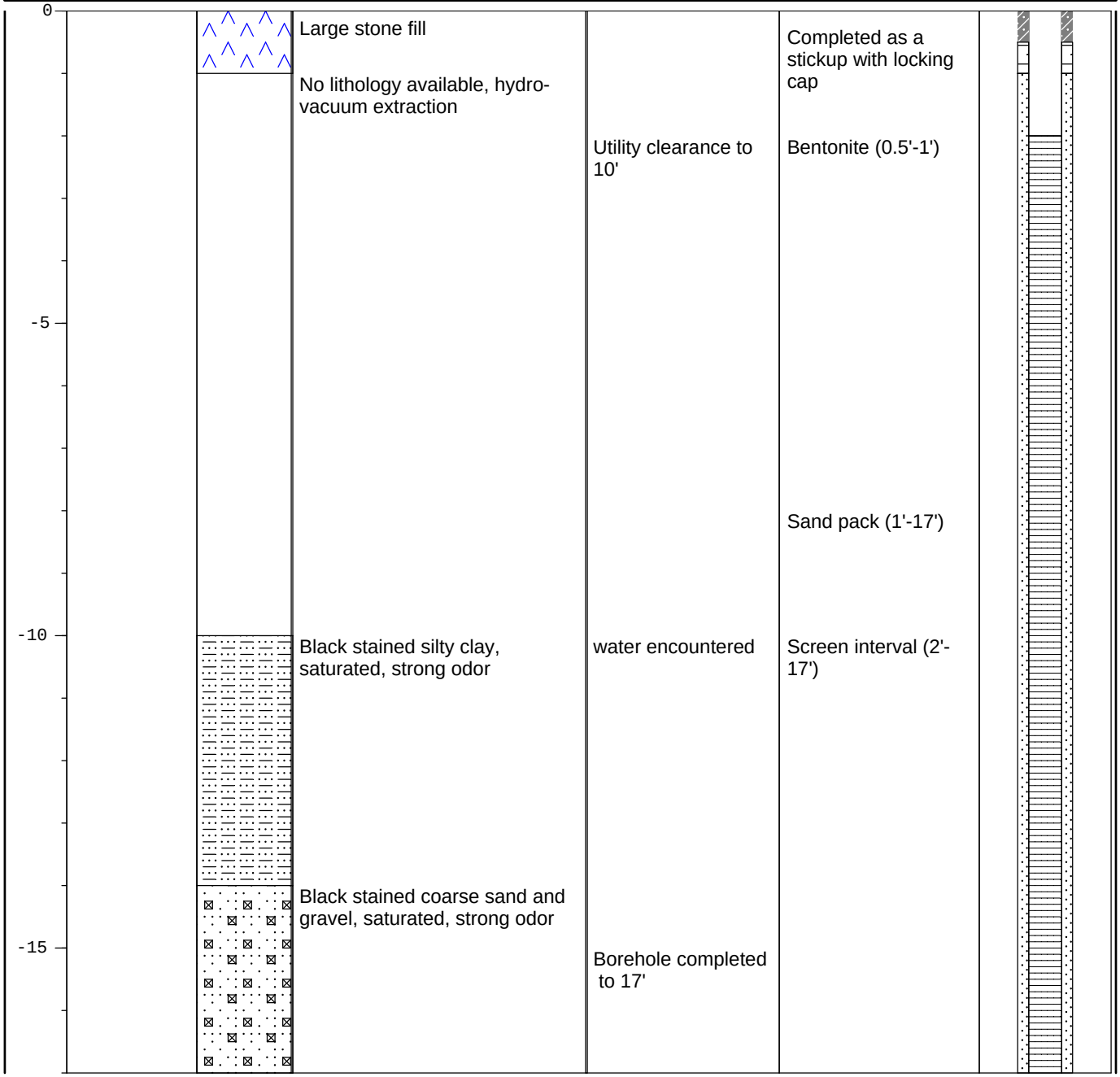
PROJECT:	**Sunoco Refinery**	DRILLING CO.:	**Total Quality Drilling**
SITE LOCATION:	**Philadelphia**	DRILLING METHOD:	**Hollow Stem Auger**
JOB NO.:	**AOI-5**	SAMPLING METHOD:	**Cuttings**
LOGGED BY:	**Kevin Martin**	SCREEN/RISER DIAMETER:	**4-inch**
DATES DRILLED:	**12 March 2007**	WELLBORE DIAMETER:	**8.25"**
TOTAL DEPTH:	**15'**	ELEVATION:	**NA**

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0		⊠ ⊠ ⊠	Dark brown silt and gravel		Completed as a stickup with locking cap	
			Black stained sandy silt, strong petroleum odor			
			No lithology available, hydro-vacuum extraction	Utility clearance to 8'	Bentonite (0.5'-1')	
-5					Sand pack (1'-15')	
-10	0.4		Dark brown plastic clay, moist		Screen interval (2'-15')	
	0.5		Dark brown plastic silty clay, moist			
	0.0		Dark brown plastic clay, wet	water encountered at 14' Borehole completed to 15'		
-15						

MONITORING WELL LOG: A-150

PROJECT:	**Sunoco Refinery**	DRILLING CO.:	**Total Quality Drilling**
SITE LOCATION:	**Philadelphia**	DRILLING METHOD:	**Hollow Stem Auger**
JOB NO.:	**AOI-5**	SAMPLING METHOD:	**Cuttings**
LOGGED BY:	**Brandee Blasi**	SCREEN/RISER DIAMETER:	**4-inch**
DATES DRILLED:	**6 March 2007**	WELLBORE DIAMETER:	**8.25"**
TOTAL DEPTH:	**17'**	ELEVATION:	**NA**

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0			Large stone fill		Completed as a stickup with locking cap	
			No lithology available, hydro-vacuum extraction			
				Utility clearance to 10'	Bentonite (0.5'-1')	
-5						
					Sand pack (1'-17')	
-10			Black stained silty clay, saturated, strong odor	water encountered	Screen interval (2'-17')	
			Black stained coarse sand and gravel, saturated, strong odor			
-15				Borehole completed to 17'		



MONITORING WELL LOG: A-151

PROJECT:	**Sunoco Refinery**	DRILLING CO.:	**Total Quality Drilling**
SITE LOCATION:	**Philadelphia**	DRILLING METHOD:	**Hollow Stem Auger**
JOB NO.:	**AOI-5**	SAMPLING METHOD:	**Cuttings**
LOGGED BY:	**Kevin Martin**	SCREEN/RISER DIAMETER:	**4-inch**
DATES DRILLED:	**1 March 2007**	WELLBORE DIAMETER:	**8.25"**
TOTAL DEPTH:	**15'**	ELEVATION:	**NA**

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0			Grass and topsoil Dark brown silty clay with some rocks	Sample A-151_071207_1.5-2	Completed as a stickup with locking cap	
			No lithology available, hydro-vacuum extraction	Utility clearance to 5'	Bentonite (0.5'-1')	
-5					Sand pack (1'-15')	
-10	0.0		Dark gray silty clay		Screen interval (2'-15')	
	0.0					
	0.0			Borehole completed to 15'		
-15						

MONITORING WELL LOG: A-152

PROJECT:	**Sunoco Refinery**	DRILLING CO.:	**Total Quality Drilling**
SITE LOCATION:	**Philadelphia**	DRILLING METHOD:	**Hollow Stem Auger**
JOB NO.:	**AOI-5**	SAMPLING METHOD:	**Cuttings**
LOGGED BY:	**Brandee Blasi**	SCREEN/RISER DIAMETER:	**4-inch**
DATES DRILLED:	**6 March 2007**	WELLBORE DIAMETER:	**8.25"**
TOTAL DEPTH:	**17'**	ELEVATION:	**NA**

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0			Light brown silty sand and gravel	Sample A-152_071207_1.5-2	Completed as a stickup with locking cap	
			No lithology available, hydro-vacuum extraction	Utility clearance to 10'	Bentonite (0.5'-1')	
-5					Sand pack (1'-17')	
-10			Silty clay, highly plastic, saturated	water encountered	Screen interval (2'-17')	
-15				Borehole completed to 17'		

MONITORING WELL LOG: A-153

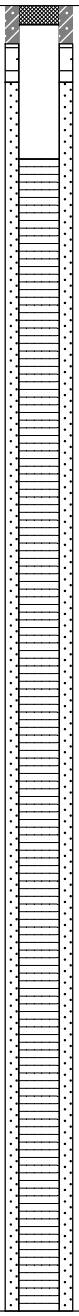
PROJECT:	**Sunoco Refinery**	DRILLING CO.:	**Total Quality Drilling**
SITE LOCATION:	**Philadelphia**	DRILLING METHOD:	**Hollow Stem Auger**
JOB NO.:	**AOI-5**	SAMPLING METHOD:	**Cuttings**
LOGGED BY:	**Kevin Martin**	SCREEN/RISER DIAMETER:	**4-inch**
DATES DRILLED:	**15 March 2007**	WELLBORE DIAMETER:	**8.25"**
TOTAL DEPTH:	**17'**	ELEVATION:	**NA**

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0			Crushed stone fill		Completed as a flushmount with locking cap	
			No lithology available, hydro-vacuum extraction	Utility clearance to 8'	Bentonite (0.5'-1')	
-5					Sand pack (1'-17')	
-10					Screen interval (2'-17')	
	1.0		Dark brown silty clay, wet	water encountered		
	1.0		Dark brown med sand with some clay, wet			
-15				Borehole completed to 17'		

MONITORING WELL LOG: A-154

PROJECT:	**Sunoco Refinery**	DRILLING CO.:	**Total Quality Drilling**
SITE LOCATION:	**Philadelphia**	DRILLING METHOD:	**Hollow Stem Auger**
JOB NO.:	**AOI-5**	SAMPLING METHOD:	**Cuttings**
LOGGED BY:	**Brandee Blasi**	SCREEN/RISER DIAMETER:	**4-inch**
DATES DRILLED:	**6 March 2007**	WELLBORE DIAMETER:	**8.25"**
TOTAL DEPTH:	**17'**	ELEVATION:	**NA**

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0			Asphalt and fill No lithology available, hydro-vacuum extraction		Completed as a flushmount with locking cap and manhole	
				Utility clearance to 10'	Bentonite (0.5'-1')	
-5						
					Sand pack (1'-17')	
-10			Sand and gravel, sheen present, odor	water encountered	Screen interval (2'-17')	
			Gray-green silty clay, wet with sheen, odor			
-15				Borehole completed to 17'		



MONITORING WELL LOG: A-155

PROJECT:	**Sunoco Refinery**	DRILLING CO.:	**Total Quality Drilling**
SITE LOCATION:	**Philadelphia**	DRILLING METHOD:	**Hollow Stem Auger**
JOB NO.:	**AOI-5**	SAMPLING METHOD:	**Cuttings**
LOGGED BY:	**Kevin Martin**	SCREEN/RISER DIAMETER:	**4-inch**
DATES DRILLED:	**2 March 2007**	WELLBORE DIAMETER:	**8.25"**
TOTAL DEPTH:	**15'**	ELEVATION:	**NA**

Depth (feet)	OVM (ppm)	USCS	LITHOLOGY	COMMENTS	WELL CONSTRUCTION	WELL DIAGRAM
0			Large stone fill		Completed as a stickup with locking cap	
			No lithology available			
				Utility clearance to 10'	Bentonite (0.5'-1')	
-5						
					Sand pack (1'-15')	
-10	0.0		Dark gray silty clay, moist		Screen interval (2'-15')	
	0.2					
	0.0			Borehole completed to 15'		
-15						

APPENDIX F

Groundwater Sampling Field Sampling Reports

APPENDIX F
GROUNDWATER FIELD SAMPLING SUMMARY
AOI-5
SUNOCO PHILADELPHIA REFINERY
PHILADELPHIA, PENNSYLVANIA

Well ID	Date Sampled	Depth to Water (feet)	Depth to Product (feet)	Total Depth (feet)	Water Column (feet)	Conversion Factor	Well Volume (gallons)	Purge Volume (gallons)
A-1	5/7/2007	4.27	NP	10	5.73	0.65	3.7	11.2
A-10	5/8/2007	3.30	NP	15	11.70	0.65	7.6	22.8
A-11	5/7/2007	4.75	NP	16	11.25	0.65	7.3	21.9
A-118	5/9/2007	2.75	NP	17.5	14.75	0.65	9.6	28.8
A-119	5/9/2007	4.41	NP	12.5	8.09	0.65	5.3	15.8
A-12	5/7/2007	4.12	NP	15.6	11.48	0.65	7.5	22.4
A-120	5/9/2007	4.80	NP	17.3	12.50	0.65	8.1	24.4
A-121	5/9/2007	6.04	NP	17.5	11.46	0.65	7.4	22.3
A-122	5/8/2007	3.72	NP	17.6	13.88	0.65	9.0	27.1
A-13	NS	5.21	4.72	NM	NM		NS	NS
A-133	5/3/2007	8.21	NP	16.6	8.39	0.65	5.5	16.4
A-134	5/3/2007	7.05	NP	17	9.95	0.65	6.5	19.4
A-135	5/3/2007	6.81	NP	17	10.19	0.65	6.6	19.9
A-137	5/7/2007	6.51	NP	14	7.49	0.65	4.9	14.6
A-139	5/7/2007	3.44	NP	18	14.56	0.65	9.5	28.4
A-13D	5/3/2007	11.43	NP	70	58.57	0.65	38.1	114.2
A-14	NS	6.78	6.45	NM	SPH	SPH	SPH	SPH
A-140	5/7/2007	4.24	NP	18	13.76	0.65	8.9	26.8
A-141	5/7/2007	4.40	NP	18.5	14.10	0.65	9.2	27.5
A-142	5/7/2007	7.88	NP	17.2	9.32	0.65	6.1	18.2
A-143	5/3/2007	5.49	NP	13.3	7.81	0.65	5.1	15.2
A-144	NS	19.87	5.24	NM	SPH	SPH	SPH	SPH
A-145	5/3/2007	2.94	NP	17	14.06	0.65	9.1	27.4
A-146	5/9/2007	5.48	NP	17	11.52	0.65	7.5	22.5
A-147	5/9/2007	1.35	NP	14	12.65	0.65	8.2	24.7
A-148	5/8/2007	2.97	NP	14.5	11.53	0.65	7.5	22.5
A-149	5/8/2007	3.40	NP	18	14.60	0.65	9.5	28.5
A-15	5/8/2007	1.04	NP	15	13.96	0.65	9.1	27.2
A-150	5/8/2007	5.02	NP	19	13.98	0.65	9.1	27.3
A-151	NS	4.13	4.12	NM	SPH	SPH	SPH	SPH
A-152	5/8/2007	2.60	NP	19.5	16.90	0.65	11.0	33.0
A-153	5/9/2007	4.00	NP	17	13.00	0.65	8.5	25.4
A-154	5/8/2007	2.02	NP	17	14.98	0.65	9.7	29.2
A-155	NS	5.84	4.81	NM	SPH	SPH	SPH	SPH
A-16	5/8/2007	3.69	NP	10	6.31	0.65	4.1	12.3
A-17	NS	2.15	NP	NM	Well Casing Damaged - Bailer or pump would not fit in well			
A-20	NS	6.50	4.72	7.2	SPH	SPH	SPH	SPH
A-21	NS	4.00	2.14	SPH to thick to determine	SPH	SPH	SPH	SPH
A-21D	5/7/2007	15.75	NP	100+	84.25	0.65	54.8	164.3
A-22	NS	5.49	5.48	15	SPH	SPH	SPH	SPH
A-23	5/8/2007	3.54	NP	16	12.46	0.65	8.1	24.3
A-24	NS	1.90	1.85	15	SPH	SPH	SPH	SPH
A-25	5/4/2007	4.81	NP	11.5	6.69	0.65	4.3	13.0
A-26	5/4/2007	5.02	NP	9	3.98	0.65	2.6	7.8
A-27	5/8/2007	6.05	NP	15	8.95	0.65	5.8	17.5
A-3	5/3/2007	4.38	NP	16	11.62	0.65	7.6	22.7
A-39	5/7/2007	2.21	NP	9	6.79	0.65	4.4	13.2
A-4	NS	SPH to thick to determine	3.84	16.5	SPH	SPH	SPH	SPH
A-40	5/7/2007	6.44	NP	17	10.56	0.65	6.9	20.6
A-41	5/7/2007	6.25	NP	15	8.75	0.65	5.7	17.1

NS - Not sampled

DRY - Insufficient well volume to collect sample

SPH - Separate phase hydrocarbons

NP - No product (SPH) in well

NM - Not measured

PUMP - Pump in well; total depth of well could not be determined

Note: All wells were gauged on 5/2/2007.

APPENDIX F
GROUNDWATER FIELD SAMPLING SUMMARY
AOI-5
SUNOCO PHILADELPHIA REFINERY
PHILADELPHIA, PENNSYLVANIA

Well ID	Date Sampled	Depth to Water (feet)	Depth to Product (feet)	Total Depth (feet)	Water Column (feet)	Conversion Factor	Well Volume (gallons)	Purge Volume (gallons)
A-43	5/3/2007	5.95	NP	11	5.05	0.65	3.3	9.8
A-44	5/3/2007	6.20	NP	14	7.80	0.65	5.1	15.2
A-45	NS	All SPH	3.61	8.5	SPH	SPH	SPH	SPH
A-46	NS	SPH to thick to determine	6.88	NM	SPH	SPH	SPH	SPH
A-47	NS	4.77	4.69	14.6	SPH	SPH	SPH	SPH
A-48	5/8/2007	4.91	NP	14.6	9.69	0.65	6.3	18.9
A-49	5/8/2007	2.99	NP	12.4	9.41	0.65	6.1	18.3
A-5	5/4/2007	4.18	NP	9.5	5.32	0.65	3.5	10.4
A-6	5/9/2007	3.40	NP	17.5	14.10	0.65	9.2	27.5
A-7	NS	3.77	2.99	NM	SPH	SPH	SPH	SPH
A-8	5/4/2007	3.39	NP	13	9.61	0.65	6.2	18.7
A-9	5/4/2007	3.17	NP	15.5	12.33	0.65	8.0	24.0
A-91	5/9/2007	4.28	NP	11.5	7.22	0.65	4.7	14.1
PZ-1	NS	DRY	DRY	3.4	DRY	DRY	DRY	DRY
PZ-2	5/3/2007	6.78	NP	9.6	2.82	0.16	0.5	1.4
PZ-3	5/3/2007	6.80	NP	10	3.20	0.16	0.5	1.5
RW-6	5/3/2007	3.88	NP	14.6	10.72	0.65	7.0	20.9
RWBH-1	NS	3.41	NP	PUMP	NS	NS	NS	NS
RWBH-2 **(A-33)**	NS	3.98	NP	8.6				
SW-1	NS	8.31	7.05	20	SPH	SPH	SPH	SPH
SW-2	5/7/2007	6.01	NP	18.6	12.59	0.65	8.2	16.0
SW-3	5/7/2007	7.11	NP	18	10.89	0.65	7.1	13.8
SW-4	NS	4.16	4.10	15.6	SPH	SPH	SPH	SPH
SW-5	NS	SPH to thick to determine	5.09	14.6	SPH	SPH	SPH	SPH
SWR-2	5/7/2007	7.85	NP	15	7.15	0.65	4.6	9.1
SWR-3	5/7/2007	7.75	NP	11.6	3.85	0.65	2.5	4.9
WP-1	5/8/2007	2.52	NP	4	DRY	DRY	DRY	DRY
WP-14	5/8/2007	6.16	NP	9	2.84	0.16	0.5	0.2
WP-16-1	NS	Could not be located			NS	NS	NS	NS
WP-16-3	5/4/2007	7.48	NP	14.5	7.02	0.16	1.1	3
WP-16-4	NS	Could not be located			NS	NS	NS	NS
WP-1A	NS	Could not be located			NS	NS	NS	NS
WP-2	NS	DRY	DRY	2	DRY	DRY	DRY	DRY
WP-2A	NS	Could not be located			NS	NS	NS	NS
WP-3	NS	DRY	DRY	4	DRY	DRY	DRY	DRY
WP-3A	NS	Could not be located			NS	NS	NS	NS
WP-4A	5/7/2007	7.00	NP	9.5	2.50	0.16	0.4	1.75
WP-5A	NS	Could not be located			NS	NS	NS	NS
WP-8	5/9/2007	3.33	NP	9	5.67	0.16	0.9	0.4
WP-9	5/8/2007	4.88	NP	13	8.12	0.16	1.3	0.6
WP-A	5/7/2007	3.24	NP	13	9.76	0.16	1.6	0.7
WP-B	5/3/2007	5.75	NP	12	6.25	0.16	1.0	0.5
WP-C	5/3/2007	6.35	NP	12.6	6.25	0.16	1.0	0.5
WP-D	5/3/2007	4.02	NP	11.6	7.58	0.16	1.2	0.6
WP-E	5/3/2007	3.74	NP	10.5	6.76	0.16	1.1	0.5

NS - Not sampled

DRY - Insufficient well volume to collect sample

SPH - Separate phase hydrocarbons

NP - No product (SPH) in well

NM - Not measured

PUMP - Pump in well; total depth of well could not be determined

Note: All wells were gauged on 5/2/2007.

APPENDIX G

LNAPL Modeling Procedures & Results

ATTACHMENT G
LNAPL MODELING PROCEDURES
AOI 5: SUNOCO PHILADELPHIA REFINERY
PHILADELPHIA, PENNSYLVANIA

G.1 INTRODUCTION AND OVERVIEW

Models which assess volume, mobility, and recoverability of light non-aqueous phase liquid (LNAPL) contamination have progressed beyond simply extrapolating LNAPL monitoring well thicknesses into the surrounding geologic materials. Instead, these models incorporate the physical properties of groundwater, LNAPL, and soil, in conjunction with an improved understanding of how fluids interact with each other and the surrounding geologic materials, and provide better estimates of LNAPL volume, mobility, and recoverability. These scientific improvements have allowed more realistic endpoints to be set during the remediation process.

For the LNAPL modeling in AOI 5 at the Sunoco Refinery in Philadelphia, PA (the Facility), Langan utilized the American Petroleum Institute (API) Publication Number 4682, "Free-Product Recovery of Petroleum Hydrocarbon Liquids," dated June 1999, as a guide for assessing LNAPL volume, mobility, and recoverability. The parameters discussed in subsequent sections are presented in API Publication 4682 as the significant variables and parameters needed to evaluate the nature and extent of free LNAPL. An updated version of the API model found in the API publication "API Interactive LNAPL Guide," version 2.0.4, dated July 2004, was used. These parameters and the API model were utilized to estimate the specific volume and mobility of LNAPL at the Facility.

G.2 INPUT PARAMETERS

Representative values obtained from the API's LNAPL and Environmental Canada's Reference Database were used to identify input parameters. Table G-1 of this attachment summarizes the LNAPL modeling input parameters used for this phase of the project. The individual input parameters used for the LNAPL models are described in detail below.

G.3 FLUID PROPERTIES

The fluids of concern in LNAPL modeling are LNAPL, groundwater, and air. Key physical properties of these fluids are density (ρ), interfacial tension (σ) and viscosity (μ). Chromatographic and mass spectroscopic hydrocarbon LNAPL characterization analyses were

conducted on collected LNAPL samples in an attempt to identify and categorize LNAPLs on site.

G.3.1 Fluid Density and Specific Gravity

Fluid density,ρ, is the mass of fluid per unit volume. Specific gravity, ρ_r, is the relative density of LNAPL with respect to the density of water. The density of LNAPL is related to its specific gravity through the following relationship:

$$\rho_r = \rho_o/\rho_w \qquad \text{(G.1)}$$

where ρ_o and ρ_w are the LNAPL and water densities, respectively.

Density estimates for LNAPL samples collected from wells within the Facility were determined from LNAPL and groundwater density data. If a density value was not available for the LNAPL in a particular monitoring well, a value was assigned based on the physical characteristics of the LNAPL observed in neighboring wells.

G.3.2 LNAPL Viscosity

Viscosity is the measure of friction between molecules within a given fluid. The dynamic (or absolute) viscosity, μ, is defined as the ratio of the shear stress to the strain rate for a Newtonian fluid (Newtonian fluids have constant viscosity and flow immediately on the application of a force). The kinematic viscosity (ν) is the ratio of the dynamic viscosity to the density of a fluid.

If a kinematic viscosity value was not available for the LNAPL within a monitoring well, a value was assigned based on the physical characteristics of the LNAPL in relation to neighboring monitor wells, or a representative viscocity value was selected from the API or Environmental Canada Database chosen based upon other LNAPL physical characteristics.

G.4 FORMATION PHYSICAL PROPERTIES

Where available, site-specific geologic and hydrogeologic data were obtained from site soil boring investigations, monitoring and recovery wells installation and sampling activities, and aquifer characteristic testing. All remaining physical property input values were obtained from reference literature.

Variations in soil type were noted from boring log descriptions. For the purpose of determining modeling parameters, generalizations of the geologic characteristics were made based on the occurrence and distribution of soil types within the LNAPL wetted screen interval of monitoring wells. Consistent with the API guidance publication, the geologic parameters of interest include: soil texture, porosity, bulk density, fluid saturation, capillary pressure relationships, and total organic carbon (TOC). These parameters are discussed in detail below.

G.4.1 Formation Texture

One of the most important parameters in determining the properties of porous media is the size range of particles in a soil, which is referred to as soil texture. Grain size is closely related to soil texture, and a grain size distribution gives the relative percentage of grain sizes within a formation.

Where available, historic site-specific grain size distribution data were used to describe the relative percentage of grain size within the various geologic units at the Facility. Regions with similar grain size distributions were grouped together, and representative values were selected. Soil within the historic maximum LNAPL wetted interval was used for this selection. Note, however, that in any given boring log, the soil type spanning the LNAPL wetted interval may actually include a range of soil types. In addition to the grain size analyses, the soil Atterberg Limits were referenced for select soil types. The Atterberg limits were used to correlate and characterize the fine-grained soil (i.e., silt and clay) in conjunction with the grain size distribution analyses.

G.4.2 Porosity

The ratio of the volume of void space in a soil to the total volume is defined as the porosity (n), which is usually written as a fraction or a percent of void space. Generally,

wider variations in particle sizes result in smaller porosity values, as the void space between the larger particles are filled by smaller particles. The effective porosity (or kinematic porosity) refers to the volume of interconnected pore spaces through which fluids can flow.

G.4.3 Bulk Density

Bulk density is a measure of the weight of the soil per unit volume, usually given on an oven-dry (110° C) basis. Variation in bulk density is attributable to the relative proportion and specific gravity of solid organic and inorganic particles and to the porosity of the soil. Most mineral soils have bulk densities between 1.0 and 2.0.

G.4.4 Fluid Saturation

According to the API guidance documents, the void space of a natural porous medium affected by an LNAPL release is filled with water, air and LNAPL. The fraction of the pore space of a representative volume of material that is occupied by a particular fluid is called the fluid saturation. The fluid saturation of each phase can range from 0 to 1, and the sum of the three phases must equal 1.

G.4.5 Capillary Pressure Relationships

According to the API guidance document, molecules located near the interface between two fluids (i.e. water and LNAPL) in one void space have a greater energy than molecules of the same fluid located within the bulk volume due to cohesive forces between the molecules. The excess energy associated with a fluid interface results in interfacial tension between the fluids, and surface tension between the liquid and vapor.

These relationships are incorporated into the API model for determining formation specific volume under vertical equilibrium.

G.5 LNAPL EFFECTIVE PERMEABILITY

Water, air, and LNAPL are in competition for the interstitial spaces within the formation. Relative permeability describes the ability of one fluid to flow in the presence of other fluids, compared to the ability of the fluid to flow if it were the only fluid present. Typically, these

differences in permeability between water and LNAPL are observed as LNAPL reaches the water table in sufficient quantities, pools, and spreads laterally as a floating layer.

The API modeling approach is to predict the LNAPL saturation and relative permeability distributions under vertical equilibrium conditions. The effective saturation and relative permeability values depend on the LNAPL thicknesses within the formation, for which the apparent monitoring well LNAPL thicknesses serve as a useful measure. The modeling objective is to replace the layer with varying saturation and relative permeability with an equivalent layer with vertically uniform characteristics.

For each well with reported apparent LNAPL thickness, the API model was run to determine the effective relative permeability of LNAPL within that well. As a first approximation, the residual saturation of LNAPL (the portion of LNAPL that is adhered to soil and not recoverable) was considered to be zero for the calculation of effective relative permeability. The residual saturation of LNAPL will be determined based on the soil grain size, fluid saturation and capillary curves for the recoverability analysis.

G.6 SOIL INTRINSIC PERMEABILITY

The intrinsic permeability of the soil was estimated using the following equation:

$$k_{soil} = \frac{K_W \mu_W}{\rho_W g} \qquad \text{(G.2)}$$

where,

k_{soil} = permeability of soil

K_w = hydraulic conductivity of groundwater for fill horizon

μ_w = dynamic viscosity of water

p_w = density of water

g = gravity

The estimates of the ground water density and viscosity were used to determine the intrinsic soil permeability. The gravity constant was assumed to be 32.2 feet/s^2 (9.81 m/s^2).

G.7 LNAPL HYDRAULIC CONDUCTIVITY AT SATURATION

To estimate the seepage velocity of the free-phase LNAPL, the hydraulic conductivity of the formation with respect to LNAPL must be known. The hydraulic conductivity of LNAPL is first calculated at 100% saturation at the LNAPL phase. Then it is corrected from the effective LNAPL relative permeability. This corrected hydraulic conductivity of LNAPL is the hydraulic conductivity of LNAPL in the formation at the estimated saturation of LNAPL. This can be estimated based on the following equation:

$$K_{oil} = k_{ro} \frac{k_{soil} \rho_{oil} g}{\mu_{oil}} \quad \text{(G.3)}$$

where,

K_{oil} = hydraulic conductivity of LNAPL in the soil at saturation

k_{ro} = effective LNAPL relative permeability

k_{soil} = permeability of soil relative to groundwater (Equation D.2)

μ_{oil} = dynamic viscosity of LNAPL

p_{oil} = density of LNAPL

g = gravity

G.8 LNAPL SPECIFIC DISCHARGE

The result of the corrected hydraulic conductivity for LNAPL saturation (Equation G.3) was used to calculate the specific velocity of the LNAPL based on hydraulic gradient of the groundwater using the following equation:

$$q_{oil} = K_{oil} \times i_w \quad \text{(G.4)}$$

where,

q_{oil} = LNAPL specific velocity of LNAPL discharge

K_{oil} = hydraulic conductivity of LNAPL in the soil at the corrected saturation

i_w = water table gradient

The water table gradient was assumed to be similar to the LNAPL table gradient. Based on the groundwater monitoring data collected to date, average water table gradients were selected.

The seepage velocity or mobility of the LNAPL was calculated based on the specific velocity calculated in Equation G.4, and correcting it for the effective porosity of the formation as follows:

$$v_{oil} = \frac{q_{oil}}{\phi_{eff}} \quad \text{(G.5)}$$

where,

v_{oil} = LNAPL seepage velocity

q_{oil} = LNAPL specific velocity of LNAPL discharge

ϕ_{eff} = effective porosity

The specific velocity of the LNAPL discharge from the previous calculation was divided by the effective porosity to determine the seepage velocity of LNAPL for all wells. For this calculation, total porosity values associated with each soil type were reduced for use as an effective porosity for LNAPL mobility.

Located in Tables G-2 and G-3 are the output results of the LNAPL modeling. Located in Table G-4 of this attachment is the LNAPL characterization data provided by Torkelson Laboratories.

Table G.1
API Model Input Parameters
AOI 5
Sunoco Philadelphia Refinery and Belmont Terminal
Philadelphia, Pennsylvania

Well ID	Apparent LNAPL Thickness Field Measurement[1]		API Database						LNAPL Density (Torkelson Geochemistry) (gm/cc)	LNAPL Type or Source of Surrogate LNAPL Type (Torkelson Geochemistry)	API or Environment Canada Database		
			Porosity Well ID (unitless)	USCS Soil Type Surrounding Well Screen[2]	Source of Soil Type	van Genuchten "N" (unitless)	van Genuchten "a" [m^{-1}]	Irreducible Water Saturation[3] (unitless)			Air/Water Surface Tension[4] (dynes/cm)	Air/LNAPL Surface Tension (dynes/cm)	LNAPL/Water Surface Tension (dynes/cm)
	meter	feet											
A-5	0.030	0.10	0.428	SM	A-5 Boring Log	2.160	2.750	0.313	0.9124	Lube Oil	65.000	31.600	27.100
A-7	0.003	0.01	0.428	SM	A-7 Boring Log	2.160	2.750	0.313	0.8905	Lube Oil	65.000	31.600	27.100
A-13	0.168	0.55	0.428	SM	A-13 Boring Log	2.160	2.750	0.313	0.9015	Lube Oil	65.000	31.600	27.100
A-14	0.061	0.20	0.428	SM	A-14 Boring Log	2.160	2.750	0.313	0.9143	Lube Oil	65.000	31.600	27.100
A-21	0.003	0.01	0.428	SM	A-21 Boring Log	2.160	2.750	0.313	0.9100	Mid Dist	65.000	26.900	22.300
A-24	0.003	0.01	0.444	ML	A-24 Boring Log	1.840	1.040	0.408	0.8953	Mid Dist	65.000	26.900	22.300
A-46	0.012	0.04	0.415	s(ML)	A-46 Boring Log	1.820	0.960	0.490	0.8926	A-47/Lube Oil	65.000	31.600	27.100
A-136	0.003	0.01	0.428	SM	A-136 Boring Log	2.160	2.750	0.313	0.9767	Residual Oil	65.000	32.100	30.200
A-144	0.488	1.60	0.444	ML	A-144 Boring Log	1.840	1.040	0.408	0.8753	Mid Dist	65.000	26.900	22.300
A-155	0.351	1.15	0.444	ML	A-155 Boring Log	1.840	1.040	0.408	0.8777	Mid Dist	65.000	26.900	22.300
SW-1	0.189	0.62	0.428	SM	A-136 Boring Log	2.160	2.750	0.313	0.9100	Mid Dist	65.000	26.900	22.300
SW-4	0.021	0.07	0.428	SM	A-21 Boring Log	2.160	2.750	0.313	0.9100	Mid Dist	65.000	26.900	22.300
WP-A	0.003	0.01	0.428	SM	A-21Boring Log	2.160	2.750	0.313	0.9356	SW-4/Mid Dist	65.000	26.900	22.300
WP-B	0.158	0.52	0.428	SM	A-21 Boring Log	2.160	2.750	0.313	0.9356	SW-4/Mid Dist	65.000	26.900	22.300

NOTES:
(1) Groundwater/LNAPL gauging event May 2011.
(2) Unified Soil Classification System

USCS Symbol	API Database/Folk Classification
SM	Silty sand
ML	Mud, silt, sandy silt
s(ML)	Sandy silt

(3) Residual LNAPL saturation in the saturated and vadose zones are considered to be negligible.
(4) SPL Interfacial Tensions:

NAPL Type	Source
Lube Oil/Light Lube Oil	Env. Canada - Gasoline Engine Lube Oil
Middle Distillate	Env. Canada - Diesel
Residual Oil	Env. Canada - Residual Fuel Oil #4

Table G.2
API Model Output
AOI 5
Sunoco Philadelphia Refinery and Belmont Terminal
Philadelphia, Pennsylvania

Well ID	Apparent LNAPL Thickness Field Measurement[(1)]		API Model Results		
			Specific Volume	Specific Volume	Relative Permeabilty
	meter	feet	meters	feet	unitless
A-5	0.030	0.10	2.354E-07	7.723E-07	1.703E-07
A-7	0.003	0.01	2.637E-10	8.652E-10	1.448E-10
A-13	0.168	0.55	9.138E-05	2.998E-04	1.184E-04
A-14	0.061	0.20	2.113E-06	6.932E-06	1.764E-06
A-21	0.003	0.01	2.630E-10	8.629E-10	1.442E-10
A-24	0.003	0.01	3.499E-10	1.148E-09	2.594E-09
A-46	0.012	0.04	1.019E-08	3.343E-08	6.718E-08
A-136	0.003	0.01	7.376E-12	2.420E-11	5.199E-13
A-144	0.488	1.60	1.266E-03	4.154E-03	2.670E-03
A-155	0.351	1.15	5.025E-04	1.649E-03	1.151E-03
SW-1	0.189	0.62	1.645E-04	5.397E-04	2.279E-04
SW-4	0.021	0.07	1.232E-07	4.042E-07	1.083E-07
WP-A	0.003	0.01	1.277E-10	4.190E-10	4.646E-11
WP-B	0.158	0.52	4.136E-05	1.357E-04	3.769E-05

NOTES:
(1) Groundwater/LNAPL gauging event May 2011.

Table G.3
Seepage Velocity Calculations
AOI 5
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

AOI	Well ID	API Database USCS Soil Type Equivalent	LNAPL Density	Dominant LNAPL Type at Each Well Location	API Model Calculated LNAPL Relative Permeabilty	Effective Porosity	Groundwater Density @ 60F (kg/m^3)	Groundwater Dynamic Viscosity (N·s/m^2)	Soil Permeabililty (m^2)	Kro (%)	Groundwater Gradient	Dynamic Viscosity of LNAPL (N·s/m2)	LNAPL Density (kg/m3)	LNAPL K @ 100% Saturation (m/day)	Corrected LNAPL K (m/day)	LNAPL Specific Discharge (m/day)	LNAPL Seepage Velocity (m/year)	LNAPL Seepage Velocity (cm/sec)
			(gm/cc)		Unitless	API Database	CRC	API Database	API Database	API Model	May 2011 AOI-5 Contour Map	API/Env. Canada Databases	Torkelson Geochemistry Inc.	Calculated	Calculated	Calculated	Calculated	Calculated
AOI 5	A-5	SM	0.9124	Lube Oil	1.703E-07	0.43	999.19	1.124E-03	3.2E-12	0.00%	0.008	1.750E-01	912.40	1.41E-02	2.41E-09	1.88E-11	1.59E-08	5.03E-14
AOI 5	A-7	SM	0.8905	Lube Oil	1.448E-10	0.43	999.19	1.124E-03	3.2E-12	0.00%	0.006	1.750E-01	890.50	1.38E-02	2.00E-12	1.26E-14	1.07E-11	3.37E-17
AOI 5	A-13	SM	0.9015	Lube Oil	1.448E-04	0.43	999.19	1.124E-03	3.2E-12	0.01%	0.008	1.750E-01	901.50	1.40E-02	2.02E-06	1.58E-08	1.34E-05	4.22E-11
AOI 5	A-14	SM	0.9143	Lube Oil	1.764E-06	0.43	999.19	1.124E-03	3.2E-12	0.00%	0.006	1.750E-01	914.30	1.42E-02	2.50E-08	1.42E-10	1.21E-07	3.81E-13
AOI 5	A-21	SM	0.9100	Mid Dist	1.442E-10	0.43	999.19	1.124E-03	3.2E-12	0.00%	0.051	4.000E-03	910.00	6.17E-01	8.90E-11	4.54E-12	3.85E-09	1.21E-14
AOI 5	A-24	ML	0.8953	Mid Dist	2.594E-09	0.44	999.19	1.124E-03	8.65E-14	0.00%	0.019	4.000E-03	895.30	1.64E-02	4.26E-11	8.09E-13	6.71E-10	2.12E-15
AOI 5	A-46	s(ML)	0.8926	Lube Oil	6.718E-08	0.42	999.19	1.124E-03	5.12E-13	0.00%	0.010	1.750E-01	892.60	2.21E-03	1.49E-10	1.49E-12	1.29E-09	4.08E-15
AOI 5	A-136	SM	0.9767	Res Oil	5.199E-13	0.43	999.19	1.124E-03	3.2E-12	0.00%	0.002	2.300E-02	976.70	1.15E-01	5.99E-14	1.38E-16	1.17E-13	3.69E-19
AOI 5	A-144	ML	0.8753	Mid Dist	2.670E-03	0.44	999.19	1.124E-03	8.65E-14	0.27%	0.003	4.000E-03	875.30	1.60E-02	4.28E-05	1.16E-07	9.59E-05	3.03E-10
AOI 5	A-155	ML	0.8777	Mid Dist	1.151E-03	0.44	999.19	1.124E-03	8.65E-14	0.12%	0.002	4.000E-03	877.70	1.61E-02	1.85E-05	4.07E-08	3.38E-05	1.07E-10
AOI 5	SW-1	SM	0.9100	Mid Dist	2.279E-04	0.43	999.19	1.124E-03	3.2E-12	0.02%	0.002	4.000E-03	910.00	6.17E-01	1.41E-04	3.23E-07	2.75E-04	8.66E-10
AOI 5	SW-4	SM	0.9100	Mid Dist	1.083E-07	0.43	999.19	1.124E-03	3.2E-12	0.00%	0.004	4.000E-03	910.00	6.17E-01	6.68E-08	2.34E-10	1.99E-07	6.26E-13
AOI 5	WP-A	SM	0.9356	Mid Dist	4.646E-11	0.43	999.19	1.124E-03	3.2E-12	0.00%	0.051	4.000E-03	935.60	6.34E-01	2.95E-11	1.50E-12	1.28E-09	4.02E-15
AOI 5	WP-B	SM	0.9356	Mid Dist	3.769E-05	0.43	999.19	1.124E-03	3.2E-12	0.00%	0.023	4.000E-03	935.60	6.34E-01	2.39E-05	5.50E-07	4.67E-04	1.47E-09

Well ID	Apparent LNAPL Thickness Field Measurement[1]		API Model Results			Calculated LNAPL Seepage Velocity
			Specific Volume	Specific Volume	Relative Permeabilty	
	meter	feet	meters	feet	unitless	cm/sec
A-5	0.030	0.10	2.354E-07	7.723E-07	1.703E-07	5.37E-13
A-7	0.003	0.01	2.637E-10	8.652E-10	1.448E-10	4.57E-16
A-13	0.168	0.55	9.138E-05	2.998E-04	1.184E-04	3.73E-10
A-14	0.061	0.20	2.113E-06	6.932E-06	1.764E-06	5.56E-12
A-21	0.003	0.01	2.630E-10	8.629E-10	1.442E-10	4.55E-16
A-24	0.003	0.01	3.499E-10	1.148E-09	2.594E-09	8.18E-15
A-46	0.012	0.04	1.019E-08	3.343E-08	6.718E-08	2.12E-13
A-136	0.003	0.01	7.376E-12	2.420E-11	5.199E-13	1.64E-18
A-144	0.488	1.60	1.266E-03	4.154E-03	2.670E-03	8.42E-09
A-155	0.351	1.15	5.025E-04	1.649E-03	1.151E-03	3.63E-09
SW-1	0.189	0.62	1.645E-04	5.397E-04	2.279E-04	7.19E-10
SW-4	0.021	0.07	1.232E-07	4.042E-07	1.083E-07	3.42E-13
WP-A	0.003	0.01	1.277E-10	4.190E-10	4.646E-11	1.47E-16
WP-B	0.158	0.52	4.136E-05	1.357E-04	3.769E-05	1.19E-10

NOTES:
(1) Groundwater/LNAPL gauging event May 2011.

N
W E
S

Legend

- Wells with Measureable LNAPL and Calculated LNAPL Specific Volumes (ft.)[2] (A-5 7.72E-07)
- Monitoring Well (Unclassified) with No Measureable LNAPL (<0.01 ft.)
- Monitoring Well with No Measureable LNAPL (<0.01 ft.)
- Fill / Alluvium Recovery Well with No Measureable LNAPL (<0.01 ft.)
- Monitoring Wells With No Gauging
- AOIs
- Sheet Pile Wall

LNAPL Type and LNAPL Specific Volume (ft.)

Middle Distillate
0.00 - 0.05

Lube Oil
0.00 - 0.05

Residual Oil
0.00 - 0.05

Notes:
1. Bing Maps aerial imagery provided by © 2010 Microsoft Corporation and its data suppliers and obtained under the licensing agreement with ESRI.
2. LNAPL thickness and mobility calculations based on the American Petroleum Institute's van Genuchten-Mualem Model of LNAPL Distribution and Relative Permeability.
3. LNAPL type was based on density, distillation curve, etc. and are intended to qualify LNAPL mobility and recoverability, not to identify historic source.
4. Wells gauged in May 2011 by Aquaterra/Stantec.

Appendix G-1: Estimated LNAPL Specific Volumes
AOI-5 Site Characterization Report/
Remedial Investigation Report
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Sunoco, Inc. (R&M)
Philadelphia Refinery
3144 Passyunk Avenue
Philadelphia, PA.
19145

0 150 300 Feet

SCALE: 1" = 150'
DATE: November 15, 2011
DRN. BY: MH
CKD. BY: DW
JOB# : 2574601

Path: \\langan.com\data\DT\data6\2574601\ArcGIS\MapDocuments\AOI 5 SCR\SCR_RIR\Appendix G-1 - LNAPL Specific Volumes_11-15-11.mxd

Well ID	Apparent LNAPL Thickness Field Measurement[1]		API Model Results			Calculated LNAPL Seepage Velocity
			Specific Volume	Specific Volume	Relative Permeabilty	
	meter	feet	meters	feet	unitless	cm/sec
A-5	0.030	0.10	2.354E-07	7.723E-07	1.703E-07	5.37E-13
A-7	0.003	0.01	2.637E-10	8.652E-10	1.448E-10	4.57E-16
A-13	0.168	0.55	9.138E-05	2.998E-04	1.184E-04	3.73E-10
A-14	0.061	0.20	2.113E-06	6.932E-06	1.764E-06	5.56E-12
A-21	0.003	0.01	2.630E-10	8.629E-10	1.442E-10	4.55E-16
A-24	0.003	0.01	3.499E-10	1.148E-09	2.594E-09	8.18E-15
A-46	0.012	0.04	1.019E-08	3.343E-08	6.718E-08	2.12E-13
A-136	0.003	0.01	7.376E-12	2.420E-11	5.199E-13	1.64E-18
A-144	0.488	1.60	1.266E-03	4.154E-03	2.670E-03	8.42E-09
A-155	0.351	1.15	5.025E-04	1.649E-03	1.151E-03	3.63E-09
SW-1	0.189	0.62	1.645E-04	5.397E-04	2.279E-04	7.19E-10
SW-4	0.021	0.07	1.232E-07	4.042E-07	1.083E-07	3.42E-13
WP-A	0.003	0.01	1.277E-10	4.190E-10	4.646E-11	1.47E-16
WP-B	0.158	0.52	4.136E-05	1.357E-04	3.769E-05	1.19E-10

NOTES:
(1) Groundwater/LNAPL gauging event May 2011.

N
W E
S

Legend

- Wells with Measureable LNAPL and LNAPL Mobility Values (cm/sec) (A-5 7.72E-07)
- Monitoring Well (Unclassified) with No Measureable LNAPL (<0.01 ft.)
- Monitoring Well with No Measureable LNAPL (<0.01 ft.)
- Fill / Alluvium Recovery Well with No Measureable LNAPL (<0.01 ft.)
- Monitoring Wells With No Gauging
- AOI Boundary
- Sheet Pile Wall

LNAPL Type and Seepage Velocity (cm/sec)

Middle Distillate
0.00 - 0.05

Lube Oil
0.00 - 0.05

Residual Oil
0.00 - 0.05

Notes:
1. Bing Maps aerial imagery provided by © 2010 Microsoft Corporation and its data suppliers and obtained under the licensing agreement with ESRI.
2. LNAPL thickness and mobility calculations based on the American Petroleum Institute's van Genuchten-Mualem Model of LNAPL Distribution and Relative Permeability.
3. LNAPL type was based on density, distillation curve, etc. and are intended to qualify LNAPL mobility and recoverability, not to identify historic source.
4. Wells gauged in May 2011 by Aquaterra/Stantec.

Appendix G-2: Calculated LNAPL Mobility Values
AOI-5 Site Characterization Report/
Remedial Investigation Report
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Sunoco, Inc. (R&M)
Philadelphia Refinery
3144 Passyunk Avenue
Philadelphia, PA.
19145

0 150 300 Feet

SCALE: 1" = 150'
DATE: November 15, 2011
DRN. BY: MH
CKD. BY: DW
JOB# : 2574601

Path: \\langan.com\data\DT\data6\2574601\ArcGIS\MapDocuments\AOI 5 SCR\SCR_RIR\Appendix G-2 - Calculated LNAPL Mobility_11-15-11.mxd

van Genuchten-Mualem Model of LNAPL Distribution and Relative Permeability

Enter Data in Yellow Region | **A-5 May 2011**

Maximum Monitoring Well LNAPL Thickness (meters)		
b_o =	0.030	0.1 ft

Soil Characteristic		SM
n =	0.428	porosity
N =	2.160	van Genuchten "N"
α =	2.750	van Genuchten "α" [m^{-1}]
S_{wr} =	0.313	irreducible water saturation
S_{orv} =	0.000	residual LNAPL saturation (saturated)
S_{ors} =	0.000	residual LNAPL saturation (vadose)

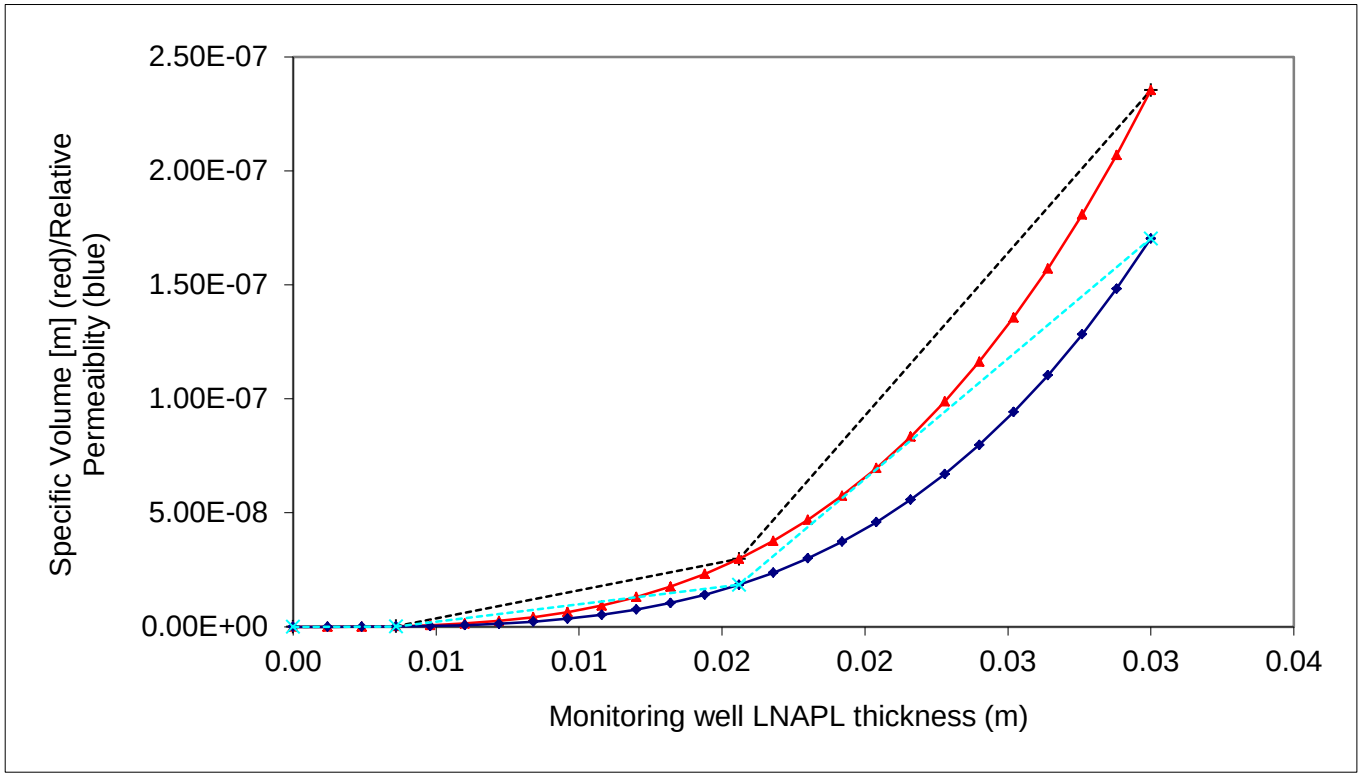
Fluid Characteristics:		Lube Oil
ρ_o =	0.9124	gm/cc
σ_{aw} =	65.000	dyne/cm
σ_{ao} =	31.600	dyne/cm
σ_{ow} =	27.100	dyne/cm

Calculated Parameters		
M =	0.537	van Genuchten "M"
α_{ao} =	5.161	air/LNAPL "α"
α_{ow} =	0.578	LNAPL/water "α"
z_{ao} =	0.003	elevation of air-LNAPL interface
z_{ow} =	-0.027	elevation of LNAPL-water interface
z_{max} =	0.003	maximum free-product elevation
λ =	0.841	pore-size distribution index
Ψ_b =	0.227	B-C displacement pressure head [m]

Press Ctrl+Shift+S to calculate sheet

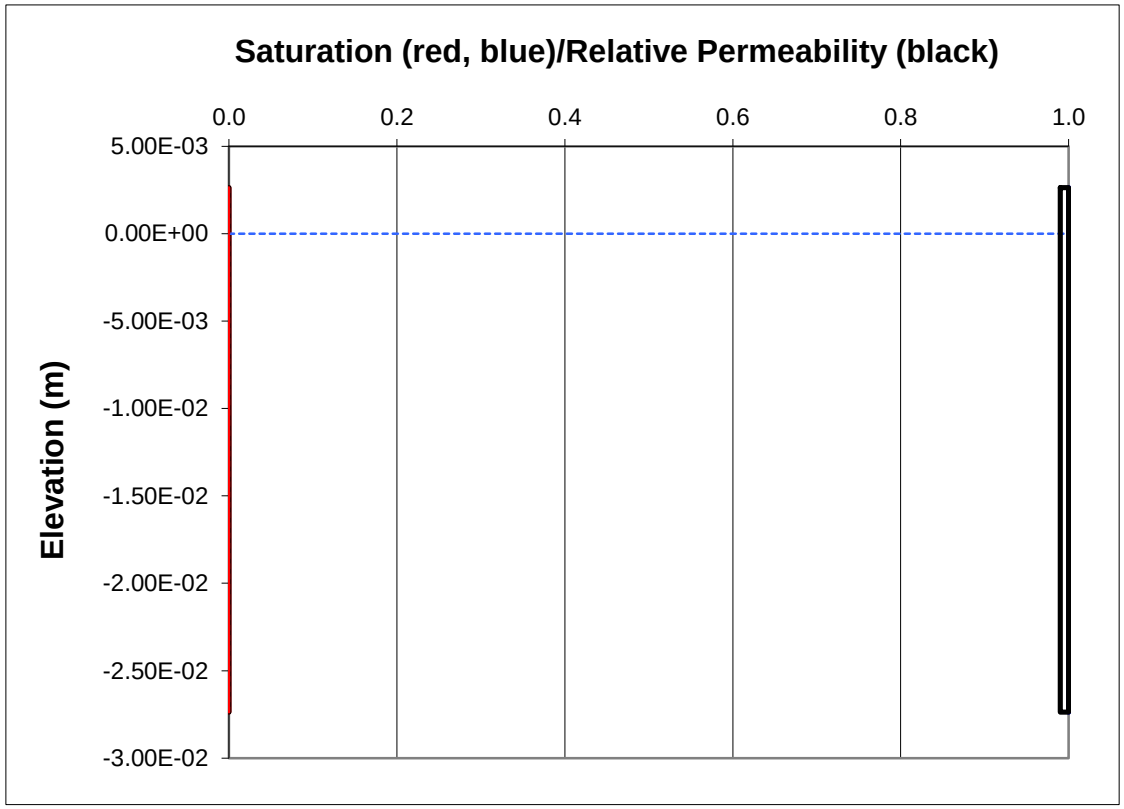
Data for curve-fitting segments								
b_o	D_o	k_{ro}	α	β	ξ	η		
0.000	0.000	0.000						
0.004	0.000	0.000	0.0000	0.000000	0.0000	0.000000		
0.016	0.000	0.000	0.0035	0.000002	0.0035	0.000002	0.01	Eps-Do
0.030	0.000	0.000	0.0135	0.000014	0.0139	0.000011	0.01	Eps-kro

Press Ctrl+Shift+S to calculate sheet



Monitoring Well LNAPL Thickness b_o (m) =			0.030
	D_o = 2.354E-07	k_{ro} =	1.703E-07

Press Ctrl+Shift+S to calculate sheet



van Genuchten-Mualem Model of LNAPL Distribution and Relative Permeability

Enter Data in Yellow Region	A-7 May 2011

Maximum Monitoring Well LNAPL Thickness (meters)		
b_o =	0.003	0.01 ft

Soil Characteristic		SM
n =	0.428	porosity
N =	2.160	van Genuchten "N"
α =	2.750	van Genuchten "α" [m^{-1}]
S_{wr} =	0.313	irreducible water saturation
S_{orv} =	0.000	residual LNAPL saturation (saturated)
S_{ors} =	0.000	residual LNAPL saturation (vadose)

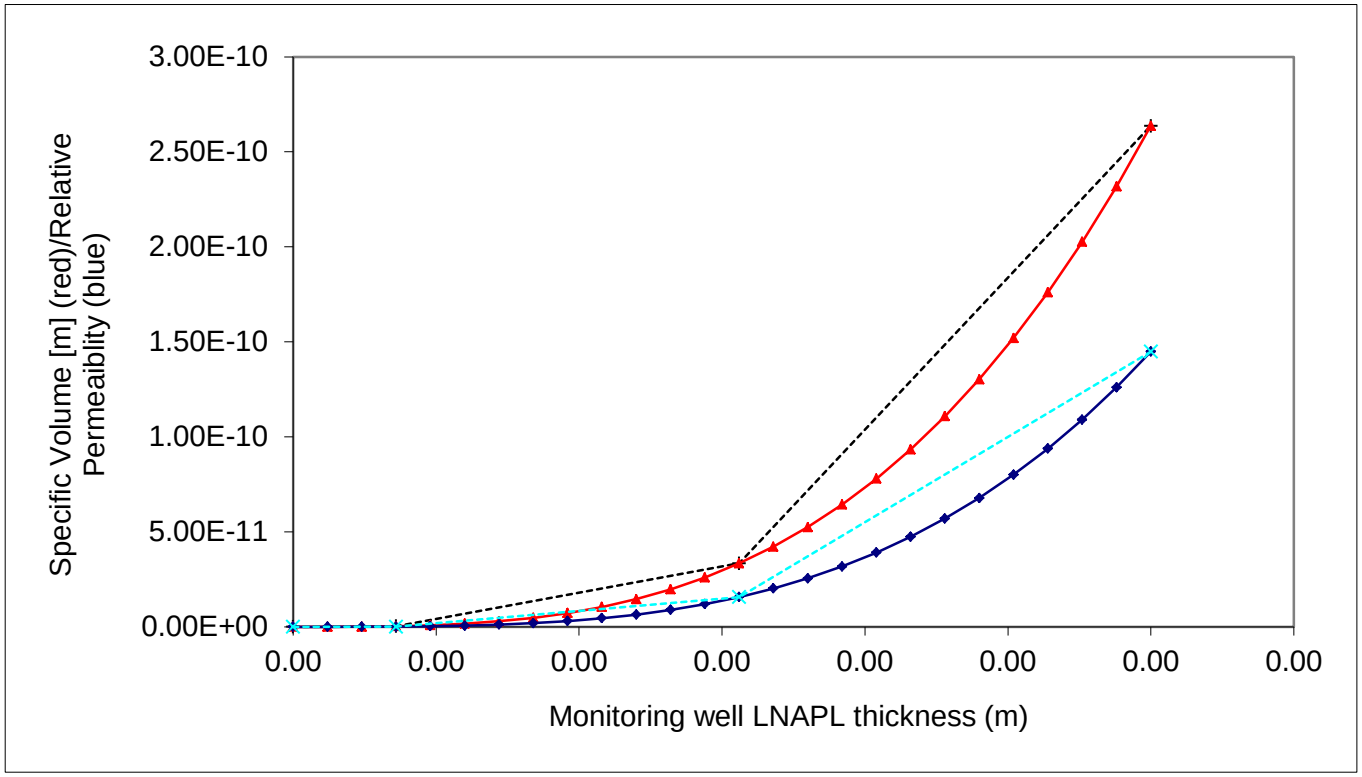
Fluid Characteristics:		Lube Oil
ρ_o =	0.8905	gm/cc
σ_{aw} =	65.000	dyne/cm
σ_{ao} =	31.600	dyne/cm
σ_{ow} =	27.100	dyne/cm

Calculated Parameters		
M =	0.537	van Genuchten "M"
α_{ao} =	5.037	air/LNAPL "α"
α_{ow} =	0.722	LNAPL/water "α"
z_{ao} =	0.000	elevation of air-LNAPL interface
z_{ow} =	-0.003	elevation of LNAPL-water interface
z_{max} =	0.000	maximum free-product elevation
λ =	0.841	pore-size distribution index
Ψ_b =	0.227	B-C displacement pressure head [m]

Press Ctrl+Shift+S to calculate sheet

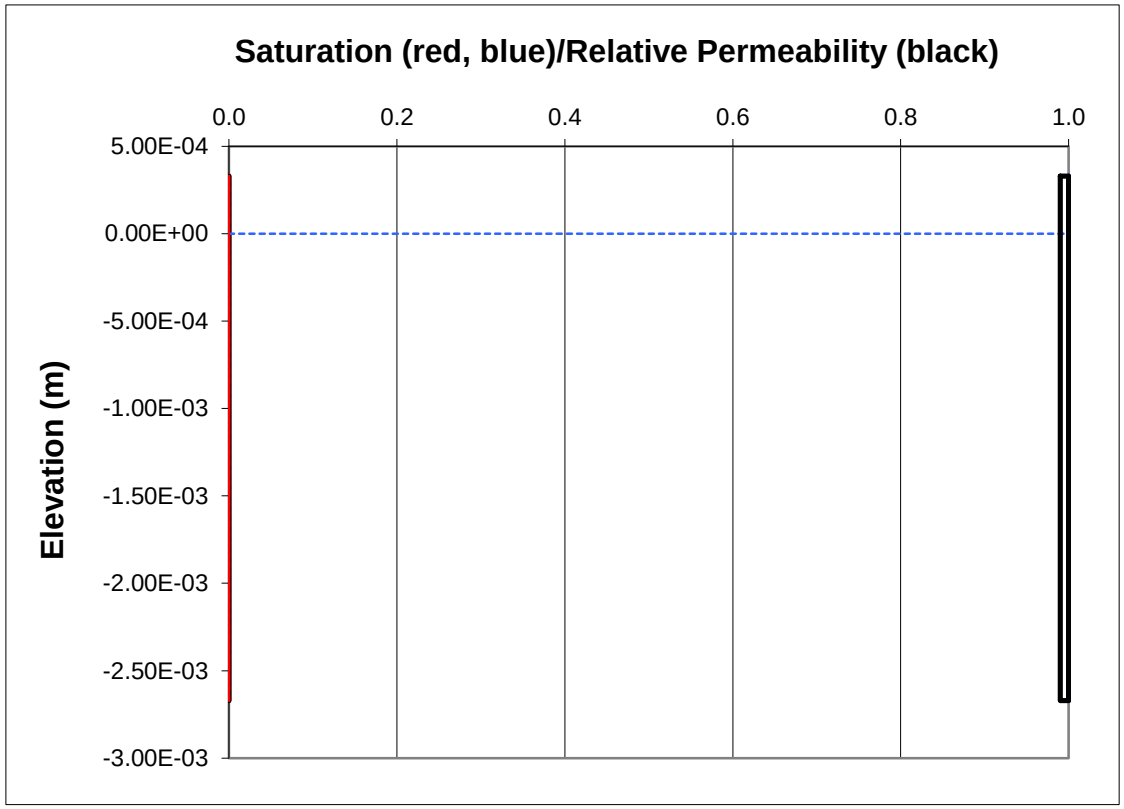
Data for curve-fitting segments								
b_o	D_o	k_{ro}	α	β	ξ	η		
0.000	0.000	0.000						
0.000	0.000	0.000	0.0000	0.000000	0.0000	0.000000		
0.002	0.000	0.000	0.0003	0.000000	0.0004	0.000000	0.01	Eps-Do
0.003	0.000	0.000	0.0014	0.000000	0.0014	0.000000	0.01	Eps-kro

Press Ctrl+Shift+S to calculate sheet



Monitoring Well LNAPL Thickness b_o (m) =			0.003
	D_o = 2.637E-10	k_{ro} =	1.448E-10

Press Ctrl+Shift+S to calculate sheet



van Genuchten-Mualem Model of LNAPL Distribution and Relative Permeability

Enter Data in Yellow Region | **A-13 May 2011**

Maximum Monitoring Well LNAPL Thickness (meters)		
b_o =	0.168	0.55 ft

Soil Characteristic		SM
n =	0.428	porosity
N =	2.160	van Genuchten "N"
α =	2.750	van Genuchten "α" [m^{-1}]
S_{wr} =	0.313	irreducible water saturation
S_{orv} =	0.000	residual LNAPL saturation (saturated)
S_{ors} =	0.000	residual LNAPL saturation (vadose)

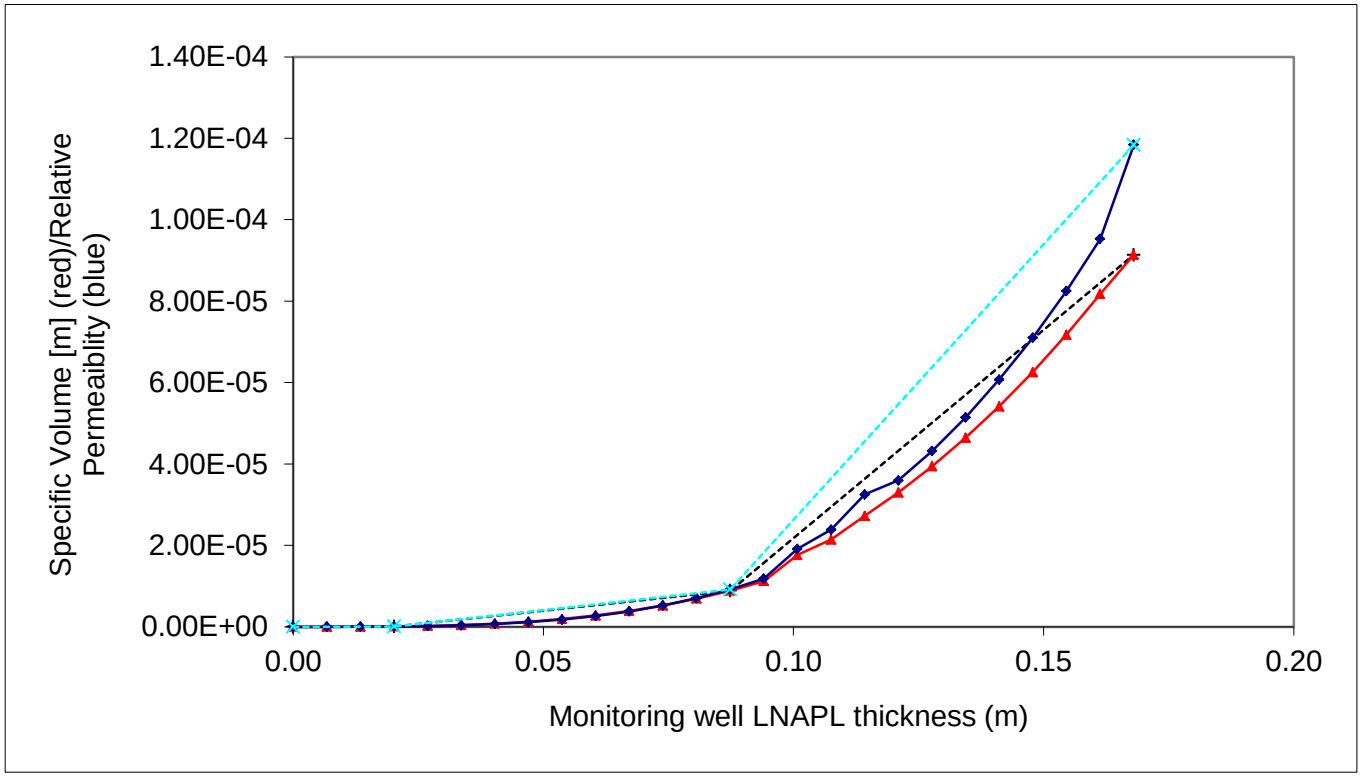
Fluid Characteristics:		Lube Oil
ρ_o =	0.9015	gm/cc
σ_{aw} =	65.000	dyne/cm
σ_{ao} =	31.600	dyne/cm
σ_{ow} =	27.100	dyne/cm

Calculated Parameters		
M =	0.537	van Genuchten "M"
α_{ao} =	5.099	air/LNAPL "α"
α_{ow} =	0.650	LNAPL/water "α"
z_{ao} =	0.017	elevation of air-LNAPL interface
z_{ow} =	-0.151	elevation of LNAPL-water interface
z_{max} =	0.047	maximum free-product elevation
λ =	0.841	pore-size distribution index
Ψ_b =	0.227	B-C displacement pressure head [m]

Press Ctrl+Shift+S to calculate sheet

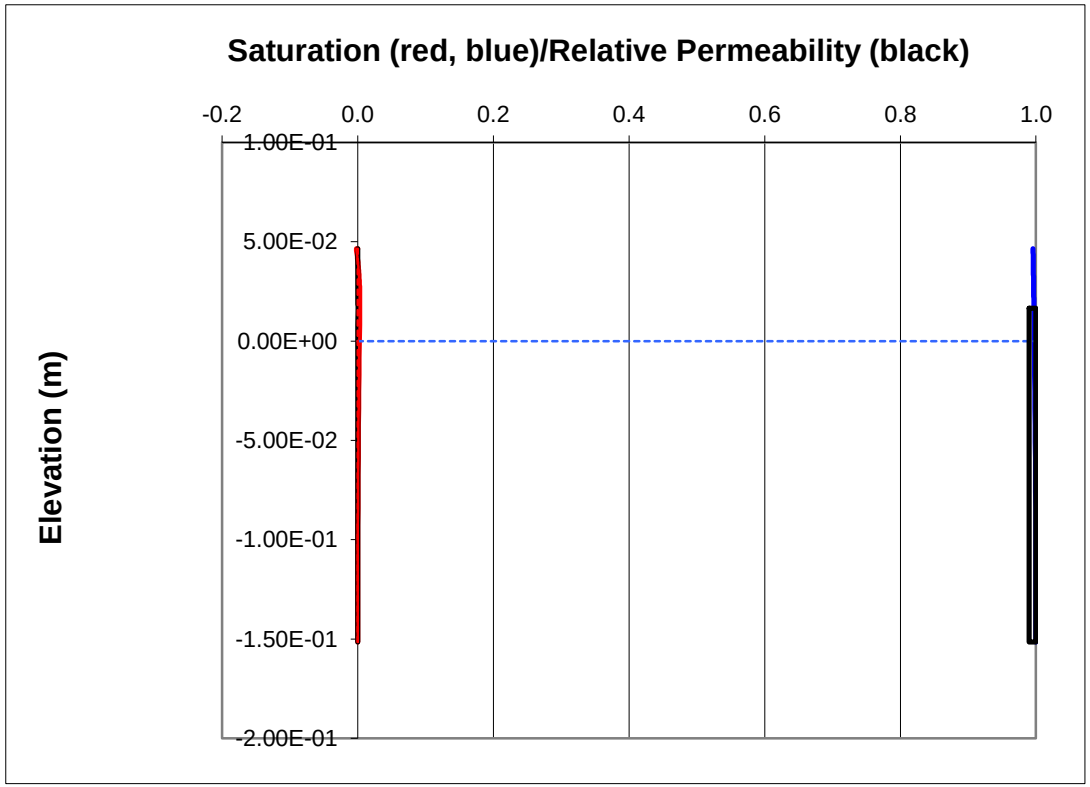
Data for curve-fitting segments								
b_o	D_o	k_{ro}	α	β	ξ	η		
0.000	0.000	0.000						
0.020	0.000	0.000	0.0000	0.000004	0.0000	0.000003		
0.087	0.000	0.000	0.0195	0.000131	0.0197	0.000136	0.1	Eps-Do
0.168	0.000	0.000	0.0787	0.001023	0.0806	0.001354	0.1	Eps-kro

Press Ctrl+Shift+S to calculate sheet



Monitoring Well LNAPL Thickness b_o (m) =			0.168
	D_o = 9.138E-05	k_{ro} =	1.184E-04

Press Ctrl+Shift+S to calculate sheet



van Genuchten-Mualem Model of LNAPL Distribution and Relative Permeability

Enter Data in Yellow Region	A-14 May 2011

Maximum Monitoring Well LNAPL Thickness (meters)		
b_o =	0.061	0.20 ft

Soil Characteristic		SM
n =	0.428	porosity
N =	2.160	van Genuchten "N"
α =	2.750	van Genuchten "α" [m^{-1}]
S_{wr} =	0.313	irreducible water saturation
S_{orv} =	0.000	residual LNAPL saturation (saturated)
S_{ors} =	0.000	residual LNAPL saturation (vadose)

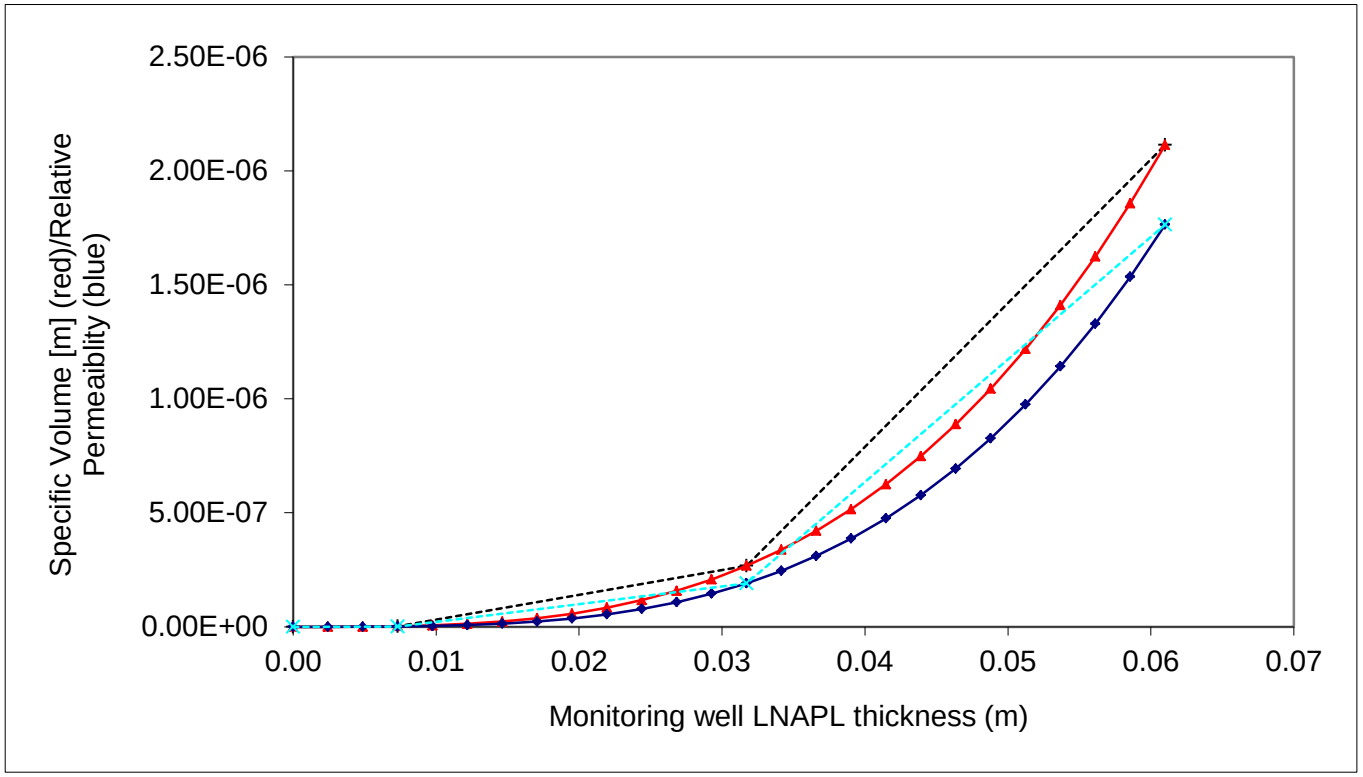
Fluid Characteristics:		Lube Oil
ρ_o =	0.9143	gm/cc
σ_{aw} =	65.000	dyne/cm
σ_{ao} =	31.600	dyne/cm
σ_{ow} =	27.100	dyne/cm

Calculated Parameters		
M =	0.537	van Genuchten "M"
α_{ao} =	5.172	air/LNAPL "α"
α_{ow} =	0.565	LNAPL/water "α"
z_{ao} =	0.005	elevation of air-LNAPL interface
z_{ow} =	-0.056	elevation of LNAPL-water interface
z_{max} =	0.005	maximum free-product elevation
λ =	0.841	pore-size distribution index
Ψ_b =	0.227	B-C displacement pressure head [m]

Press Ctrl+Shift+S to calculate sheet

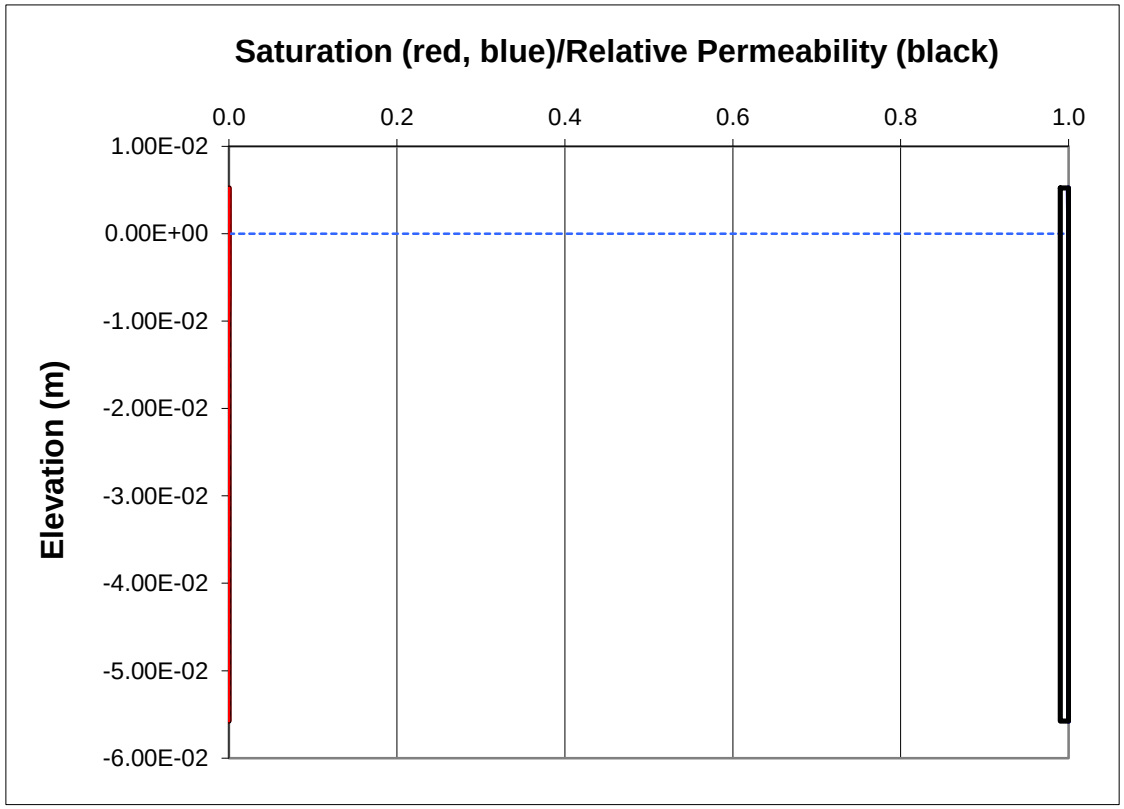
Data for curve-fitting segments								
b_o	D_o	k_{ro}	α	β	ξ	η		
0.000	0.000	0.000						
0.007	0.000	0.000	0.0000	0.000000	0.0000	0.000000		
0.032	0.000	0.000	0.0071	0.000011	0.0072	0.000008	0.01	Eps-Do
0.061	0.000	0.000	0.0275	0.000063	0.0282	0.000054	0.01	Eps-kro

Press Ctrl+Shift+S to calculate sheet



Monitoring Well LNAPL Thickness b_o (m) =			0.061
	D_o = 2.113E-06	k_{ro} =	1.764E-06

Press Ctrl+Shift+S to calculate sheet



van Genuchten-Mualem Model of LNAPL Distribution and Relative Permeability

Enter Data in Yellow Region	A-21 May 2011

Maximum Monitoring Well LNAPL Thickness (meters)		
b_o =	0.003	0.01 ft

Soil Characteristic		SM
n =	0.428	porosity
N =	2.160	van Genuchten "N"
α =	2.750	van Genuchten "α" [m^{-1}]
S_{wr} =	0.313	irreducible water saturation
S_{orv} =	0.000	residual LNAPL saturation (saturated)
S_{ors} =	0.000	residual LNAPL saturation (vadose)

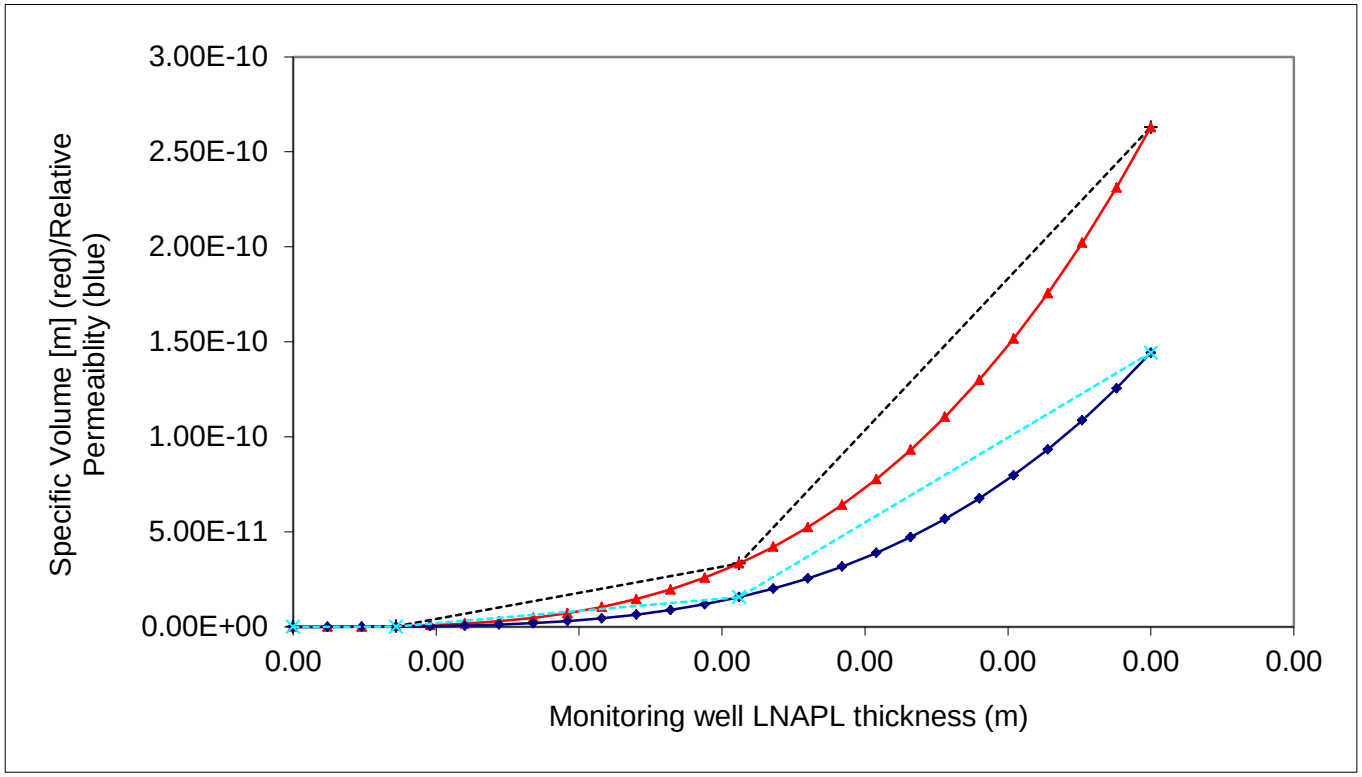
Fluid Characteristics:		Middle Distillate
ρ_o =	0.9100	gm/cc
σ_{aw} =	65.000	dyne/cm
σ_{ao} =	26.900	dyne/cm
σ_{ow} =	22.300	dyne/cm

Calculated Parameters		
M =	0.537	van Genuchten "M"
α_{ao} =	6.047	air/LNAPL "α"
α_{ow} =	0.721	LNAPL/water "α"
z_{ao} =	0.000	elevation of air-LNAPL interface
z_{ow} =	-0.003	elevation of LNAPL-water interface
z_{max} =	0.000	maximum free-product elevation
λ =	0.841	pore-size distribution index
Ψ_b =	0.227	B-C displacement pressure head [m]

Press Ctrl+Shift+S to calculate sheet

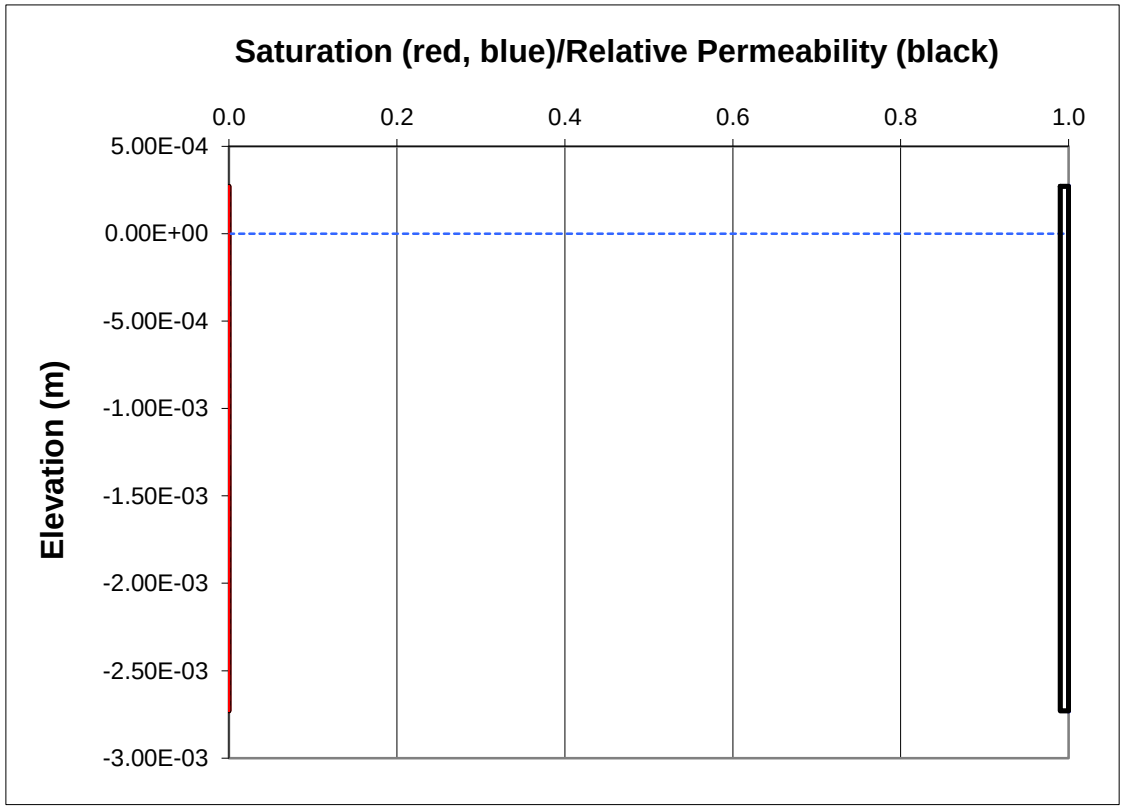
Data for curve-fitting segments								
b_o	D_o	k_{ro}	α	β	ξ	η		
0.000	0.000	0.000						
0.000	0.000	0.000	0.0000	0.000000	0.0000	0.000000		
0.002	0.000	0.000	0.0003	0.000000	0.0004	0.000000	0.01	Eps-Do
0.003	0.000	0.000	0.0014	0.000000	0.0014	0.000000	0.01	Eps-kro

Press Ctrl+Shift+S to calculate sheet



Monitoring Well LNAPL Thickness b_o (m) =			0.003
	D_o = 2.630E-10	k_{ro} =	1.442E-10

Press Ctrl+Shift+S to calculate sheet



van Genuchten-Mualem Model of LNAPL Distribution and Relative Permeability

Enter Data in Yellow Region	A-24 May 2011

Maximum Monitoring Well LNAPL Thickness (meters)		
b_o =	0.003	0.01 ft

Soil Characteristic		ML
n =	0.444	porosity
N =	1.840	van Genuchten "N"
α =	1.040	van Genuchten "α" [m^{-1}]
S_{wr} =	0.408	irreducible water saturation
S_{orv} =	0.000	residual LNAPL saturation (saturated)
S_{ors} =	0.000	residual LNAPL saturation (vadose)

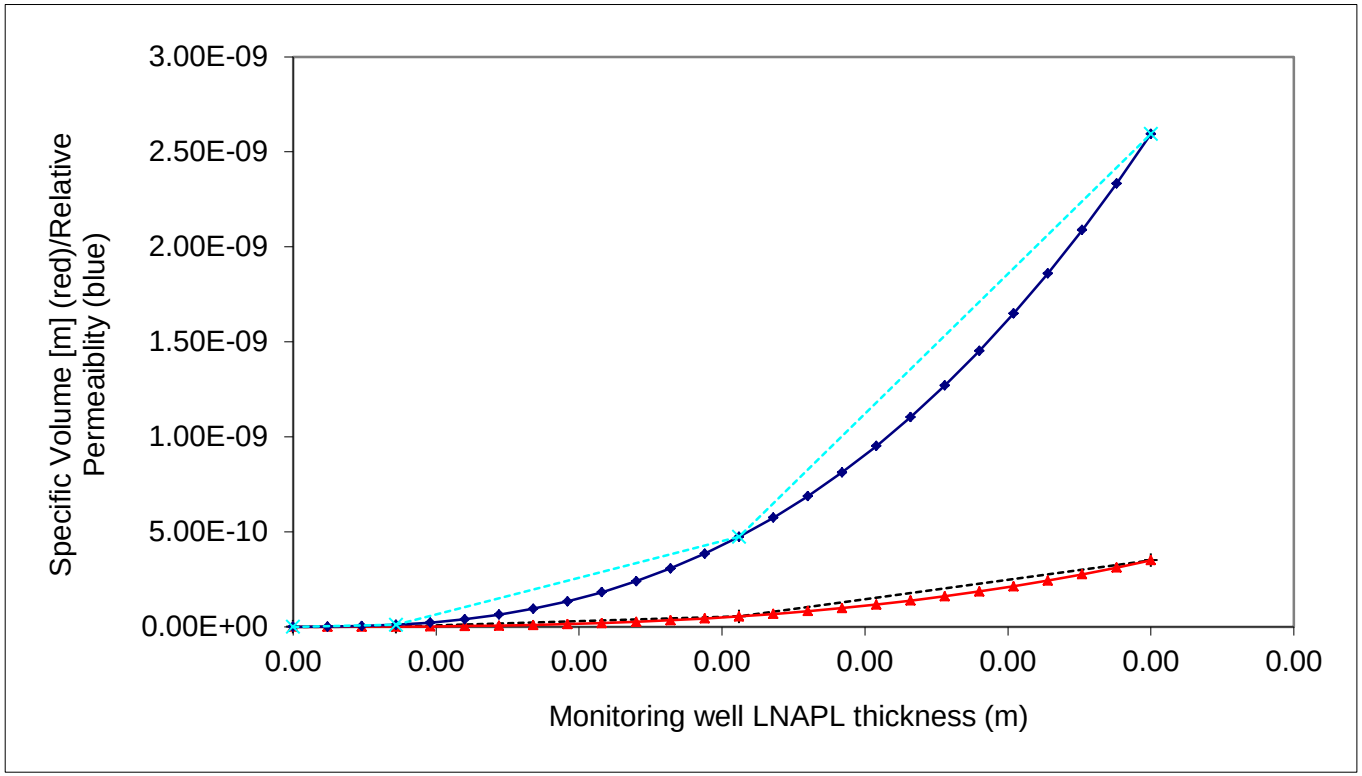
Fluid Characteristics:		Middle Distillate
ρ_o =	0.8953	gm/cc
σ_{aw} =	65.000	dyne/cm
σ_{ao} =	26.900	dyne/cm
σ_{ow} =	22.300	dyne/cm

Calculated Parameters		
M =	0.457	van Genuchten "M"
α_{ao} =	2.250	air/LNAPL "α"
α_{ow} =	0.317	LNAPL/water "α"
z_{ao} =	0.000	elevation of air-LNAPL interface
z_{ow} =	-0.003	elevation of LNAPL-water interface
z_{max} =	0.000	maximum free-product elevation
λ =	0.656	pore-size distribution index
Ψ_b =	0.600	B-C displacement pressure head [m]

Press Ctrl+Shift+S to calculate sheet

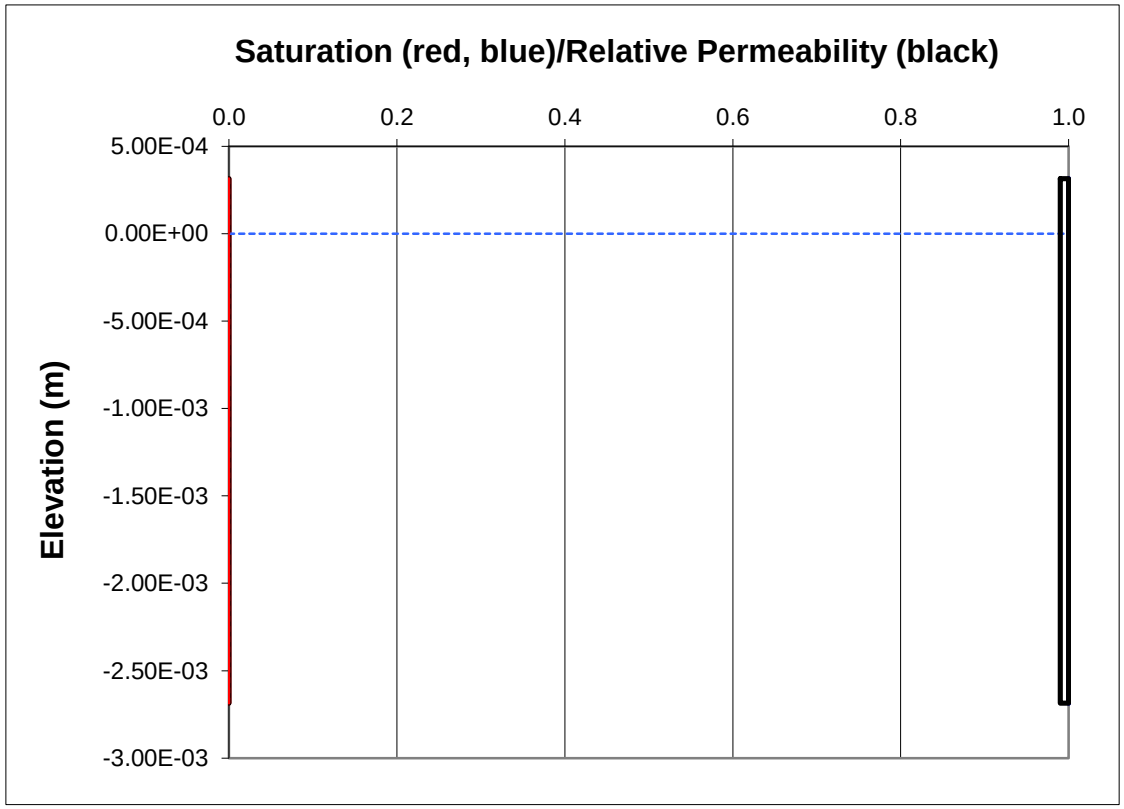
Data for curve-fitting segments								
b_o	D_o	k_{ro}	α	β	ξ	η		
0.000	0.000	0.000						
0.000	0.000	0.000	0.0000	0.000000	0.0000	0.000000		
0.002	0.000	0.000	0.0003	0.000000	0.0003	0.000000	0.01	Eps-Do
0.003	0.000	0.000	0.0013	0.000000	0.0012	0.000001	0.01	Eps-kro

Press Ctrl+Shift+S to calculate sheet



Monitoring Well LNAPL Thickness b_o (m) =			0.003
	D_o = 3.499E-10	k_{ro} =	2.594E-09

Press Ctrl+Shift+S to calculate sheet



van Genuchten-Mualem Model of LNAPL Distribution and Relative Permeability

Enter Data in Yellow Region	A-46 May 2011

Maximum Monitoring Well LNAPL Thickness (meters)		
b_o =	0.012	0.04 ft

Soil Characteristic		s(ML)
n =	0.415	porosity
N =	1.820	van Genuchten "N"
α =	0.960	van Genuchten "α" [m^{-1}]
S_{wr} =	0.490	irreducible water saturation
S_{orv} =	0.000	residual LNAPL saturation (saturated)
S_{ors} =	0.000	residual LNAPL saturation (vadose)

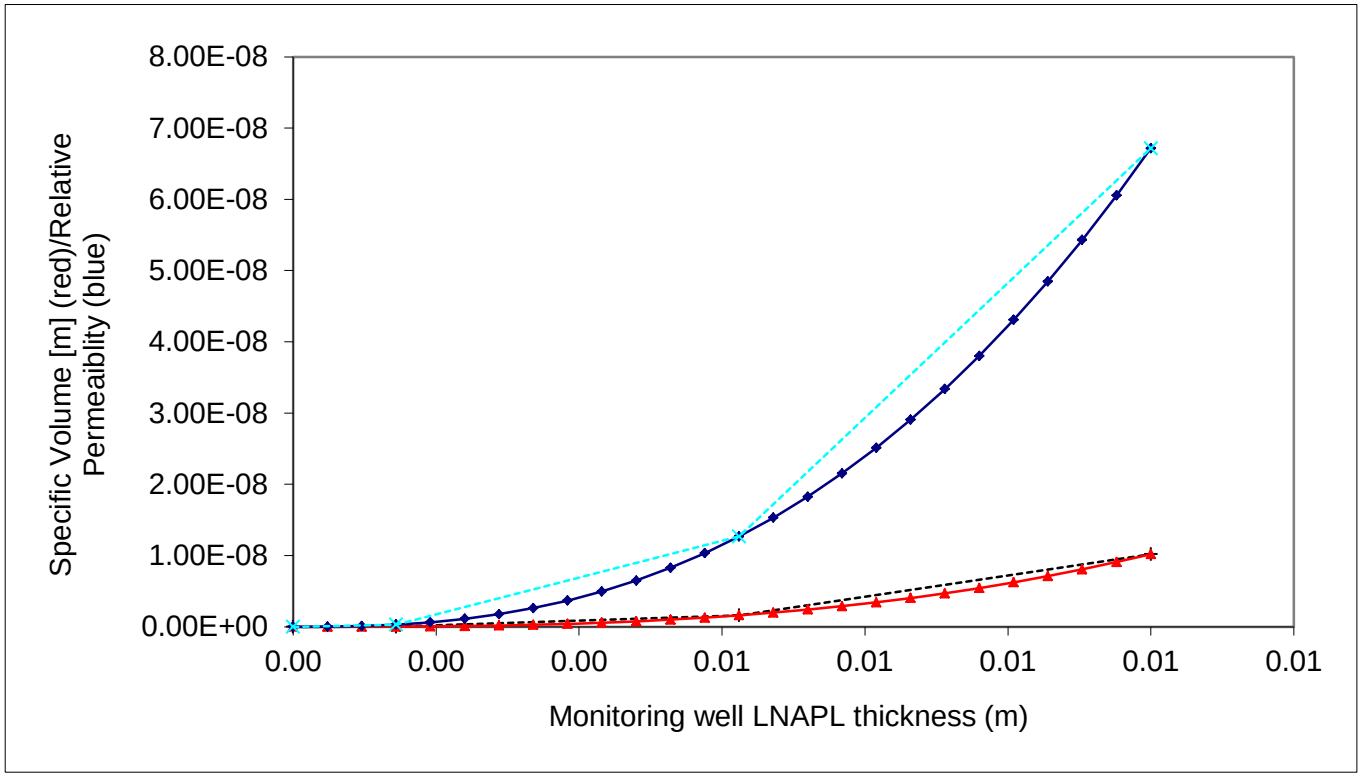
Fluid Characteristics:		Lube Oil
ρ_o =	0.8926	gm/cc
σ_{aw} =	65.000	dyne/cm
σ_{ao} =	31.600	dyne/cm
σ_{ow} =	27.100	dyne/cm

Calculated Parameters		
M =	0.451	van Genuchten "M"
α_{ao} =	1.763	air/LNAPL "α"
α_{ow} =	0.247	LNAPL/water "α"
z_{ao} =	0.001	elevation of air-LNAPL interface
z_{ow} =	-0.011	elevation of LNAPL-water interface
z_{max} =	0.001	maximum free-product elevation
λ =	0.644	pore-size distribution index
Ψ_b =	0.650	B-C displacement pressure head [m]

Press Ctrl+Shift+S to calculate sheet

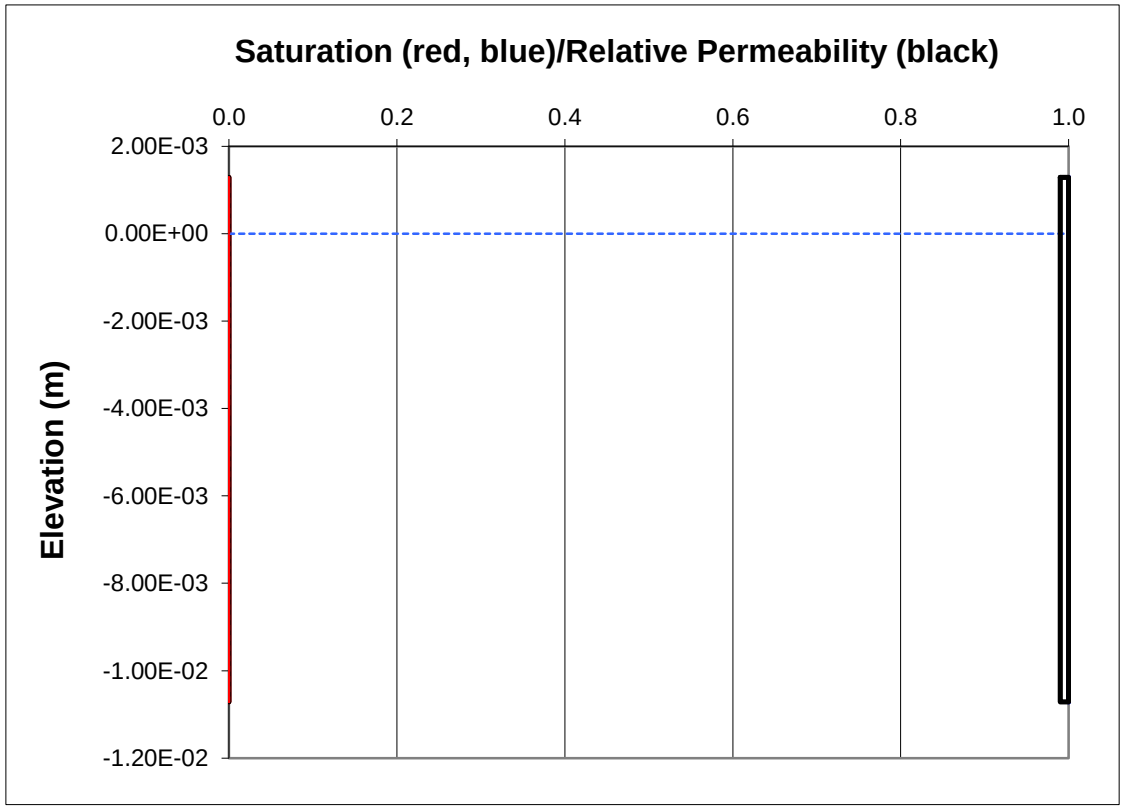
Data for curve-fitting segments								
b_o	D_o	k_{ro}	α	β	ξ	η		
0.000	0.000	0.000						
0.001	0.000	0.000	0.0000	0.000000	0.0000	0.000000		
0.006	0.000	0.000	0.0014	0.000000	0.0013	0.000003	0.01	Eps-Do
0.012	0.000	0.000	0.0052	0.000001	0.0049	0.000009	0.01	Eps-kro

Press Ctrl+Shift+S to calculate sheet



Monitoring Well LNAPL Thickness b_o (m) =			0.012
	D_o = 1.019E-08	k_{ro} =	6.718E-08

Press Ctrl+Shift+S to calculate sheet



van Genuchten-Mualem Model of LNAPL Distribution and Relative Permeability

Enter Data in Yellow Region	A-136 May 2011

Maximum Monitoring Well LNAPL Thickness (meters)		
b_o =	0.003	0.01 ft

Soil Characteristic		SM
n =	0.428	porosity
N =	2.160	van Genuchten "N"
α =	2.750	van Genuchten "α" [m^{-1}]
S_{wr} =	0.313	irreducible water saturation
S_{orv} =	0.000	residual LNAPL saturation (saturated)
S_{ors} =	0.000	residual LNAPL saturation (vadose)

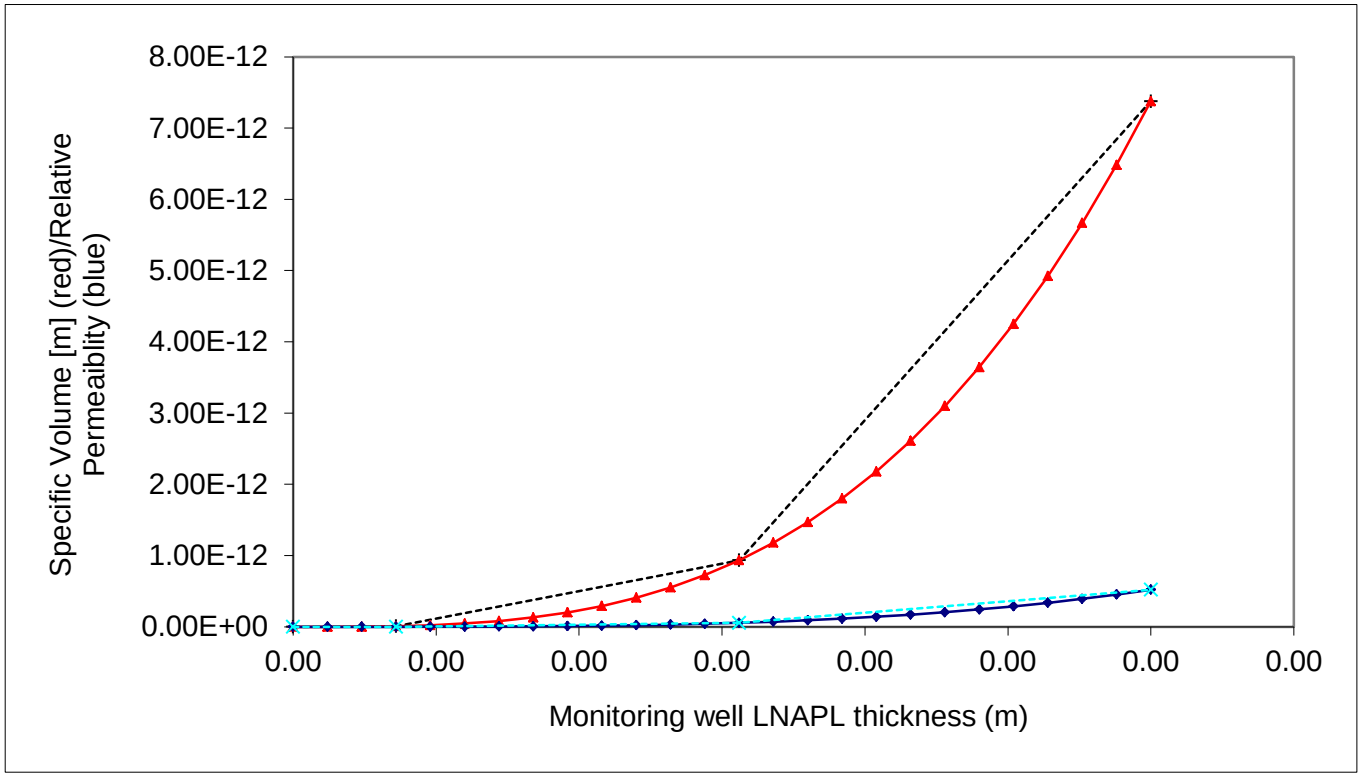
Fluid Characteristics:		Residual Oil
ρ_o =	0.9767	gm/cc
σ_{aw} =	65.000	dyne/cm
σ_{ao} =	32.100	dyne/cm
σ_{ow} =	30.200	dyne/cm

Calculated Parameters		
M =	0.537	van Genuchten "M"
α_{ao} =	5.439	air/LNAPL "α"
α_{ow} =	0.138	LNAPL/water "α"
z_{ao} =	0.000	elevation of air-LNAPL interface
z_{ow} =	-0.003	elevation of LNAPL-water interface
z_{max} =	0.000	maximum free-product elevation
λ =	0.841	pore-size distribution index
Ψ_b =	0.227	B-C displacement pressure head [m]

Press Ctrl+Shift+S to calculate sheet

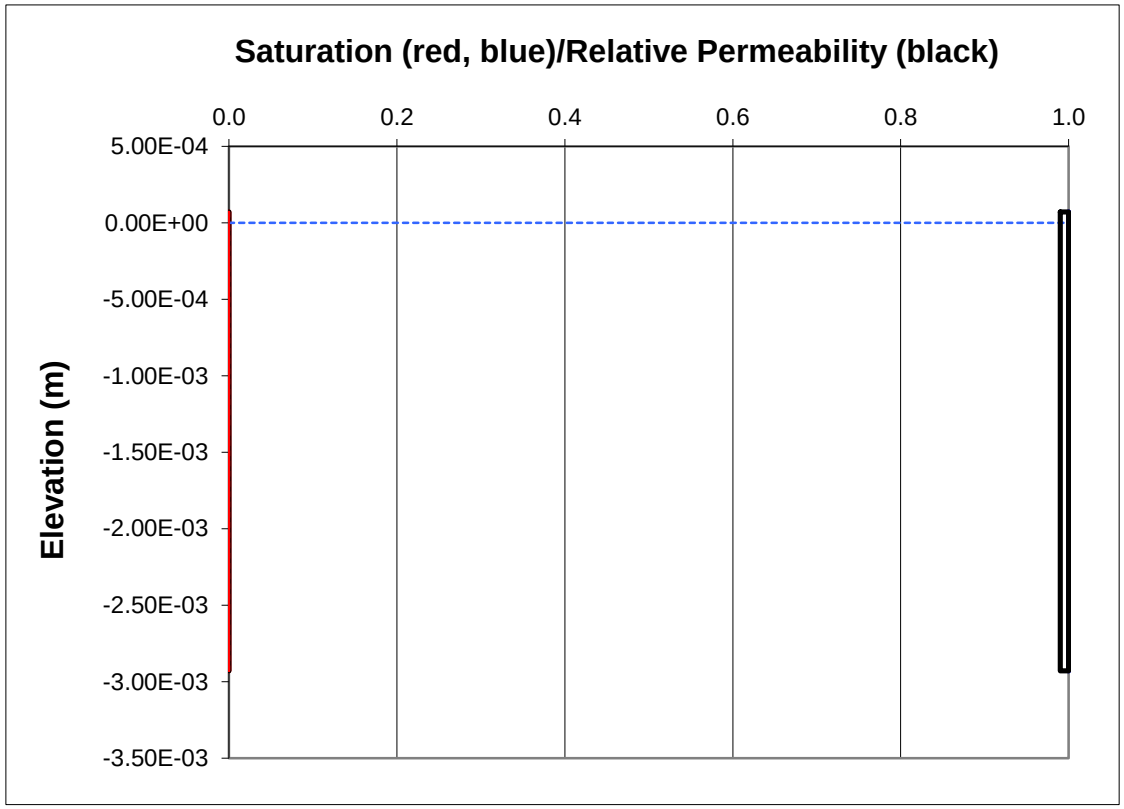
Data for curve-fitting segments								
b_o	D_o	k_{ro}	α	β	ξ	η		
0.000	0.000	0.000						
0.000	0.000	0.000	0.0000	0.000000	0.0000	0.000000		
0.002	0.000	0.000	0.0003	0.000000	0.0004	0.000000	0.01	Eps-Do
0.003	0.000	0.000	0.0014	0.000000	0.0014	0.000000	0.01	Eps-kro

Press Ctrl+Shift+S to calculate sheet



Monitoring Well LNAPL Thickness b_o (m) =			0.003
	D_o = 7.376E-12	k_{ro} =	5.199E-13

Press Ctrl+Shift+S to calculate sheet



van Genuchten-Mualem Model of LNAPL Distribution and Relative Permeability

Enter Data in Yellow Region	A-144 May 2011

Maximum Monitoring Well LNAPL Thickness (meters)		
b_o =	0.488	1.60 ft

Soil Characteristic		ML
n =	0.444	porosity
N =	1.840	van Genuchten "N"
α =	1.040	van Genuchten "α" [m^{-1}]
S_{wr} =	0.408	irreducible water saturation
S_{orv} =	0.000	residual LNAPL saturation (saturated)
S_{ors} =	0.000	residual LNAPL saturation (vadose)

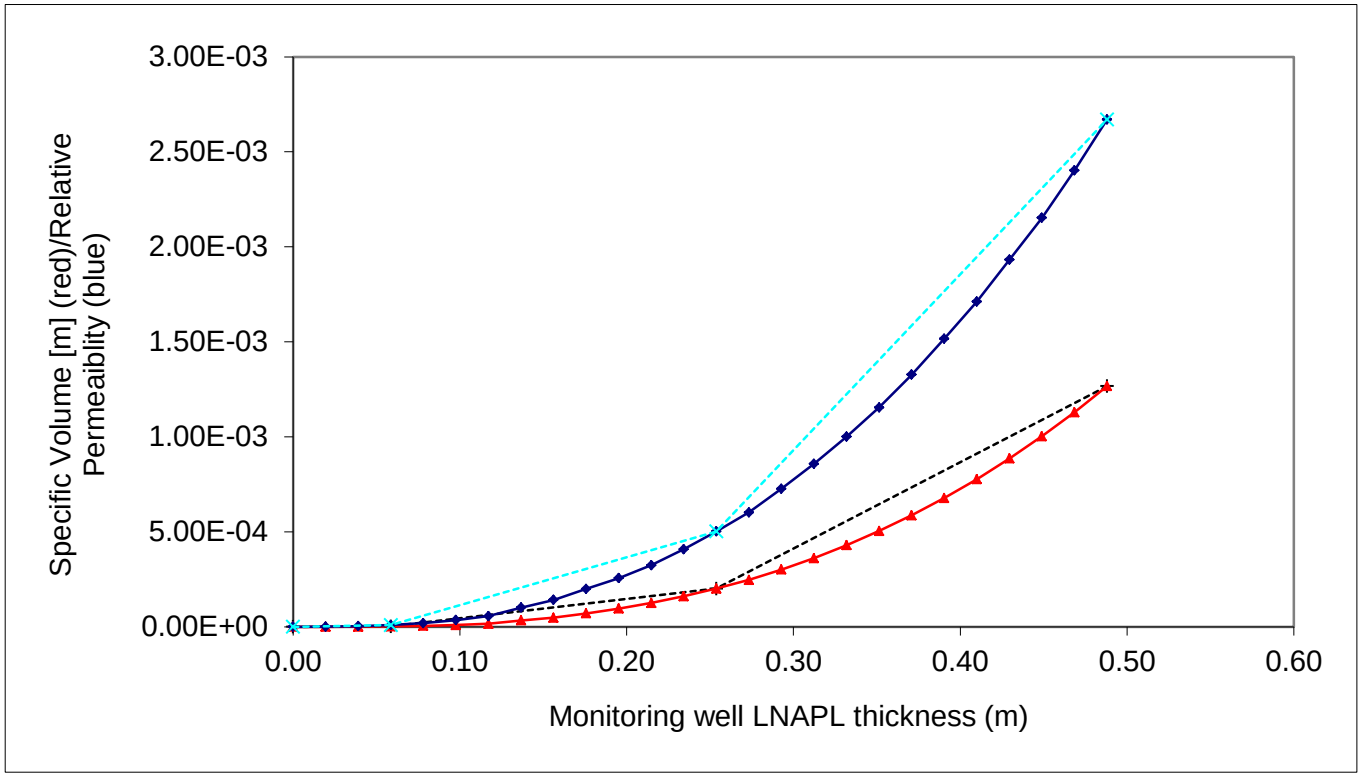
Fluid Characteristics:		Middle Distillate
ρ_o =	0.8753	gm/cc
σ_{aw} =	65.000	dyne/cm
σ_{ao} =	26.900	dyne/cm
σ_{ow} =	22.300	dyne/cm

Calculated Parameters		
M =	0.457	van Genuchten "M"
α_{ao} =	2.200	air/LNAPL "α"
α_{ow} =	0.378	LNAPL/water "α"
z_{ao} =	0.061	elevation of air-LNAPL interface
z_{ow} =	-0.427	elevation of LNAPL-water interface
z_{max} =	0.161	maximum free-product elevation
λ =	0.656	pore-size distribution index
Ψ_b =	0.600	B-C displacement pressure head [m]

Press Ctrl+Shift+S to calculate sheet

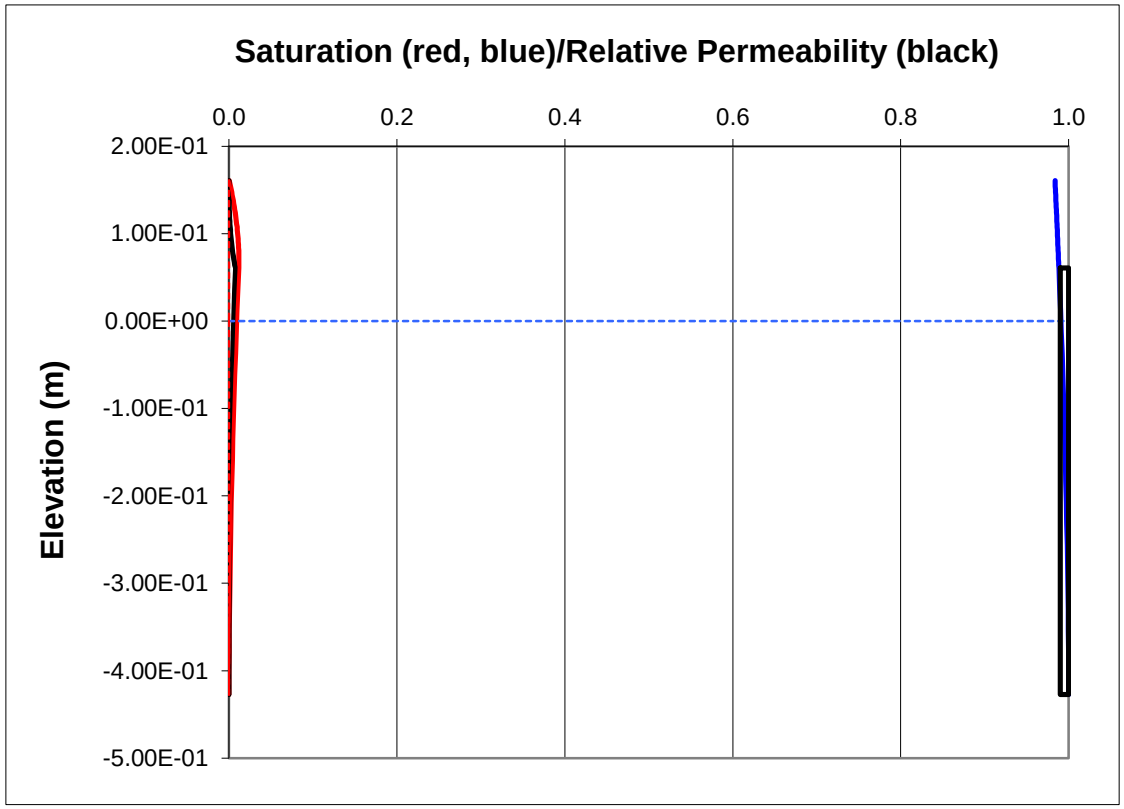
Data for curve-fitting segments								
b_o	D_o	k_{ro}	α	β	ξ	η		
0.000	0.000	0.000						
0.059	0.000	0.000	0.0000	0.000038	0.0000	0.000158		
0.254	0.000	0.001	0.0564	0.001020	0.0549	0.002522	0.01	Eps-Do
0.488	0.001	0.003	0.2095	0.004546	0.1996	0.009257	0.01	Eps-kro

Press Ctrl+Shift+S to calculate sheet



Monitoring Well LNAPL Thickness b_o (m) =			0.488
	D_o = 1.266E-03	k_{ro} =	2.670E-03

Press Ctrl+Shift+S to calculate sheet



van Genuchten-Mualem Model of LNAPL Distribution and Relative Permeability

Enter Data in Yellow Region	A-155 May 2011

Maximum Monitoring Well LNAPL Thickness (meters)		
b_o =	0.351	1.15 ft

Soil Characteristic		ML
n =	0.444	porosity
N =	1.840	van Genuchten "N"
α =	1.040	van Genuchten "α" [m^{-1}]
S_{wr} =	0.408	irreducible water saturation
S_{orv} =	0.000	residual LNAPL saturation (saturated)
S_{ors} =	0.000	residual LNAPL saturation (vadose)

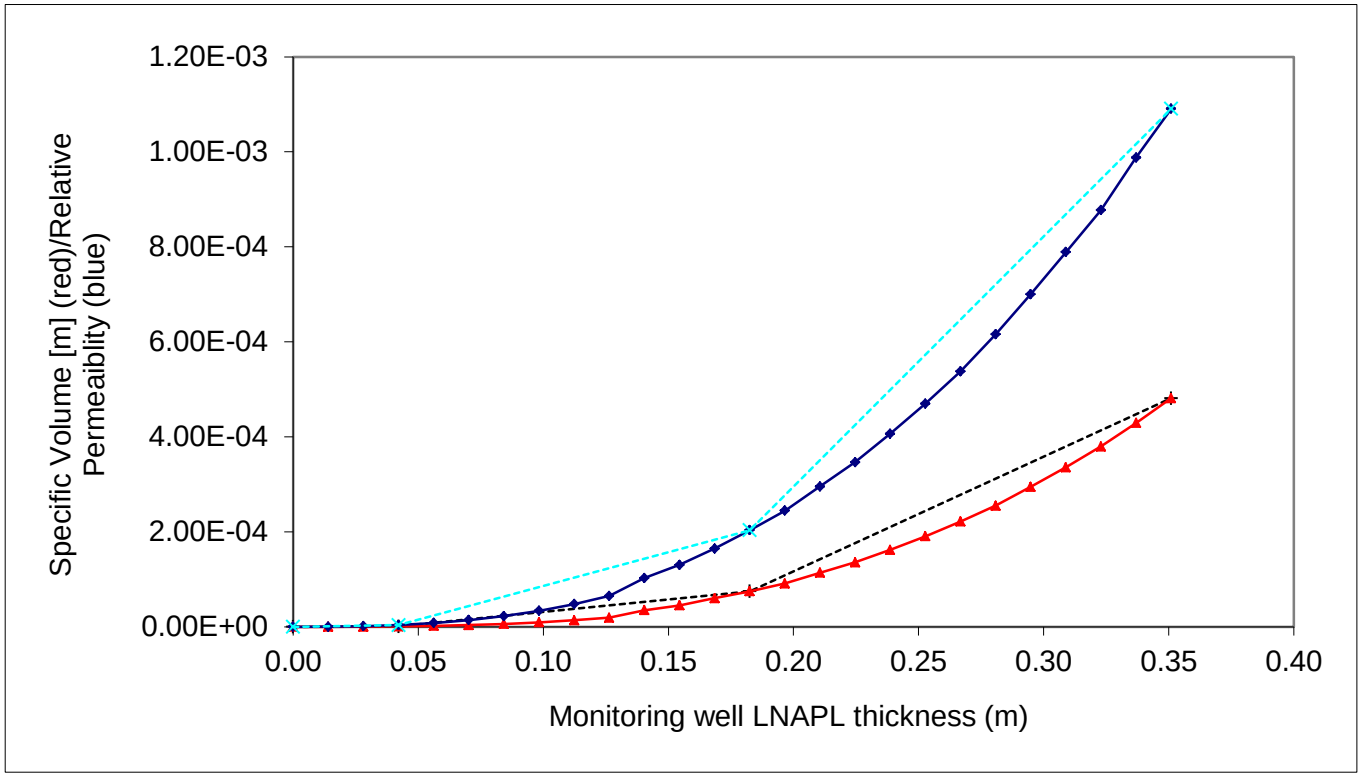
Fluid Characteristics:		Middle Distillate
ρ_o =	0.8777	gm/cc
σ_{aw} =	65.000	dyne/cm
σ_{ao} =	26.900	dyne/cm
σ_{ow} =	22.300	dyne/cm

Calculated Parameters		
M =	0.457	van Genuchten "M"
α_{ao} =	2.206	air/LNAPL "α"
α_{ow} =	0.371	LNAPL/water "α"
z_{ao} =	0.043	elevation of air-LNAPL interface
z_{ow} =	-0.308	elevation of LNAPL-water interface
z_{max} =	0.113	maximum free-product elevation
λ =	0.656	pore-size distribution index
Ψ_b =	0.600	B-C displacement pressure head [m]

Press Ctrl+Shift+S to calculate sheet

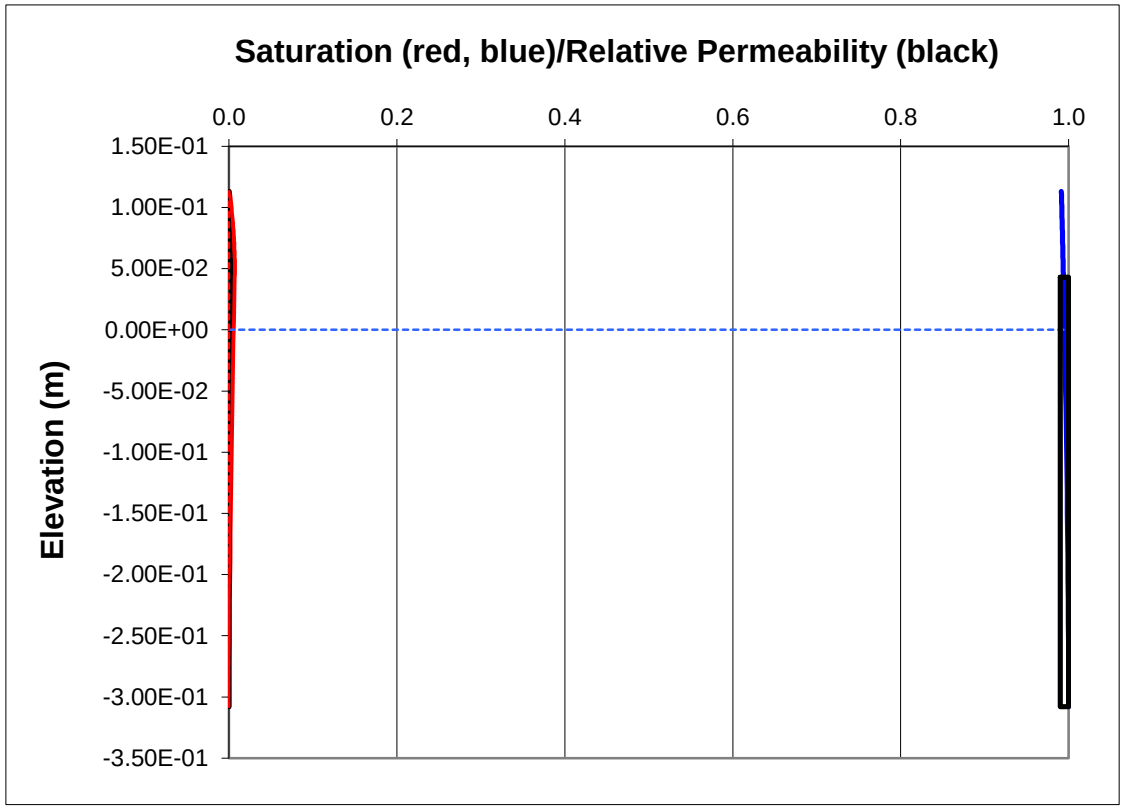
Data for curve-fitting segments								
b_o	D_o	k_{ro}	α	β	ξ	η		
0.000	0.000	0.000						
0.042	0.000	0.000	0.0000	0.000020	0.0000	0.000089		
0.183	0.000	0.000	0.0405	0.000527	0.0395	0.001422	0.01	Eps-Do
0.351	0.000	0.001	0.1515	0.002413	0.1439	0.005268	0.01	Eps-kro

Press Ctrl+Shift+S to calculate sheet



Monitoring Well LNAPL Thickness b_o (m) =			0.351
	D_o = 4.814E-04	k_{ro} =	1.091E-03

Press Ctrl+Shift+S to calculate sheet



van Genuchten-Mualem Model of LNAPL Distribution and Relative Permeability

Enter Data in Yellow Region	SW-1 May 2011

Maximum Monitoring Well LNAPL Thickness (meters)		
b_o =	0.189	0.62 ft

Soil Characteristic		SM
n =	0.428	porosity
N =	2.160	van Genuchten "N"
α =	2.750	van Genuchten "α" [m^{-1}]
S_{wr} =	0.313	irreducible water saturation
S_{orv} =	0.000	residual LNAPL saturation (saturated)
S_{ors} =	0.000	residual LNAPL saturation (vadose)

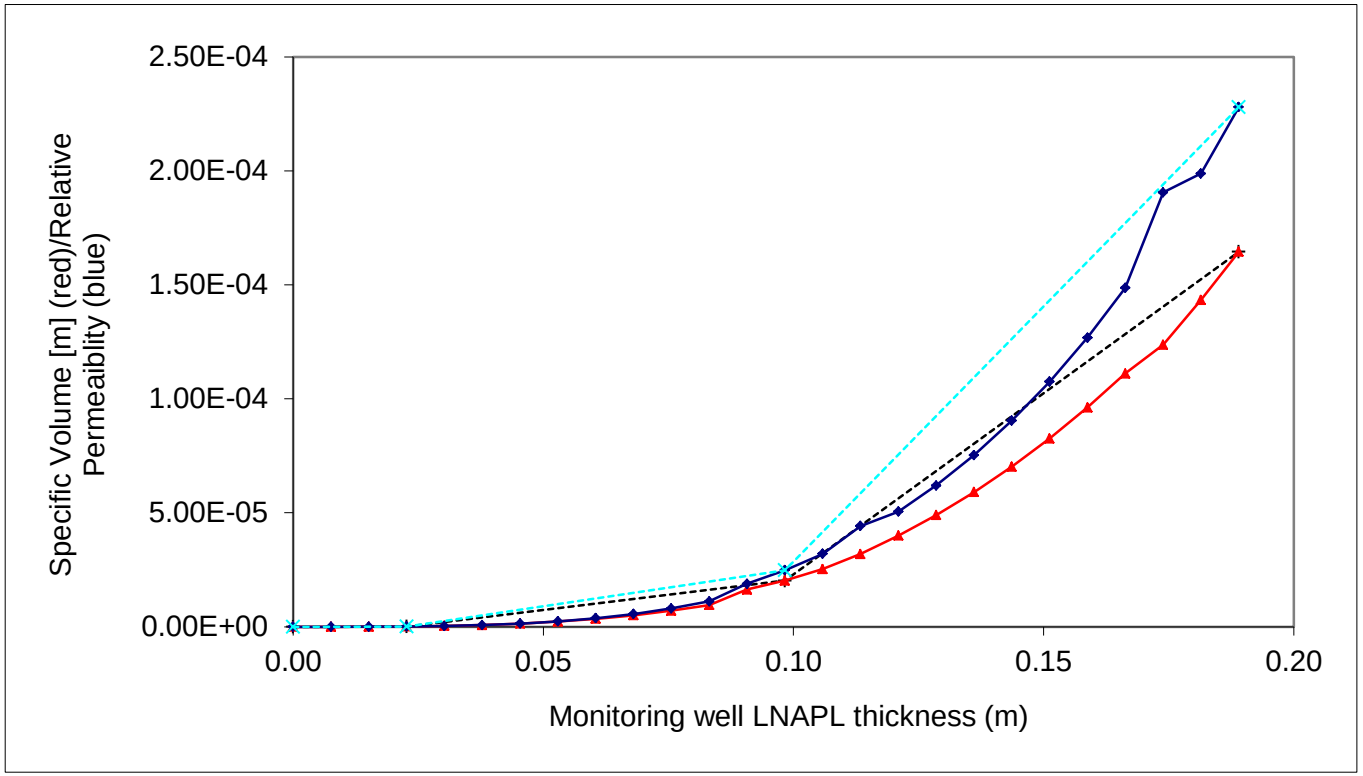
Fluid Characteristics:		Middle Distillate
ρ_o =	0.9100	gm/cc
σ_{aw} =	65.000	dyne/cm
σ_{ao} =	26.900	dyne/cm
σ_{ow} =	22.300	dyne/cm

Calculated Parameters		
M =	0.537	van Genuchten "M"
α_{ao} =	6.047	air/LNAPL "α"
α_{ow} =	0.721	LNAPL/water "α"
z_{ao} =	0.017	elevation of air-LNAPL interface
z_{ow} =	-0.172	elevation of LNAPL-water interface
z_{max} =	0.047	maximum free-product elevation
λ =	0.841	pore-size distribution index
Ψ_b =	0.227	B-C displacement pressure head [m]

Press Ctrl+Shift+S to calculate sheet

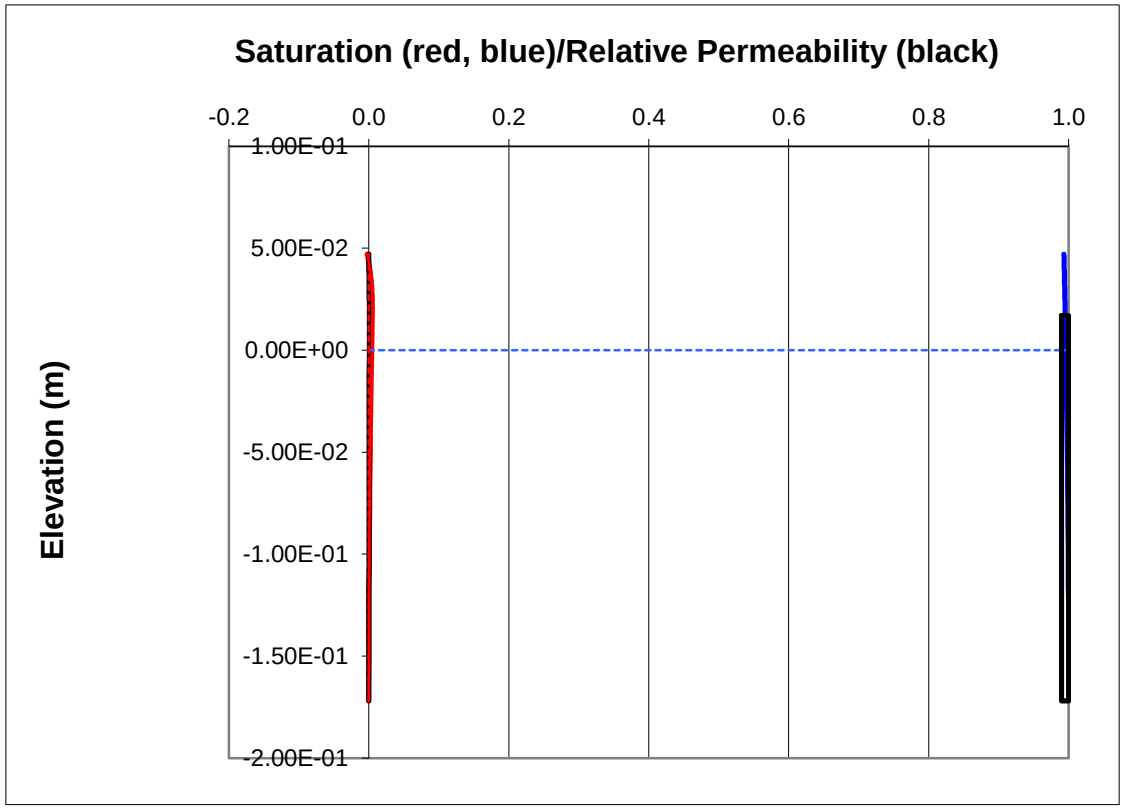
Data for curve-fitting segments								
b_o	D_o	k_{ro}	α	β	ξ	η		
0.000	0.000	0.000						
0.023	0.000	0.000	0.0000	0.000007	0.0000	0.000006		
0.098	0.000	0.000	0.0221	0.000266	0.0223	0.000326	0.1	Eps-Do
0.189	0.000	0.000	0.0855	0.001590	0.0872	0.002239	0.1	Eps-kro

Press Ctrl+Shift+S to calculate sheet



Monitoring Well LNAPL Thickness b_o (m) =			0.189
	D_o = 1.645E-04	k_{ro} =	2.279E-04

Press Ctrl+Shift+S to calculate sheet



van Genuchten-Mualem Model of LNAPL Distribution and Relative Permeability

Enter Data in Yellow Region	SW-4 May 2011

Maximum Monitoring Well LNAPL Thickness (meters)		
b_o =	0.021	0.07 ft

Soil Characteristic		SM
n =	0.428	porosity
N =	2.160	van Genuchten "N"
α =	2.750	van Genuchten "α" [m^{-1}]
S_{wr} =	0.313	irreducible water saturation
S_{orv} =	0.000	residual LNAPL saturation (saturated)
S_{ors} =	0.000	residual LNAPL saturation (vadose)

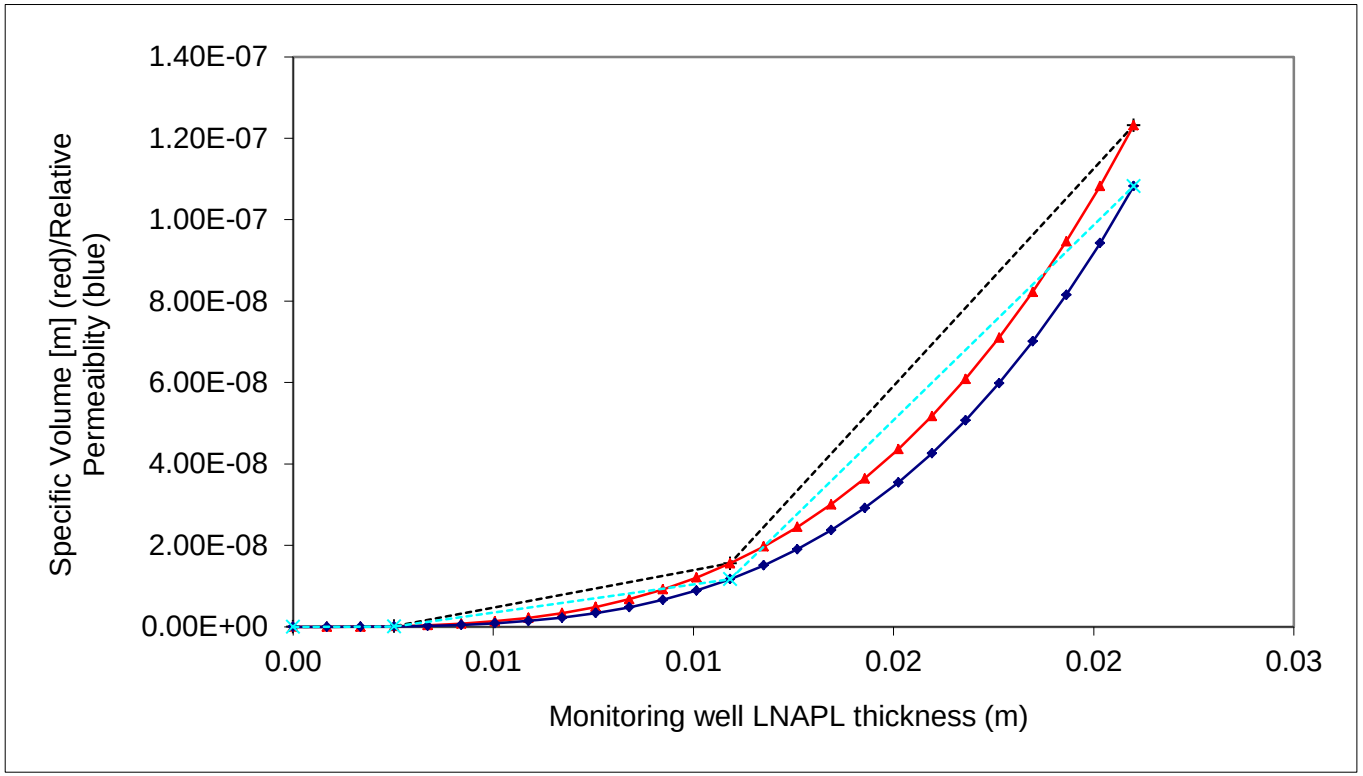
Fluid Characteristics:		Middle Distillate
ρ_o =	0.9100	gm/cc
σ_{aw} =	65.000	dyne/cm
σ_{ao} =	26.900	dyne/cm
σ_{ow} =	22.300	dyne/cm

Calculated Parameters		
M =	0.537	van Genuchten "M"
α_{ao} =	6.047	air/LNAPL "α"
α_{ow} =	0.721	LNAPL/water "α"
z_{ao} =	0.002	elevation of air-LNAPL interface
z_{ow} =	-0.019	elevation of LNAPL-water interface
z_{max} =	0.002	maximum free-product elevation
λ =	0.841	pore-size distribution index
Ψ_b =	0.227	B-C displacement pressure head [m]

Press Ctrl+Shift+S to calculate sheet

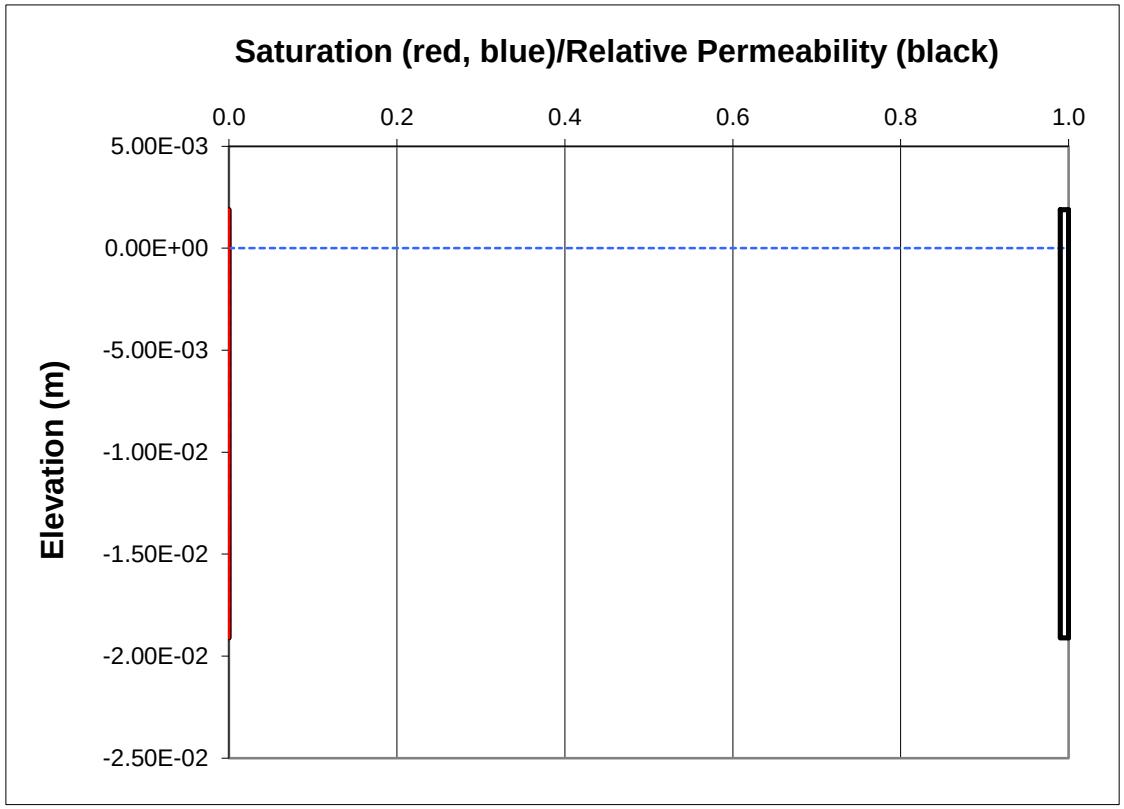
Data for curve-fitting segments								
b_o	D_o	k_{ro}	α	β	ξ	η		
0.000	0.000	0.000						
0.003	0.000	0.000	0.0000	0.000000	0.0000	0.000000		
0.011	0.000	0.000	0.0024	0.000002	0.0025	0.000001	0.001	Eps-Do
0.021	0.000	0.000	0.0095	0.000011	0.0097	0.000010	0.001	Eps-kro

Press Ctrl+Shift+S to calculate sheet



Monitoring Well LNAPL Thickness b_o (m) =			0.021
	D_o = 1.232E-07	k_{ro} =	1.083E-07

Press Ctrl+Shift+S to calculate sheet



van Genuchten-Mualem Model of LNAPL Distribution and Relative Permeability

Enter Data in Yellow Region	WP-A May 2011

Maximum Monitoring Well LNAPL Thickness (meters)		
b_o =	0.003	0.01 ft

Soil Characteristic		SM
n =	0.428	porosity
N =	2.160	van Genuchten "N"
α =	2.750	van Genuchten "α" [m^{-1}]
S_{wr} =	0.313	irreducible water saturation
S_{orv} =	0.000	residual LNAPL saturation (saturated)
S_{ors} =	0.000	residual LNAPL saturation (vadose)

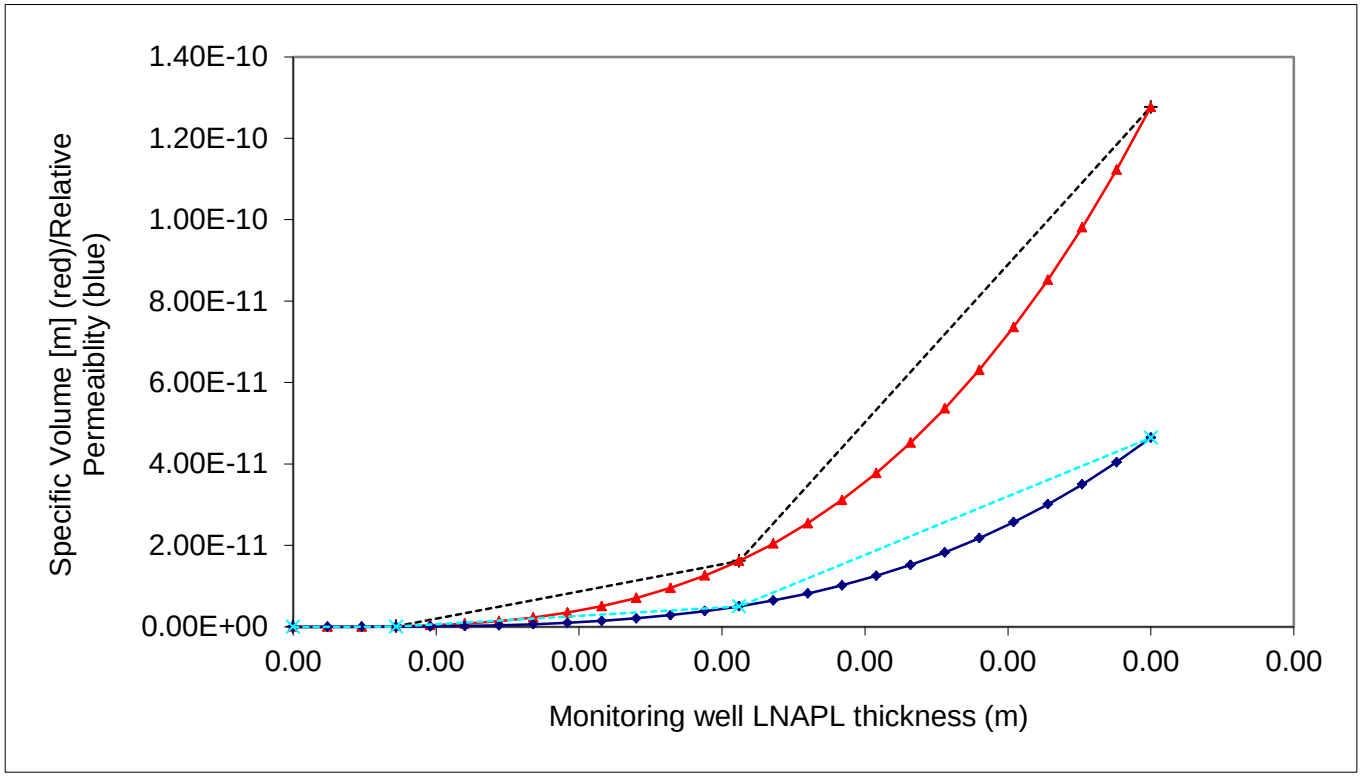
Fluid Characteristics:		Middle Distillate
ρ_o =	0.9356	gm/cc
σ_{aw} =	65.000	dyne/cm
σ_{ao} =	26.900	dyne/cm
σ_{ow} =	22.300	dyne/cm

Calculated Parameters		
M =	0.537	van Genuchten "M"
α_{ao} =	6.217	air/LNAPL "α"
α_{ow} =	0.516	LNAPL/water "α"
z_{ao} =	0.000	elevation of air-LNAPL interface
z_{ow} =	-0.003	elevation of LNAPL-water interface
z_{max} =	0.000	maximum free-product elevation
λ =	0.841	pore-size distribution index
Ψ_b =	0.227	B-C displacement pressure head [m]

Press Ctrl+Shift+S to calculate sheet

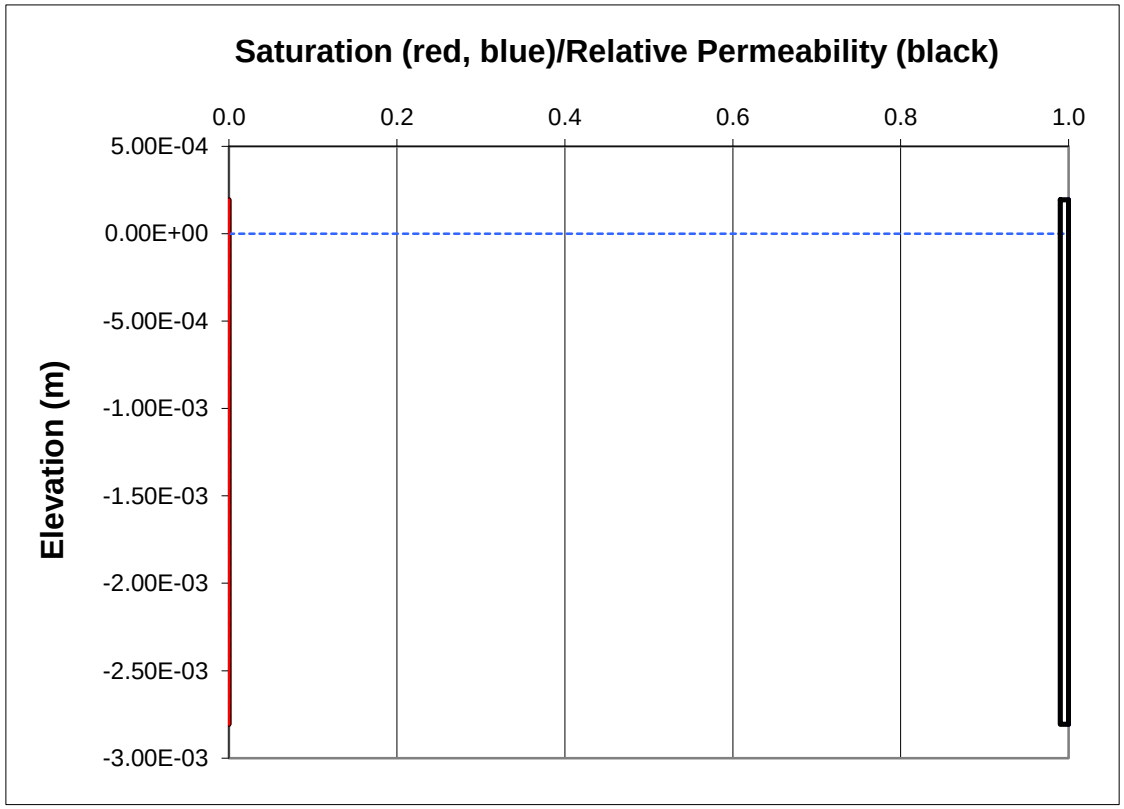
Data for curve-fitting segments								
b_o	D_o	k_{ro}	α	β	ξ	η		
0.000	0.000	0.000						
0.000	0.000	0.000	0.0000	0.000000	0.0000	0.000000		
0.002	0.000	0.000	0.0003	0.000000	0.0004	0.000000	0.001	Eps-Do
0.003	0.000	0.000	0.0014	0.000000	0.0014	0.000000	0.001	Eps-kro

Press Ctrl+Shift+S to calculate sheet



Monitoring Well LNAPL Thickness b_o (m) =			0.003
	D_o = 1.277E-10	k_{ro} =	4.646E-11

Press Ctrl+Shift+S to calculate sheet



van Genuchten-Mualem Model of LNAPL Distribution and Relative Permeability

Enter Data in Yellow Region	WP-B May 2011

Maximum Monitoring Well LNAPL Thickness (meters)		
b_o =	0.158	0.52 ft

Soil Characteristic		SM
n =	0.428	porosity
N =	2.160	van Genuchten "N"
α =	2.750	van Genuchten "α" [m^{-1}]
S_{wr} =	0.313	irreducible water saturation
S_{orv} =	0.000	residual LNAPL saturation (saturated)
S_{ors} =	0.000	residual LNAPL saturation (vadose)

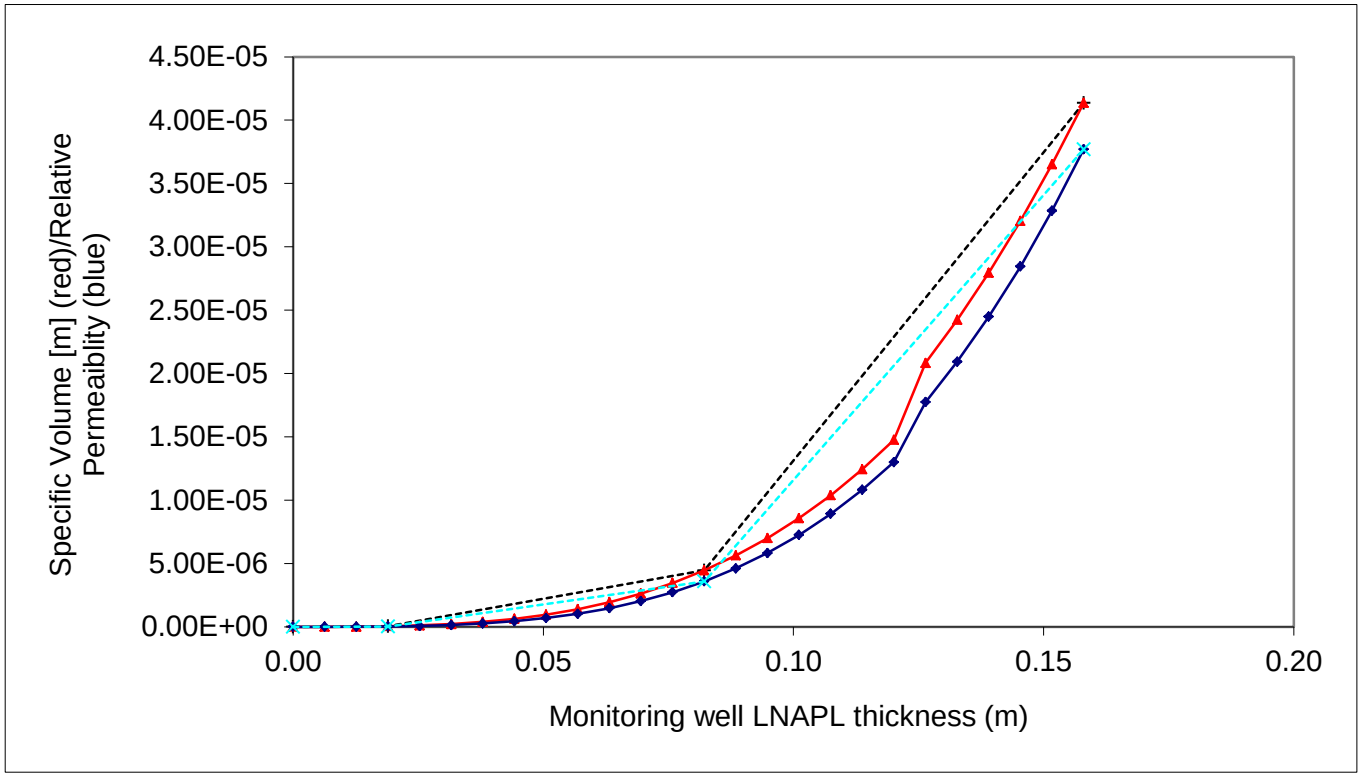
Fluid Characteristics:		Middle Distillate
ρ_o =	0.9356	gm/cc
σ_{aw} =	65.000	dyne/cm
σ_{ao} =	26.900	dyne/cm
σ_{ow} =	22.300	dyne/cm

Calculated Parameters		
M =	0.537	van Genuchten "M"
α_{ao} =	6.217	air/LNAPL "α"
α_{ow} =	0.516	LNAPL/water "α"
z_{ao} =	0.010	elevation of air-LNAPL interface
z_{ow} =	-0.148	elevation of LNAPL-water interface
z_{max} =	0.020	maximum free-product elevation
λ =	0.841	pore-size distribution index
Ψ_b =	0.227	B-C displacement pressure head [m]

Press Ctrl+Shift+S to calculate sheet

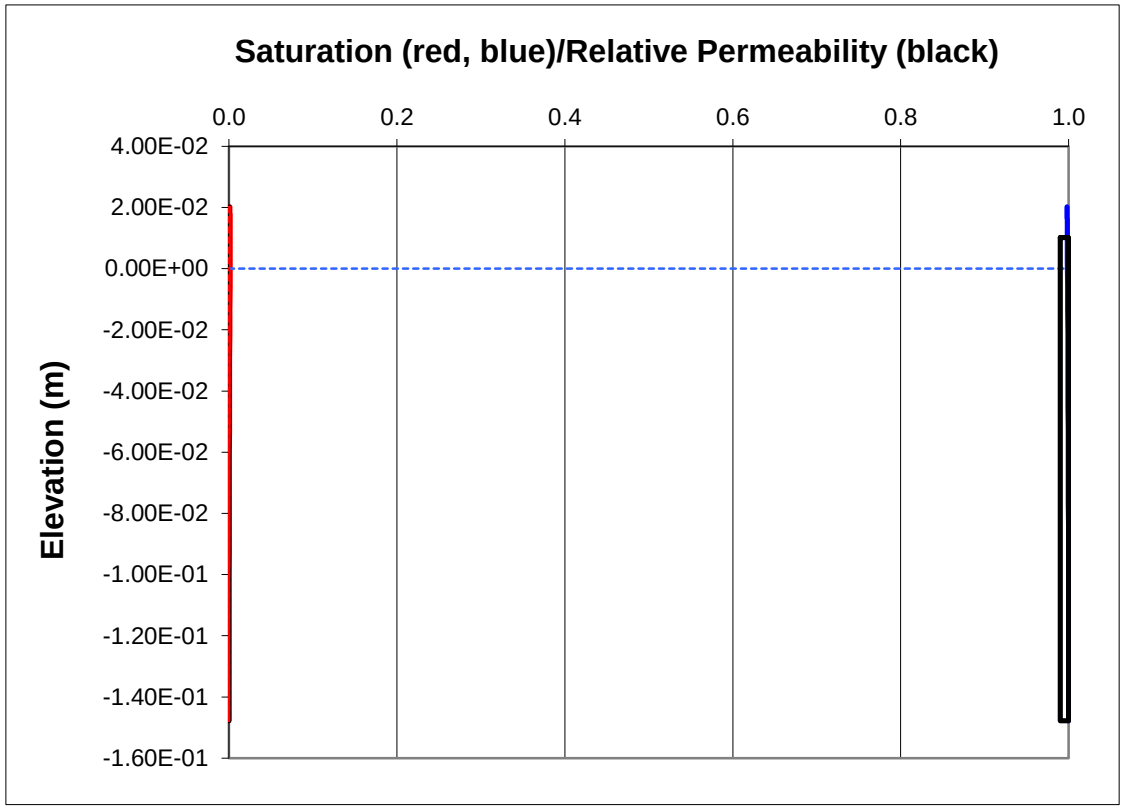
Data for curve-fitting segments								
b_o	D_o	k_{ro}	α	β	ξ	η		
0.000	0.000	0.000						
0.019	0.000	0.000	0.0000	0.000002	0.0000	0.000001		
0.082	0.000	0.000	0.0183	0.000070	0.0185	0.000056	0.001	Eps-Do
0.158	0.000	0.000	0.0730	0.000487	0.0742	0.000450	0.001	Eps-kro

Press Ctrl+Shift+S to calculate sheet



Monitoring Well LNAPL Thickness b_o (m) =			0.158
	D_o = 4.136E-05	k_{ro} =	3.769E-05

Press Ctrl+Shift+S to calculate sheet



APPENDIX H

Fate and Transport Modeling

APPENDIX H

FATE AND TRANSPORT MODELING PROCEDURES

AOI 5: SUNOCO PHILADELPHIA REFINERY

PHILADELPHIA, PENNSYLVNIA

QUICK DOMENICO MODELING

H.1 INTRODUCTION

Fate and transport calculations were completed for groundwater in Area of Interest (AOI) 5 to evaluate potential migration pathways/potential impacts to receptors. Four constituents of concern (COCs) were detected in groundwater during the May 2007 groundwater sampling event at concentrations above their respective used-aquifer, non-residential groundwater medium specific concentrations (MSCs). These COCs are benzene, chrysene, methyl tertiary butyl ether (MTBE) and lead. Cumene was initially detected above its MSC in May 2007, but upon resampling in April 2009 it was detected below its screening concentration and therefore will not be included in this assessment. To address the potential future migration of these COCs, a fate and transport analysis was performed. Per the PADEP ACT 2 Guidance, fate and transport analysis was performed using the predictive models recommended in the PADEP ACT 2 Guidance. The Quick Domenico Version 2 (QD) model and the SWLOAD model are used for fate and transport in groundwater. PENTOXSD is used when assessing potential impacts of groundwater on surface water. Site-specific data was used to complete the fate and transport calculations, when available.

H.2 QUICK DOMENICO AND SWLOAD MODEL OVERVIEW

The QD and SWLOAD models are Microsoft Excel spreadsheet applications based on the analytical contaminant transport equation developed by P.A. Domenico in *"An Analytical Model For Multidimensional Transport of a Decaying Contaminant Species,"* Journal of Hydrology, 91 (1987), pp. 49-58. The QD model calculates contaminant concentrations at any down-gradient location after a specified interval of time. The SWLOAD model calculates groundwater contaminant concentrations just before discharge to surface water. Both models incorporate the processes of advection, first order decay, retardation, and dispersion to describe fate and transport of compounds.

H.3 MODEL LIMITATIONS

Limitations of the QD and SWLOAD models include:

- Groundwater flow is assumed to be steady state, and one-dimensional;
- Aquifer properties are assumed to be reasonably uniform;
- Applicable only to unconsolidated aquifers;
- Intended for use primarily with dissolved organic compounds;
- Does not account for the transformation of parent compounds into daughter products as the result of biodegradation;
- Compounds are considered individually, and are assumed to not react with each other; and
- The contaminant source is limited to a single and continuous source concentration.

H.4 INITIAL SCREENING AND APPROACH TO FATE AND TRANSPORT ANALYSIS

Benzene was detected above its used-aquifer, non-residential groundwater MSC at five shallow well locations in AOI 5 (A-154, A-135, A-134, A-150 and A-119) ranging in concentration from 9 ug/l to 50 ug/l. Four of these locations are in the interior of AOI 5 while one (A-119) is located along the eastern property boundary. The point of compliance (POC) wells located down-gradient of A-154, A-135, A-134 and A-150 do not have detections of benzene above its groundwater MSC. Fate and transport analysis of benzene at these locations was not undertaken. Fate and transport analysis of benzene at A-119 was completed because there are no POC wells between A-119 and the AOI 5 property boundary.

Methyl tertiary butyl ether (MTBE) was detected above its groundwater MSC in the lower sand unit (Farrington Sand) at A-19D. Groundwater flow in the lower sand is towards the Schuylkill River. Well A-13D is located hydraulically down-gradient of A-19D and contains no detectable MTBE. Due to its proximity to the AOI 5 property line, fate and transport analysis was undertaken for A-19D as if groundwater flowed to the north.

Chrysene was detected above its groundwater MSC at eight locations (A-25, A-133, WP-E, WP-B, WP-A, SWR-3, WP-8 and A-5). Under typical conditions chrysene is insoluble in groundwater and has a strong affinity to sorb to aquifer materials. Due to low mobility, the chrysene fate and transport analysis in AOI 5 was focused on chrysene exceedences along the sheet pile wall/Schuylkill River. Five zones were identified along the bulkhead and within approximately

300 feet of the sheet pile wall. These five zones contained wells with chrysene detections above the groundwater MSC or measureable LNAPL (Figure H.1). The five zones were used to define the chrysene plume source widths for five QD models representing each of the zones. Five SWLOAD models were also constructed to further determine if groundwater might impact surface water requiring the use of PENTOXSD to derive site-specific groundwater screening criteria protective of surface water

Lead was detected at concentrations above its groundwater MSC of 5 ug/l at PZ-2 (5.8 ug/l) and WP16-3 (12 ug/l). PZ-2 and WP16-3 were not included in the evaluation as they are located hydraulically up-gradient of several wells where lead has not been detected above the MSC (A-134, A-133 and WP-B).

H.5 MODEL INPUT PARAMTERS

In preparation of this report, input values for the QD and SWLOAD models were compiled from available site-specific data. When no site-specific data was available, estimated input values from the PADEP spreadsheet "Number Please!2011," which is based on PA Code, Chapter 250, Appendix A, Table 5; or other acceptable literature sources, were utilized. The input parameters are discussed in detail in the following sections. An Excel spreadsheet interface developed by Langan was used to construct the QD simulations. This interface allowed the simulation of multiple compounds simultaneously and saved in a single electronic file. Results of the QD and SWLOAD modeling can be found in Figures H.2 through H.14 in this appendix. A summary of all fate and transport modeling results for AOI 5 can be found in Table H.1

H.5.1 Source Concentration

Results from the most recent AOI 5 site wide groundwater sampling (May 2007) were used as the starting concentrations in the QD simulations for A-19D, A-119, PZ-2 and WP16-3. In the QD and SWLOAD simulations for Zones 1, 3 and 4, the maximum detected chrysene concentration in each zone was used as the starting concentration. In Zones 2 and 5 chrysene was not detected in May 2007, however, measureable LNAPL was. To include these two Zones in the fate and transport analysis it was assumed that chrysene is impacting groundwater similar to Zones 1, 3, and 4. The reported solubility of chrysene is 1.9 ug/l (value obtained from PADEP Number Please!2011 spreadsheet) which is also the chrysene groundwater non-residential MSC. To be conservative, a concentration of 190 ug/l (100x the MSC) was used as a starting

concentration in Zones 2 and 5. A concentration of 190 ug/l is similar in magnitude to the highest chrysene groundwater concentration detected in Zones 1, 3 and 4 of 130 ug/l (Zone 1 at A-133).

H.5.2 Distance to Location of Concern (x)

Distance to the Location of Concern (distance) for QD simulations is the distance from the subject well to the point of compliance which is either the Schuylkill River/sheet pile wall or the east property line. For Zones 1 through 5 the distance to the POC was determined by the well closest to the sheet pile wall. These measurements were obtained from the GIS developed for the site.

H.5.3 Dispersivity

Dispersivity is the tendency of a dissolved plume to "spread out" as it moves down-gradient.

- Longitudinal dispersivity (A_X) occurs in the direction parallel to groundwater flow;
- Transverse dispersivity (A_Y) occurs in the same plane as longitudinal dispersivity but perpendicular to the direction of groundwater flow; and
- Vertical dispersivity (A_Z) occurs in the upward direction, normal to the plane in which longitudinal and transverse dispersivity occur (Vertical dispersivity is usually negligible and is typically omitted from most QD analyses).

Dispersivity estimates are difficult to quantify and are commonly estimated from the following relationships:

1. $A_X = X/10$ (where, X is the distance a contaminant has traveled by advective transport)
2. $A_Y = A_X/10$
3. $A_Z = A_X/20$ to $A_X/100$ (generally, it is recommended that A_Z be a very small number (0.001) unless vertical monitoring can reliably justify a larger number. Additionally, a value of 0.0001 is suggested for un-calibrated or conceptual applications).

As stated above the value for A_Y was estimated to be 10 percent of A_X. A value of 0.0001 was used as a value for A_Z.

H.5.4 Lambda

Lambda is the first order decay constant. It is determined by dividing 0.693 by the half-life of the compound. The value can typically be estimated for shrinking plumes by evaluating at concentrations versus time or distance. Lambda can also sometimes be estimated for stable plumes by evaluating concentration versus time using the methodology outlined in Buscheck and Alcantar (1995). Important considerations to estimating Lambda from site data include:

1. Are the measured concentrations along the centerline of the plume?
2. Are the measured concentrations the result of the single source area?
3. Are there no remedial systems and/or activities that effected the migration of the plume during the time interval of evaluation?

If the answer is yes to these questions, then the methodologies outlined in Buscheck and Alcantar may be utilized to estimate a site-specific lambda from site data.

Based on review of the available site data, the criteria necessary to calculate a site-specific lambda could not be met; therefore, a default value for lambda (when appropriate and available) was obtained from the PADEP spreadsheet "Number Please!2011" which is based on PA Code, Chapter 250, Appendix A, Table 5. An effective biodegradation rate of zero was used for lead because it does not biodegrade.

H.5.5 Source Dimensions

Source width is the maximum width of the area measured perpendicular to the direction of groundwater flow. Source thickness is the thickness of the soils below the water table that contribute contamination to groundwater. In addition to the saturated zone, fluctuation in groundwater elevation may create a smear zone in the unsaturated portion of an aquifer. As an estimate of the thickness of the smear zone, average fluctuation can be used. A source width of 100 ft was used at A-119. The source thickness at A-119 was determined from cross section R-R' and was 15 feet. The source thicknesses for zones 1 through 4 were 10 feet, which was also based on cross-section R-R'. The

source thickness of Zone 5 was 15 feet due to the thickening of the alluvium/fill towards the eastern boundary of AOI 5.

H.5.6 Hydraulic Conductivity (K)

The hydraulic conductivity used in the QD simulation for A-19D is 135 ft/d which is the average hydraulic conductivity of the lower sand unit as reported in USGS Water Supply Paper 2346, "Geohydrology and Ground-Water Resources of Philadelphia Pennsylvania." The hydraulic conductivity used for A-119 is the site-wide average for alluvium of 4.64 ft/d.

Along the sheet pile wall, the movement of groundwater and contamination through the alluvium/fill towards the Schuylkill River (the POC) is limited by the hydraulic conductivity of the sheet pile wall. This is because groundwater behind the sheet pile wall can discharge no faster to the Schuylkill River than the sheet pile wall permits. The lower hydraulic conductivity of the sheet pile wall also causes groundwater to mound up behind it. To account for the presence of the sheet pile wall in the QD and SWLOAD models the effective hydraulic conductivity used for simulating Zones 1 through 5 was 0.283 ft/d (10^{-5} cm/sec) which represents unsealed sheet piling (Waterloo Barrier, Inc.).

H.5.7 Hydraulic Gradient

Hydraulic gradient is the change in hydraulic head relative to the distance between head measurement locations. The hydraulic gradient is measured parallel to the direction of ground water flow assuming horizontal flow and a uniform gradient. Site specific hydraulic gradients were derived from May 2011 groundwater elevations at each modeled well or zone.

H.5.8 Porosity (n)

Porosity is measured as the ratio of the volume of void space in a geologic material to the total volume of material. Porosity values used in the fate and transport modeling for AOI 5 were based on historical geotechnical analysis.

H.5.9 Soil Bulk Density (ρb)

Soil bulk density is the dry weight of a sample divided by the total volume of the sample in an undisturbed state. Soil bulk density can either be determined by a laboratory or by the equation

$$\rho_b = 2.65 * (1- n).$$

Soil bulk density values used in the fate and transport modeling were based on historical geotechnical analysis.

H.5.10 Organic Carbon Partition Coefficient (K_{oc})

The organic carbon partition coefficient is chemical specific and is provided in the PADEP EP spreadsheet "Number Please!2011" which is based on PA Code, Chapter 250, Appendix A, Table 5. These values were used in the fate and transport modeling.

H.5.11 Fraction Organic Carbon (f_{oc})

The fraction of organic carbon is the organic carbon content of a soil. A laboratory using ASTM methods can determine this value. Samples for organic carbon are taken from the same soil horizon in which the contaminant occurs, but outside of the impacted area. Since no site specific fraction of organic carbon data was available for the site, the fate and transport modeling used the model-recommended default concentration of 0.005, which is a conservative value based on the description of site soils.

H.5.12 Time (t)

'Time zero' is the point at which contamination was introduced into the aquifer. Time since 'time zero' is measured in days. The final simulation time of 1×10^{99} days was used to ensure that a steady-state plume was simulated.

H.6 QUICK DOMENICO and SWLOAD MODELING RESULTS

QD modeling results for well A-19D, which is near the north and east AOI 5 property boundary, indicates that MTBE would need to travel 29 feet to attenuate to the MTBE groundwater MSC of 0.02 mg/l. The nearest property boundary to A-19D is approximately 50 feet away. At A-119 the predicted distance for benzene to attenuate to its groundwater MSC of 0.005 mg/l is 40 feet. The shortest distance to the property boundary from A-119 is 255 feet. Neither MTBE nor benzene in groundwater has the potential to reach the AOI 5 property boundary. Under observed field conditions lead was not detected in any well locations hydraulically down-gradient from PZ-2 and WP16-3.

Complete QD and SWLOAD modeling results can be found in this Appendix in Figures H.2 through H.14. A summary of all fate and transport modeling results for AOI 5 can be found in Table H.1.

QD modeling results for Zones 1 through 5 indicate that chrysene has very low potential to migrate under observed conditions. The predicted distance for chrysene to attenuate to its groundwater MSC of 0.0019 mg/l ranged from less than 1 foot to 4 feet. This result is consistent with the low aqueous solubility of chrysene and its strong tendency to sorb to aquifer materials. SWLOAD results using the same initial concentrations and aquifer parameters as the QD models indicate that chrysene will not reach the bulkhead and potentially discharge to the Schuylkill River, therefore, a PENTOXSD analysis was not required.

Figure H.2
Quick Domenico
Fate and Transport Model Input and Output
A-19D
Sunoco Philadehphia Refinery
Philadelphia, Pennsylvania

Project
Prepared by TS
Date Prepared 11/16/2011

Generic Input Parameters				Data Source
Source Identification (or Well ID)			**A-19D**	
Sample Date			08/14/07	
Source Width		ft	100	CCR
Source Thickness		ft	40	Thickness of fill/alluvium on R-R'
Longitudinal Dispersivity	A_x	ft	200	CCR
Transverse Dispersivity	A_y	ft	20.0	CCR
Vertical Dispersivity	A_z	ft	0.0001	CCR
Hydraulic Conductivty	k	ft/day	135	USGS Water Supply Paper 2346
Hydraulic Gradient		ft/ft	0.00012	Derived from wells A-19D and A-13D gauged June/July 2011
Porosity		decimal fraction	0.32	PADEP Act 2 Guidance
Soil Bulk Density	p_b	g/cm3	1.7	PADEP Act 2 Guidance
Fraction of Organic Carbon	f_{OC}	decimal fraction	0.005	PADEP Act 2 Guidance
Time		days	1.00E+99	steady-state

Chemical Specific Input Parameters				Data Source
Sim 1				
Contaminant			MTBE	A-119
Source Concentration (mg/L)		mg/L	0.0340	May 2007 sampling
Lambda (per day)		day^{-1}	0.002	Number Please!2011
KOC			12	Number Please!2011

Output (Distance from Source Where Concentration Equals Respective Ground Water MSC)				
Contaminant	**Starting Concentration (mg/L)**	**GW MSC[1] Non-Residential (mg/L)**	**Predicted Concentration (mg/L)**	**Predicted Distance to Meet Non-Residential GW MSC (Rounded Upward to the Nearest foot)**
Sim 1 - MTBE	0.0340	0.020	0.020	**29**

[1] ACT 2 TGM, Appendix A, Table 1 MSC for a Non-residential Used Aquifer with Total Dissolved Solids less than or equal to 2500.

ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION,1ST ORDER DECAY and RETARDATION - WITH CALIBRATION TOOL

Project:	0							
Date:	11/16/2011	Prepared by:	TS					
		Contaminant:	MTBE					

SOURCE CONC (MG/L)	Ax (ft)	Ay (ft)	Az (ft)	LAMBDA day-1	SOURCE WIDTH (ft)	SOURCE THICKNESS (ft)	Time (days) (days)
0	2.00E+02	2.00E+01	1.00E-04	0.00189041	100	40	1E+99

Hydraulic Cond (ft/day)	Hydraulic Gradient (ft/ft)	Porosity (dec. frac.)	Soil Bulk Density (g/cm^3)	KOC	Frac. Org. Carb.	Retard-ation (R)	V (=K*i/n*R) (ft/day)
1.35E+02	0.00012	0.32	1.7	12	5.00E-03	1.31875	0.038388626

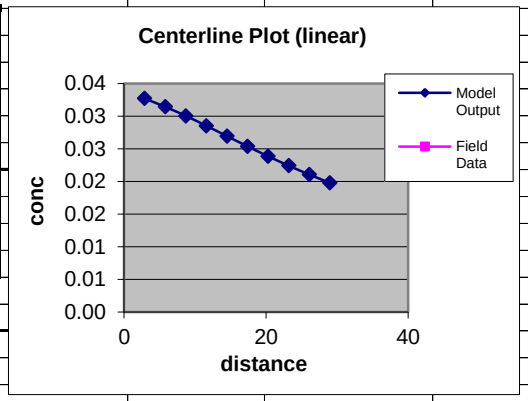
NEW QUICK_DOMENICO.XLS

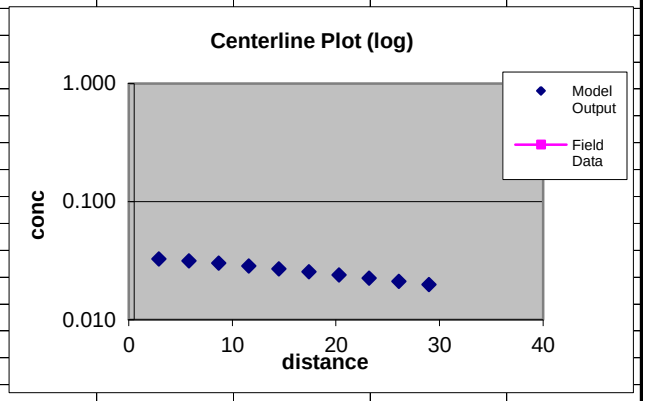
SPREADSHEET APPLICATION OF "AN ANALYTICAL MODEL FOR MULTIDIMENSIONAL TRANSPORT OF A DECAYING CONTAMINANT SPECIES" P.A. Domenico (1987) Modified to Include Retardation

Point Concentration

x(ft)	y(ft)	z(ft)
28.51297175	0	0

	x(ft)	y(ft)	z(ft)
Conc. At	28.51297175	0	0
at	1E+99	days =	0.020 mg/l





	AREAL MODEL	CALCULATION DOMAIN
	Length (ft)	29
	Width (ft)	100

	2.9	5.8	8.7	11.6	14.5	17.4	20.3	23.2	26.1	29
100	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.002
50	0.016	0.016	0.015	0.015	0.014	0.013	0.013	0.012	0.012	0.011
0	0.033	0.031	0.030	0.029	0.027	0.025	0.024	0.022	0.021	0.020
-50	0.016	0.016	0.015	0.015	0.014	0.013	0.013	0.012	0.012	0.011
-100	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.002

Field Data:	Centerline C	Concentration
	Distance from Source	

Figure H.02 A-19D MTBE QD2 Model.xlsx
SIM 1

Figure H.3
Quick Domenico
Fate and Transport Model Input and Output
A-119
Sunoco Philadehphia Refinery
Philadelphia, Pennsylvania

Project
Prepared by TS
Date Prepared 11/16/2011

Generic Input Parameters				Data Source
Source Identification (or Well ID)			**A-119**	
Sample Date			May-07	
Source Width		ft	100	CCR
Source Thickness		ft	20	Thickness of fill/alluvium on R-R'
Longitudinal Dispersivity	A_x	ft	200	CCR
Transverse Dispersivity	A_y	ft	20.0	CCR
Vertical Dispersivity	A_z	ft	0.0001	CCR
Hydraulic Conductivty	k	ft/day	4.64	Site-wide average for alluvium
Hydraulic Gradient		ft/ft	0.0015	Derived from nearby wells A-148 and A-118 gauged May 2011
Porosity		decimal fraction	0.32	PADEP Act 2 Guidance
Soil Bulk Density	p_b	g/cm3	1.7	PADEP Act 2 Guidance
Fraction of Organic Carbon	f_{OC}	decimal fraction	0.005	PADEP Act 2 Guidance
Time		days	1.00E+99	steady-state

Chemical Specific Input Parameters				Data Source
Sim 1				
Contaminant			benzene	A-119
Source Concentration (mg/L)		mg/L	0.0150	May 2007 sampling
Lambda (per day)		day^{-1}	0.001	Number Please!2011
KOC			58	Number Please!2011

Output (Distance from Source Where Concentration Equals Respective Ground Water MSC)				
Contaminant	**Starting Concentration (mg/L)**	**GW MSC[1] Non-Residential (mg/L)**	**Predicted Concentration (mg/L)**	**Predicted Distance to Meet Non-Residential GW MSC (Rounded Upward to the Nearest foot)**
Sim 1 - benzene	0.0150	0.005	0.005	**40**

[1] ACT 2 TGM, Appendix A, Table 1 MSC for a Non-residential Used Aquifer with Total Dissolved Solids less than or equal to 2500.

ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION,1ST ORDER DECAY and RETARDATION - WITH CALIBRATION TOOL

Project:	0										
Date:	11/16/2011	Prepared by:	TS								
		Contaminant:	benzene								
SOURCE CONC (MG/L)	Ax (ft)	Ay (ft)	Az (ft) >=.001	LAMBDA day-1	SOURCE WIDTH (ft)	SOURCE THICKNESS (ft)	Time (days) (days)				
0	2.00E+02	2.00E+01	1.00E-04	0.0009589	100	20	1E+99				
Hydraulic Cond (ft/day)	Hydraulic Gradient (ft/ft)	Porosity (dec. frac.)	Soil Bulk Density (g/cm^3)	KOC	Frac. Org. Carb.	Retard-ation (R)	V (=K*i/n*R) (ft/day)				
4.64E+00	0.0015	0.32	1.7	58	5.00E-03	2.540625	0.008560886				

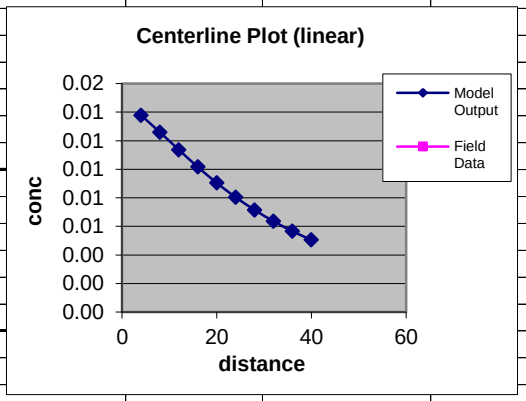
NEW QUICK_DOMENICO.XLS

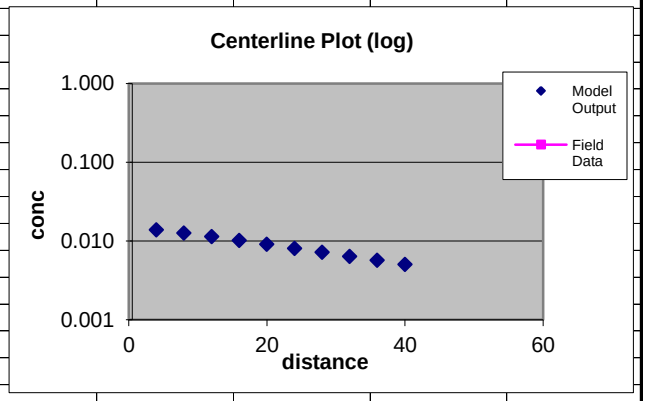
SPREADSHEET APPLICATION OF "AN ANALYTICAL MODEL FOR MULTIDIMENSIONAL TRANSPORT OF A DECAYING CONTAMINANT SPECIES" P.A. Domenico (1987) Modified to Include Retardation

Point Concentration

x(ft)	y(ft)	z(ft)
40.33969042	0	0

	x(ft)	y(ft)	z(ft)
Conc. At	40.33969042	0	0
at	1E+99	days =	0.005 mg/l





	AREAL MODEL	CALCULATION DOMAIN
	Length (ft)	40
	Width (ft)	100

	4	8	12	16	20	24	28	32	36	40
100	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001
50	0.007	0.006	0.006	0.005	0.005	0.004	0.004	0.004	0.003	0.003
0	0.014	0.013	0.011	0.010	0.009	0.008	0.007	0.006	0.006	0.005
-50	0.007	0.006	0.006	0.005	0.005	0.004	0.004	0.004	0.003	0.003
-100	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001

Field Data:	Centerline C	Concentration								
	Distance from Source									

Figure H.03 A-119 Benzene QD2 Model.xlsx
SIM 1

Figure H.4
Quick Domenico
Fate and Transport Model Input and Output
Bulkhead Zone 1
Sunoco Philadehphia Refinery
Philadelphia, Pennsylvania

Project
Prepared by TS
Date Prepared 11/16/2011

Generic Input Parameters				Data Source
Source Identification (or Well ID)			**Zone 1**	
Sample Date			May-07	
Source Width		ft	755	CCR
Source Thickness		ft	10	estimated from cross-section R-R'
Longitudinal Dispersivity	A_x	ft	200	CCR
Transverse Dispersivity	A_y	ft	20.0	CCR
Vertical Dispersivity	A_z	ft	0.0001	CCR
Hydraulic Conductivty	k	ft/day	0.283	Unsealed sheet pile (Waterloo Barrier, Inc.)
Hydraulic Gradient		ft/ft	0.023	May 2011 measured i between A-133 and WP-B
Porosity		decimal fraction	0.32	PADEP Act 2 Guidance
Soil Bulk Density	p_b	g/cm3	1.7	PADEP Act 2 Guidance
Fraction of Organic Carbon	f_{OC}	decimal fraction	0.005	PADEP Act 2 Guidance
Time		days	1.00E+99	steady-state

Chemical Specific Input Parameters				Data Source
Sim 1				
Contaminant			chrysene	A-133
Source Concentration (mg/L)		mg/L	0.1300	May 2007 sampling
Lambda (per day)		day $^{-1}$	3.562E-04	Number Please!2011
KOC			490000	Number Please!2011

Output (Distance from Source Where Concentration Equals Respective Ground Water MSC)				
Contaminant	**Starting Concentration (mg/L)**	**GW MSC[1] Non-Residential (mg/L)**	**Predicted Concentration (mg/L)**	**Predicted Distance to Meet Non-Residential GW MSC (Rounded Upward to the Nearest foot)**
Sim 1 - chrysene	0.1300	0.0019	0.0019	**4**

[1] ACT 2 TGM, Appendix A, Table 1 MSC for a Non-residential Used Aquifer with Total Dissolved Solids less than or equal to 2500.

ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION,1ST ORDER DECAY and RETARDATION - WITH CALIBRATION TOOL

Project:	0										
Date:	11/16/2011	Prepared by:	TS								
		Contaminant:	chrysene								
SOURCE CONC (MG/L)	Ax (ft)	Ay (ft)	Az (ft) >=.001	LAMBDA day-1	SOURCE WIDTH (ft)	SOURCE THICKNESS (ft)	Time (days) (days)				
0	2.00E+02	2.00E+01	1.00E-04	0.00035616	755	10	1E+99				
Hydraulic Cond (ft/day)	Hydraulic Gradient (ft/ft)	Porosity (dec. frac.)	Soil Bulk Density (g/cm^3)	KOC	Frac. Org. Carb.	Retard-ation (R)	V (=K*i/n*R) (ft/day)				
2.83E-01	0.023	0.32	1.7	490000	5.00E-03	13016.625	1.56267E-06				

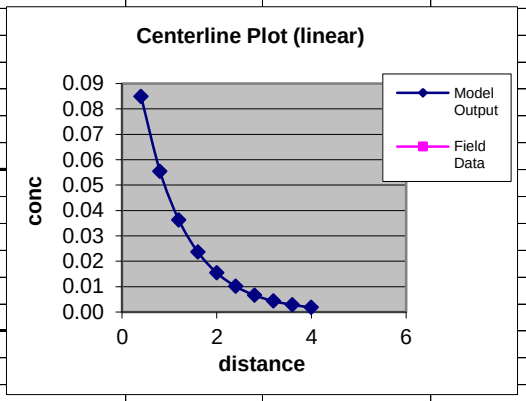
NEW QUICK_DOMENICO.XLS

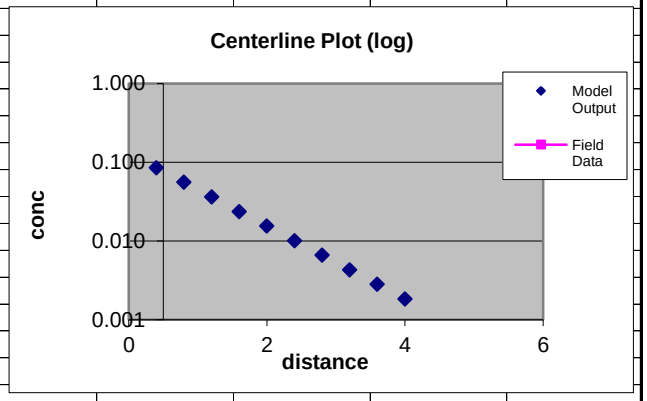
SPREADSHEET APPLICATION OF "AN ANALYTICAL MODEL FOR MULTIDIMENSIONAL TRANSPORT OF A DECAYING CONTAMINANT SPECIES" P.A. Domenico (1987) Modified to Include Retardation

Point Concentration

x(ft)	y(ft)	z(ft)
3.96800888	0	0

	x(ft)	y(ft)	z(ft)
Conc. At	3.96800888	0	0
at	1E+99	days =	0.002
			mg/l





	AREAL MODEL	CALCULATION DOMAIN									
	Length (ft)	4									
	Width (ft)	755									
	0.4	*0.8*	*1.2*	*1.6*	*2*	*2.4*	*2.8*	*3.2*	*3.6*	*4*	
755	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
377.5	0.042	0.028	0.018	0.012	0.008	0.005	0.003	0.002	0.001	0.001	
0	0.085	0.055	0.036	0.024	0.015	0.010	0.007	0.004	0.003	0.002	
-377.5	0.042	0.028	0.018	0.012	0.008	0.005	0.003	0.002	0.001	0.001	
-755	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
Field Data:	Centerline C	Concentration									
	Distance from Source										

Figure H.5
Quick Domenico
Fate and Transport Model Input and Output
Bulkhead Zone 2
Sunoco Philadehphia Refinery
Philadelphia, Pennsylvania

Project	AOI 5
Prepared by	TS
Date Prepared	11/16/2011

Generic Input Parameters				Data Source
Source Identification (or Well ID)			**Zone 2**	
Sample Date			May-07	
Source Width		ft	40	May 2011 groundwater sampling and NAPL gauging results
Source Thickness		ft	10	estimated from cross-section R-R'
Longitudinal Dispersivity	A_x	ft	200	CCR
Transverse Dispersivity	A_y	ft	20.0	CCR
Vertical Dispersivity	A_z	ft	0.0001	CCR
Hydraulic Conductivty	k	ft/day	0.283	Unsealed sheet pile (Waterloo Barrier, Inc.)
Hydraulic Gradient		ft/ft	0.0023	May 2011 calculated i betweenA-136 and SW-1
Porosity		decimal fraction	0.32	PADEP Act 2 Guidance
Soil Bulk Density	p_b	g/cm3	1.7	PADEP Act 2 Guidance
Fraction of Organic Carbon	f_{OC}	decimal fraction	0.005	PADEP Act 2 Guidance
Time		days	1.00E+99	steady-state

Chemical Specific Input Parameters				Data Source
Sim 1				
Contaminant			chrysene	SW-1
Source Concentration (mg/L)		mg/L	0.1900	100x maximum solubility
Lambda (per day)		day^{-1}	3.562E-04	Number Please!2011
KOC			490000	Number Please!2011

Output (Distance from Source Where Concentration Equals Respective Ground Water MSC)				
Contaminant	**Starting Concentration (mg/L)**	**GW MSC[1] Non-Residential (mg/L)**	**Predicted Concentration (mg/L)**	**Predicted Distance to Meet Non-Residential GW MSC (Rounded Upward to the Nearest foot)**
Sim 1 - chrysene	0.1900	0.0019	0.0019	**1**

[1] ACT 2 TGM, Appendix A, Table 1 MSC for a Non-residential Used Aquifer with Total Dissolved Solids less than or equal to 2500.

ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION,1ST ORDER DECAY and RETARDATION - WITH CALIBRATION TOOL

Project:	AOI 5						
Date:	11/16/2011	Prepared by:	TS				
		Contaminant:	chrysene				

SOURCE CONC (MG/L)	Ax (ft)	Ay (ft)	Az (ft) >=.001	LAMBDA day-1	SOURCE WIDTH (ft)	SOURCE THICKNESS (ft)	Time (days) (days)
0	2.00E+02	2.00E+01	1.00E-04	0.00035616	40	10	1E+99

Hydraulic Cond (ft/day)	Hydraulic Gradient (ft/ft)	Porosity (dec. frac.)	Soil Bulk Density (g/cm^3)	KOC	Frac. Org. Carb.	Retard-ation (R)	V (=K*i/n*R) (ft/day)
2.83E-01	0.0023	0.32	1.7	490000	5.00E-03	13016.625	1.56267E-07

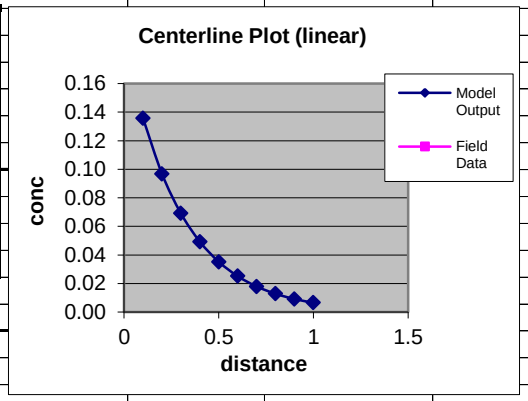
NEW QUICK_DOMENICO.XLS

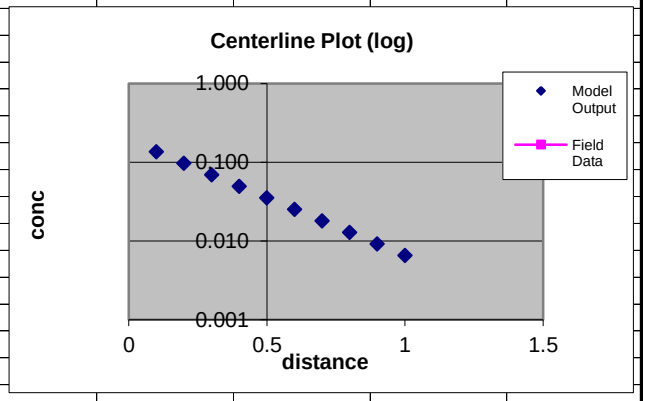
SPREADSHEET APPLICATION OF "AN ANALYTICAL MODEL FOR MULTIDIMENSIONAL TRANSPORT OF A DECAYING CONTAMINANT SPECIES" P.A. Domenico (1987) Modified to Include Retardation

Point Concentration

x(ft)	y(ft)	z(ft)
1.363267537	0	0

	x(ft)	y(ft)	z(ft)
Conc. At	1.363267537	0	0
at	1E+99	days =	0.002 mg/l





	AREAL MODEL	CALCULATION DOMAIN
	Length (ft)	1
	Width (ft)	40

	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
40	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	0.068	0.048	0.035	0.025	0.018	0.013	0.009	0.006	0.005	0.003
0	0.136	0.097	0.069	0.049	0.035	0.025	0.018	0.013	0.009	0.007
-20	0.068	0.048	0.035	0.025	0.018	0.013	0.009	0.006	0.005	0.003
-40	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Field Data:	Centerline C	Concentration
	Distance from Source	

Figure H.6
Quick Domenico
Fate and Transport Model Input and Output
Bulkhead Zone 3
Sunoco Philadehphia Refinery
Philadelphia, Pennsylvania

Project	AOI 5
Prepared by	TS
Date Prepared	11/16/2011

Generic Input Parameters				Data Source
Source Identification (or Well ID)			**Zone 3**	
Sample Date			May-07	
Source Width		ft	400	May 2011 groundwater sampling and NAPL gauging results
Source Thickness		ft	10	estimated from cross-section R-R'
Longitudinal Dispersivity	A_x	ft	200	CCR
Transverse Dispersivity	A_y	ft	20.0	CCR
Vertical Dispersivity	A_z	ft	0.0001	CCR
Hydraulic Conductivty	k	ft/day	0.283	Unsealed sheet pile (Waterloo Barrier, Inc.)
Hydraulic Gradient		ft/ft	0.01	May 2011 calculated i between A-12 and RWBH-2
Porosity		decimal fraction	0.32	PADEP Act 2 Guidance
Soil Bulk Density	p_b	g/cm3	1.7	PADEP Act 2 Guidance
Fraction of Organic Carbon	f_{OC}	decimal fraction	0.005	PADEP Act 2 Guidance
Time		days	1.00E+99	steady-state

Chemical Specific Input Parameters				Data Source
Sim 1				
Contaminant			chrysene	
Source Concentration (mg/L)		mg/L	0.0062	SWR-3
Lambda (per day)		day^{-1}	3.562E-04	Number Please!2011
KOC			490000	Number Please!2011

Output (Distance from Source Where Concentration Equals Respective Ground Water MSC)				
Contaminant	**Starting Concentration (mg/L)**	**GW MSC[1] Non-Residential (mg/L)**	**Predicted Concentration (mg/L)**	**Predicted Distance to Meet Non-Residential GW MSC (Rounded Upward to the Nearest foot)**
Sim 1 - chrysene	0.0062	0.0019	0.0019	**1**

[1] ACT 2 TGM, Appendix A, Table 1 MSC for a Non-residential Used Aquifer with Total Dissolved Solids less than or equal to 2500.

ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION,1ST ORDER DECAY and RETARDATION - WITH CALIBRATION TOOL

Project:	AOI 5										
Date:	11/16/2011	Prepared by:	TS								
		Contaminant:	chrysene								
SOURCE CONC (MG/L)	Ax (ft)	Ay (ft)	Az (ft) >=.001	LAMBDA day-1	SOURCE WIDTH (ft)	SOURCE THICKNESS (ft)	Time (days) (days)				
0	2.00E+02	2.00E+01	1.00E-04	0.00035616	400	10	1E+99				
Hydraulic Cond (ft/day)	Hydraulic Gradient (ft/ft)	Porosity (dec. frac.)	Soil Bulk Density (g/cm^{3})	KOC	Frac. Org. Carb.	Retard-ation (R)	V (=K*i/n*R) (ft/day)				
2.83E-01	0.01	0.32	1.7	490000	5.00E-03	13016.625	6.7942E-07				

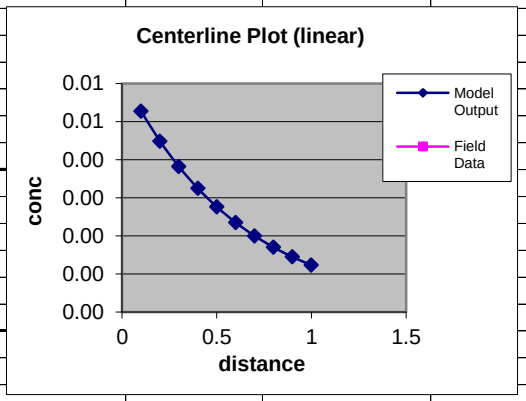
NEW QUICK_DOMENICO.XLS

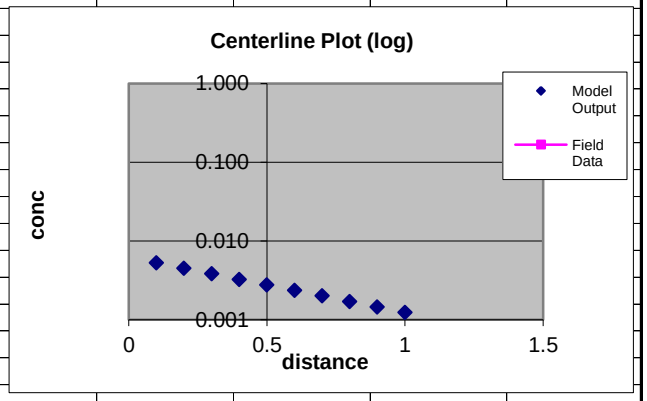
SPREADSHEET APPLICATION OF "AN ANALYTICAL MODEL FOR MULTIDIMENSIONAL TRANSPORT OF A DECAYING CONTAMINANT SPECIES" P.A. Domenico (1987) Modified to Include Retardation

Point Concentration

x(ft)	y(ft)	z(ft)
0.731362046	0	0

	x(ft)	y(ft)	z(ft)
Conc. At	0.731362046	0	0
at	1E+99	days =	**0.002** mg/l





	AREAL MODEL	CALCULATION DOMAIN
	Length (ft)	1
	Width (ft)	400

	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
200	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001
0	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.001	0.001
-200	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001
-400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Field Data:	Centerline C	Concentration
	Distance from Source	

Figure H.7
Quick Domenico
Fate and Transport Model Input and Output
Bulkhead Zone 4
Sunoco Philadehphia Refinery
Philadelphia, Pennsylvania

Project	AOI 5
Prepared by	TS
Date Prepared	11/16/2011

Generic Input Parameters				Data Source
Source Identification (or Well ID)			**Zone 4**	
Sample Date			May-07	
Source Width		ft	480	May 2011 groundwater sampling and NAPL gauging results
Source Thickness		ft	10	estimated from cross-section R-R'
Longitudinal Dispersivity	A_x	ft	200	CCR
Transverse Dispersivity	A_y	ft	20.0	CCR
Vertical Dispersivity	A_z	ft	0.0001	CCR
Hydraulic Conductivty	k	ft/day	0.283	Unsealed sheet pile (Waterloo Barrier, Inc.)
Hydraulic Gradient		ft/ft	0.0078	May 2011 calculated i between A-13 and A-5
Porosity		decimal fraction	0.32	PADEP Act 2 Guidance
Soil Bulk Density	p_b	g/cm3	1.7	PADEP Act 2 Guidance
Fraction of Organic Carbon	f_{OC}	decimal fraction	0.005	PADEP Act 2 Guidance
Time		days	1.00E+99	steady-state

Chemical Specific Input Parameters				Data Source
Sim 1				
Contaminant			chrysene	
Source Concentration (mg/L)		mg/L	0.0085	WP-8
Lambda (per day)		day^{-1}	3.562E-04	Number Please!2011
KOC			490000	Number Please!2011

Output (Distance from Source Where Concentration Equals Respective Ground Water MSC)				
Contaminant	**Starting Concentration (mg/L)**	**GW MSC[1] Non-Residential (mg/L)**	**Predicted Concentration (mg/L)**	**Predicted Distance to Meet Non-Residential GW MSC (Rounded Upward to the Nearest foot)**
Sim 1 - chrysene	0.0085	0.0019	0.0019	**1**

[1] ACT 2 TGM, Appendix A, Table 1 MSC for a Non-residential Used Aquifer with Total Dissolved Solids less than or equal to 2500.

ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION,1ST ORDER DECAY and RETARDATION - WITH CALIBRATION TOOL

Project:	AOI 5		
Date:	11/16/2011	Prepared by:	TS
		Contaminant:	chrysene

NEW QUICK_DOMENICO.XLS

SPREADSHEET APPLICATION OF "AN ANALYTICAL MODEL FOR MULTIDIMENSIONAL TRANSPORT OF A DECAYING CONTAMINANT SPECIES" P.A. Domenico (1987) Modified to Include Retardation

SOURCE CONC (MG/L)	Ax (ft)	Ay (ft)	Az (ft) >=.001	LAMBDA day-1	SOURCE WIDTH (ft)	SOURCE THICKNESS (ft)	Time (days) (days)
0	2.00E+02	2.00E+01	1.00E-04	0.00035616	480	10	1E+99

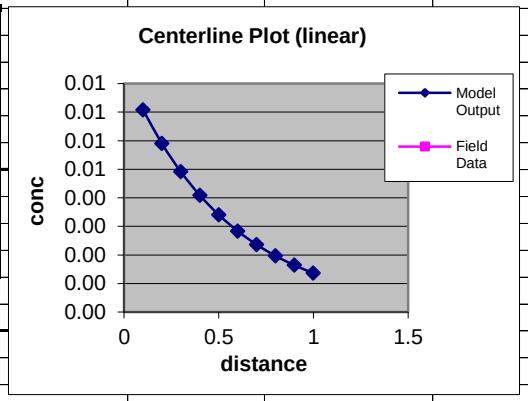
Hydraulic Cond (ft/day)	Hydraulic Gradient (ft/ft)	Porosity (dec. frac.)	Soil Bulk Density (g/cm^{3})	KOC	Frac. Org. Carb.	Retard-ation (R)	V (=K*i/n*R) (ft/day)
2.83E-01	0.0078	0.32	1.7	490000	5.00E-03	13016.625	5.29947E-07

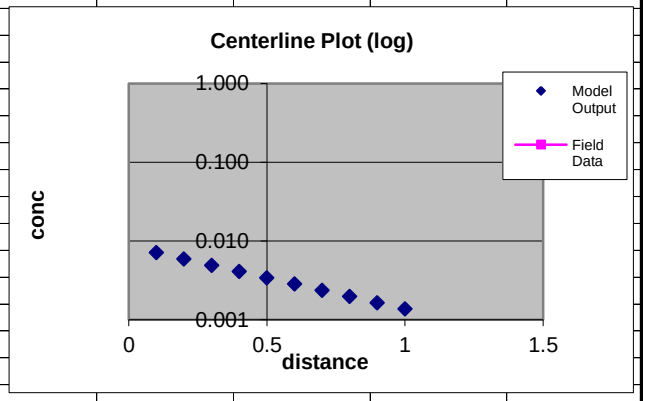
Point Concentration

x(ft)	y(ft)	z(ft)
0.818610618	0	0

	x(ft)	y(ft)	z(ft)
Conc. At	0.818610618	0	0
at	1E+99	days =	

0.002 mg/l





	AREAL MODEL	CALCULATION DOMAIN
	Length (ft)	1
	Width (ft)	480

	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
480	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
240	0.004	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001
0	0.007	0.006	0.005	0.004	0.003	0.003	0.002	0.002	0.002	0.001
-240	0.004	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001
-480	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Field Data:	Centerline C	Concentration
	Distance from Source	

Figure H.07 Zone 4 QD2 Model.xlsx
SIM 1

Figure H.8
Quick Domenico
Fate and Transport Model Input and Output
Bulkhead Zone 5
Sunoco Philadehphia Refinery
Philadelphia, Pennsylvania

Project	AOI 5
Prepared by	TS
Date Prepared	11/16/2011

Generic Input Parameters				Data Source
Source Identification (or Well ID)			**Zone 5**	
Sample Date			May-07	
Source Width		ft	305	May 2011 groundwater sampling and NAPL gauging results
Source Thickness		ft	15	estimated from cross-section R-R'
Longitudinal Dispersivity	A_x	ft	200	CCR
Transverse Dispersivity	A_y	ft	20.0	CCR
Vertical Dispersivity	A_z	ft	0.0001	CCR
Hydraulic Conductivty	k	ft/day	0.283	Unsealed sheet pile (Waterloo Barrier, Inc.)
Hydraulic Gradient		ft/ft	0.0049	May 2011 calculated i between A-41 and A-4
Porosity		decimal fraction	0.32	PADEP Act 2 Guidance
Soil Bulk Density	p_b	g/cm3	1.7	PADEP Act 2 Guidance
Fraction of Organic Carbon	f_{OC}	decimal fraction	0.005	PADEP Act 2 Guidance
Time		days	1.00E+99	steady-state

Chemical Specific Input Parameters				Data Source
Sim 1				
Contaminant			chrysene	
Source Concentration (mg/L)		mg/L	0.1900	100x maximum solubility
Lambda (per day)		day $^{-1}$	3.562E-04	Number Please!2011
KOC			490000	Number Please!2011

Output (Distance from Source Where Concentration Equals Respective Ground Water MSC)				
Contaminant	**Starting Concentration (mg/L)**	**GW MSC[1] Non-Residential (mg/L)**	**Predicted Concentration (mg/L)**	**Predicted Distance to Meet Non-Residential GW MSC (Rounded Upward to the Nearest foot)**
Sim 1 - chrysene	0.1900	0.0019	0.0019	**2**

[1] ACT 2 TGM, Appendix A, Table 1 MSC for a Non-residential Used Aquifer with Total Dissolved Solids less than or equal to 2500.

ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION,1ST ORDER DECAY and RETARDATION - WITH CALIBRATION TOOL

Project:	AOI 5										
Date:	11/16/2011	Prepared by:	TS								
		Contaminant:	chrysene								
SOURCE CONC (MG/L)	Ax (ft)	Ay (ft)	Az (ft) >=.001	LAMBDA day-1	SOURCE WIDTH (ft)	SOURCE THICKNESS (ft)	Time (days) (days)				
0	2.00E+02	2.00E+01	1.00E-04	0.00035616	305	15	1E+99				
Hydraulic Cond (ft/day)	Hydraulic Gradient (ft/ft)	Porosity (dec. frac.)	Soil Bulk Density (g/cm^3)	KOC	Frac. Org. Carb.	Retard-ation (R)	V (=K*i/n*R) (ft/day)				
2.83E-01	0.0049	0.32	1.7	490000	5.00E-03	13016.625	3.32916E-07				

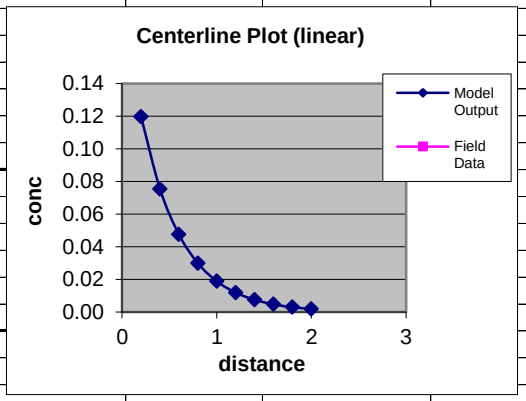
NEW QUICK_DOMENICO.XLS

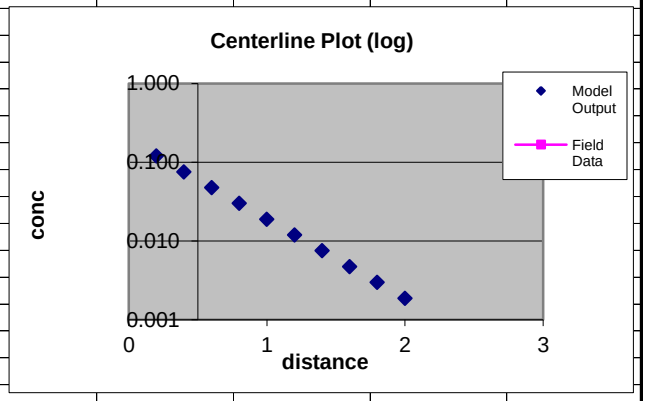
SPREADSHEET APPLICATION OF "AN ANALYTICAL MODEL FOR MULTIDIMENSIONAL TRANSPORT OF A DECAYING CONTAMINANT SPECIES" P.A. Domenico (1987) Modified to Include Retardation

Point Concentration

x(ft)	y(ft)	z(ft)
1.993460201	0	0

	x(ft)	y(ft)	z(ft)
Conc. At	1.993460201	0	0
at	1E+99	days =	0.002 mg/l





	AREAL MODEL	CALCULATION DOMAIN
	Length (ft)	2
	Width (ft)	305

	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2
305	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
152.5	0.060	0.038	0.024	0.015	0.009	0.006	0.004	0.002	0.001	0.001
0	0.120	0.075	0.048	0.030	0.019	0.012	0.007	0.005	0.003	0.002
-152.5	0.060	0.038	0.024	0.015	0.009	0.006	0.004	0.002	0.001	0.001
-305	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Field Data:	Centerline C	Concentration
	Distance from Source	

APPENDIX I

Development of Site-Specific Standards and
Risk Assessment

APPENDIX I
DEVELOPMENT OF SITE-SPECIFIC STANDARDS
AOI 5: SUNOCO PHILADELPHIA REFINERY
PHILADELPHIA, PENNSYLVANIA

Based on the current and future intended non-residential site use, an exposure assessment was conducted for all compounds in surficial soil (0-2 feet) which exceeded the nonresidential direct contact statewide health standards in AOI 5. Potential human health exposures for the Refinery are evaluated for an industrial worker scenario.

In AOI 5, shallow soil samples were collected from within the three RCRA Solid Waste Management Units (SWMU) Areas and analyzed for total lead; samples were also collected outside the three SWMU areas and analyzed for the site-specific compounds (as specified in the June 15, 2007 AOI 5 Site Characterization Workplan). To determine if any risk to the industrial worker exists due to direct contact, the results of these samples were compared to the non-residential direct contact medium specific concentrations [PA Code Title 25, Chapter 250.305, Appendix A, Tables 3A and 4A]. Within the three SWMU areas, concentrations of total lead were detected above their respective direct contact MSCs. Outside the SWMU designated areas, concentrations of benzene and total lead were detected above their respective direct contact MSCs. In accordance with Section IV of the PADEP's Technical Guidance Manual (TGM) (dated June 8, 2002), the COCs listed above were further screened against the EPA Region III Risk-Based Concentrations (RBCs) (aka, EPA Regional Screening Levels) for industrial soil to potentially reduce the list of compounds carried through the risk assessment. Concentrations of benzene were below the EPA Region III RBC for industrial soil (5.4 mg/kg) and therefore site-specific criterion for benzene were not developed. Concentrations of lead were above the EPA Region III RBCs and therefore site-specific criterion was developed, as further described below.

Since total lead exceeded both the non-residential statewide health standard and EPA Region III RBC, a site-specific standard was calculated using PADEP default intake parameters for an on-site industrial worker. For calculating a site-specific standard for workers exposed to lead, Sunoco used the Society of Environmental Geochemistry and

Health (SEGH) model used by PADEP to develop the non-residential MSC. The input parameters used to develop the site-specific standards for total lead are provided in Table I-1 and described below. The calculated site specific standard for total lead is 1,708 mg/kg.

The site-specific screening level for lead was calculated based on ingestion. As presented in 25 Pa. Code § 250.306(e), Appendix A, Table 7, the non-residential soil screening value for lead is based on the method presented in the report 'The Society for Environmental Geochemistry and Health (SEGH) Task Force Approach to the Assessment of Lead in Soil' (Wixson, 1991). Based on the SEGH model and PADEP's default parameters, PADEP's non-residential direct contact MSC default value for lead in surface soil is 1,000 mg/kg. To develop a site-specific criteria for lead, the values used by PADEP for the target blood lead concentration (T) and geometric mean background blood lead concentration (B) were revised in consideration of site-specific conditions and updated lead data collected by the US Center for Disease Control and Prevention (CDC). Revised values for these parameters are discussed in the following paragraphs.

Target blood lead concentration (T) – The default target blood lead concentration used by the PADEP to develop the non-residential MSC is 20 ug/dL; however, the Center for Disease Control (CDC) recommends that worker blood lead levels be maintained below 25 ug/dL (NIOSH, 2008) to prevent adverse health effects for most workers from exposure to lead throughout a working lifetime. Based on conversations between representatives of Sunoco and EPA, the target lead blood level identified by the CDC is the level used in the site-specific calculations in Tables I-1 and I-2.

Geometric mean background blood lead concentration (B) – B is the background blood lead concentration in the target population from sources other than soil and dust. The PADEP's default value for B is 4 ug/dL and, as summarized in PADEPs reference document (Wixson, 1991), is based on data gathered in the United Kingdom from young children. The CDC has monitored blood lead levels in US children and adults since 1976 and, based on the most recent results published by the National Center for Environmental Health of the CDC (NCEH,

2005), the mean blood lead concentration for an adult 20 years of age or older is 1.56 ug/dL. Based on the more recent study by the US CDC, the value used for B in the site specific calculation has been revised to 1.56 ug/dL.

CONCLUSIONS

Concentrations of total lead detected in AOI 5 were compared to the calculated site-specific standard (1,708 mg/kg). Lead exposure is dependent on the blood/lead concentration and not risk based; therefore, lead could not be incorporated into the cumulative risk calculation. Locations with concentrations of total lead detected above the site-specific standard have been delineated and will be remediated as described in the Clean-up Plan (Section 10).

References

NCEH (2005). Third National Report on Human Exposure to Environmental Chemicals. Centers for Disease Control and Prevention, National Center for Environmental Health, Division of Laboratory Sciences. Atlanta, Georgia. NCEH. Pub. No. 05-0570.

NIOSH (2008). Adult Blood Lead Epidemiology and Surveillance (ABLES). http://www.cdc.gov/niosh/topics/ABLES

Wixson, B.G., (1991). The Society of Environmental Geochemistry and Health (SEGH) Task Force Approach to the Assessment of Lead in Soil. Trace Substances in Environmental Health. 11-20.

Table I-1
Derivation of Site-Specific Soil Value
for Lead[1]
AOI 5
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Parameter	Abbreviation	Assumption	Units	Source[2]
Blood lead target concentration	T	25	ug/dL	CDC - ABLES (NIOSH, 2008)
Geometric standard deviation of the blood lead distribution	G	1.4	unitless	25 Pa. Code § 250, Appendix A Table 7
Background blood lead concentration in the population from sources other than soil or dust	B	1.56	ug/dL	NCEH Pub. No. 05-0570 (NCEH, 2005)
Number of standard deviations corresponding to the degree of protection required for the population at risk	n	1.645	unitless	25 Pa. Code § 250, Appendix A Table 7
Response of the blood lead versus soil lead relationship	δ	7.5	ug/dL blood / ug/g soil	25 Pa. Code § 250, Appendix A Table 7

Site-Specific, Non-Residential (Onsite Worker) Screening Value **1,708** **ug/g (mg/kg)**

Notes:

1. The site specific screening value for lead was calculated for ingestion based on the SEGH model as specified by 25 Pa. Code 250.306(e)

$$MSC\ (mg/kg) = \frac{[(T/G^{n}) - B] \times 1000}{\delta}$$

2. Sources for blood lead target level (T) based on conversation between James Oppenheim of Sunoco and Hon Lee of EPA in November 2010.

NIOSH (2008). Adult Blood Lead Epidemiology and Surveillance (ABLES). http://www.cdc.gov/niosh/topics/ABLES

NCEH (2005). Third National Report on Human Exposure to Environmental Chemicals. Centers for Disease Control and Prevention, National Center for Environmental Health, Division of Laboratory Sciences. Atlanta, Georgia. NCEH. Pub. No. 05-0570.

Table I-2
Site Specific Cumulative Risk Evaluation
AOI 5
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

				Lead (7439-92-1)	
AOI 5 Sunoco Philadelphia Refinery Philadelphia, Pennsylvania	**Sample ID**	**Sample Interval**	**Sample Date**	**Reported Result (mg/kg)**	**Calculated Blood Lead Conc.[2] (ug/dL)**
A-139	A-139_071207_1.5-2.0	1.5-2.0	7/12/2007	191	5
A-140	A-140_071207_1.5-2.0	1.5-2.0	7/12/2007	2460	**35**
A-142	A-142_1.5-2.0	1.5-2.0	7/12/2007	377	8
A-143	A-143_0712_1.5-2.0	1.5 - 2.0	7/12/2007	446	9
A-151	A-151_071207_1.5-2.0	1.5 - 2.0	7/12/2007	112	4
A_152	A-152_071207_1.5-2.0	1.5 - 2.0	7/12/2007	110	4
BH-04-07	BH-04-07_1-2	1.0 - 2.0	7/13/2007	203	5
BH-05-07	BH-05-07_1-2	1.0 - 2.0	7/12/2007	316	7
BH-06-07	BH-06-07_1.0-2.0	0.5 - 1.0	4/4/2007	373	8
BH-07-07	BH-07-07_1-2	1.0 - 2.0	7/13/2007	1250	19
BH-08-07	BH-08-07_.75-2	0.75 - 2.0	7/13/2007	506	9
BH-13-07	BH-13-07_0.5-0.75	0.5 - 1.0	4/4/2007	310	7
BH-18-07	BH-18-07_1.0-2.0	1.0 - 2.0	4/4/2007	3190	**44**
BH-20-07	BH-20-07_0.75-2.0	0.75 - 2.0	7/11/2007	21.7	3
BH-21-07	BH-21-07_1.75-2	1.75 - 2.0	4/4/2004	26.7	3
BH-23-07	BH-23-07_0-0.5	0 - 0.5	7/11/2007	1920	**28**
BH-24-07	BH-24-07_1.5-2	1.75 - 2.0	4/4/2004	152	5
BH-25-07	BH-25-07_1-2	1.0 - 2.0	7/11/2007	103	4
BH-26-07	BH-25-07_1-2	1.0 - 2.0	7/11/2007	41.7	3
BH-27-07	BH-27-07_1.5-2.0	1.5 - 2.0	7/12/2007	3700	**51**
A-140	A-140_0.5-2.0	0.5 - 2.0	4/6/2009	316	7
A-141	A-141_0.5-2.0	0.5 - 2.0	4/6/2009	660	11
A-144	A-1440.0-2.0	0.0 - 2.0	4/6/2009	156	5
A-150	A-150_0.0-2.0	0.0 - 2.0	4/7/2009	190	5
A-153	A-153_0.0-2.0	0.0 - 2.0	4/8/2009	37.4	3
A-155	A-155_0.0-2.0	0.0 - 2.0	4/7/2009	446	9
BH-01-09	BH-01-09_0.0-2.0	0.0 - 2.0	4/7/2009	494	9
BH-02-09	BH-02-09_0.0-2.0	0.0 - 2.0	4/7/2009	17900	**236**
BH-03-09	BH-03-09_0.0-2.0	0.0 - 2.0	4/7/2009	316	7
BH-04-09	BH-04-09_0.0-2.0	0.0 - 2.0	4/7/2009	1810	**26**
BH-05-09	BH-05-09_0.0-2.0	0.0 - 2.0	4/8/2009	449	9
BH-06-09	BH-06-09_0.0-2.0	0.0 - 2.0	4/8/2009	407	8
BH-07-09	BH-07-09_0.0-2.0	0.0 - 2.0	4/7/2009	748	12
BH-08-09_AOI5	BH-08-09_AOI5_0.0-2.0	0.0 - 2.0	4/7/2009	563	10
BH-09-09	BH-09-09_0.0-2.0	0.0 - 2.0	4/7/2009	2430	**34**
BH-10-09	BH-10-09_0.0-2.0	0.0 - 2.0	4/6/2009	441	8
BH-11-09	BH-11-09_0.0-2.0	0.0 - 2.0	4/7/2009	613	11
BH-12-09	BH-12-09_0.0-2.0	0.0 - 2.0	4/6/2009	806	13
BH-13-09	BH-13-09_1.0-2.0	1.0 - 2.0	4/6/2009	298	7
BH-14-09	BH-14-09_1.0-2.0	1.0 - 2.0	4/6/2009	285	6
BH-15-09	BH-15-09_0.5-2.0	0.5 - 2.0	4/6/2009	323	7
BH-16-09	BH-16-09_0.0-2.0	0.0 - 2.0	4/6/2009	2030	**29**
BH-17-09	BH-17-09_0.0-2.0	0.0 - 2.0	4/8/2009	790	13
BH-18-09	BH-18-09_0.0-2.0	0.0 - 2.0	4/8/2009	327	7
BH-19-09	BH-19-09_0.0-2.0	0.0 - 2.0	4/8/2009	228	6
BH-20-09	BH-20-09_0.0-2.0	0.0 - 2.0	4/8/2009	453	9
BH-21-09	BH-21-09	0.0 - 2.0	6/8/2009	1210	18
BH-22-09	BH-22-09	0.0 - 2.0	6/8/2009	1780	**26**
BH-23-09	BH-23-09	0.0 - 2.0	6/8/2009	1220	19
BH-24-09	BH-24-09	0.0 - 2.0	6/8/2009	1100	17
BH-25-09	BH-25-09_0.0-2.0	0.0 - 2.0	4/7/2009	1100	17
BH-26-09	BH-26-09_0.0-2.0	0.0 - 2.0	4/7/2009	102	4
BH-33-09	BH-33-09	0.0 - 2.0	7/9/2009	790	13
BH-34-09	BH-34-09	0.0 - 2.0	7/9/2009	485	9
BH-35-09	BH-35-09	0.0 - 2.0	7/9/2009	772	13
BH-36-09	BH-36-09	0.0 - 2.0	7/9/2009	374	8
BH-37-09	BH-37-09	0.0 - 2.0	7/9/2009	1310	20
BH-38-09	BH-38-09	0.0 - 2.0	7/9/2009	36.8	3
BH-39-09	BH-39-09	0.0 - 2.0	7/9/2009	1050	16
BH-40-09	BH-40-09	0.0 - 2.0	7/9/2009	219	6
BH-41-09	BH-41-09	0.0 - 2.0	7/9/2009	387	8
BH-42-09	BH-42-09	0.0 - 2.0	7/9/2009	183	5

Notes:

(1) All soil samples collected and analyzed were unsaturated.

(2) Calculated based on site specific parameters provided in Table F-4. The CDC (NIOSH, 2008) recommends that blood lead levels be maintained below 25 ug/dL.

Bold indicates blood lead concentrations calculated above the CDC recommended value of 25 ug/dL.