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PRELIMINARY HYDROGEOLOGIC AND CONTAMINANT ASSESSMENT REPORT

Exxon RAS #2-8077
14258 Jarrettsville Pike
Phoenix, Maryland

MDE Case Number 2006-0303BA2

JULY 2006

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QUALITY ASSURANCE/QUALITY CONTROL

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ABBREVIATIONS AND ACRONYMS

Accutest	Accutest Laboratories, Inc.
ARMA	Air and Radiation Management Administration
AST	aboveground storage tank
ATW	Aquifer Test for Windows
BG&E	Baltimore Gas & Electric Company
bgs	below ground surface
DIPE	di-isopropyl ether
DPE	dual-phase extraction
EIP	electronic interface probe
EPA	Environmental Protection Agency
ETBE	ethyl tert butyl ether
ExxonMobil	Exxon Mobil Corporation
FLUTe™	Flexible Liner Underground Technologies
ft/day	feet per day
ft/sec/psi	feet per second per pound per square inch
GAC	granular activated carbon
gpm	gallons per minute
K	hydraulic conductivity
LPH	liquid-phase hydrocarbon
MASW	Multi-Channel Analysis of Surface Waves
MDE	Maryland Department of the Environment
µg/L	micrograms per liter
MSL	mean sea level
MTBE	methyl tertiary-butyl ether
NPDES	National Pollutant Discharge Elimination System
PE	potable effluent
PI	potable influent
PID	photoionization detector
PM	potable mid-point
POET	point-of-entry treatment system
ppb	parts per billion
ppm	parts per million
QA/QC	Quality Assurance/Quality Control
SOP	standard operating procedure
SVE	Soil Vapor Extraction
T	Transmissivity
TPH-DRO	total petroleum hydrocarbons – diesel range organics
USGS	United States Geological Survey
UST	underground storage tank
TAME	tert-amyl methyl ether
TBA	tert butyl alcohol
VOCs	volatile organic compounds

1.0 INTRODUCTION

On behalf of Exxon Mobil Corporation (ExxonMobil), Kleinfelder is conducting site assessment, remedial investigation, and interim remedial activities at the former ExxonMobil retail facility #2-8077 (Maryland Department of the Environment [MDE] Case Number 2006-0303BA2) located at 14258 Jarrettsville Pike in Phoenix, Maryland. This document was prepared in response to the May 3, 2006 letter from the MDE requiring ExxonMobil to prepare a *Preliminary Hydrogeologic and Contaminant Assessment Report* for the site. The MDE acknowledges in its May 3, 2006 letter that assessment activities are ongoing, that interpretation of results is preliminary based on current data, and that the requested data augment daily and weekly data and information deliverables that have been provided to the MDE by ExxonMobil. Weekly submissions continue to be provided.

Assessment and interim remedial activities were initiated in response to the discovery of petroleum hydrocarbons in existing groundwater monitoring wells that had previously been installed at the facility as required[1]. The purpose of the ongoing assessment activities is to acquire geologic, hydrogeologic, and chemical data for the development of a site conceptual model that will describe the nature, extent, and migration of hydrocarbon constituents within the physical framework of the site. This understanding of site conditions has been, and will be, used to support the selection of the interim and final remediation approach for the site. This assessment, including a final analysis of all data collected, is not yet complete. A supplemental report will be provided at a later date.

Activities completed in support of the hydrogeologic and contaminant assessment include the following:

- General review of geologic maps and literature
- Advancement of 213 boreholes as of June 9, 2006; 208 boreholes were completed as groundwater monitoring wells, four boreholes were abandoned, and one was completed as an air sparge point
- Acquisition of three bedrock core samples
- Sampling of 273 private supply wells within an approximate ½-mile radius of the site
- Completion of four seismic survey profiles
- Completion of five electrical resistivity imaging profiles
- Completion of one area microgravity survey and four microgravity survey profiles
- Borehole geophysical logging (typically optical televiewer, acoustic televiewer, caliper, fluid temperature, natural gamma, fluid resistivity, spontaneous potential, resistivity, and single point resistance) in 11 bedrock boreholes
- Completion of hydraulic profiling with blank Flexible Liner Underground Technologies (FLUTe™) liners in three bedrock boreholes
- Installation of custom FLUTe™ liners with discrete sampling ports in four bedrock boreholes
- Implementation and analysis of two constant-rate aquifer pumping tests in the northeast and southwest portions of the site
- Implementation and analysis of 127 slug tests in 42 groundwater monitoring wells
- Completion of soil gas sampling adjacent to building structures on six properties northeast of the site
- Geologic inspection of the tank field excavation
- Collection and analysis of 1,483 groundwater samples
- Collection and analysis of 31 surface water (stream and pond) samples
- Implementation of 170 rounds of groundwater potentiometric surface and product thickness level gauging events

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[1] Monitoring wells were installed to comply with COMAR 26.10.02.03 and 26.10.03.02-.03 for High Risk Groundwater Use Areas

Data presented herein were acquired from the start of the hydrogeologic characterization program on February 18, 2006, until approximately June 9, 2006, based on the availability of data and analyses completed at the time of this writing, unless otherwise noted. Data presented herein have been subject to quality assurance/quality control (QA/QC) review. Additional data that were either not final or collected subsequently will be included in the periodic data deliverables to MDE, or provided in a supplemental report.

In addition, interim remedial measures have been initiated pending completion of the site characterization process. A brief summary of the interim remedial measures is also provided in this report. These activities were reported to the MDE in an *Interim Remedial Measures Plan* (GSC|Kleinfelder, March 27, 2006).

2.0 SITE DESCRIPTION

The service station property is located at 14258 Jarrettsville Pike, on the southwest corner of the intersection of Paper Mill Road (MD 145) and Jarrettsville Pike (MD 146) in Phoenix, Baltimore County, Maryland (see Figure 1). Based on parcel information provided by the Maryland Department of Assessments and Taxation, the service station property is assessed to be approximately 1.71 acres with a 1,845 square-foot building. The legal identifier for the service station property is Map 35, Parcel 185, and Grid 24.

The service station building is a single-story concrete block structure on a poured concrete slab. The building includes an office, restrooms, and three automotive service bays. The Exxon service station sanitary and sink water discharge to a septic system that drains to a leaching field located southwest of the service station building. Figure 2 displays former and current improvements to the service station property.

Overhead utilities include telephone and electric lines running along the south side of Paper Mill Road and the west side of Jarrettsville Pike. The electric lines run underground along the western property boundary to the service station building. The telephone lines cross onto the service station property overhead to the service station building. Below grade communication lines are located along the south side of Paper Mill Road and west side of Jarrettsville Pike and do not enter the service station property. One storm drain, located in the center of the service station property, is connected to storm drain piping located within a storm water easement on the southern property boundary. Surface water flow at the previously graded and developed service station property is by sheet flow into the local drainage system. Immediately adjacent to the service station property is a retention basin for roadway runoff with a stand pipe connected to an incised ephemeral drainage channel. The Exxon service station private supply well (PW-01) is located on the northwest corner of the service station property. The well is 300 feet deep (open bedrock) and solid cased to a depth of 42 feet below ground surface (bgs).

The underground storage tanks (USTs), associated piping, and dispenser islands were removed from the service station property between March 4, 2006 and April 10, 2006. These activities were reported to the MDE in the *Tank Excavation Assessment Report* (GSC|Kleinfelder, April 28, 2006). Prior to UST removal activities, the service station features consisted of a canopy covering three dispenser islands, two 8,000-gallon gasoline USTs, one 10,000-gallon diesel UST, one 12,000-gallon gasoline UST and associated single-walled fiberglass piping. The USTs were installed in 1985 and were constructed of double-walled, fiberglass-coated steel. In July 1992 and May 1997, one 1,000-gallon fiberglass used-oil UST and one 1,000-gallon fiberglass heating-oil UST were removed from the service station property, respectively. A 280-gallon fuel-oil aboveground storage tank (AST) is currently in use at the service station facility.

3.0 SITE SETTING

The site is located on the United States Geological Survey (USGS) Phoenix, Maryland Topographic Quadrangle Map at 39.5183º N latitude, 76.5596º W Longitude at an approximate elevation of 590 feet above mean sea level (MSL) in Baltimore County, Maryland (Figure 3). The following sections describe the surrounding land use, physical setting, and geologic/hydrogeologic characteristics of the area investigated.

3.1 Surrounding Land Use

The service station property is located at the southwest corner of the intersection of Paper Mill Road, Jarrettsville Pike, and Sweet Air Road; the local businesses are concentrated around this intersection (Figure 4).

Beyond this “business district” the land use is primarily single-family residential properties interspersed with some vacant, undeveloped lots and wooded areas (Figure 4). To the north of the service station property is a small shopping center which contains various retail, financial, and food service establishments, as well as a dry cleaner. The Phoenix Post Office and a grocery market are also located to the north. The northeast corner of this intersection is occupied by a bank, a small office building with a variety of tenants, a former veterinary clinic, and a Baltimore Gas & Electric Company (BG&E) substation. A retail petroleum distributor is located to the east of the service station property across Jarrettsville Pike along with a grocery market and a variety of retail, financial, and food service establishments. The area to the south of the service station property is occupied by a dry cleaner, an operating veterinary clinic, several retail establishments, and a retail petroleum distributor. West of the service station property is a vacant lot, a small office building with a variety of tenants, and residential properties.

3.2 Utilities, Septic Systems, and Private Supply Wells

There are underground electric and telephone services to the service station property and most of the surrounding community. The business district to the east of the service station property is served by aboveground electrical service. The sewage disposal in the area is handled by private septic systems. Water is obtained from private supply wells (Figure 5). The location and available well construction information for area private supply wells are addressed later in this report. There is no known public gas service to the service station facility or adjacent properties. Some of the local businesses and residences are known to have private propane gas systems; other properties are known to use heating oil.

3.3 Physical Setting and Framework

This section describes the physical setting and underlying physical framework of the area where the site is located. The underlying geologic framework is presented first, followed by a description of the area soils. The area hydrogeology and physiography, which are directly related to the geologic and soil framework, are described subsequently.

3.3.1 Area Geology

The site is underlain by metamorphic rocks comprising the southern flank of the Phoenix Dome, regionally mapped by Moller (1979) as the Loch Raven Schist of the Wissahickon Group. The Loch Raven Schist encountered during the course of the investigation is primarily uniform, medium-grained schist consisting of biotite, oligoclase, muscovite, quartz, and various accessory minerals including staurolite, kyanite, actinolite, and garnet (Moller, 1979). Sub-units encountered during the investigation included an epidote-amphibolite gneiss and pegmatite. The gneiss is a fine- to medium-grained, thinly banded, black and white gneiss. The pegmatite consists of lenses of coarse-grained quartz, feldspars, and muscovite. The bedrock types encountered during the investigation are consistent with the regional mapping.

Photo 1: Bedrock foliation looking southwest in tank field excavation.

The primary bedrock structural feature is the metamorphic foliation, which is mapped to strike northeast and dip northwest (Moller, 1979). This structural orientation is consistent with geologic observations, manual measurements, and borehole geophysical measurements of the foliation orientation completed as part of this investigation.

3.3.2 Soils

Photo 2: Relict foliation in saprolite observed in tank field test pit.

Conformably overlying bedrock is a layer of saprolite (Cleaves, 1974). Saprolite is a geologic material which has formed by in-situ chemical weathering of the local bedrock, resulting in a gradational weathering profile. The minerals that formed the parent rock have been altered and decomposed and replaced with less dense minerals, primarily clay minerals. In some cases, the fabric of the parent rock can be observed as less labile minerals, such as quarts and micas. These minerals tend to retain their original orientation and position.

The soils encountered during the investigation of the site overlay the saprolite and are generally composed of silty to sandy clays and clayey to silty sands. The soils are generally colluvium, and residual soils resulting from the in-situ weathering of the local metamorphic bedrock. There are localized areas of alluvium primarily within the stream channels in the vicinity of the site. The colluvial, alluvial, and residual soils have not been differentiated and are referred to in this report collectively as "overburden." The thickness of the overburden across the site ranges from 5 feet to 65 feet. The soils in the region are primarily moderately eroded Glenelg Loam (GcB2 and GcC2) with lesser amounts of moderately to severely eroded Manor Loam (MbB2, MbC2, MbC3, and MbD3) occurring on some of the steeper slopes (Reybold, 1976). There are minor amounts of Glenville Silt Loam (GnB) limited to the drainage areas of the site. These soil types are deep, variable in the degree to which they drain, and may exhibit moderate permeability. These soils are consistent with the soils encountered during the investigation.

3.3.3 Area Hydrogeology

The Piedmont Physiographic Province is characterized by bedrock aquifers within the Precambrian and Paleozoic age metamorphic and igneous rocks of the region (Nutter, 1974). The primary (intergranular) porosity of the bedrock is relatively minimal compared to the secondary porosity (fractures, joints, foliation, etc.) of the bedrock, in which groundwater flow may occur. The spacing and extent (persistence) of the secondary porosity affect the availability of groundwater within the bedrock aquifer. Groundwater within the bedrock is generally restricted to flow within the secondary porosity.

Within area bedrock aquifers, groundwater generally occurs under water table (unconfined) conditions, although confined conditions do occur locally (Dingman et al., 1956). Locally, the top of bedrock surface may exist at an elevation above that of the water table (Figures 6A – 6C). In these areas, groundwater occurs exclusively within the secondary porosity of the bedrock, and where present, interconnected and continuous fractures provide flow paths. The water table may also occur within the weathered residuum (saprolite or soil) above bedrock (Figures 6A – 6C). Within the saprolite layer, groundwater occurs within the pore spaces between the weathered mineral grains and within the relict foliation.

Precipitation is the principal source of groundwater recharge (Nutter and Otten, 1969), which occurs as precipitation infiltrates the soil and percolates downward to the water table. The water table in the Piedmont area fluctuates naturally (Nutter and Otten, 1969; Bennet and Meyer, 1952). Fluctuation occurs due to seasonal and longer period variations in precipitation. The rate of water infiltration is affected by the amount and rate of precipitation, the permeability of the soil, and storm water control features.

The depth to groundwater ranges from near the ground surface (approximately 3 feet bgs) at the northeast and southwest ends of the site where the gaining streams occur to approximately 40 feet bgs beneath the service station property in the vicinity of the former tank field. Stream channels in the study area have the thickest layers of saprolite, and groundwater occurs closest to the ground surface in those areas. The water table in areas of high topography generally exists within bedrock. Figure 7 presents a groundwater potentiometric surface elevation contour map for the study area. This map is based on gauging data from the existing groundwater monitoring well network under groundwater extraction conditions. This contour map was computer generated using the Surfer software contouring package. The computer generated output was reviewed, and adjustments to the contour map were made as appropriate based on hydrogeologic interpretation.

3.3.4 Area Topography and Physiography

The site exists within the Summit Uplands portion of the Piedmont Physiographic Province of Maryland (Schmidt, 1993). The site topography (Figure 3) is closely related to the geology of the region (e.g., foliated bedrock structure and differential weathering). The Summit Uplands are characterized by gently rolling hills and incised stream valleys. The local topographic features depicted on Figure 3 (e.g., drainages that trend southwesterly and northeasterly away from the service station property, and the ridge upon which the service station property is located) are geomorphic expressions of the underlying bedrock surface and structural orientation (Figures 8 and 6A – 6C). The topographic features observed at the site (the drainages and ridges) are roughly parallel to the strike of this foliation described previously.

Two ephemeral streams are within the investigation limits of this project. The geometry of these streams is controlled by the local geology. These streams have formed by eroding into a weak zone within the bedrock which is generally parallel to the foliation of the rock. These are referred to in the literature as "strike streams" (Strahler, 1960), because they are linear and trend in the direction of the strike of the bedrock foliations.

The southwest portion of the site is drained by a tributary to the Greene Branch of Gunpowder Falls, which in turn drains into Loch Raven Reservoir approximately 1.5 miles west of the site. The northeast portion of the site is drained by a tributary to the Sawmill Branch of Little Gunpowder Falls. The headwaters of these drainages, the portions of these drainages which are local to the site, are ephemeral streams that flow intermittently during periods of precipitation and snow melt. At higher elevations, closer to the service station property, the ephemeral drainage channels are stormwater control features. At farther distances from the service station property, these are gaining streams.

4.0 PRIVATE SUPPLY WELL SAMPLING

At the direction of the MDE, a sampling program is being conducted to monitor water quality in private supply wells in the vicinity of the service station property. This sampling program includes both the periodic sampling of private supply wells within ¼-mile and ½-mile radii of the site and the weekly/twice-weekly sampling of select private supply wells. Figures 9 and 10 generally identify the properties located within the ¼-mile and ½-mile radii, as well as the properties where weekly/twice weekly sampling has been conducted. Construction details for private supply wells in the vicinity of the site are summarized in Table 1, and copies of the corresponding private supply well records are provided in Appendix A. A more detailed description of the private supply well sampling program is presented in Section 4.1.

Based on (1) the site characterization data and/or (2) results of the private supply well sampling program, MDE required installation of point-of-entry treatment (POET) systems (i.e. water filtration systems) at select properties either as a preventative measure or to treat the private water supply. The locations where MDE has required the installation of POET systems are shown on Figure 10. These POET systems are maintained and monitored on a regular basis in conjunction with the private supply well sampling program. A more detailed description of the POET program is presented in Section 4.2.

4.1 Private Supply Well Sampling Program

As stated above, the private supply well sampling program has two components: (1) periodic sampling of private supply wells within ¼-mile and ½-mile radii of the service station property, and (2) weekly/twice-weekly sampling of select private supply wells. The frequency of sampling has been directed by the MDE. The sampling events conducted at the direction of the MDE are summarized below. The locations of the private supply wells, identified by property address, are shown on Figure 9.

¼-Mile and ½-Mile Radii Sampling

At the direction of the MDE, ¼-mile and ½-mile radii sampling was conducted as described below:

- Based on field direction from the MDE on February 19, 2006, three properties (3313 Paper Mill Road, 3305 Paper Mill Road, and 14242 Jarrettsville Pike) in the immediate vicinity of the service station property were sampled.

- Based on verbal direction from the MDE on February 21, 2006, sampling was expanded to include those properties located within the southwest quadrant (south of Paper Mill Road and west of Jarrettsville Pike) and within ½-mile of the service station property. This sampling event was completed on February 28, 2006.

- Based on verbal direction from the MDE, the February 2006 sampling was expanded with additional sampling conducted between March 2 and March 4, 2006. This additional sampling event included those properties located within the northeast quadrant (north of Sweet Air Road and east of Jarrettsville Pike) and within ¼-mile of the service station property.

- Base on MDE correspondence dated March 10, 2006, a precautionary round of sampling was conducted for those private supply wells located within a ½-mile radius of the service station property that had not previously been sampled. Accordingly, from March 14 through March 22, 2006, the private supply wells were sampled at the following locations:
  - In the northeast quadrant, between ¼-mile and ½-mile of the service station property
  - In the northwest quadrant (north of Paper Mill Road and west of Jarrettsville Pike), within ½-mile of the service station property
  - In the southeast quadrant (south of Sweet Air Road and east of Jarrettsville Pike), within ½-mile of the service station property

- Based on verbal direction during a March 20, 2006, conference call with the MDE, additional sampling of private supply wells was conducted within the southwest quadrant (½-mile radius) and northeast quadrant (¼-mile radius) from March 27 through March 29, 2006.

- Based on MDE correspondence dated March 31, 2006, an additional round of sampling was conducted in the southwest and northeast quadrants (both ½-mile radii) from April 17 through April 29, 2006.

- Based on MDE correspondence dated May 15, 2006, an additional round of sampling was conducted in the southwest (¼-mile radius) and northeast (modified ½-mile radius) from June 12 through June 17, 2006. The results of this sampling event are not included in this report, but are to be submitted to the MDE separately.

Weekly/Twice-Weekly Sampling

At the direction of the MDE, weekly/twice-weekly sampling was conducted as described below. A total of 31 private supply wells are or have been sampled on a weekly or twice-weekly basis. At present, all 31 of these wells are sampled weekly. Based on verbal direction of the MDE during a March 2, 2006 meeting, weekly private well sampling was conducted at 10 properties in the vicinity of the service station property. This instruction was followed up in writing by the MDE in correspondence dated March 14, 2006. These 10 properties are identified as follows:

- 14221 Robcaste Road
- 14223 Robcaste Road
- 14225 Robcaste Road
- 14240 Jarrettsville Pike
- 14242 Jarrettsville Pike
- 14243 Jarrettsville Pike
- 14301 Jarrettsville Pike
- 14307 Jarrettsville Pike
- 3313 Paper Mill Road
- 3320 Paper Mill Road

The 14240 and 14301 Jarrettsville Pike properties, however, have not been sampled weekly for the following reasons: the 14301 Jarrettsville Pike private supply well was removed from service and a temporary water tank was installed. The 14240 Jarrettsville Pike property is being sampled by BP/Amoco at the direction of the MDE, as part of an unrelated incident.

Based on direction from the MDE on March 14, 2006, 11 additional properties were added to the weekly sampling program. These 11 properties are identified as follows:

- 14210 Robcaste Road
- 3500 Hampshire Glen
- 3501 Hampshire Glen
- 3502 Hampshire Glen
- 3503 Hampshire Glen
- 3504 Hampshire Glen
- 3505 Hampshire Glen
- 3506 Hampshire Glen
- 3507 Hampshire Glen
- 3508 Hampshire Glen
- 3600 Hampshire Glen

In addition, the MDE added two more properties to the weekly sampling program on March 20, 2006. These properties are identified as follows:

- 3606 Hampshire Glen
- 3608 Hampshire Glen

Based on MDE correspondence dated April 3, 2006, weekly sampling was conducted for 10 additional properties:

- 14212 Robcaste Road
- 14330 Jarrettsville Pike
- 3510 Hampshire Glen
- 3602 Hampshire Glen
- 3604 Hampshire Glen
- 3605 Southside Avenue
- 3605A Southside Avenue
- 3605B Southside Avenue
- 3605C Southside Avenue
- 3605D Southside Avenue

Four of the wells identified above (3503, 3506, and 3508 Hampshire Glen; and 14223 Robcaste Road) were identified by the MDE for twice-weekly sampling. Currently, 14223 Robcaste Road is on a weekly sampling schedule and POET systems have been installed on the private supply wells for the other three formerly twice-weekly properties.

State-certified personnel conduct the private supply well sampling. Following MDE guidelines, the private well samples are collected as close to the well as practical and, if possible, prior to the water going through any treatment or filtering devices. The water sample is collected near the holding tank (whenever practical), after allowing the water to flow for 20 minutes at approximately 5 gallons per minute (gpm) (i.e., allow sufficient purge time for the pump to cycle at least 2 times). Standard operating procedures (SOPs), followed for the private supply well sampling program, are included in Appendix B. All samples are sent to Accutest Laboratories, Inc. (Accutest) in Dayton, New Jersey, for analysis of volatile organic compounds (VOCs) using U.S. Environmental Protection Agency (EPA) Method 524.2. In addition to target compounds, analyses are also performed for the following non-target gasoline additives (oxygenates):

- Methyl tertiary-butyl ether (MTBE)
- Tert-amyl methyl ether (TAME)
- Tert butyl alcohol (TBA)
- Di-isopropyl ether (DIPE)
- Ethyl tert butyl ether (ETBE)

A summary of the private supply well sampling results for benzene and MTBE are presented on Table 2. A summary of the private supply well sampling results for all detected analytes is presented on Table 3 and the complete analytical reports are included in Appendix C. Benzene concentrations detected in private supply wells located west and east of Jarrettsville Pike are shown on Figures 11 and 12, respectively. MTBE concentrations detected in private supply wells west and east of Jarrettsville Pike are shown on Figures 13 and 14, respectively. Benzene and MTBE were selected as hydrocarbon indicator constituents for the tables and figures presented in this report.

A summary of the private supply well sampling data is presented below:

- A total of 273 private supply wells have been sampled from February 20, 2006 through June 8, 2006. The results for all but the last sampling event are included in this report.

- A total of nine private supply wells (shown and identified by parcel and lot ID on Figure 5) currently have or historically have had (since February 20, 2006) MTBE concentrations above the MDE's action level for MTBE of 20 parts per billion (ppb). The following table identifies the property address, the total number of sampling events from February 20, 2006 through June 9, 2006, and a summary of MTBE results:

Parcel and Lot ID	Site Address	Number of Sampling Events	Min. MTBE	Max. MTBE	Avg. MTBE	POET System Status
P182	14240 Jarrettsville Pike	5	443	508	483	(1)
P183	14242 Jarrettsville Pike	17	35.6	4,610	786	(2)
P217	14243 Jarrettsville Pike	13	6.9	123	31	(1)
P031	14301 Jarrettsville Pike	1	773,000	773,000	773,000	(3)
P193	3410 Sweet Air Road	2	23.7	77.6	50.7	(1)
P356-L22-01	3507 Hampshire Glen Ct	15	6.9	57.1	27.3	(2)
P356-L22-02	3507 Hampshire Glen Ct	9	1.0	30.4	15.7	(2)
P356-L09	3604 Hampshire Glen Ct	12	6.4	41.7	25.0	(2)
P356-L11	3606 Hampshire Glen Ct	13	11.4	20.4	16.2	(2)

(1) POET system previously installed by others

(2) POET system installed at the direction of the MDE as part of current remedial activities

(3) POET system previously installed by others; the well was also taken offline and a temporary water tank was installed

- The remaining 264 private supply wells have not exceeded the MDE's 20 ppb action level for MTBE during the sampling period.

- Two private supply wells (14242 Jarrettsville Pike and 14301 Jarrettsville Pike) currently have or historically have had (since February 20, 2006) additional hydrocarbon compounds (benzene, ethylbenzene, and toluene) detected above the MDE's action levels.

- The remaining 271 private supply wells have not exceeded the MDE's action levels for additional hydrocarbon compounds during the sampling period.

4.2 POET Program

At the MDE's direction, POET systems were installed on the private supply wells at eight properties. The location of the eight properties and the date of installation are as follows:

- 14242 Jarrettsville Pike, installed March 4, 2006
- 3507 Hampshire Glen Court, installed March 16, 2006[2]
- 3606 Hampshire Glen Court, installed March 22, 2006
- 3608 Hampshire Glen Court, installed March 22, 2006
- 3503 Hampshire Glen Court, installed April 27, 2006
- 3506 Hampshire Glen Court, installed April 27, 2006
- 3508 Hampshire Glen Court, installed April 27, 2006
- 3604 Hampshire Glen Court, installed April 28, 2006

Performance sampling is conducted at these eight locations on a weekly basis. As previously stated, 3503, 3506, and 3508 Hampshire Glen were originally selected by MDE for twice weekly sampling. However, in accordance with the MDE's letter dated March 3, 2006, sampling of these locations has been modified to weekly following the installation of the POET systems. The property at 14223 Robcaste Road was offered a POET system, but has not accepted this offer.

State-certified personnel conduct the POET system sampling. The performance samples are collected from the POET systems at three points: before the liquid granular activated carbon (GAC) units, POET influent (PI); between the units, POET mid-point (PM); and at a point after the units, POET effluent (PE). SOPs followed for the POET system sampling are included in Appendix B. The water samples from the POET systems are sent to Accutest for analysis of VOCs and oxygenates using EPA method 524.2. The analytical results for benzene and MTBE at the locations where POET systems have been installed are summarized on Table 4, and the laboratory analytical reports are included as Appendix C. A summary of the POET system water filtration system sampling data is presented below.

- MTBE has not been detected in the PM or PE samples. This demonstrates that, while MTBE may have been present in the untreated groundwater (influent), it is not present in the treated groundwater (effluent). Based on the review of the analytical data, the water filtration systems are working as designed for the removal of MTBE.

- Carbon disulfide and 2-butanone have been detected in the PI, PM, and PE samples following the installation of the water filtration systems. The detections of these compounds in the treated water (PE sample) have been at concentrations that are below MDE action levels. Carbon disulfide and 2-butanone are not constituents of gasoline. These are associated with glue compounds used for the plumbing of the water filtration system and are expected to dissipate with time.

A summary of the POET sampling results for benzene and MTBE is presented on Table 4 and the analytical laboratory reports are included in Appendix C.

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[2] The two private supply wells located on this property are connected to one POET system.

5.0 REMEDIAL INVESTIGATION ACTIVITIES, METHODS, AND RESULTS

This section provides a description of the remedial investigation activities completed and the methods of implementation. Results obtained during the reporting period are also summarized in this section.

5.1 Well Installation and Development

A total of 208 groundwater monitoring wells were installed from February 18, 2006 through May 17, 2006, utilizing a combination of air rotary, hollow-stem auger and direct-push drilling methods (see Figure 15). These monitoring wells were installed for the following purposes: (1) assessing subsurface hydrogeologic conditions; (2) logging geologic and hydrocarbon screening data of selected locations; (3) obtaining groundwater samples for chemical analysis; (4) measuring groundwater potentiometric surface elevations and hydrocarbon thickness, if any; and (5) conducting interim groundwater remedial activities, as appropriate. The wells range from 1 to 6 inches in diameter, and were advanced to depths ranging from 10 to 350 feet bgs. Well construction varied depending on well location, depth and intended use (Table 5). The majority of the wells were completed flush with the ground surface and finished with a concrete pad and a bolt-down lid with a locking compression cap; however, selected wells were completed with above-grade locking steel well protectors, or otherwise have remedial well head completions.

Site-related wells were classified by “series,” which corresponds to the relative depth and/or type of well. The series of a well is identified by a “letter” descriptor on the end of the well number. Monitoring wells with no “letter” or an “A” letter classification fall into the “A” series classification, which are screened across the water table. Series “B” wells are screened below the bottom of the corresponding series “A” well (commonly 10 feet deeper). Series “C” wells are deep bedrock wells that generally correspond to the total depth of the potable drinking water wells in the area. Series “R” wells identify wells with specific screen intervals and depths for enhanced groundwater extraction. Series “P” wells are piezometers used for monitoring of groundwater levels and/or vacuum response, though groundwater samples may be collected from these piezometers, as well. Individual well construction diagrams are included as Appendix D.

5.1.1 Series “A” Wells

Wells in this series were installed utilizing air rotary or hollow-stem auger methods to monitor the water table. These wells either have no letter descriptor (e.g. MW-25) or in many cases, if paired with deeper wells, have an “A” descriptor (e.g. MW-41A). Many of the series “A” wells were intended to delineate liquid-phase hydrocarbon (LPH) or dissolved-phase impacts and subsequently serve as monitoring or groundwater recovery wells. These wells are 2, 4 or 6 inches in diameter and were installed in 6-, 8- or 10-inch diameter boreholes, respectively, depending upon the intended use. Series “A” wells were constructed using variable lengths of 0.020-inch machine-slotted, schedule 40 PVC well screen with a flush threaded solid PVC riser to depths ranging from 15 to 109 feet bgs (Table 5). The annular space of each well was filled with No. 2 sand to a level approximately one foot above the screened interval, followed by a hydrated bentonite seal to near grade.

5.1.2 Series “B” Wells

Wells in this series were installed utilizing air rotary or hollow-stem auger methods and have a “B” descriptor (e.g. MW-41B). Series “B” wells are screened approximately ten feet below the bottom of the corresponding series “A” wells for vertical delineation. These wells are 2, 4 or 6 inches in diameter and were installed in 6-, 8- or 10-inch boreholes, respectively. Series “B” wells were constructed using variable lengths of 0.020-inch machine-slotted, schedule 40 PVC well screen with a flush threaded solid PVC riser to depths ranging from 30 to 83 feet bgs (Table 5). The annular space of each well was filled with No. 2 sand to a level approximately one foot above the screened interval followed by a hydrated bentonite seal to near grade.

5.1.3 Series “C” Wells

Wells in this series were installed utilizing air rotary drilling methods and have a “C” descriptor (e.g. MW-41C). Series “C” wells generally correspond to the total depth of the area potable water wells. Figure 16 presents the location of the series “C” wells relative to area potable wells on a topographic base. These were installed to facilitate observation of the bedrock structure using various borehole geophysical methods (detailed in Section 5.4) and to serve as deep monitoring wells. Series “C” wells were installed as 6-inch diameter open boreholes within a 6-inch diameter steel casing. The steel casings were keyed approximately 20 to 25 feet into the competent bedrock and grouted to the surface to isolate the shallow portion of the aquifer (e.g. saturated overburden and/or shallow bedrock) from the deeper portion of the aquifer. These wells were advanced to total depths ranging from 300 to 350 feet bgs (Table 5), and borehole geophysical logging was conducted in each of these boreholes. Subsequent to borehole geophysical logging, Flexible Liner Underground Technologies (FLUTe™) liners were installed into several of the series “C” boreholes to seal and/or enable monitoring of discrete intervals within the deep bedrock aquifer. The design of the FLUTe™ liner with regard to discrete sampling intervals was based on the identification of potential fractures from borehole geophysical logging results.

5.1.4 Series “R” Wells

Wells in the series that have an “R” descriptor were installed utilizing air drilling methods for groundwater recovery. These monitoring wells are 6-inches in diameter and were installed in 10-inch diameter boreholes. Series “R” wells were constructed using variable lengths of 0.020-inch machine-slotted, schedule 40 PVC well screen with a flush threaded solid PVC riser to depths ranging from 38 to 75 feet bgs (Table 5). These wells were installed specifically as recovery wells for remediation; however, other wells (e.g., series “A” and series “B” wells) are also used as remediation recovery wells. The annular space of each well was filled with No. 2 sand to a level approximately one foot above the screened interval followed by a bentonite seal to near grade. One series “D” well (MW-59D) was installed to the corresponding “A” level as a larger diameter well to facilitate groundwater extraction. MW-59D is effectively designed for recovery, similar to other “R” series wells.

5.1.5 Series “P” Wells

Wells in this series were installed utilizing air rotary, hollow-stem auger or direct push methods and have a “P” descriptor (e.g. MW-57P). These monitoring wells are either 1 or 2 inches in diameter and were installed in 3- or 6-inch diameter boreholes, respectively, for use as piezometers in which to measure potentiometric surface elevations, generally adjacent to groundwater recovery wells. Series “P” wells were constructed using variable lengths of 0.020-inch machine-slotted, schedule 40 PVC well screen with a flush threaded solid PVC riser to depths ranging from 30 to 98 feet bgs (Table 5). The annular space of each well was filled with No. 2 sand to a level approximately one foot above the screened interval followed by a bentonite seal to grade. The screen lengths of the “P” series wells generally correspond to that the screen lengths of adjacent recovery wells.

5.1.6 Qualitative Soil Screening

Soils were screened for VOCs utilizing a hand-held photoionization detector (PID) calibrated to an isobutylene standard to yield total VOCs in parts per million (ppm). Field screening results are shown on the well logs (Appendix D). Recorded PID responses were collected either by screening of the discrete soil samples obtained during direct-push and hollow-stem auger drilling, or by screening of the drill cuttings during air rotary drilling.

5.1.7 Monitoring Well Development

Wells were developed following completion to ensure the collection of representative groundwater samples, and to improve well efficiency by removing smaller particles from the annular space that may clog the filter pack. The well development process is ongoing. Certain monitoring wells were developed following installation using an electric Grundfos® pump to achieve over-pumping conditions. The wells were pumped and surged until evacuated water was generally free of suspended solids.

5.2 Well Gauging and Sampling

As new groundwater monitoring wells were completed, they were generally gauged and sampled within one day of installation and subsequently incorporated into the well gauging and sampling schedules as discussed below. Initially, top of well casing elevation data were based on an on-site benchmark (monitoring well MW-3) set at an arbitrary datum of 100 feet. Kleinfelder personnel surveyed newly installed wells relative to this benchmark until a professional survey, relative to mean sea level, was completed. The professional survey data have since replaced the survey data obtained by Kleinfelder.

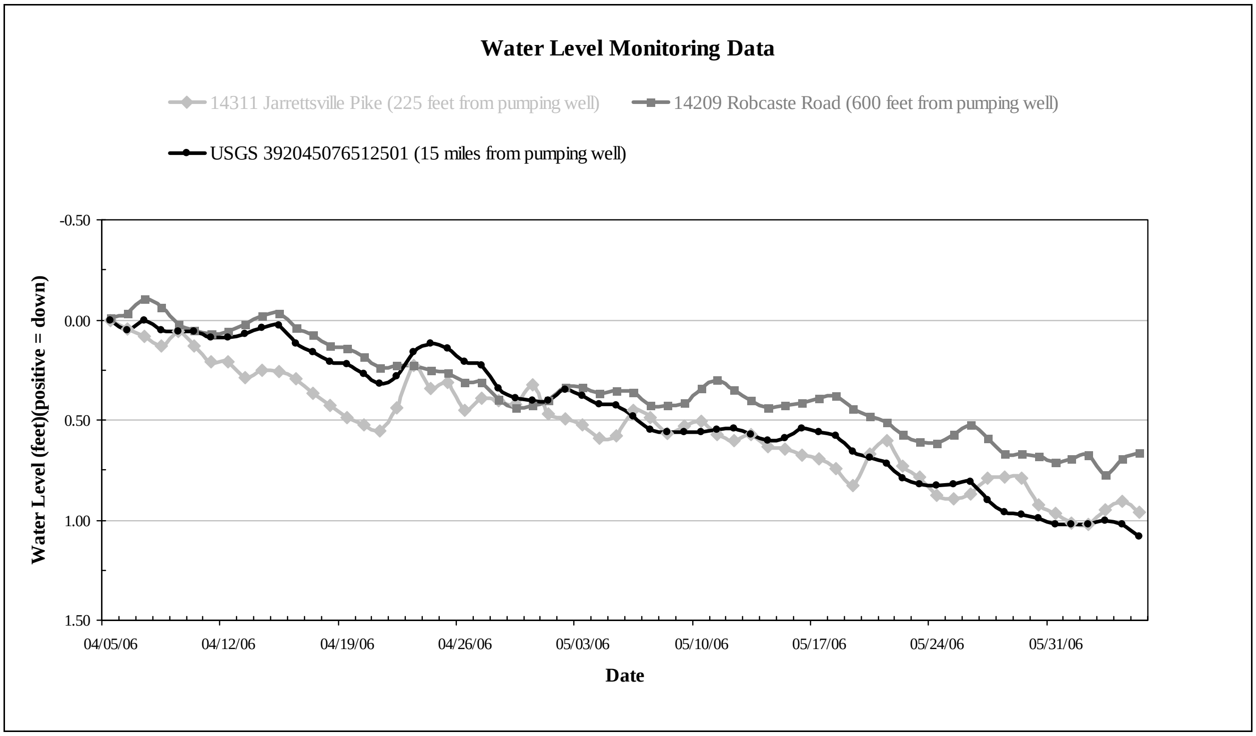
5.2.1 Well Gauging

Accessible wells were gauged using an electronic interface probe (EIP) to measure water levels and determine if any LPH was present. In general, well gauging was conducted on the following schedule:

- Daily or more frequent basis from February 18 through April 14, 2006
- Every other day, with the exception of weekends, from April 15, 2006 through May 1, 2006
- Weekly basis from May 2, 2006 through present

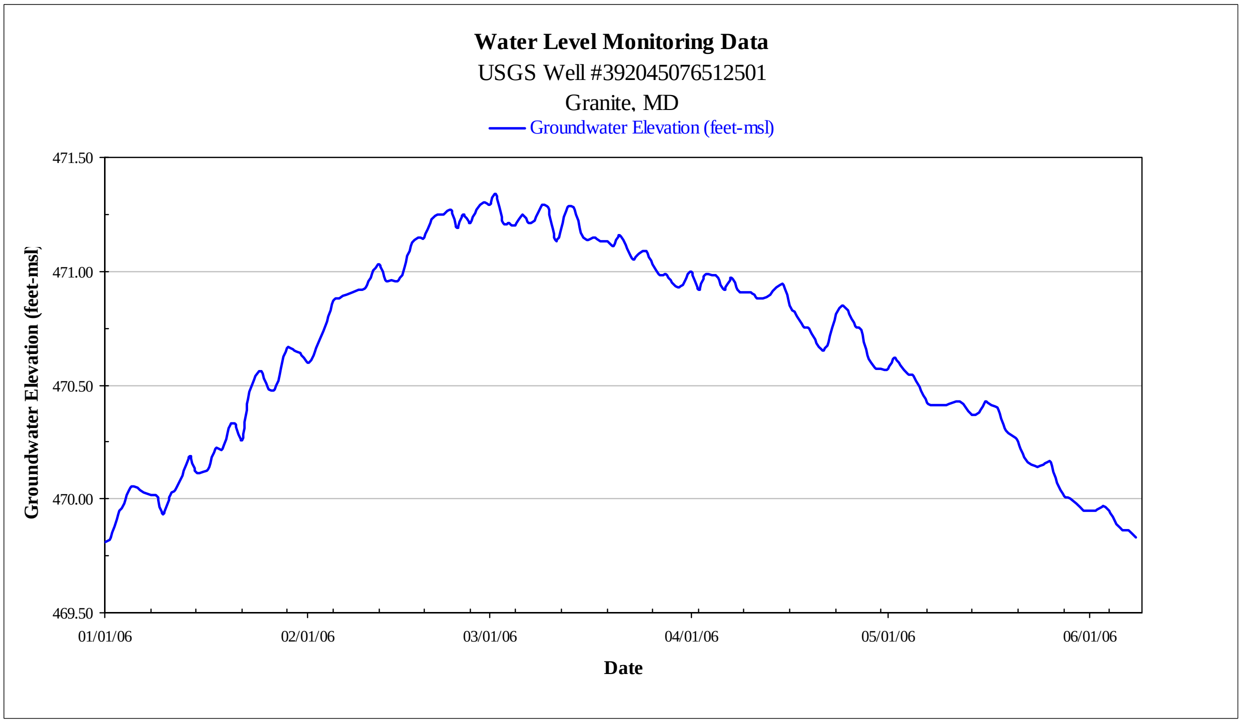
Well gauging data are provided in Table 6. Figure 17 shows the LPH distribution measured during the investigation. Figure 18 shows the LPH distribution under interim remediation conditions on June 5, 2006. Figure 7 presents the groundwater potentiometric surface elevation contour map as measured on June 5, 2006, under interim remediation conditions. The June 5, 2006, potentiometric surface elevation contour map is presented because it is the most recent groundwater potentiometric surface elevation contour map for the data presented herein. The groundwater monitoring well network was also substantially complete prior to June 9, 2006.

Data logging pressure transducers were also deployed in some unused potable wells in the vicinity of the site for the purpose of monitoring water levels over time in potable wells in the vicinity of the interim remedial measures area. Additionally, gauging data from USGS Well #392045076512501 are being acquired to provide an indication of the overall groundwater level trends in the region. These data are presented up through June 9, 2006, consistent with the date range of this report. The USGS well is located on the east edge of Patapsco Valley State Park, approximately 15 miles from the site. Hydrographs from unused potable wells are provided in Appendix E. The following hydrograph corresponds to unused potable wells in the study area and are plotted with the hydrograph from the USGS well located approximately 15 miles from the site for comparison to regional groundwater level trends for a two-month period during interim remedial activities. The water level gauging data presented for the two unused potable wells were selected to represent conditions northeast and southwest of the station property. These data were also relatively free of disturbances associated with factors such as groundwater sampling.



Note: Plotted data are average daily water levels.

Data from the USGS well from the beginning of 2006 are plotted in the following graph to illustrate the longer term groundwater level trend in the region:



Note: Plotted data are average daily water levels.

These data indicate a regional trend of decreasing groundwater levels since March 2, 2006, that is apparently due to seasonal fluctuation. This trend is also reflected in the local water level data.

5.2.2 Groundwater Sampling

Four types of wells were sampled according to their use and purpose: (1) monitoring wells (i.e. contained no remedial equipment); (2) remediation wells (i.e. contained remedial equipment such as a pump); (3) open borehole wells (i.e. series "C" wells without a constructed PVC well); and (4) FLUTe™ wells. The depth, purge volume, and type of well dictated the method by which the well was purged and sampled. Purged groundwater is temporarily stored in a portable polyethylene carboy then pumped through disposable tubing into the onsite fractionation tanks for eventual shipment to an approved disposal facility or treatment on site.

Monitoring wells are typically purged by one of two methods, bailer or electric pump. Manual bailing is typically used to remove smaller volumes of water from 2- or 4-inch diameter shallow wells. The bailer is decontaminated between wells to minimize the potential for cross-contamination. An electric submersible pump is used to purge larger volumes of water associated with the 4- or 6-inch diameter deeper wells. In either case, wells are sampled using a bailer. The pumps are decontaminated between well locations and used discharge tubing is replaced with new tubing.

Remediation system wells contain pneumatic pumps, electric pumps or a drop tube used in dual-phase extraction (DPE). During normal operation, groundwater is recovered from these wells on a frequent or continuous basis and therefore purging is not necessary. Samples are collected from the remediation wells either by deploying a disposable, polyethylene bailer into the well to collect a grab sample or by opening a sample tap on the discharge pipeline to collect a sample directly into the appropriate container(s). Remediation wells that are not actively pumping are purged and sampled following the monitoring well sampling protocols.

FLUTe™ liners were installed into selected series "C" wells in order to obtain samples at specific depth intervals within the well. Through a set of interconnected tubing and check valves, compressed nitrogen was applied to displace water from the FLUTe™ sample port to the surface. Once the tubing was purged, a groundwater sample was collected directly into the appropriate container(s).
Groundwater samples are submitted to Accutest for analysis according to the Maryland VOC list, including oxygenates, in accordance with SW846 Method 8260B. Groundwater sampling results are summarized in Table 7 and shown on Figures 19 and 20. Copies of the complete groundwater laboratory analytical reports are provided as Appendix F.

5.2.3 Discussion of LPH and Dissolved-Phase Hydrocarbon Distribution

Figures 17 and 18 present the historic and recent extent of measurable LPH in the subsurface during the course of this investigation. Inspection of these figures indicates that LPH migrated along a linear trend to the southwest and northeast away from the service station property. This linear trend has been termed the "strike line" because it is parallel/subparallel to the strike of the bedrock foliation. The southwest and northeast strike lines are slightly offset and follow slightly different orientations. The farthest extent of measurable LPH to the southwest was measured at MW-72 (352 feet from the station property boundary). The farthest extent of measurable LPH to the northeast was measured at MW-77A (1,159 feet from the station property boundary). LPH migration beyond these two locations has not been observed. Additionally, interim remedial measures have reduced the extent of measurable LPH to a few wells located on or very close to the service station property (Figure 18).

Figures 19 and 20 present the recent (data through June 9, 2006) distribution of dissolved MTBE and benzene in groundwater, respectively. MTBE and benzene are mapped as indicator compounds to represent the distribution of dissolved-phase hydrocarbon constituents in groundwater. Dissolved-phase hydrocarbon migration has also extended to the southwest and northeast in an elongate pattern that is generally consistent with the line of bedrock foliation strike and the direction of decreasing potentiometric surface elevations (Figure 7). Dissolved-phase hydrocarbons have been detected beyond the historic extent of LPH associated with the site. Analytical results for surface water samples collected from the gaining streams northeast and southwest of the site have been below the laboratory reporting limits (i.e., non-detect) for the respective analytes.

5.3 Geophysical Investigation

Surface and borehole geophysical investigation methods were conducted at the site by ARM Group Inc. The *Geophysical Survey Report* prepared by ARM Group Inc. is provided as Appendix G.

5.3.1 Surface Geophysical Investigation

Geophysical measurement techniques were employed in an attempt to supplement physical observations regarding spatial differences in the physical properties of soil and rock. These methods provide a supplemental means of broadly screening for subsurface features that may not be as readily identified by conventional intrusive investigation methods. Geophysical results may (1) potentially indicate the presence of a subsurface anomaly that requires additional investigation, (2) be supportive of other lines of evidence on which a conceptual model is based, or (3) be inconclusive. Three types of surface geophysical methods were employed:

- Electrical Resistivity Imaging Surveys
- Seismic Surveys
- Gravity Surveys

The *Geophysical Survey Report* provides a detailed description of the various geophysical methods employed, the field data collection activities specific to the study area, and processing/analysis of the geophysical data. Figure 21 presents a site plan showing the location of surface geophysical testing locations and arrays.

<u>Electrical Resistivity Imaging Surveys</u>

Electrical resistivity imaging data were acquired from five transects within the study area (Figure 21). The objective of acquiring electrical resistivity imaging data was to identify zones with contrasting hydrogeologic properties. Specifically, soil, competent bedrock, and fractured/weathered bedrock possess differing properties of electrical conductivity. Additionally, the degree of water saturation of soil or rock can also be reflected in the electrical resistivity measurement.

The *Geophysical Survey Report* provides a detailed description of the electrical resistivity imaging results. The narrow zone of hydrocarbon migration in groundwater generally appears to occur coincident to more electrically conductive zones identified in traverses that are located farther from the service station property. Based on the *Geophysical Survey Report*, the more electrically conductive zones may be attributable to a combination of weaker/weathered rock that tends to have higher porosity and to be more saturated with groundwater.

<u>Multi-Channel Analysis of Surface Waves – Seismic Surveys</u>

Seismic data were acquired from four transects using the Multi-Channel Analysis of Surface Waves (MASW) method. The seismic profiles were coincident with four of the electrical resistivity profiles (Figure 21). The objective of the MASW survey was to profile the bedrock surface based on the difference in velocities of seismic waves that travel through differing geologic materials. Seismic waves generally travel more rapidly through more rigid materials (e.g., bedrock).

According to the *Geophysical Survey Report*, the MASW data correlate with boring logs prepared during the site investigation. Zones of low seismic velocity were identified coincident with, and in proximity to, zones of hydrocarbon migration in groundwater. The zones of low seismic velocity are characteristic of less competent bedrock, which tends to be more conducive to fluid migration.

Microgravity Survey

A microgravity survey was conducted on the service station property. Microgravity data were also collected along profile lines that traverse the properties directly east of the intersection of State Routes 145 and 146 (i.e., 14301 and 14307 Jarrettsville Pike). The microgravity survey may potentially be applied to facilitate the identification of variations in subsurface lithology or degree of weathering due to differences in material density, which yield different gravity signatures.

The *Geophysical Survey Report* provides a detailed description of the microgravity survey results. Microgravity survey data reveal a trend from higher gravity measurement to the north-northwest trending to lower gravity measurements to the south-southeast. This pattern is likely indicative of a change in lithology. This observation is consistent with observations from various drilling locations that have identified different lithology in the north compared to that in the south. Specifically, the rock core extracted from the MW-18 location was hard, competent rock of a distinctly mafic lithology (i.e., rich in dense, ferromagnesian minerals). A rock core sample acquired to the south from the MW-23 drilling location (and across the direction of strike) is a weathered schist, rich in low-density minerals (e.g., mica). Additionally, the *Geophysical Survey Report* identifies a southwest-northeast trending low density feature through the area of the gravity survey.

5.3.2 Borehole Geophysical Investigation

Geophysical borehole logging was conducted in 11 bedrock boreholes/wells that were drilled at locations throughout the study area from southwest to northeast (Figure 21). The *Geophysical Survey Report* provides a detailed description of the borehole geophysical logging conducted. The following borehole geophysical methods were implemented:

- Optical Televiewer
- Acoustic Televiewer
- Caliper
- Fluid Temperature
- Natural Gamma
- Fluid Resistivity
- Spontaneous Potential
- Resistivity
- Single Point Resistance
- Heat Pulse Flow Meter

The objectives of the borehole geophysical logging were to identify the depth and structural orientation of secondary porosity features (bedrock foliation, fractures, and joints) and to evaluate the water-bearing characteristics of these features.

Table 8 presents a compilation of the strike and dip measurements of secondary porosity features measured with borehole geophysical instrumentation. Structural data from multiple foliation measurements from each boring location indicate a strong strike orientation from southwest to northeast across the study area. The strike orientation of joints (which include partings along foliation) is also strongly aligned southwest-northeast. In addition to this general trend, the strike of measured joint orientations is somewhat variable, particularly in the 14301 Jarrettsville Pike private supply well and MW-56C.

5.3.3 Discussion of Geophysical Testing Results

The surface and borehole geophysical results provide supplemental data regarding the subsurface hydrogeologic framework that acts to control the groundwater flow regime; however, these testing results do not reveal distinct subsurface anomalies that can be identified with extreme clarity. The following observations are made based on the geophysical results obtained:

- In some instances, more electrically conductive zones in the subsurface can be identified coincident with the "strike line" of hydrocarbon migration in groundwater. This can be explained by the fact that fracture-filled saturation with ionic groundwater would be more electrically conductive than unfractured bedrock, which is relatively electrically resistive.

- Microgravity survey data indicate contrasting rock density from north to south: higher density in the north and lower density in the south. This is consistent with the contrasting lithology identified at individual drilling locations from north to south. These data also indicate a zone of higher density protruding in a southeasterly direction underneath 14301 Jarrettsville Pike. Microgravity survey data also indicate the existence of a northeast-southwest trending weathered zone through the service station and the 14301 Jarrettsville Pike properties that generally trends in the direction of the strike of the bedrock foliation and local topographic features.

- Borehole geophysical data indicate a dominant foliation and joint orientation trending northeast-southwest, which has been corroborated by local geologic observations in the study area (e.g., Photo 1, embedded in the Area Geology section of this report) and geologic mapping in the area. Borehole geophysical data for some locations also indicate a general lack of fractures at greater depths (commonly deeper than 55 to 75 feet bgs) within the boreholes tested.

5.4 FLUTe™ Liner Installation and Conductivity Profiling

In March and April 2006, flexible tubular liners were installed in bedrock monitoring wells MW-41C, MW-53C, MW-56C, and MW-78C. The liners, manufactured by FLUTe™, were utilized as a means to determine the location and flow characteristics of fractures (or other flowpaths such as joints, solution channels, etc.) intersected by the boreholes, and to facilitate discrete sampling of zones of interest within each well. Velocity profiles from the relative hydraulic conductivity (K) profiling are provided as Appendix H.

5.4.1 Relative Hydraulic Conductivity Profiling Procedure

In March 2006, monitoring wells MW-41C, MW-56C, and MW-78C were profiled during installation of "blank" FLUTe™ liners. The blank liner is a flexible, urethane-coated nylon tube, closed at one end, and having a tether line that extends within the interior of the liner from the closed "bottom" end to the open "top" end. The liner arrives at the site spooled on a reel. To begin the profiling, the depth to water in the well is measured. The open end of the liner is attached to the well head. A length of the liner is then manually inserted into the well, forming a pocket. Clean water is then gradually and continually introduced into the pocket by means of a hose. The potable water supply was provided by South Jersey Water Conditioning, Inc. The weight of the water causes the liner to roll out (evert) into the borehole. Once the eversion point of the liner reaches the groundwater surface, an excess head within the liner (i.e. head above the static water level) is maintained. This differential head provides the necessary driving pressure to evert the liner downward within the borehole until all significant flowpaths have been sealed. During this process, FLUTe™ utilizes a patented device (the "Profiler") consisting of a series of rollers to precisely measure the descent velocity of the liner and head within the liner. Data are analyzed real-time through proprietary software to provide the user with velocity versus depth data, which may be used to evaluate the relative hydraulic conductivity of fractured zones within a borehole.

5.4.2 Water FLUTe™ Sampling System Installation

In March and April 2006, Water FLUTe™ sampling systems were installed in bedrock monitoring wells MW-41C, MW-53C, MW-56C, and MW-78C. A Water FLUTe™ is a flexible liner system, similar to the blank liner previously described, which is manufactured with sampling ports set at pre-determined depths, which correspond to zones of interest within a borehole, based on the identification of potential fractures identified with borehole geophysical logs. The portion of the borehole to be sampled is defined by a spacer and sample port fitted to the outside of the liner. Groundwater from the formation enters the interstitial space between the spacer and the borehole wall, and enters the perforated sampling tube. The water within the sampling tube is subsequently lifted to the surface by means of a specialized pump system attached to each sample port. The sample intervals in each monitoring well are summarized in the table below.

Water FLUTe™ Sampling Intervals

Well ID	Sampling Ports	Sampling Intervals (feet bgs)
MW-41C	4	75-80
		95-97
		120-130
		190-195
MW-53C	2	215-220
		225-235
MW-56C	3	100-110
		310-315
		320-325
MW-78C	1	60-70

The sampling intervals for the Water FLUTe™ system were selected based on drilling observations and geophysical data discussed in Section 5.3.

5.4.3 Summary of Results

Monitoring Well MW-41C

Static depth to water in MW-41C was measured at approximately 25 feet below top of casing. The last transmissive flowpath within the borehole was encountered at a depth of approximately 148 feet bgs, as indicated by the velocity versus depth profile (Appendix H). Descent rates below that depth slowed to 0.0018 feet per second per pound per square inch (ft/sec/psi).

Monitoring Well MW-53C

Profiling of monitoring well MW-53C was not conducted, because geophysical logging of this borehole indicates few secondary porosity features similar to MW-56C in which FLUTe™ deployment was extremely slow.

Monitoring Well MW-56C

Depth to water in MW-56C was measured at approximately 12 feet below top of casing. The installation began as described previously; however, liner descent velocity slowed abruptly at the groundwater surface. An excess head of approximately 12 feet was maintained, but descent velocities did not exceed 0.001 ft/sec/psi. Such a finding is useful, because it indicates very low transmissivity (T) within the borehole below the steel casing. Geophysical data collected previously from MW-56C corroborated this finding, and the profiling effort was terminated. The sampling intervals for the Water FLUTe™ system were selected based on geophysical data discussed in Section 5.3 that indicated the possibility of a few fracture features. The velocity profile for MW-56C is presented in Appendix H.

Monitoring Well MW-78C

The static water level in MW-78C was measured at approximately 4 feet below top of casing. Due to the shallow water table at this location, the well casing was temporarily extended to a height of approximately 4.5 feet above grade. This extension was deemed necessary to allow sufficient head differential to evert the liner. Scaffolding was erected over MW-78C to elevate the Profiler and roller to a sufficient height. The liner was attached to the temporary casing, and the profiling proceeded from that point according to the procedure described previously. Liner descent velocity decreased abruptly as the liner exited the casing. Descent rates below a depth of 80 feet dropped to 0.001 ft/sec/psi, which suggest there is minimal flow below that depth. The velocity profile from which the Water FLUTe™ sampling interval for MW-78C was selected, are included in Appendix H.

5.4.4 Discussion of Relative Hydraulic Conductivity Profiling Results

The relative hydraulic conductivity profile for MW-41C represents one location where productive fractures may exist at depth; however, the relative hydraulic conductivity profiling results from the other wells tested indicate that borehole hydraulic conductivity commonly diminishes considerably at depths below the bottom of the casings (60 feet). This is consistent with borehole geophysical testing that also indicates a common decrease in fracture density at greater depths.

5.5 Aquifer Testing

Aquifer testing was conducted to measure and estimate aquifer parameters (transmissivity and hydraulic conductivity), evaluate pumping well performance, and evaluate hydraulic influence and anisotropy within the aquifer. Specifically, slug tests and pumping tests were conducted, as described in the following sections.

5.5.1 Rising Head Slug Testing

A total of 127 rising head slug tests were performed on 42 monitoring wells between March 24, 2006 and May 19, 2006. Slug testing was conducted by measuring the depth to water with an EIP, installing a pressure transducer (In-Situ MiniTroll®) to approximately the middle of the screened interval of the well, measuring the return of the water table to static level, removing a solid slug of known volume from the well, and measuring the water level until approximately 90% of the drawdown had been recovered. The test was performed three times on each well, with the exception of wells MW-4 and MW-87P, which were tested four times, and well MW-89, which was tested twice.

Due to physical encumbrances between the slug and the pressure transducer, four slug tests were not analyzed (MW-142 Test #1; and MW-148A Tests #1, #2, and #3). Additionally, a preliminary review of the data collected from MW-148B Tests #1, #2, and #3 indicated that the borehole wall was solid and not transmissive, based on no measurable change after the initial displacement of the slug in or out.

The monitoring wells that were slug tested are constructed with screened intervals in the saturated overburden and/or bedrock. Those monitoring wells screened entirely within the competent bedrock are presumed to intersect water-bearing fractures.

The slug test data were analyzed using the Bouwer and Rice method (Bouwer and Rice, 1976; Bouwer, 1989) for evaluation of K in unconfined aquifers. This analytical method should also provide reasonable estimates of K for confined aquifer conditions that may be encountered on site (Bouwer, 1989). The analyses were performed using commercially available aquifer test analysis software (Aquifer Test for Windows [ATW] and AQTESOLV™ for Windows). The resulting data are considered order of magnitude estimates, and are valuable collectively, as they illustrate the relative differences in hydraulic conductivity distribution of the aquifer.

The K determined by the analyses ranged from 0.1 feet per day (ft/day) for Test #1 conducted in MW-46 to 15.8 ft/day for Test #3 conducted in MW-133B. The geometric mean of all slug tests analyzed was 3 ft/day, and the variability, as standard deviation, was 4.01. For those monitoring wells analyzed which were screened entirely in the bedrock (MW-41A, MW-50, MW-62A, MW-73, MW-87P, MW-91, MW-94, MW-103, MW-107, MW-108, MW-120, MW-125, MW-126, MW-130, MW-143, and MW-149), the maximum K calculated was 13.7 ft/day, the minimum K calculated was 0.2 ft/day, the geometric mean of K was 2.27 ft/day, and the variability, as standard deviation, was 4.15. A summary of these results is provided in Table 9 and the Bouwer-Rice solutions for each of the slug tests are attached as Appendix I.

5.5.2 Pumping Tests

Aquifer pumping tests, including a step-drawdown test and constant-rate pumping tests, have been conducted to assess the aquifer properties in two areas of the site. These tests were conducted as opportunities permitted. Specifically, it was not desirable to stop ongoing interim remedial measures longer than necessary to conduct a more prolonged pumping test. On April 12 through 14, 2006, a pumping test was conducted using an electric submersible pump installed in MW-77B in order to estimate aquifer parameters and hydraulic influence in the northeastern portion of the site. On May 8 through May 12, 2006, a pumping test was performed using an electric submersible pump installed in MW-112 in order to estimate aquifer parameters and hydraulic influence in the southwestern portion of the site. Groundwater extracted during these tests was pumped through the interim remedial measures piping and containerized before being shipped off-site for proper disposal. A pumping test calculation brief is provided as Appendix J.

<u>Northeast Pumping Test (MW-77B)</u>

On April 13, 2006, MW-77B (the extraction well for this pumping test), MW-77A, MW-77R, MW-82R, MW-89, MW-106, MW-61A, MW-61B, MW-76P, MW-81, MW-48A, and MW-48B were gauged using an EIP. Additionally, In-Situ Inc. MiniTroll® pressure sensors were deployed in monitoring wells MW-61A, MW-76P, MW-77R, MW-80B, MW-82, and MW-83R. Sensors were pre-programmed to record data on a linear scale at one-minute time intervals. Remedial system wells were shut down in the area and the aquifer was allowed to recover. Pumping from MW-77B began at approximately 5:41 p.m. on April 13, 2006. The average pumping rate was 10.6 gpm. Pumping was continued for approximately 1,441 minutes, and the pump was turned off at approximately 5:39 p.m. on April 14, 2006.

Hydraulic conductivity results calculated from the MW-77B pumping test are summarized below. Additional details about the analysis are provided in the pumping test calculation brief (Appendix J).

Summary of MW-77B Pumping Test Hydraulic Conductivity Results

K (ft/day)	Method of Analysis	Data Collection	Observation Wells
15.8	Cooper-Jacob Distance-Drawdown	Manual Gauging	MW-61A, MW-77R, MW-81, MW-83R
15.5	Cooper-Jacob Distance-Drawdown	Pressure Transducers	MW-61A, MW-77R, MW-81, MW-83R
13.6	Cooper-Jacob Time-Distance Drawdown	Pressure Transducers	MW-77R, MW-80B, MW-83R

Southwest Pumping Test (MW-112)

On May 8, 2006, at approximately 10:00 a.m., water levels were measured at extraction well MW-112 and the surrounding observation wells using an EIP prior to installation of the pressure sensors. At approximately 3:00 p.m., In-Situ Inc. MiniTroll® pressure sensors were deployed to a depth of approximately one-foot above the top of pump in wells MW-40, MW-63, MW-72, MW-102, MW-111, MW-112, MW-113, MW-118, MW-119, and MW-124. Pressure sensors were pre-programmed to record data on a linear scale at one-minute time intervals beginning at 5:00 p.m. on May 8, 2006.

A recovery test to monitor groundwater recovery upon temporary shutdown of the interim remedial system in the area of the pumping test was conducted. At approximately 6:00 p.m. on May 8, 2006, the groundwater extraction pumps in wells MW-40, MW-55, MW-60, MW-71, MW-72, MW-102, MW-111, MW-112, MW-113, MW-116, MW-117, MW-118, MW-119, MW-123, MW-124, and MW-126 were deactivated, and recovery data were recorded. The MiniTroll® sensors deployed in wells MW-40, MW-63, MW-72, MW-102, MW-111, MW-112, MW-113, MW-118, MW-119, and MW-124 were deactivated at approximately 8:00 a.m. on May 10, 2006. On May 10, 2006, at approximately 12:00 p.m. and 3:00 p.m., water levels were re-measured using an EIP in the wells around MW-112. The duration of the initial recovery test was approximately 2,280 minutes, from 6:00 p.m. on May 8, 2006 through 8:00 a.m. on May 10, 2006.

On May 10, 2006, a step-drawdown pumping test was conducted to determine the performance of the extraction well, MW-112. Based on flow data collected at this well during remedial pumping conditions, four steps were planned at flow rates of 3, 5, 7 and 9 gpm. Prior to the test, the MiniTroll® sensor in this well was programmed to record data on a linear scale at five-second (0.083-minute) time intervals. At approximately 7:15 a.m. the Grundfos Redi-Flo4® electric submersible pump, set 38.9 feet below the top of the well casing of MW-112, was activated and the flow rate was adjusted to approximately 2.6 gpm. This flow rate was maintained for approximately 200 minutes and water levels in well MW-112 were measured periodically using an EIP. At approximately 10:35 a.m. the flow rate was adjusted to the second step of approximately 5.0 gpm and water levels in well MW-112 were measured for 185 minutes. At approximately 1:40 p.m. the flow rate was adjusted to the third step of approximately 6.7 gpm and water levels in well MW-112 were measured for 200 minutes. At approximately 5:00 p.m. the flow rate was adjusted to the fourth and final step of approximately 9.1 gpm and water levels in well MW-112 were measured for 180 minutes. At the conclusion of the step-drawdown pumping test, the submersible pump in well MW-112 was deactivated and the water level was allowed to recover in advance of the constant-rate pumping test.

Based on the step-drawdown test, a pumping rate of approximately 7 gpm was selected for a 1,920-minute, constant-rate pumping test conducted on May 11 and 12, 2006. Prior to the initiating the test, the following activities were completed:

- MiniTroll® sensors deployed in wells MW-40, MW-63, MW-72, MW-102, MW-111, MW-112, MW-113, MW-118, MW-119, and MW-124 were programmed to record data on a linear scale at five-second (0.083-minute) time intervals beginning at 8:00 a.m. on May 11, 2006

- To augment data collection, additional MiniTroll® sensors were installed into wells MW-55, MW-60, MW-71, MW-116, MW-117, MW-120, MW-122, MW-123, MW-126, and MW-140B and programmed to record data on a linear scale at five-second (0.083-minute) time intervals beginning at 8:00 a.m. on May 11, 2006

- Water levels were measured at extraction well MW-112 and the surrounding observation wells using an EIP

During the pumping test, both an analog and a digital flow meter and totalizer were used to record the volume pumped and the instantaneous flow rate. The flow rate of the pump was directed using an electronic frequency control. Water table levels were recorded using pressure transducers in MW-112, MW-113, MW-120, MW-122, MW-123, MW-124, and MW-140B. The electronic water level measurements were augmented by manual measurements for depth to water recorded using EIPs.

The average overall pumping rate was 6.7 gpm. At the end of 1,920 minutes of pumping, the drawdown in MW-112 was 11.61 feet. After approximately 1,920 minutes of pumping, the pump was deactivated and the return of the water table towards static pre-pumping elevation (residual drawdown) was recorded for a period of approximately 105 minutes.

Hydraulic conductivity results calculated from the MW-112 pumping test are summarized below. Additional details about the analysis are provided in the pumping test calculation brief (Appendix J).

Summary of MW-112 Pumping Test Hydraulic Conductivity Results

K (ft/day)	Method of Analysis	Data Collection	Observation Wells
28.9	Cooper-Jacob Distance Drawdown (corrected for recharge)	Manual Gauging	MW-60, MW-63, MW-64, MW-67, MW-70, MW-113, MW-120, MW-122, MW-123, MW-126, MW-140A, MW-140B
33.6	Cooper-Jacob Distance Drawdown (uncorrected for recharge)	Manual Gauging	MW-60, MW-70, MW-113, MW-120, MW-122, MW-123, MW-140A, MW-140B
23.9	Cooper-Jacob Distance Drawdown (at 1680 minutes, uncorrected for recharge)	Pressure Transducers	MW-113, MW-120, MW-122, MW-123, MW-140B
21.0	Cooper-Jacob Distance Drawdown (at 1980 minutes, uncorrected for recharge)	Pressure Transducers	MW-113, MW-120, MW-122, MW-123, MW-140B
28.1	Cooper-Jacob Time-Distance-Drawdown	Pressure Transducers	MW-122, MW-123
11.6	Cooper-Jacob Time-Distance Drawdown	Pressure Transducers	MW-120

5.5.3 Discussion of Aquifer Testing Results

This section provides a preliminary summary and assimilation of aquifer testing results, and is subject to change based on additional data and review of information.

Hydraulic Conductivity

Hydraulic conductivity results calculated via slug and pumping test analyses are displayed and contoured on Figure 22. Inspection of this spatial presentation of hydraulic conductivity results reveals an elongate, longitudinal distribution pattern trending northeast-southwest with a core of greater hydraulic conductivity (8 to 28.9 ft/day) transitional to values of lesser hydraulic conductivity at the periphery (<1.0 ft/day). This pattern is generally coincident with (1) the observed distribution of hydrocarbon constituents in groundwater; (2) the strike of the bedrock foliation; and (3) physiographic features (e.g., stream channels incised into bedrock).

The hydraulic conductivity results from distance-drawdown analyses conducted for the northeast (MW-77B) and southwest (MW-112) pumping tests were selected as being most representative of the pumping test analyses for the following reason:

- The distance-drawdown method is considered less susceptible to the effects of background recharge during aquifer pumping tests than time-drawdown methods, and can be more easily corrected

The distance-drawdown method incorporates multiple monitoring points in the aquifer, thus providing a broader number of spatial samples, and a means of evaluating whether these data fit a predictable trend on a distance-drawdown plot.

Hydraulic Influence

The following table summarizes the greatest distance at which drawdown was measured relative to the structural orientation of the bedrock foliation:

Summary of Farthest Distances from Pumping Wells at which Drawdown was Measured

Pumping Well	Observation Well	Distance (feet)	Drawdown (feet)	Structural Orientation
MW-77B	MW-61A	185	0.07	Updip
	MW-81	223	0.09	Along Strike (Downgradient)
MW-112	MW-70	268	0.04	Updip
	MW-113	122	0.08	Along Strike (Downgradient)

Note: Drawdown reflects measured data not corrected for background recharge (aquifer recovery due to remedial shutdown and/or regional recharge).

5.6 On-Site Soil Quality

During the course of the soil investigation, UST system sampling, and remedial soil excavations, 98 soil samples have been collected to evaluate the on-site soil quality. A summary of the on-site soil sampling conducted to date has been provided in this section. Table 10 summarizes the soil analytical data. The soil laboratory analytical reports are provided as Appendix K.

5.6.1 Soil Investigation

On February 18 and 19, 2006, during the installation of monitoring wells MW-5, MW-6 and MW-7, soil samples were collected to characterize soil quality in proximity to the UST area. Soil samples RW-5 (16-16.5), RW-6 (20-20.5) and RW-7 (30-30.5) were collected based on VOC detections with a PID. As summarized in Table 10, all hydrocarbon-related VOCs were either not detected at or above the laboratory reporting limit or were detected at concentrations below the MDE Soil Protection of Groundwater Standards.

5.6.2 UST System Sampling

During the period of March 1 through April 10, 2006, UST system decommissioning activities were conducted which included the removal of two 8,000-gallon gasoline USTs, one 12,000-gallon gasoline UST, one 10,000-gallon diesel UST and associated product piping. A total of 74 soil samples were collected from the vicinity of the UST system (Figure 23 and Table 10). The results of these activities were previously reported to the MDE in the *Tank Excavation Assessment Report* (GSC|Kleinfelder, April 28, 2006). A copy of the report is included in Appendix L.

5.7 Soil Vapor Assessment

At the direction of the MDE, a soil vapor sampling program was conducted at several properties located to the northeast of the service station property. A "Scope of Work for Soil Vapor Sampling and Analysis" (Scope of Work) was submitted to the MDE on March 30, 2006. The objectives of the Scope of Work were to provide an initial assessment of the soil vapor conditions around the foundations of three structures located at 3503, 3506, and 3508 Hampshire Glen Court, and enable periodic monitoring of soil vapor conditions at these locations. The Scope of Work was expanded at the request of MDE to include 14301 Jacksonville Pike, 3504 Hampshire Glen Court, and 3600 Hampshire Glen Court. As directed by MDE, the program currently includes monthly soil vapor sampling at the five residences and the bank.

The soil vapor sampling program has been conducted in accordance with the Scope of Work dated March 30, 2006, which was approved by the MDE in an e-mail dated March 31, 2006, and amended in a letter from the MDE dated April 28, 2006. The soil vapor sampling results and recommendations for monitoring were presented in the letter report dated May 5, 2006, titled *Soil Vapor Sampling and Analysis Report*. A supplemental report will also be submitted. Supporting documentation for the soil vapor assessment is provided as Appendix M. The work performed and the results of the soil vapor sampling program are summarized below. Details regarding the sampling and analytical methods, a full listing of analytical results and data evaluation are provided in Appendix M.

5.7.1 Soil Vapor Sampling Program

The sampling events conducted at the direction of the MDE are summarized below:

- Soil vapor sampling points were installed, soil vapor samples were collected, and ambient air samples were collected at four properties from April 5 through April 19, 2006. These properties include the following:

    - 3503 Hampshire Glen Court
    - 3506 Hampshire Glen Court
    - 3508 Hampshire Glen Court
    - 14301 Jarrettsville Pike

- From April 18 through April 28, 2006, confirmatory soil vapor samples were collected from the sampling points at each of the four above-referenced properties.

- On April 20 and April 28, 2006, two additional rounds of confirmatory soil vapor samples were collected at 3506 Hampshire Glen Court.

- Pursuant to an April 28, 2006 letter from the MDE (Appendix M), the 3504 and 3600 Hampshire Glen Court properties were added to the soil vapor sampling program. Accordingly, from May 11 through May 12, 2006, soil vapor sampling points were installed; soil vapor samples were collected; and ambient air samples were collected at these two properties.

- In accordance with recommendations presented in the *Soil Vapor Sampling and Analysis Report*, dated May 5, 2006, and approved by the MDE, soil vapor samples were collected at four properties from May 10 through May 19, 2006. These properties included the following:

- 3503 Hampshire Glen Court
- 3506 Hampshire Glen Court
- 3508 Hampshire Glen Court
- 14301 Jarrettsville Pike

Monthly Sampling

In accordance with recommendations presented in the May 5, 2006, *Soil Vapor Sampling and Analysis Report*, and as directed by the MDE in a June 2, 2006 letter, monthly soil vapor sampling is being conducted at six properties in the vicinity of the service station property. These six properties are identified as follows:

- ➢ 3503 Hampshire Glen Court
- ➢ 3504 Hampshire Glen Court
- ➢ 3506 Hampshire Glen Court
- ➢ 3508 Hampshire Glen Court
- ➢ 3600 Hampshire Glen Court
- ➢ 14301 Jarrettsville Pike

5.7.2 Discussion of Soil Vapor Analytical Results

Analytical results for the soil vapor and ambient air samples collected at 3503, 3504, 3506, 3508, and 3600 Hampshire Glen Court and 14301 Jarrettsville Pike are summarized in Appendix M (Tables 11 though 16, respectively). These data tables include the results for those VOCs that were detected at least once in any of the samples collected during the course of the investigation. The complete analytical reports are also included in Appendix M.

Based upon the evaluation of data presented in the *Soil Vapor Sampling and Analysis Report*, dated May 5, 2006, the current soil vapor sampling results do not indicate potential for measurable contribution of VOCs to indoor air. The results of the soil vapor monitoring conducted subsequent to May 6, 2006, are similar to the prior results and do not indicate potential for measurable contribution of VOCs to indoor air. In a letter dated June 2, 2006, the MDE noted that levels detected are below any relevant risk level.

6.0 INTERIM REMEDIAL MEASURES

Interim remedial measures have been conducted concurrently with assessment activities. The *Interim Remedial Measures Plan* (GSC|Kleinfelder, March 27, 2006) previously submitted to the MDE provides a description of the initial remedial response at the site and the plan for implementation of interim remedial measures. The following paragraphs summarize the interim remedial measures at the site. The interim remediation system layout is presented on Figure 24.

6.1 Groundwater and Liquid-Phase Hydrocarbon Recovery

Groundwater and LPH (if present) are currently being recovered using pneumatic and electric submersible pumps. Groundwater and LPH (if present) are also recovered using DPE. A summary of the interim remedial measures operational flow rates is provided in the following table:

Summary of Interim Remedial Measures Groundwater Extraction

Location	Operating Flow Rate Range (gpm) Low	High	Wells in Zone
NE area			
NE transverse capture line			
- @ MW-77 pumping line	7.8	13.9	MW-77,82,83
- end of NE piping	2.0	4.0	MW-78,80,100
NE core area/mass removal			
- commercial properties	4.3	7.2	MW-32,37,38,45,84,85
- DPE	0.5	1.5	MW-36,74,75
- recovery wells along strike	4.7	5.8	MW-43,57,58,59,76,137
NE area Subtotal	***19.3***	***32.4***	
SW area			
SW transverse capture line			
- @ MW-71 pumping line	4.8	8.4	MW-55,60,71,113,116,117
- @ MW-72 pumping line	1.0	3.0	MW-2,102,111,112,118,119, 123,124
SW core area/mass removal			
- SW of detention basin	0.5	1.0	MW-40,49,51,126,127
- detention basin	1.0	6.0	MW-29,30,31,33,34,35
- service station (SW of dispenser)	3.0	4.0	MW-1,2,9,17,19,21,22,23,24, 25,26,28,52,109
- service station (DPE)	0.6	1.0	MW-3,4,6,7,13,16,27,144
SW area Subtotal	***10.9***	***23.4***	
TOTAL	***30.2***	***55.8***	

Notes:
Data presented are from May to June 7, 2006

Fluids recovered through the DPE system are separated from extracted vapors in a phase separator tank. Recovered groundwater is conveyed into 21,000-gallon fractionating tanks that are staged on the service station property and 3410 Sweet Air Road. The contents of the fractionating tanks are transported off site daily by tanker trucks for disposal at International Petroleum Corporation in Wilmington, Delaware. A portion of recovered groundwater, treated by air stripping and carbon filtration systems located on 3313 Papermill Road and 3418 Sweet Air Road, is also being discharged under a National Pollutant Discharge Elimination System (NPDES) permit (2006-OGR-9826A [MDG919826A]) to the headwaters of the streams to the northeast and southwest of the site. Discharge occurs after sampling results are obtained verifying that the concentrations are in compliance with the permit discharge limits. The total amount of water and LPH transported off site and treated water discharged to surface water is reported to the MDE in the site status updates.

6.2 Vapor Phase Hydrocarbon Recovery

Vapor phase hydrocarbon recovery is currently conducted using soil vapor extraction (SVE) and DPE systems. Off gas in the southwest is treated through the flame oxidizer unit staged to the southwest of the service station, in accordance with the MDE Air and Radiation Management Administration (ARMA) general permit for SVE (Permit ID No. 005-9-1258). Vapors recovered via DPE in the southwest are treated through a thermal oxidizer unit (MDE ARMA general permit for SVE (Permit ID No. 005-9-1286). The off gas of each SVE/DPE system in the northeast is treated through either a thermal oxidizer unit located at 3410 Sweet Air Road, in accordance with the MDE ARMA general permit for SVE (Permit ID No. 005-9-1261), or a flame oxidizer unit located at 3410 Sweet Air Road (Permit ID No. 005-9-1285).

6.3 Remedial Soil Excavations

Interim remedial activities also addressed affected soil located on the service station property. As part of remedial investigation activities proposed to the MDE in the *Remedial Soil Excavation Plan* (GSC|Kleinfelder, April 11, 2006), soil excavation activities were conducted on April 10, 13 and 14, 2006, to address the sorbed hydrocarbons identified in the soil samples collected from the product and vapor recovery piping trenches. Soils were removed to depths ranging from 4 to 8 feet bgs based on VOC detections with a PID.

On April 10, 2006, a small soil excavation was conducted in the vicinity of piping samples PP-23 (3.5) and PP-24 (4.5). Soil was removed to a depth of approximately 6 feet bgs and one post-excavation soil sample (PE-1 (6.0)) was collected. All volatile constituents were below the laboratory reporting limit in sample PE-1 (6.0).

On April 13 and 14, 2006, a remedial soil excavation was conducted to address dispenser, product and vapor piping samples DI-1 through DI-7, PP-1 through PP-9, PP-12, PP-13 and PP-16 through PP-19. The final dimensions of the remedial excavation were 40 feet wide by 60 feet long. The remedial soil excavation depths are summarized as follows:

- North – 4 feet bgs
- South – 4 feet bgs
- Center – 6 feet bgs
- Southeast wall – 8 feet bgs

A total of 15 post-excavation soil samples (PES-2 through PES-16) were collected from the excavation (Figure 23). Two soil samples were collected from each sidewall at approximately 3 to 3.5 feet bgs. Four bottom samples were collected from 4 to 4.5 feet bgs along the northern and southern excavation extents. Eight bottom samples were collected from 6 to 6.5 and 8 to 8.5 feet bgs from the central and southeastern excavations, respectively. One additional sidewall sample was collected at 7 to 7.5 feet bgs from the deeper, 8-foot excavation. As shown on Table 10, adsorbed phase hydrocarbon concentrations in these soil samples were below the MDE Soil Protection of Groundwater Standards with the exception of naphthalene and total petroleum hydrocarbons – diesel range organics (TPH-DRO) in post-excavation soil sample PES-16 (3-3.5).

On May 17, 2006, an additional, limited remedial excavation was conducted to address the adsorbed phase hydrocarbons detected in post-excavation soil sample PES-16 (3-3.5). Soil was excavated from an area approximately 9 feet wide by 13 feet long by 4 feet deep. Three post-excavation soil samples (PES-16 36”, PES-17 36” and PES-18 48”) were collected from the sidewalls and bottom of the excavation. As shown on Table 10, all constituents in these soil samples were below the MDE Soil Protection of Groundwater Standards.

7.0 SUMMARY OF PRELIMINARY FINDINGS

Preliminary findings are summarized in this section, based on the data acquired and evaluated through early June 2006, which have undergone QA/QC. Data acquisition and analysis are ongoing and these findings are subject to change based on new information and analyses. Preliminary findings regarding site conditions and potential receptors are presented in the following paragraphs:

- **Geology:** The site is underlain by metamorphic rocks (dominantly schist) with a foliation that strikes to the northeast and dips to the northwest. The top of the bedrock surface and structural orientation of the foliation (Figure 8) represent the subsurface framework that in part controls the area topography, surface water drainage, and direction of groundwater flow. This bedrock framework is susceptible to weathering which weakens the bedrock structure along the direction of foliation. A lithologic change trending in the direction of strike and separating the schist to the south from an epidote-amphibolite gneiss to the north has been identified based on: (1) geologic mapping in the area (Moller, 1979); (2) core samples collected from beneath the station; (3) geophysical data; and (4) general drilling observations.

- **Hydrogeology:** Groundwater exists within the secondary bedrock porosity along joints, foliation planes, and fractures and within the intergranular porosity of overlying saprolite and soils. Closer to the service station property (higher elevation), the water table is within the bedrock (Figures 6A – 6C). To the northeast and southwest extents of the site (lower elevation), the water table is within the soil and saprolite (Figures 6A – 6C). The highest groundwater potentiometric surface elevations are measured north of the site and intermediate groundwater potentiometric surface elevations are measured south of the site and beneath the service station property (Figure 7). The groundwater potentiometric surface decreases in elevation away from the service station property, converging at lower elevations corresponding to the drainage valleys to the northeast and southwest (Figure 7). The aquifer is characterized by anisotropy corresponding to the structural orientation of the bedrock foliation. Apparent hydraulic influence (0.04 feet of uncorrected drawdown) under pumping conditions was measured at a maximum distance of 268 feet from the corresponding pumping well. The distribution of hydraulic conductivity across the site forms an elongate northeast-southwest trending pattern with a core of greater hydraulic conductivity decreasing to lesser hydraulic conductivity at the periphery (Figure 22). Analysis of potentiometric data and pumping test results indicate that interim remedial groundwater extraction measures are effective at enhancing groundwater convergence in the groundwater remediation areas.

- **LPH Distribution:** LPH migration occurred along linear trends to the southwest and northeast away from the service station property (Figure 17). These trends are slightly off-set and follow slightly different orientations, which is attributable to the structural trend of the bedrock and the nature of the geologic contact between the schist and epidote-amphibolite gneiss. The farthest extent of measurable LPH to the southwest was gauged at MW-72 (352 feet from the service station property). The farthest extent of measurable LPH to the northeast was gauged at MW-77A (1,159 feet from the service station property). LPH migration beyond these two locations has not been observed. Additionally, interim remedial measures have reduced the extent of measurable LPH to only one well located on the service station property (Figure 18).

- **Dissolved-Phase Hydrocarbon Distribution:** Dissolved-phase hydrocarbon migration also occurred to the southwest and northeast in an elongate pattern that is generally consistent with the strike of the bedrock foliation and the direction of decreasing potentiometric surface elevations (Figures 7, 19, and 20). Dissolved-phase hydrocarbons in groundwater have been detected beyond the historic extent of LPH associated with the site. Analytical results for surface water samples collected from the streams that are fed by groundwater discharge to the northeast and southwest extents of the site have been below the laboratory reporting limits (i.e., non-detect) for the respective analytes. Using MTBE as an indicator, the extent of the dissolved-phase plume has been delineated to less than the MDE action level of 20 micrograms per liter (μg/L) in the northeast for "A" and "B" series monitoring wells. In the southwest, MTBE has been delineated to less than the 20 μg/L action level for "A" and "C" series wells and within 5 μg/L of the 20 μg/L MTBE action level for the "B" series wells.

- **Private Supply Wells:** Of the 273 private supply wells sampled to date as part of this study, nine have had detections of compounds above MDE action levels. A total of eight of these wells have been connected to POET systems as part of recent activities, and are monitored weekly. One well is no longer in service and a temporary water tank was installed.

- **Soil Vapor Evaluation:** Based upon the evaluation of data presented in the *Soil Vapor Sampling and Analysis Report*, dated May 5, 2006, the current soil vapor sampling results do not indicate potential for measurable contribution of VOCs from the vadose zone to indoor air. The results of the soil vapor monitoring conducted subsequent to May 6, 2006, are similar to the prior results and also do not indicate potential for measurable contribution of VOCs to indoor air.

- **Surface Water:** Surface water sampling analytical results have been below laboratory reporting limits (i.e., non-detect), indicating that groundwater, which discharges to the local streams, is not adversely affecting these receptors.

8.0 FUTURE REMEDIAL INVESTIGATION ACTIVITIES AND ANALYSIS

Assessment activities were ongoing as this *Preliminary Hydrogeologic and Contamination Assessment Report* was being prepared. Additional assessment activities are anticipated in the future to augment existing information and to refine a site conceptual model that is being formulated based on existing information.

Additional assessment activities are expected to proceed in support of three separate, but complementary areas: (1) continuation of the remedial investigation; (2) future sampling of private supply wells; and (3) assessing the potential effects of groundwater extraction upon the area groundwater supply and hydrology in support of the water allocation permit application for groundwater withdrawal pursuant to the May 5, 2006 letter from the MDE Water Supply Program to ExxonMobil. The remainder of this section addresses areas 1 and 2 above, as these relate more directly to the remedial investigation.

8.1 Future Remedial Investigation Activities

Future remedial investigation activities will be conducted concurrently with ongoing remedial efforts to meet the following objectives:

- Continue to verify the effectiveness of interim remedial measures
- Develop a site conceptual model
- Evaluate the safe yield of the aquifer
- Contribute to the final remedial design

Future remedial investigation activities to meet the aforementioned remedial investigation objectives will be based on the ongoing review of information presented herein, and will continue to be made in consultation with the MDE Oil Control Program. The following activities were contemplated at the time this report was written, but are subject to change based on the ongoing review and evaluation of information:

- Drilling and installation of additional groundwater monitoring wells to refine the current lateral and vertical delineation of dissolved-phase constituents, and to augment the network of potentiometric monitoring points

- Completion of a petrologic review of core samples by an independent geologist with expertise in local geology

- Continued periodic groundwater sampling and monitoring well gauging.

8.2 Future Private Supply Well Sampling

Private supply well sampling activities are ongoing as this *Preliminary Hydrogeologic and Contamination Assessment Report* has been prepared. As described in Section 4.0, a round of sampling in the southwest (quarter-mile radius) and northeast (modified half-mile radius) was conducted from June 12 to June 17, 2006. The results of this sampling event will be provided to the MDE's Oil Control Program under separate cover. The weekly private supply sampling is also ongoing. The results of weekly sampling events will continue to be presented to the MDE on an ongoing basis. Future private supply well sampling will be conducted at the direction of the MDE's Oil Control Program.

8.3 Future Analysis

As the remedial investigation proceeds, the conceptual model will continue to be refined with future emphasis on the following areas of analysis:

- Evaluating the degree of hydraulic control exerted by interim remedial groundwater extraction and determining optimal future groundwater extraction parameters;

- Analyzing the potential effect of groundwater extraction and natural variation on area groundwater levels;

- Investigating potential remedial enhancements and optimization.

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