FIRST 2009 SEMIANNUAL MONITORING REPORT

CHEVRON CINCINNATI FACILITY

HOOVEN, OHIO

December 23, 2009

Project #: 500-017-012

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1.0 INTRODUCTION

Chevron Environmental Management Company (Chevron) is performing final groundwater corrective measures implementation and monitoring of the remedy performance at the former Gulf Refinery located approximately 20 miles west of Cincinnati, Ohio, near the intersection of Ohio State Route 128 and US Highway 50, as shown on Figure 1-1. The groundwater remedy was designed to be protective of human health and the environment, with the long-term objective of reducing dissolved phase hydrocarbon concentrations to meet cleanup objectives. Achieving the long-term objective will take many years; therefore the following interim objectives have been adopted for the groundwater remedy:

- Monitor soil vapor concentrations and prevent migration of volatile petroleum hydrocarbons into indoor air above risk based limits
- Measure the stability of LNAPL and dissolved phase petroleum hydrocarbons
- Remove recoverable LNAPL to agreed upon end-points
- Stabilize the west bank of the Great Miami River to prevent erosion of soils containing petroleum hydrocarbons

Groundwater remediation and monitoring efforts are being conducted in accordance with a November 2006 Administrative Order on Consent (2006 AOC) between Chevron and the United States Environmental Protection Agency (USEPA; Docket No: RCRA-05-2007-0001). The primary components of the groundwater remedy specified in the 2006 AOC include:

- Re-establishment of natural hydraulic conditions beneath the facility, Hooven, and off-site properties to the southwest (commonly referred to as the Southwest Quad) through discontinuance of year round groundwater recovery (although, as subsequently discussed, hydraulic containment via groundwater extraction from the production wells situated along the facilities eastern boundary were resumed in March 2009)
- Focused LNAPL removal during periods of extreme low water table conditions through high-grade pumping over the next decade
- Combined operation of the horizontal soil vapor extraction (HSVE) system beneath Hooven with high-grade recovery (though the USEPA ordered discontinuance of the HSVE system between January 2008 and October 2009 while soil vapor monitoring was conducted by the USEPA Superfund Technical Assessment & Response Team)

- Continued seasonal operation of the Gulf Park biovent system during low water table conditions
- Engineered stabilization of the bank of the Great Miami River at the former refinery and Gulf Park to prevent erosion of soil containing petroleum hydrocarbons
- Long-term monitoring of natural source zone attenuation including dissolved and vapor phase biodegradation

A fundamental concept of the final groundwater remedy is the continued stability of the LNAPL and dissolved phase petroleum hydrocarbons. The majority of recoverable LNAPL has been removed from beneath the former refinery and off-site properties over the past two decades. This is especially true in the upper and middle reaches of the smear zone, where LNAPL saturations are low. High-grade recovery is intended to focus on remaining LNAPL removal within the lower reaches of the smear zone and portions of the smear zone with the highest remaining LNAPL saturations. However, it is understood that the long-term remedy objective will be accomplished primarily through natural attenuation processes that drive contaminant degradation and removal over time.

A detailed discussion of the objectives and activities to be conducted to achieve the groundwater remedy goals, are described in the documents titled, *Remedy Implementation Plan (RIP) for Final Groundwater Remedy, Chevron Cincinnati Facility* (Trihydro 2007a) and the *Operation, Maintenance, and Monitoring (OMM) Plan for Final Groundwater Remedy, Chevron Cincinnati Facility* (Trihydro 2007b).

Some components of the RIP and OMM plan were amended with a June 30, 2008 modification to the 2006 AOC, which was put in place per USEPA plans for conducting an independent vapor monitoring program in Hooven. The USEPA's Hooven vapor monitoring program was not completed by the end of 2008 as originally intended, so plans for monitoring and system operation during 2009 were further clarified in a February 18, 2009 letter from USEPA to Chevron. The results of any modifications to 2009 system operation per the AOC clarification letter will be addressed in the *Second 2009 Semiannual Monitoring Report*.

1.1 SUMMARY OF SITE CONCEPTUAL MODEL

A detailed site conceptual model (SCM) for groundwater was presented in the *First 2008 Semiannual Monitoring Report, Chevron Cincinnati Facility, Hooven, Ohio* (Trihydro 2009a). A summary of the SCM is provided herein including updates made using data collected during the first half of 2009. Figure 1-2 shows a diagrammatic SCM for the facility, Hooven, and Southwest Quad.

1.1.1 SETTING

Refinery operations at the former Gulf Oil refinery began in 1931. Chevron acquired Gulf Oil Company in 1985 and that same year, an oily sheen was observed on the Great Miami River along the southeast portion of the facility. Hydraulic containment measures were implemented to minimize migration of petroleum hydrocarbons off-site. The refinery ceased production in 1986 and the refinery infrastructure was subsequently dismantled. Interim measures performed at the facility since early 1985 focused on hydraulic control of LNAPL and dissolved phase petroleum hydrocarbons by extracting groundwater and creating inward hydraulic gradients. These measures were expanded to include excavation of refinery related wastes; soil vapor extraction and six-phase heating beneath the Islands; bioventing beneath Gulf Park; and operation of the HSVE system designed to remove hydrocarbons beneath State Route 128 and Hooven. Historic remediation activities have recovered millions of gallons of LNAPL.

The former refinery is situated in a glacial valley incised into Ordovician-age shale and partially filled with glacial outwash and fluvial deposits of the Great Miami River (Spieker and Durrell 1961, Spieker 1968, Watkins and Spieker 1971). The fluvio-glacial aquifer ranges from approximately 20 to 100 feet thick, and is composed of dominantly coarse sediment, referred to as the Buried Valley Aquifer. An upward fining sequence is present in areas along the riverbank and flood plain on the former refinery. In addition, a clayey-silt layer is exposed at the ground surface in the western portion of Hooven with a thickness of at least 10 feet along the western edge of town. This layer serves as an apparent aquiclude with runoff flowing eastward over the shallow aquiclude before descending towards the groundwater table and joining regional flow.

Groundwater within the Buried Valley Aquifer generally flows from north to south, although episodic flooding tends to result in redirection of the flow to the west for periods ranging from days to weeks dependant on the magnitude of the flood event. A partially penetrating sheet pile wall was installed at the facility as part of the riverbank stabilization measures between September and December 2008. The partial penetrating wall does not affect horizontal flow conditions (i.e. flow direction primarily parallel to the river bank) within the Buried Valley Aquifer under ambient conditions. However, as designed, communication between groundwater and surface water has been dampened locally near the barrier wall during periods of increasing or decreasing discharge within the Great Miami River.

1.1.2 SOURCE

Refinery operations terminated in 1986, and the distribution of LNAPL stabilized as gravity and capillary forces approached equilibrium. Vertical smearing of the LNAPL occurred over time as a result of seasonal fluctuation of the water table, leaving some LNAPL within the pore spaces below and above the water table. The top and bottom of the "smear zone" are roughly coincident with the historic high and low groundwater elevation. Therefore, some smear zone is exposed above the water table, even during periods of seasonal high groundwater, although the maximum exposure of LNAPL occurs during low water table events. The thickness of the smear zone generally increases from inches at the plume periphery, to as much as 20 feet in locations of the production wells. The depth to the top of the smear zone varies across the site, from as little as 10 feet near the Great Miami River, to approximately 30 feet across most of the former process areas and tank farms, 40 feet beneath the Southwest Quad, and up to 60 feet under the town of Hooven.

Petroleum hydrocarbon liquids are a mixture of hundreds of individual compounds from many families, including aliphatics, aromatics, paraffins, isoparaffins, olefins, and naphthalenes. Each compound has somewhat different physical, chemical, and toxicological properties, but some are sufficiently volatile and toxic to pose a potential human health risk via dermal contact, ingestion, and inhalation if present at sufficient concentration. In the area adjacent to the distribution of LNAPL, some hydrocarbons dissolve in groundwater and migrate as solutes in the aqueous phase. Volatilization from LNAPL or dissolved phase hydrocarbons can produce vapors in the unsaturated zone immediately above the water table.

1.1.3 PLUME STABILITY

A fundamental concept of the final groundwater remedy is the continued stability of LNAPL and dissolved phase petroleum hydrocarbons. The majority of recoverable LNAPL has been removed from beneath the former refinery and off-site properties over the past two decades. This is especially true in the upper and middle reaches of the smear zone, where LNAPL saturations are low. High-grade recovery is intended to focus on removal of LNAPL within the lower reaches of the smear zone and portions of the plume with the highest remaining LNAPL saturations. However, it is understood that the long-term remedy objective will be accomplished primarily through natural processes that drive contaminant degradation and removal over time.

The LNAPL and dissolved phase plume boundaries are generally coincident at the up-gradient and lateral edges of the smear zone (i.e., western limit in Hooven and eastern limit along the Great Miami River), where dissolved phase petroleum hydrocarbons are generally indicative of LNAPL within the smear zone. Whereas, in the primary flow direction towards the south, a dissolved phase "halo" extends several hundred feet down-gradient from the LNAPL plume boundary.

Dissolved phase plume stability is expected to continue over the long-term, however, it was anticipated that some re-distribution of dissolved phase hydrocarbons would occur at the down-gradient edge of the plume after discontinuance of hydraulic containment that was performed for more than two decades. It is anticipated that the dissolved phase plume stability will become re-established during the first few years after pumping is discontinued. It should be noted that detections of dissolved phase benzene in monitoring wells MW-35 and MW-133 were observed during the past year, as discussed further in Section 2.2, are not believed to be associated with re-distribution of the dissolved phase limits. The benzene detected in these two wells is likely derived from an alternate source in the Southwest Quad, as the measured dissolved phase concentrations do not follow trends that would be expected if contaminants were migrating down-gradient from the smear zone limits to the point of compliance (POC) well.

The primary driver for dissolved phase plume stability is believed to be active biodegradation at the down-gradient limits of the plume. Most petroleum hydrocarbons are readily degradable by soil microorganisms in the presence of oxygen (O_2), a process referred to as aerobic biodegradation. Petroleum hydrocarbons are also degraded by soil microorganisms in the absence of O_2 via anaerobic respiration, but generally at a lower rate compared with aerobic degradation.

The pathway for migration of petroleum hydrocarbon in soil vapor into structures located in Hooven and the Southwest Quad is considered incomplete. Soils within the vadose zone to the west of the refinery are predominantly sand and gravel, which allow water to drain relatively freely; therefore, the pore-spaces are mostly air-filled, which provides a pathway for vapor migration. The migration of hydrocarbon vapors from the vapor source at depth is retarded by biological degradation where soil microbes metabolize hydrocarbon vapors as a source of energy. Beneath Hooven, where the vadose zone is nearly 60 feet thick, the hydrocarbon vapors are generally reduced through aerobic biodegradation where O_2 in the atmosphere diffuses down into the unsaturated zone and is reduced along with the petroleum hydrocarbon vapors. As discussed in Section 1.1.5, alternate sources are present in the vadose zone from surface releases of petroleum and non-petroleum related chemicals in Hooven. These releases affect the vertical profile of constituents of concern and fixed gases through utilization of O_2 and mixing of vapors within the intermediate portions of the vadose zone.

Microbiological degradation can also occur in the absence of O_2, where secondary oxidizers such as iron, sulfate, nitrates, etc. are reduced producing methane (CH_4). The CH_4 will subsequently diffuse upward and is generally degraded at shallower intervals where O_2 concentrations are sufficient. Anaerobic degradation is typically observed in the deeper intervals above the LNAPL and dissolved phase plume; however anaerobic conditions can persist in the intermediate portions of the vadose zone during seasonally low water table conditions or if a secondary sources of petroleum hydrocarbons are present in the shallow subsurface utilizing available O_2.

Biodegradation is a primary driver not only for stability of the vapor and dissolved phase petroleum hydrocarbons, but also for hydrocarbon mass reduction throughout the plume. Aerobic and anaerobic processes reduce contaminant mass in the dissolved and vapor phase. Whenever O_2 is available, aerobic biodegradation processes predominate. Aerobic degradation processes are the dominant mechanism for reductions in petroleum hydrocarbon concentrations in the plume periphery. Within the interior portions of the plume where dissolved oxygen is depleted, anaerobic biodegradation processes will tend to dominate. These anaerobic processes are expected to continue in portions of the smear zone where secondary oxidizers are available, given the relatively consistent supply of petroleum hydrocarbons (i.e., source of carbon) from the smear zone.

1.1.4 RECEPTOR

Receptors that have the potential to be affected by dissolved and LNAPL petroleum hydrocarbons include residents within Hooven, commercial workers in business situated in the Southwest Quad, sensitive ecological communities along the Great Miami River, visitors and workers employed in remedy support and redevelopment activities on the former refinery, and trespassers coming onto the facility property. As the groundwater beneath the facility, Hooven, or Southwest Quad is not used for drinking purposes or secondary uses (e.g., irrigation, bathing, etc.) ingestion and dermal contact with dissolved phase petroleum hydrocarbons associated with the former refinery will not occur. Administrative and engineering controls, as well as personal protective equipment will be used as appropriate to prevent site workers and visitors from unacceptable levels of exposure to LNAPL or dissolved phase petroleum hydrocarbons during redevelopment on the former refinery. Bank stabilization measures along the Great Miami River prevent soil containing petroleum hydrocarbons from eroding into the river or the discharge of dissolved phase petroleum hydrocarbons to surface water.

With respect to vapor intrusion, the receptor would be any occupant of a building on the former refinery, in Hooven, or to the southwest if subsurface vapors entered that building at concentrations that pose a potential health risk. If soil vapors diffuse within the “zone of influence” of a structure without degrading, they will become available to be transported into the structure via advection and convection through drains, cracks, utility entrances, sumps, or other permeable discontinuities in the building floor or basement walls. Wind load on the side of a building, barometric pressure changes, HVAC system operation, or temperature differences can all contribute to building depressurization that can drive advection. Most of these processes are reversible, so gases generally flow into and out of buildings under varying conditions. Atmospheric air also enters buildings through doors, windows, and small openings, and the rate of air exchange in buildings typically reduces soil vapor concentrations by a factor of 100 to 10,000 (Johnson 1999), depending on building design, construction, use, maintenance, soil conditions, weather conditions and similar factors.

The vapor intrusion pathway in Hooven was demonstrated to be incomplete during the subsurface investigation completed in 2005, through characterization of the contaminant source, soil vapor, and migration pathway. In addition, the soil vapor data collected from the nested monitoring wells from 1997 to 1999 and following the 2005 investigation have also indicated vapors from the plume are not migrating from the smear zone to indoor air within the residences, businesses, or school at concentrations sufficient to pose an unacceptable excess health risk. In portions of the Southwest Quad overlying the smear zone, commercial structures were constructed with a passive vapor barrier beneath the slab as a protective measure for inhibiting migration of vapors into the building, if present.

1.1.5 SECONDARY SOURCES

There are several potential secondary sources of LNAPL and dissolved phase petroleum hydrocarbons within proximity of the former refinery. These include a former service station (currently a non-commercial automotive service center) located directly north of the facility, former operations at the Dravo quarry including several diesel and gasoline underground storage tanks removed in 1991, the Kroger service station, dry wells installed in the Southwest Quad, the Whitewater Reclamation (formerly Golsch) construction and demolition landfill, as well as local point sources in the Southwest Quad and Hooven.

Volatile petroleum hydrocarbons are ubiquitous in indoor and outdoor air from industrial and commercial sources, automobiles, combustion sources (e.g., gasoline, fuel oil, natural gas, etc.), combustion byproducts (e.g., diesel, wood, coal, candles, etc.), water treatment chemicals and byproducts, a variety of different consumer products, small power tools, tobacco smoke, glues, household cleaners, carpeting, and furniture. Indoor air often contains measurable concentrations of volatile and semivolatile compounds from household activities, consumer products, building materials, furnishings, and outdoor air sources. Urban areas can also have shallow releases of hydrocarbons to the subsurface from commercial businesses, gasoline powered tools (lawnmowers, chainsaws, trimmers, snow blowers, etc.), vehicles with leaks of oil or gas, runoff from roads, heating oil tank releases, and similar sources. Therefore, it is expected that hydrocarbon vapors are present in the vadose zone beneath Hooven associated with releases from these surface sources.

1.2 PURPOSE

The primary purpose of this report is to provide a summary of the operations and monitoring conducted in accordance with the 2006 AOC, RIP (Trihydro 2007a), and OMM Plan (Trihydro 2007b) from January 1, 2009 to June 30, 2009. In addition, this report will provide a summary of the re-establishment of hydraulic controls in the Southwest Quad via groundwater extraction from the production wells situated along the facilities eastern boundary which was resumed in March 2009. The remainder of this report is organized into the following sections:

- Section 2.0 – Describes the infrastructure, methods, and results of groundwater monitoring activities conducted during the first semiannual reporting period in 2009.
- Section 3.0 – Presents the preliminary qualitative and quantitative lines of evidence supporting the efficacy of natural attenuation mechanisms to degrade petroleum hydrocarbons within the smear zone.
- Section 4.0 – Describes the results of biovent system operation and groundwater monitoring conducted in Gulf Park.

2.0 MONITORING NETWORK AND RESULTS

The primary component of the final groundwater corrective measures program is routine monitoring to evaluate the progress towards meeting the interim and long term remedy objectives. The monitoring network has been established to meet multiple performance and compliance monitoring criteria including collection of data to support remedial system operation; confirmation of high-grade pumping and HSVE system effectiveness; determination of compliance at boundaries where sensitive receptors are present; and evaluation of natural attenuation mechanisms. For the purpose of this report, monitoring has been divided into the following activities:

- Fluid level gauging including continuous monitoring using pressure transducers as well as weekly, monthly, and bimonthly manual measurements
- Groundwater sampling to demonstrate dissolved phase plume stability, protection of sensitive receptors, and efficacy of monitored natural attenuation
- Lysimeter monitoring to collect data regarding precipitation infiltrate to assist in understanding electron acceptor flux into the upper plane of the smear zone
- ROST monitoring to confirm stability of the LNAPL plume at the lateral edge of the smear zone
- LNAPL and soil core analysis to track changes in LNAPL composition over time
- River monitoring to ensure that petroleum hydrocarbons do not affect surface water within the Great Miami River
- Vapor monitoring to track the vapor intrusion pathway beneath Hooven and the Southwest Quad and evaluate natural attenuation mechanisms in the vadose zone

The following sections describe the results of monitoring conducted to support the groundwater remedy between January 1 and June 30, 2009. A description of the methods used for installation, monitoring, and analysis have been previously described within the RIP (Trihydro 2007a) and OMM Plan (Trihydro 2007b). Additional information pertinent to these activities is described herein when deviations from these plans was necessary.

2.1 FLUID LEVEL MONITORING

Pressure transducers are generally deployed across the monitoring well network listed on Figure 2-1 to evaluate rapid fluctuations in hydraulic conditions across the facility. The pressure transducers are relocated as the goals of short term monitoring change such as during flood events or groundwater recovery. Transducers log groundwater elevations on a daily basis. High frequency groundwater elevation data recorded using the pressure transducers are provided in Appendix A.

Pressure transducers were relocated in March 2009 as hydraulic control of groundwater was re-established down-gradient of the facility using production wells PROD_15 and PROD_24. Groundwater recovery using these two production wells was resumed in response to detections of benzene in sentinel well MW-35 and POC well MW-133. Pressure transducers were deployed in an expanded network (including wells MW-12, MW-20S, MW-26R, MW-35, MW-37, MW-81S, MW-93S, MW-94S, MW-96S, MW-100S, MW-101, MW-112, MW-120, MW-128, MW-131, MW-132, MW-133, MW-134, PROD_15, and PROD_24) across the Southwest Quad to allow continuous monitoring of hydraulic gradients. Section 2.2 provides a further explanation of the groundwater monitoring results and re-initiation of hydraulic controls at the down-gradient limits of the facility.

Manual fluid level gauging is conducted on a bimonthly basis in each of the monitoring wells located on the facility, Hooven, Southwest Quad, and Gulf Park. In addition, fluid levels are gauged weekly in select groundwater monitoring wells, and river bank gauging point RBGP-44 located along the west bank of the river. Weekly gauging in these wells is conducted to supplement the bimonthly fluid level measurements in tracking trends in river and groundwater table elevations, as wells as in LNAPL thickness. The frequency of fluid level monitoring was increased in the Southwest Quad during the operation of PROD_15 and PROD_24. Fluid levels have been manually gauged on a weekly basis in selected monitoring wells (including wells MW-1R, MW-12, MW-20S, MW-26R, MW-35, MW-37, MW-81S, MW-93S, MW-94S, MW-96S, MW-100S, MW-101, MW-112, MW-115S, MW-120, MW-128, MW-131, MW-132, MW-133, MW-134, MW-138, MW-139, MW-140, MW-141, MW-142, PROD_15, and PROD_24) since hydraulic controls were re-started in early March 2009.

Appendix B provides manual fluid level gauging data collected during the first half of 2009. Potentiometric surface maps for January, March, and May 2009 generated using data collected during bimonthly monitoring are provided as Figures 2-2 through 2-4. During the January and March 2009 events groundwater flow in the Buried Valley Aquifer was generally to the south, consistent with monitoring events conducted since the termination of continuous pumping in January 2008. The potentiometric surface map generated using fluid level data collected on May 20, 2009 shows depression of the water table and groundwater flow towards production wells PROD_15 and PROD_24 in the southern portions of the facility and Southwest Quad.

2.2 DISSOLVED PHASE MONITORING

Dissolved phase monitoring is conducted at the facility, Hooven, and Southwest Quad to assess plume stability, evaluate natural attenuation within the saturated portions of the smear zone, and measure performance of the final groundwater remedy. Groundwater samples are analyzed for the constituents of concern including benzene, ethylbenzene, toluene, total xylenes, chlorobenzene, arsenic, and lead. Benzene is the constituent most frequently reported in groundwater samples above remedial objectives, with historic concentrations as high as 13 milligrams per liter (mg/L). Dissolved phase benzene is not generally detected more than a few hundred feet outside the LNAPL smear zone, due to intrinsic biodegradation at the plume periphery.

Groundwater samples are also collected from selected wells for analysis of natural attenuation indicators including alkalinity, total calcium, total chloride, chemical oxygen demand, ferric iron (Fe3+), ferrous iron (2+), total iron, dissolved manganese, total manganese, methane, nitrogen, nitrogen as ammonia, nitrate, nitrite, total potassium, total sodium, sulfate, sulfide, and total organic carbon.

Field forms for groundwater samples collected between January and June 2009 are included in Appendix C. Laboratory analytical reports for groundwater samples collected during the first 2009 semiannual monitoring period are provided in Appendix D-1. Data validation reports for each of the analytical packages provided by the laboratory are provided in Appendix D-2. The following subsections present the results of dissolved phase monitoring conducted between January and June 2009. Interpretation of the dissolved phase analytical results is provided in Section 3.0.

2.2.1 SENTINEL AND POINT OF COMPLIANCE MONITORING

There are three sentinel wells (MW-35, MW-131, and MW-132) and four POC monitoring wells (MW-37, MW-120, MW-132, and MW-133) located at the down-gradient edge of the dissolved phase plume in the Southwest Quad. The sentinel and POC monitoring networks are presented on Figure 2-5.

Groundwater samples were collected from the sentinel and point of compliance monitoring wells MW-131 through MW-134 on February 17 through 19, 2009, as these wells were newly installed in late 2007 and are being monitored on a quarterly basis for the first two years. Groundwater samples were collected from the entire sentinel and point of compliance network again between March and April 2009. Groundwater analytical results for the dissolved phase constituents of concern are provided on Table 2-1. Dissolved arsenic was detected in sentinel well MW-131 at a concentration of 0.0144 mg/L during the February 2009 sampling event. As reported in the *Evaluation of Background Metal Concentrations in Ohio Soils* (Cox-Colvin & Associates, Inc. 1996) and the *Closure Plan Review Guidance for*

RCRA Facilities (OEPA 1999), several metals including arsenic and lead are naturally occurring in soils across Ohio and the United States. Arsenic and lead have been sporadically detected in groundwater collected from monitoring wells located throughout the Southwest Quad over the more than two decades of monitoring. There were not any reported detections of dissolved lead or arsenic in the point of compliance monitoring wells in the groundwater samples collected in February and March-April 2009.

As discussed in the *Second 2008 Semiannual Monitoring Report* (Trihydro 2009b) and summarized in the *Work Plan for Contingency Measures in the Southwest Quad* (Trihydro 2009c), groundwater samples were collected from the sentinel and POC network in November 2008, as part of routine monitoring activities. Benzene was detected in the groundwater sample collected from sentinel well MW-35 at a concentration of 0.13 mg/L, which exceeded the MCL (0.005 mg/L). None of the other constituents of concern (ethylbenzene, toluene, xylenes, chlorobenzene, arsenic, or lead) were detected above laboratory detection limits in samples collected from well MW-35 or any of the other sentinel or POC monitoring wells during sampling conducted in November 2008.

Sentinel well MW-35 and the corresponding down-gradient POC well MW-133 along with wells MW-131 through MW-134 were re-sampled between February 17 and 19, 2009 for the dissolved phase constituents of concern. Benzene was reported in the groundwater sample collected from well MW-35 at a concentration of 0.021 mg/L, in addition to the sample collected from the POC well MW-133 at an estimated concentration of 0.003 mg/L. Groundwater analytical results for samples collected in February 2009 are provided on Table 2-1.

2.2.1.1 RESPONSE TO DISSOLVED PHASE BENZENE DETECTIONS

During a conference call between Chevron and the USEPA on March 10, 2009, Chevron proposed to install additional groundwater monitoring wells up-gradient of well MW-35 and to resume operation of the production wells to re-establish hydraulic controls beneath the Southwest Quad. The USEPA approved installation of the proposed monitoring wells and subsequent start up of hydraulic containment in the Southwest Quad and Hooven in a letter dated March 12, 2009. Between March 11 and 18, 2009, five additional groundwater monitoring wells (MW-138 through MW-142) were installed up-gradient of sentinel well MW-35 to characterize the relationship between the dissolved phase detections reported in this monitoring well and those detected in the up-gradient portions of the smear zone in the Southwest Quad.

Hydraulic control of groundwater in the Southwest Quad was re-initiated via pumping from production wells PROD_15 and PROD_24. These two production wells were restarted on March 29, 2009 with groundwater primarily extracted from production well PROD_15 at a rate of 875 to 1,000 gallons per minute (gpm) and secondarily from well PROD_24 at a rate between 250 and 450 gpm from March 29 to August 10, 2009, then subsequently increased to 750 gpm. Comparison of the March and May 2009 potentiometric surface maps demonstrate that hydraulic containment extends throughout the Southwest Quad.

Hydraulic containment using these two wells ceased on August 20, 2009, at the start of seasonal high-grade pumping using production well PROD_20. Since then, groundwater has been extracted from production wells PROD_19, PROD_20, and PROD-24 at an approximate rate of 2,500 gpm and hydraulic control continues to be maintained beneath the Southwest Quad. Once the high-grade recovery event is completed, containment pumping using production wells PROD_15 and PROD_24 will be resumed. The results of the high-grade pumping event completed in 2009 will be provided in the *Second 2009 Semiannual Monitoring Report*.

The frequency of fluid level and dissolved phase monitoring was increased in the Southwest Quad in response to the benzene detected in groundwater samples collected from POC well MW-133. As discussed in Section 2.1, fluid levels have been manually gauged on a weekly basis and pressure transducers have been deployed in an expanded network within the Southwest Quad to allow continuous monitoring of hydraulic gradients and LNAPL thicknesses.

Groundwater samples were collected from the five newly installed monitoring wells, in addition to the sentinel and POC monitoring network for the constituents of concern between March 27 and April 3, 2009. Samples collected from selected wells including MW-26R, MW-132, MW-134, MW-138, MW-139, MW-140, and MW-142 were also analyzed for an expanded constituent list to evaluate potential alternate sources of benzene measured in wells MW-35 and MW-133. This expanded list included both petroleum and non-petroleum related constituents.

Subsequently, groundwater samples were collected and analyzed for the constituents of concern on a monthly basis from wells MW-35, MW-133, and newly installed wells MW-138, MW-139, and MW-140. Groundwater analytical results since November 2008 are summarized on Table 2-1 and Figure 2-6. Dissolved phase petroleum hydrocarbons were irregularly detected in the sentinel and POC monitoring wells prior to restarting the production wells in late March, with detections only in samples collected from wells MW-35 and MW-133. Dissolved phase benzene was only detected in well MW-138 during the March and May 2009 monitoring periods. Dissolved phase benzene concentrations decreased rapidly in sentinel well MW-35 following resumption of hydraulic controls to the point where benzene was no longer measured above detection limits in samples collected after early April 2009. Whereas, concentrations of dissolved phase benzene persisted in POC monitoring well MW-133 until August 2009 despite re-establishment of hydraulic controls beneath the Southwest Quad.

As depicted on Figure 2-6, well MW-139 is the nearest up-gradient well where benzene has been reported in samples collected since May 2009. Monitoring well MW-139 is located more than 400 feet up-gradient of POC well MW-133 and is situated at the lateral limit of the smear zone. If the smear zone was the source of the dissolved phase benzene it would be expected that the constituent concentrations would show a consistent decreasing trend in the down-gradient direction. Constituent concentrations have not behaved in this manner in the Southwest Quad, with dissolved phase benzene decreasing to non-detect concentrations down-gradient of the smear zone and then increasing again at the POC boundary well MW-133. Potentiometric surface maps generated using data prior to reinitiating hydraulic controls do not indicate preferential flow paths beneath the Southwest Quad. If there was redistribution of dissolved phase impacts it would be expected to occur across the entire smear zone and the constituents would be more uniformly detected across the down-gradient monitoring network. This is suggestive of a localized alternate source of benzene. On October 1, 2009 Chevron submitted a *Work Plan for Contingency Measures in the Southwest Quad, Chevron Cincinnati Facility, Hooven, Ohio* (Trihydro 2009c). This work plan describes the nature of the dissolved phase constituents measured in the Southwest Quad, the lines of evidence supporting an alternate source for benzene measured in samples collected from sentinel well MW-35 and POC well MW-133, a proposed plan to return to ambient flow conditions, and contingency measures that could be implemented if it is determined that the future detection of dissolved phase benzene at the down-gradient POC is associated with releases from the former refinery during future monitoring events following shut-down of the containment pumping system.

2.2.2 PERIMETER, INTERIOR, AND SUPPLEMENTAL MONITORING

As discussed in the SCM presented in Section 1.0 and supported by data collected to date, the LNAPL and dissolve-phase petroleum hydrocarbons are laterally stable and degrading over time. Remaining LNAPL in the smear zone is gradually depleted through several mass loss mechanisms including dissolution into groundwater and subsequent dispersion and biodegradation, as well as volatilization and degradation within the vadose zone. As such, groundwater samples were collected from three groups of monitoring wells for evaluation of natural attenuation mechanisms within the saturated zone: perimeter, interior plume and supplemental monitoring wells.

- Perimeter groundwater monitoring wells include those wells situated at the margins of the smear zone but not considered to be compliance boundaries for dissolved phase petroleum hydrocarbons in the saturated zone. Monitoring wells that are included in this network include MW-26R, MW-33, MW-48S, MW-85S, MW-94S, MW-95S, MW-100S, MW-104S, and MW-115S.

- Interior plume monitoring wells are those wells located within the smear zone that will be tracked on a consistent basis over the course of the remedy and include ten wells: MW-10, MW-17, MW-18R, MW-20S, MW-22, MW-58S, MW-81S, MW-85D, MW-88, MW-93S, and MW-96S. A groundwater sample could not be collected from monitoring well MW-58S during the first 2009 semiannual monitoring period due to the presence of LNAPL within the well.

- Supplemental monitoring wells include additional wells that will be targeted for sampling to support evaluation of natural attenuation over the long-term remedy. The supplemental well network may be modified based upon data gaps identified during previous monitoring periods. Supplemental monitoring wells sampled during the first semiannual monitoring period in 2009 include wells L-1RR, L-3R, MW-21, MW-51, MW-64, MW-80, and MW-99S.

Groundwater analytical results for the dissolved phase constituents of concern reported in samples collected from the perimeter, interior plume, and supplemental monitoring wells are provided on Table 2-2.

Groundwater samples were also collected from 12 monitoring wells for analysis of natural attenuation indicators during the first semiannual monitoring period including wells L-1RR, MW-18R, MW-20S, MW-33, MW-35, MW-38, MW-51, MW-81S, MW-85S, MW-96S, MW-100S, MW-112, MW-114, and MW-115S. Groundwater analytical results for the dissolved phase natural attenuation indicators are included on Table 2-3.

2.3 LYSIMETERS

Between September 22 and September 30, 2008, two soil moisture lysimeters were constructed at the grouped media locations near wells MW-18, MW-20, MW-21, and MW-93, in accordance with details presented in the RIP (Trihydro 2007a). The lysimeters are used to measure the makeup of recharge water (particularly oxidizers) from infiltrating precipitation and evaluate the contribution of the makeup water to biodegradation within the upper limits of the saturated zone. A shallow and deep lysimeter were installed at each grouped media location, the first set at a depth above the smear zone and the second set at an average groundwater elevation within or near the upper smear zone limit. Placement of each lysimeter was a function of the elevation of the top of the smear zone.

Each lysimeter consists of a small ceramic receptacle (4-inch diameter by 18-inches tall) placed into a borehole to the target depth. The ceramic receptacle has two Teflon tubes extending to the ground surface, a pressure-vacuum access tube and a sample discharge tube. A vacuum is applied to the lysimeter ceramic cup which wicks precipitation infiltrate from the vadose zone and can subsequently be extracted by applying pressure to the receptacle.

In accordance with the OMM Plan (Trihydro 2007b) a vacuum was applied to the shallow and deep lysimeters on May 5, 2009. Subsequently, on May 14, 2009, the rainwater infiltrate was collected from the shallow lysimeters. Samples were not collected from the deep lysimeter at each location due to the high water table. Infiltrating precipitation collected from the lysimeters was analyzed for dissolved oxygen and oxidation-reduction potential (ORP) in the field prior to preserving the samples and submitting them for laboratory analysis of nitrate, sulfate, dissolved/total iron, dissolved/total manganese, and methane. The lysimeter sampling results are presented in Table 2-4.

Lysimeter sampling results indicate that the chemistry of precipitation infiltrate varies across the smear zone. At the northernmost lysimeter, L-21S, the concentrations of electron acceptors (oxygen, sulfate, and nitrate) and byproducts (iron, manganese, methane) are relatively low. This may be an indication that there is low availability of oxidizers and little biodegradation is occurring in the vadose zone pore water at this location. Above the core of the smear zone at lysimeter L-18S, the methane concentration within the infiltrate is relatively high (1.9 mg/L), which may be related to attenuation of petroleum hydrocarbons within the saturated or vadose zones, and subsequent partitioning of gas-phase methane and volatile petroleum hydrocarbons to vadose zone pore water. In the southern portions of the smear zone (lysimeters L-20S and L-93S), the pore water contains relatively high levels of sulfate, which is an important electron acceptor for biodegradation in the underlying smear zone. Another electron acceptor, nitrate, is also present in the infiltrate measured in lysimeter L-93S at relatively high concentrations. This elevated nitrate may be related to historical releases from septic systems that were used until 2007 for managing sanitary waste within the town of Hooven.

Precipitation and subsequent infiltration comprise an important component of the aquifer water budget. Much of this infiltrating water contains electron acceptors that are used by microorganisms in the smear zone to destroy hydrocarbons. The lysimeter data are useful in understanding this process. This is demonstrated by the assimilative capacity bar graph presented in Figure 2-7. The assimilative capacity is estimated by summing the concentrations of electron acceptors and subtracting biodegradation byproducts, scaled to stoichiometric coefficients for biodegradation of hydrocarbons. As shown on this figure, pore water in the northern and central portion of the smear zone (as evaluated using lysimeters L-21S and L-18S) has a relatively low assimilative capacity. This is an indication that precipitation infiltrate at these locations does not have significant potential to further degrade hydrocarbons. On the other hand, the assimilative capacity of infiltrate in the southern portions of the smear zone (assessed using lysimeters L-20S and L-93S) are much higher. This is primarily due to the elevated concentrations of sulfate at both locations, and the elevated nitrate at lysimeter L-93S.

2.4 ROST MONITORING

Three ROST monitoring transects (RT-1 through RT-3) are in place perpendicular to the leading edge of the LNAPL plume, as shown in Figure 2-5. ROST technology was identified as the preferred tool for monitoring the potential for LNAPL migration at the leading edge of the plume because it is designed to provide rapid real-time analysis of the physical and chemical characteristics of the distribution of petroleum hydrocarbons to distinguish between soils containing LNAPL and those outside of the smear zone.

The ROST monitoring transects consist of blank polyvinyl chloride (PVC) casing above the smear at three locations within each transect: an interior location (I) situated at the approximate lateral limit of the smear zone, an intermediate location (M) located 20-feet from the approximate lateral limit of the smear zone, and an outer location (O) installed 40-feet from the approximate lateral limit of the smear zone. ROST technology and installation methodology is presented in greater detail in the RIP (Trihydro 2007a).

Monitoring within the ROST monitoring wells was conducted between June 18 and 20, 2009. The tool was advanced from approximately 5 feet above the water table to approximately 5 feet below the water table in each of the wells. Two attempts were made to advance the tool to the projected depth of 45 feet at the middle boring at Transect 3 (RT-3M). However, the ROST could not be advanced past 35 feet below ground surface during both attempts. Each of the ROST monitoring locations within Transects 2 and 3 will be pre-probed using a direct push drilling rig during the next monitoring event scheduled for December 2009. ROST monitoring results are provided in Appendix E. Data collected during the first half of 2009 indicate that the smear zone is stable. There was not an indication of the presence of LNAPL within any of the intermediate or outer ROST monitoring wells based on laser induced fluorescence measurements in the three transects.

2.5 SMEAR ZONE SOIL CORING

Soil cores were collected within the smear zone during May 2009 from the grouped media sampling location near monitoring well MW-93 and adjacent to monitoring well MW-96. The smear zone coring was completed using a direct push drilling technique with soil collected within 2-inch acetate liners that were approximately 5-feet in length. Heterogeneity was accounted for by collecting three cores at the MW-96 location. Due to subsurface conditions and the anticipated low LNAPL saturations within the smear zone adjacent to MW-93, only one soil boring was cored. The single core near monitoring well MW-93 and the first of the three cores collected adjacent to well MW-96 were continuously logged from the ground surface to several feet below the bottom of the smear zone. The recovered soil within each core was visually described and logged in general accordance with the Unified Soil Classification System. An aliquot of soil from 5-foot sections of the recovered core was field screened for total organic vapors using a RAE Systems™ MiniRae® 2000 photoionization detector. The total organic vapor results were recorded on the lithologic logs included in Appendix F.

Based upon the lithologic log, the depth intervals for the top, middle, and bottom of the smear zone were established for the soil cores at each location. The top of the smear zone was located within the unsaturated zone, the middle was established near the vadose-saturated zone interface, and the bottom of the smear zone was situated within the saturated zone. Soil core samples were collected within the top, middle, and bottom of the smear zone intervals based upon observed petroleum hydrocarbons or elevated total organic vapor measurements. An approximate 18-inch long section of the acetate liner was cut and immediately capped at the selected interval within each portion of the smear zone. Soil cores were analyzed for selected volatile organic constituents, as well as total petroleum hydrocarbons. The laboratory analytical results are provided in Appendix G. Soil cores will be collected at the grouped media sampling locations and other selected locations within the smear zone every five years to evaluate changes in the smear zone composition and vertical LNAPL distribution.

2.6 RIVER MONITORING

A partially penetrating sheet pile barrier wall and bank stabilization measures were installed along the west bank of the Great Miami River between September and December 2008. As part of these bank stabilization measures, a barrier wall performance monitoring network was installed along the restored river bank in accordance with the work plan titled *Performance Monitoring Plan, Sheet Pile Barrier Along Great Miami River, Chevron Cincinnati Facility, Hooven, Ohio* (Trihydro 2007c). This work plan also specified measures to characterize baseline conditions and monitor performance of the partially penetrating sheet pile wall during implementation of the final corrective measures for groundwater. The performance of the sheet pile wall is monitored by observing the hydraulic gradients in groundwater and surface water, as well as evaluating groundwater, hyporheic water, and surface water quality over time.

The barrier monitoring network was constructed between November 10 and December 29, 2008. The monitoring network is comprised of three monitoring transects along the northern, central, and southern portions of the barrier wall as illustrated on Figure 2-8. Each transect includes a groundwater monitoring nest (shallow, intermediate, and deep wells) situated inboard of the sheet pile wall and a groundwater monitoring nest located on the outboard side of the wall. In addition, a hyporheic/surface water monitoring well was also constructed outboard of the wall at each monitoring transect. A description of the installation and construction details for the sheet pile wall, stabilization measures, and performance monitoring network is provided in the *Second 2008 Semiannual Monitoring Report, Chevron Cincinnati Facility, Hooven, OH* (Trihydro 2009b).

2.6.1 FLUID LEVEL MONITORING

Pressure transducers were deployed on April 27, 2009 in the groundwater and surface water monitoring wells in the northern and southern monitoring transects to evaluate horizontal and vertical gradients across the partial penetrating barrier wall. Transducers are programmed to record elevations on an hourly basis. High frequency groundwater elevation data recorded using the pressure transducers are provided in Appendix A. Manual fluid level gauging was also conducted on April 27 and June 3, 2009 to supplement the transducer data and measure LNAPL gradients (if present) within the inboard portions of the barrier wall. LNAPL was not detected in any of the monitoring wells situated on the west bank of the river between January and June 2009. Manual fluid level measurements are included in Appendix B.

Transducer data from select monitoring wells was used to illustrate vertical hydraulic gradients on the interior and exterior of the barrier wall at the north and south monitoring transects (Figure 2-9 and Figure 2-10). As shown in these two figures, under typical flow conditions, the groundwater elevation on the interior of the wall is generally higher than the surface water elevation along the southern monitoring transect, whereas, the groundwater and surface water elevations are relatively similar near the northern transect. The average difference in water elevations between the groundwater and surface water at the southern transect during the monitoring period was 1.2 feet. These elevation differences in the southern transect were compared to the difference in elevations recorded in groundwater monitoring well MW-48S and the abandoned river bank gauging point RBGP-48, located approximately 525 feet from the southern monitoring transect during 2006 (prior to installation of the bank stabilization measures). During 2006 there was an average difference in groundwater and surface water elevations of 0.75 feet. This increase in the hydraulic head between the groundwater and surface water under typical discharge conditions in the river indicates a reduction in hydraulic communication between groundwater and surface water due to the partial penetrating barrier wall. As anticipated, groundwater must follow a more tortuous pathway beneath the barrier wall before discharging to surface water.

Furthermore, as the river stage increases, there was a downward vertical gradient observed on the outboard side of the wall with a corresponding upward vertical gradient on the inboard side of the barrier. The downward gradient (represented by a negative head difference) was significantly greater on the outboard side of the wall compared with the upward gradient on the inboard side of the wall. The large difference in gradients between the interior and exterior of the wall also indicates a diminished hydraulic communication between surface water and groundwater associated with the partial penetrating barrier wall.

2.6.2 GROUNDWATER, HYPORHEIC, AND SURFACE WATER MONITORING

The groundwater, hyporheic, and surface water monitoring wells were purged and sampled using a low flow methodology to prevent potential disturbance of the water quality. An inflatable packer system was used within the hyporheic/surface water zone monitoring wells to isolate a one foot interval within the uppermost portion of the water column to collect the surface water sample, and then to isolate a portion of the screen at the surface water/groundwater interface to collect the hyporheic water sample. Samples collected from the barrier monitoring network during March and June 2009 were analyzed for the dissolved phase constituents of concern. In addition, samples collected from the middle and southern transects in June 2009 were also analyzed for natural attenuation indicators. Field forms from these monitoring events are provided in Appendix C. Groundwater, hyporheic zone, and surface water analytical reports and data validation reports are included in Appendix D.

A summary of the groundwater results for constituents of concern and natural attenuation parameters are provided on Tables 2-5a and 2-5b. There were low level, estimated concentrations of benzene, ethylbenzene, total xylenes, and dissolved phase arsenic measured in samples collected from the outboard monitoring wells during the March and June 2009 monitoring events. These constituents were not detected in the inboard monitoring wells indicating the source of impacts was not associated with petroleum hydrocarbons present in the smear zone along the west bank of the river. The surface water screening standards were not exceeded in any of the hyporheic or surface water samples collected during the first half of 2009.

2.7 VAPOR MONITORING

Soil vapor monitoring is conducted as part of the routine monitoring program associated with the final corrective measures program to: (1) confirm that there is not a completed pathway, or an increase in incremental risk to residents in Hooven associated with intrusion of volatile constituents present in soil vapor that are associated with releases from the former refinery, (2) track remedial system effectiveness on reducing the concentration of petroleum related constituents present in the deep portions of the vadose zone, and (3) estimate the mass of petroleum hydrocarbons that are attenuated within the smear zone over the course of the final groundwater remedy. Soil vapor samples are collected from selected nested wells in Hooven (VW-93, VW-96, VW-99, VW-128, and VW-129) and on-site (wells VW-18, VW-20, and VW-21) in accordance with the schedule established in the RIP (Trihydro 2007a) and OMM plan (Trihydro 2007b). As such, vapor samples were not collected from the nested vapor wells in Hooven or on the facility during the first semiannual monitoring period in 2009. Samples were collected from the nested vapor monitoring wells in Hooven during September and October 2009 and will be reported in the *Second 2009 Semiannual Monitoring Report.* However, helium tracer testing was conducted in selected nested vapor wells located in Hooven and on the facility during the spring of 2009. Helium tracer testing was performed to estimate the vapor diffusion coefficient (VDC) in areas overlying the smear zone and is discussed in the following subsection. Field forms for the helium tracer testing are provided in Appendix H.

2.7.1 VAPOR DIFFUSION COEFFICIENT

The VDC is defined as the “ease” at which vapors can move through the vadose zone soils. Vapors are transported more easily through soils with a high VDC. The VDC was measured at multiple locations within the vadose zone in the spring of 2009 to provide supporting data for future estimates of hydrocarbon mass loss rates in the vapor phase, as well as updating the site conceptual model.

The VDC of selected intervals in nested wells VW-18, VW-20, VW-21, VW-93, VW-96, VW-99, and GP-7 were estimated using a tracer test methodology during the first half of 2009 and reported in Table 2-6. The tracer method involves injection of 300 milliliters of ultra high purity grade helium into the selected vapor point with an airtight syringe followed by injection of a known volume of ambient air. The volume of ambient air injected into each vapor point is equal to the volume of ambient air present in the tubing between the ball valve at the top of the interval and the soil vapor probe at depth, such that the helium is displaced into the formation around the vapor probe. An instantaneous sample was collected by purging the same volume of ambient air and helium that was injected to the vapor point using the airtight syringe. After purging, approximately 300 milliliters of soil gas were collected into a 1-liter Tedlar bag and the instantaneous helium concentration was measured. This helium concentration was recorded as the “time zero” concentration. The vapor probe and line were then flushed with 10-liters of ambient air. This procedure was subsequently repeated and helium concentrations were recorded over two successive time intervals (approximately 20 and 60 minutes) following injection of the tracer gas. The change in helium concentration recorded over the three injection intervals (approximately 0, 20, and 60 minutes) during tracer testing can be used to estimate the VDC of the formation or fill material surrounding the soil vapor probe using the equations provided in Johnson et al. (1998) for a point source.

This tracer methodology was slightly modified during testing performed in 2009 compared to previous events conducted in 2008. The first adjustment involved rehabilitation of selected vapor points within nested well VW-18. These vapor points had diminished soil gas permeability based on previous VDC testing and monitoring and were rehabilitated by injecting gaseous nitrogen to clear the screen intervals. Several days following rehabilitation, tracer testing was performed.

The second adjustment to the tracer test methodology included measurement of the initial methane and helium concentration within the soil vapor point at each well to account for interference of methane gas. If present in a vapor sample, methane can produce a false positive for helium detections using the field instrumentation, with higher methane concentrations yielding higher false positive helium results. To adjust for this, a pre-test sample was taken from each vapor point and the sample was measured for ambient response using the helium meter. This value was recorded on the field log and was assumed as a false positive because no helium was expected to be present in the formation prior to conducting the test. This pre-test helium measurement was used to adjust the VDC values reported in Table 2-6. The adjusted VDC values were estimated by subtracting the measured pre-test helium concentration from the helium concentration at time zero.

The VDC estimates calculated from data collected in 2009 ranged from 4.6 x 10^{-4} square centimeters per second (cm^2/s) at the five foot interval in well VW-18 to 2.1 x 10^{-2} cm^2/s within the five foot interval in nested well VW-93. This is similar to the range reported for previous monitoring events conducted in 2008. The vapor points that had been rehabilitated in well VW-18 had slightly higher VDC values in spring 2009 compared to previous test results. In cases where the pre-test helium measurement was greater than zero, the adjusted VDC values were slightly lower than the unadjusted VDC values.

3.0 INTERPRETATION

Data collected during the first half of 2009 and included herein continue to demonstrate that the intrinsic processes in the saturated and unsaturated zones are degrading petroleum hydrocarbons in the smear zone. These same processes are reducing dissolved and vapor phase petroleum hydrocarbons to levels that are protective of sensitive receptors at the point of compliance boundaries in Hooven and the Southwest Quad. It should be noted that in accordance with the schedule established in the RIP (Trihydro 2007a) and OMM plan (Trihydro 2007b), soil vapor samples were not collected from the nested vapor wells in Hooven or on the facility during the first semiannual monitoring period in 2009. Therefore, this report does not provide an update regarding intrinsic biodegradation processes and stability of petroleum hydrocarbons within the vadose zone. Samples were collected from the nested vapor monitoring wells in Hooven during September and October 2009 and an update regarding attenuation processes within the vadose zone will be provided in the *Second 2009 Semiannual Monitoring Report.*

In general, natural attenuation occurs as constituents present in the smear zone partition to groundwater and soil vapor, where they are biodegraded via aerobic and anaerobic processes. There are two general lines of evidence provided herein to support the efficacy of natural attenuation processes to degrade petroleum hydrocarbons at a rate that will achieve remedial goals for groundwater (i.e. maximum contaminant levels) in a timeframe comparable to active remedial measures. The primary lines of evidence demonstrate the stability of petroleum hydrocarbons in the smear zone beneath the Site and protectiveness of sensitive receptors (Section 3.1); as well as meaningful trends of decreasing constituent concentrations over time (Section 3.2). The secondary lines of evidence, discussed in Section 3.3, includes evaluation of hydrogeochemical data that demonstrate indirectly the natural attenuation mechanisms are acting to transform hydrocarbon constituents, reduce concentrations, and inhibit mobility of the LNAPL, dissolved phase, and vapor phase impacts. Baseline qualitative and quantitative lines of evidence were discussed in the *First 2008 Semiannual Monitoring Report, Chevron Cincinnati Facility, Hooven, Ohio* (Trihydro 2009a). Updates to these lines of evidence for which data was collected during the first half of 2009 are included herein.

3.1 PLUME STABILITY AND PROTECTIVENESS OF SENSITIVE RECEPTORS

During execution of the final groundwater remedy at the Site, Chevron must continue to demonstrate that the LNAPL and dissolved phase plumes are stable and that sensitive receptors remain protected (USEPA 1999). If the extent of the LNAPL, dissolved, or vapor phase petroleum hydrocarbons are determined to be mobile or impacting sensitive receptors above risk based limits, contingency measures would be employed as outlined in the OMM Plan (Trihydro 2007b).

3.1.1 LNAPL

As discussed in the *Update to Site Conceptual Model and Summary of Remedial Decision Basis* (Chevron Cincinnati Groundwater Task Force 2005) and outlined within the *First 2008 Semiannual Monitoring Report, Chevron Cincinnati Facility, Hooven, Ohio* (Trihydro 2009a), LNAPL within the smear zone is stable. This determination was made based on (1) the age of the release; (2) a decrease in LNAPL gradients, transmissivity, and saturations due to natural degradation and engineered recovery; (3) morphology of the smear zone with a "thicker" core, which thins at the lateral edges; (4) there having been no expansion of LNAPL beyond the originally defined limits of the smear zone; and (5) preferential depletion of petroleum related constituents within the LNAPL at the soil gas and groundwater interface (otherwise referred to as outside-in weathering of the plume).

Data collected during the first half of 2009 continue to support that the smear zone is stable based on the laser induced fluorescence measurements in the three ROST monitoring transects conducted on June 18 and 20, 2009. Additionally, LNAPL was not measured in any of the sentinel or point of compliance monitoring wells installed in the Southwest Quad or in any of the wells located beyond the smear zone extent in Hooven during gauging events conducted in the first half of 2009. Fluid level gauging within the performance monitoring network installed along the west bank of the Great Miami River also confirmed the stability of the smear zone along the restored river bank.

Historical petrophysical tests on soil cores collected in the saturated portions of the smear zone indicate two-phase (water-oil) LNAPL residual saturation ranges from about 18 to 25%. Data collected from the facility show an exponential decrease in the ability of LNAPL to migrate at saturations below 20 to 25%. Field testing completed in the late 1990s indicates that the two-phase LNAPL saturations in the majority of the plume were below residual values (i.e., immobilized). Additionally, soil core samples were collected on the facility in November 2008 and soil saturations calculated using this data also demonstrated that LNAPL saturations within the upper, middle, and lower portions of the smear zone were below residual values.

Smear zone coring was completed in May 2009 in Hooven near monitoring wells MW-93 and MW-96 and the LNAPL saturations were estimated using the total petroleum hydrocarbon concentrations averaged for the soil cores collected at each location, soil bulk density, LNAPL density, and soil porosity. The total petroleum hydrocarbon concentrations for smear zone location SZ-93, as well as the upper and middle location at well SZ-96 indicate that petroleum hydrocarbons are sorbed to soil or present in the dissolved phase, and LNAPL is no longer present. Average LNAPL saturations in the lower portion of the smear zone near monitoring well MW-96 was 5.6%. As with the saturations measured within the soil cores collected on the facility in November 2008, the LNAPL saturations in Hooven were below the residual values and the plume is considered immobile.

3.1.2 DISSOLVED PHASE

As previously described in Section 2.2.1, benzene was detected in the groundwater sample collected from sentinel well MW-35 during routine monitoring conducted in November 2008 at a concentration of 0.13 mg/L, which exceeded the MCL (0.005 mg/L). None of the other constituents of concern (ethylbenzene, toluene, xylenes, chlorobenzene, arsenic, or lead) were detected above laboratory detection limits in samples collected from well MW-35 or any of the other sentinel or POC monitoring wells during sampling conducted in November 2008.

Sentinel well MW-35 and the corresponding down-gradient POC well MW-133 along with wells MW-131 through MW-134 were re-sampled between February 17 and 19, 2009 for the dissolved phase constituents of concern. Benzene was reported in the groundwater sample collected from well MW-35 at a concentration of 0.021 mg/L, in addition to the sample collected from the POC well MW-133 at an estimated concentration of 0.003 mg/L. Again, there were no other detections of the dissolved phase constituents of concern within any of the other wells. Although the source of the dissolved phase benzene was not believed to be associated with historical releases from the refinery present in the smear zone, hydraulic containment pumping was resumed in late March 2009. Containment pumping using production wells PROD_15 and PROD_24 continued until August 2009 when high-grade recovery was initiated.

During routine monitoring conducted in the first half of 2009, none of the constituents of concern were measured in any of the other sentinel or POC wells installed in the Southwest Quad. Benzene has not been measured above detection limits in samples collected from sentinel well MW-35 since March 2009, while benzene persisted in groundwater samples collected from POC well MW-133 until August 2009. As described in the *Work Plan for Contingency Measures in the Southwest Quad, Chevron Cincinnati Facility, Hooven, Ohio* (Trihydro 2009c), there are several lines of evidence indicating that the dissolved phase benzene detected in sentinel well MW-35 and POC well MW-133 are associated with alternate sources within the Southwest Quad. Thus, the detections of benzene are not believed to be associated with re-distribution of petroleum hydrocarbons associated with the former refinery and the dissolved phase plume is concluded to be stable beneath the Southwest Quad.

3.2 CONSTITUENT TRENDS

It is expected that the data collected over the course of the remedy will show a meaningful trend of decreasing hydrocarbon mass and/or constituent concentrations over time. Analyses that may be used in evaluating the progress of the long term remedy in meeting remedial goals (i.e., MCLs in groundwater) include evaluation of temporal trends in contaminant concentrations, LNAPL mass, or LNAPL saturations; comparisons of observed contaminant distributions with predictions; as well as comparison of calculated attenuation rates with those necessary to meet remedial goals within the required time frame. These analyses can be complicated as a result of variation in the petroleum hydrocarbon distribution across the site, temporal fluctuations related to seasonal and longer term trends, heterogeneity in the vadose and saturated zones across the plume footprint, along with measurement variability. These complications necessitate the use of multiple lines of evidence and expanded monitoring networks to reduce uncertainty.

3.2.1 LNAPL AND SOIL CORE CONSTITUENT TRENDS

Figure 3-1 shows the mole fraction of benzene in LNAPL samples collected in 1997, 1999, and 2005 from four sets of wells (MW-1R/PROD_20, MW-58/PROD_12, PROD_15, and MW-96S) on a logarithmic-linear scale. This figure also shows the decline in the average mole fraction of benzene for all the LNAPL samples collected over this timeframe. The trends presented on this figure depict a first order degradation rate for benzene in the LNAPL since 1997.

As the LNAPL saturation and transmissivity continue to decrease across the smear zone over time, it may become infeasible to collect LNAPL samples for laboratory analysis. As a result, smear zone soil coring will be conducted to provide a means of measuring LNAPL composition. As described in Section 2.5, soil coring was conducted near monitoring wells MW-93 and MW-96 in Hooven in May 2009. The mole fraction of volatile organic constituents of concern, including benzene, within the LNAPL were calculated using the soil core analytical results from the bottom of the smear zone collected at location SZ-96. To complete these calculations using the soil cores instead of LNAPL samples, two main assumptions must be made:

1. The majority of organic matter measured in the smear zone soil is present in the form of LNAPL. Therefore, both the laboratory results for individual constituents of concern and the total petroleum hydrocarbon ranges are representative of LNAPL. This assumption is not true for the soil cores collected from location SZ-93 as well as the upper and middle portions of the smear zone at location SZ-96.
2. The total petroleum hydrocarbon results used to estimate the molecular weight of the LNAPL within the soil core are comprised of 100% aliphatic compounds. This is a conservative assumption because this will tend to provide a lower estimate of the molecular weight of the LNAPL and therefore a higher estimate of the mole fraction results.

The benzene mole fractions estimated within the soil cores collected during 2008 and 2009 were compared to the mole fraction benzene in LNAPL shown on Figure 3-1. There was general agreement between benzene mole fractions reported in the LNAPL samples collected in 2005 and smear zone soil cores collected in 2008 and 2009, with slightly higher concentrations estimated in the soil cores. This is likely a function of the conservative assumptions used in calculating mole fraction benzene in LNAPL from the soil core samples.

It is important to note that the TPH concentrations measured in the soil core samples collected at boring SZ-93, as well as the top and middle samples collected at the locations SZ-96 were below 100 mg/kg. These low values are typically associated with petroleum hydrocarbons present as the dissolved phase, and sorbed to soil organic matter, rather than being present as LNAPL. The average TPH concentration measured in bottom samples collected at location SZ-96 was 3,055 mg/kg. This corresponds to an LNAPL saturation of approximately 5.6%, based on API guidance (API Interactive LNAPL Guide, version 2.0.4, 2004).

In the past, LNAPL has been observed to enter monitoring wells MW-93 and MW-96. Under equilibrium conditions, LNAPL presence in a monitoring well would correspond to LNAPL presence in the formation near the water table. However, based on the TPH data, currently LNAPL is only present at the base of the smear zone near monitoring well MW-96, and absent near monitoring well MW-93. This suggests that environmental dynamics, such as a fluctuating water table, high grade LNAPL recovery, and HSVE operation, have acted to remove much of the subsurface LNAPL in these portions of Hooven. Future monitoring of the smear zone in Hooven will focus on the bottom sampling interval at location at SZ-96, where LNAPL is still present. This location will be re-sampled on five year intervals. This will provide a smaller sample set compared to the on-site soil core locations where the top, middle, and bottom of the smear zone will be monitored every five years.

3.2.2 DISSOLVED PHASE CONSTITUENT TRENDS

The distribution of selected dissolved phase benzene, toluene, ethylbenzene, and total xylenes in groundwater as well as total petroleum hydrocarbons concentrations for samples collected during the first 2009 semiannual monitoring period are displayed on Figure 3-2. It is useful to evaluate the dissolved phase constituent trends in two ways. First, dissolved phase constituent trends within individual groundwater monitoring wells can be used to assess spatial variability in engineered mass removal and intrinsic biodegradation processes across the smear zone footprint and identify areas that are not behaving as predicted. Second, groundwater quality trends can be averaged within areas of the smear zone (i.e., up-gradient, interior, down-gradient) to assess overall trends in natural attenuation processes. For discussion purposes, there are two areas up-gradient of the smear zone, one to the north of the facility property and the second to the west along the Buried Valley Aquifer-bedrock interface in Hooven.

3.2.2.1 TRENDS WITHIN INDIVIDUAL MONITORING WELLS

While useful for inferring source zone depletion of individual constituents, temporal trends observed in the dissolved constituent concentrations collected from individual wells can also be essential indicators of plume stability and progress toward meeting remedial goals. In the absence of remedial efforts, (i.e. HSVE system operation), decreasing dissolved phase concentrations over time within the plume area indicate that natural attenuation processes are acting to reduce contaminant mass and concentrations. Trend analyses should be conducted in monitoring locations situated throughout the distribution of petroleum hydrocarbons to assess the range of dominant intrinsic processes acting on the plume. Temporal trends in individual wells may also indicate changes in climatic, hydrogeochemical, contaminant release, site reuse, or other conditions unrelated to attenuation processes and need to be evaluated in the context of other lines of evidence.

Historically, groundwater samples have not been collected from the interior plume monitoring wells due to the presence of LNAPL during sampling. For the purpose of this analysis, trends are inferred for wells that have groundwater data from at least three monitoring events spanning three separate years. Of the ten interior plume wells, six monitoring wells (MW-10R, MW-18R, MW-20S, MW-58S, MW-88, and MW-96S) do not have data that meet these criteria. Constituent of concern concentrations reported in the samples collected from interior monitoring well MW-85D were all reported below the remedial goals, which is expected as this well is screened in the deeper portions of the Buried Valley Aquifer, well below the vertical distribution of dissolved phase petroleum hydrocarbons. Dissolved phase trends for the three remaining interior plume monitoring wells (MW-17, MW-22 and MW-81S) are provided on Figure 3-3, Figure 3-4, and Figure 3-5. Monitoring well MW-17 is located in the interior of the smear zone and dissolved phase benzene concentrations continue to be measured at concentrations above remedial goals. There is a slight decreasing trend in benzene concentrations over time. This decreasing trend may become more pronounced over time as the smear zone up-gradient of well MW-17 becomes depleted and attenuation continues from the “outside-in.” Monitoring well MW-22 is located north of well MW-17, closer to the up-gradient edge of the smear zone, and accordingly shows a stronger decreasing trend in benzene concentrations over time. Monitoring well MW-81S is situated in the southwest limit of Hooven adjacent to State Route 128. Dissolved phase constituent concentrations in this well show a clear decreasing trend between 1996 and 2008. This trend is likely associated with startup of the groundwater production, LNAPL recovery, and HSVE systems between 1999 and 2000, focused on remediation of petroleum hydrocarbons beneath Hooven.

Of the eight supplemental groundwater monitoring wells (L-1RR, L-3R, MW-21, MW-33, MW-51, MW-64, MW-80, and MW-99), wells L-1RR, L-3R, MW-21, MW-33, MW-64, and MW-99S had sufficient data (i.e., results from at least three monitoring events spanning more than three years) to complete a trend analysis. The dissolved phase results for the constituents of concern reported in samples collected from well MW-33 have remained below MCLs over time. As presented on Figures 3-6 through 3-8, dissolved phase benzene concentrations reported in supplemental monitoring wells L-1RR, L-3R, and MW-21 showed a first order degradation rate over time. These wells are generally located outside of the footprint of remedial measures at the facility; therefore these decreasing trends are indicative of natural attenuation processes. The rate of decline in benzene concentrations is greater in well MW-21 compared to monitoring wells L-1RR and L-3R, as this well is located along the up-gradient edge of the smear zone. The dissolved phase benzene concentrations reported in samples collected from monitoring wells MW-64 (Figure 3-9) and MW-99S (Figure 3-10) also show decreasing trends over time. These two monitoring wells are located on the eastern and western edge of the smear zone, respectively, and also demonstrate preferential depletion of benzene along the smear zone margins (i.e., outside-in weathering).

Temporal analysis of the dissolved phase results can also be conducted for three additional monitoring wells (MW-85S, MW-93S, and MW-115S) located within the distribution of hydrocarbons at the facility, as these wells have a sufficient monitoring history with concentrations above remedial goals. Figures 3-11 through 3-13 show decreasing trends in dissolved phase benzene concentrations over time in these three monitoring wells. Monitoring wells MW-85S and MW-115S are located outside the influence of historic remedial efforts along the Great Miami River and in the Southwest Quad, respectively. Trends within these two wells are considered indicative of natural attenuation processes. Well MW-93S is located in Hooven and the trends observed in the groundwater analytical results from this well most likely have been influenced by hydraulic and vapor recovery efforts since 1999.

The average first order degradation rate estimated using the dissolved phase analytical results from eleven monitoring wells (L-1RR, L-3R, MW-17, MW-21, MW-22, MW-64, MW-81S, MW- 85S, MW-93S, MW-99S, and MW-115S) is approximately 6.6 x 10^{-4} per day. This compares well with previously estimated first order decay rates for the benzene mole fraction in LNAPL. The average estimated first order decay rate for benzene in LNAPL, based on LNAPL and smear zone soil samples collected between 1997 and 2009, is 5.2 x 10^{-4} per day.

As additional dissolved phase data is collected, it will be possible to make meaningful decisions regarding the temporal trends across the distribution of hydrocarbons. Attenuation rates will be compared over time within individual wells installed across the plume and progress towards meeting the remedial goals will be further considered.

3.2.2.2 AVERAGE TRENDS ACROSS SMEAR ZONE

Table 3-1 provides the average dissolved phase constituent concentrations measured in the up-gradient, interior, and down-gradient portions of the smear zone during the first half of 2009. The average dissolved phase constituent and total petroleum hydrocarbon concentrations are indicative of ongoing natural attenuation processes, with preferential LNAPL depletion at the smear zone boundaries. The average dissolved phase benzene concentration was 0.003 mg/L in samples collected from the monitoring wells located in the two up-gradient areas while the average concentration of dissolved phase benzene within the smear zone was 1.19 mg/L. Down-gradient of the smear zone, the average benzene concentration was 0.027 mg/L. This indicates that attenuation processes such as dispersion, sorption, and biodegradation reduce the dissolved phase concentration, reduce mobility of the plume, and/or transform constituents of concern as the plume exits the smear zone.

The average dissolved phase benzene concentration trends for selected monitoring wells located in the up-gradient (MW-21 and MW-22), interior (L-1RR, L-3R, MW-17, and MW-18R), and down-gradient (MW-48S, MW-94S, and MW-115S) portions of the smear zone are presented on Figure 3-14. Dissolved phase concentrations depicted were reported during monitoring conducted in 2002, 2004, 2008, and 2009 and are averaged for the up-gradient, interior, and down-gradient wells. Irrespective of the well locations, there is a decreasing trend in the dissolved phase benzene concentration reported between 2002 and 2009, indicative of benzene depletion from the smear zone. These decreasing trends are more pronounced at the margins of the smear zone compared to the interior portion of the plume. At its margins, the smear zone is thinner and LNAPL saturations are lower. In addition, as reported on Table 3-1, groundwater enriched in electron acceptors intercepts the smear zone north of the facility and again to the southeast of the Buried Valley Aquifer-bedrock interface in Hooven creating a situation whereby petroleum hydrocarbons including benzene are attenuated more quickly along the margins than the interior of the smear zone. These observations are consistent with the expectation of outside-in attenuation of petroleum hydrocarbons within the smear zone.

As the up-gradient portion of the smear zone is depleted of petroleum hydrocarbons, the benzene removal rates from the interior portion of the smear zone will increase as outside-in weathering continues. It is anticipated that the dissolved phase benzene concentrations reported in monitoring wells L-1RR and MW-17 will show trends similar to those currently observed in wells MW-21 and MW-22. This may then be followed by a similar transition in the dissolved phase benzene trends observed in monitoring wells L-3R and MW-18R. Over time, it is expected that benzene concentrations in groundwater will continue to decrease across the smear zone, eventually approaching remedial goals (i.e., USEPA MCL).

3.3 GEOCHEMICAL INDICATORS OF NATURAL ATTENUATION

Characterization of geochemical variations in the vadose and saturated zones provides evidence of the types of biodegradation processes that are thought to be attenuating petroleum hydrocarbons in the smear zone. Many of the processes attenuating hydrocarbons in the smear zone cannot be measured directly (e.g., biological transformation of contaminants). However, the processes may cause changes in geochemical parameters, leaving an observable "footprint" that can be related qualitatively and quantitatively to the natural attenuation processes (National Research Council 2000). In general, geochemical species serve as electron acceptors and are reduced during microbial degradation (i.e., oxidation) of petroleum hydrocarbons.

3.3.1 DISSOLVED PHASE CONSTITUENTS

During microbial degradation of petroleum impacts, the dissolved oxygen concentrations steadily decrease until anaerobic conditions prevail. Once anaerobic conditions exist and multiple potential electron acceptors (i.e., oxidizers) are available, microorganisms preferentially use the electron acceptor that is thermodynamically most favorable. The general order of preference for anaerobic hydrocarbon biodegradation based on the Gibb's energy of the reaction is:

- Denitrification (reduction of nitrate), with the eventual production of molecular nitrogen
- Reduction of manganese from Mn4+ to Mn2+
- Reduction of ferric iron (Fe3+) to ferrous iron (Fe2+)
- Sulfate reduction, with eventual production of sulfide
- Reduction of carbon dioxide and generation of methane

These microbial processes generally segregate into distinct zones dominated by oxygen, nitrate, ferric iron, sulfate, and carbon dioxide reduction. Furthermore, given the different electron acceptors consumed and final products produced it is theoretically possible to differentiate the "zones" of microbial processes across the smear zone.

If dissolved oxygen is present in groundwater above 0.5 mg/L, then aerobic biodegradation of petroleum hydrocarbons is the dominant process. If dissolved oxygen concentrations are less than 0.5 mg/L, but nitrate concentrations exceed 1.0 mg/L, then denitrification dominates. Because nitrite is an unstable intermediate product of denitrification, the presence of measurable nitrite concentrations is indicative of nitrate reduction. If groundwater is deprived of dissolved oxygen, nitrate, and nitrite; but concentrations of ferrous iron are greater than 0.5 mg/L then iron reduction will be the dominant biodegradation process. If groundwater is depleted in ferrous iron but contains concentrations of sulfate above 1.0 mg/L and hydrogen sulfide above 0.05 mg/L, then sulfate reduction will be the predominant process. Finally, if the groundwater is depleted in all the electron acceptors and by-products, with the exception of methane greater than 0.2 mg/L, then methanogenesis is the predominant process degrading petroleum hydrocarbons. When applied at a field scale this differentiation of microbial zones commonly encounters uncertainties as many of the by-products of microbial metabolism (such as ferric iron, hydrogen sulfide, and methane) are readily transported down-gradient. Based on data collected in 2008, sulfate reduction and methanogenesis account for more than 90% of smear zone natural attenuation within the saturated zone.

The spatial distribution of electron acceptors measured during the first 2009 semiannual monitoring period is displayed on Figure 3-15. Nitrate and sulfate concentrations were higher up-gradient of the smear zone compared to within the smear zone. Specifically, the average nitrate and sulfate concentrations in up-gradient groundwater, as provided in Table 3-1, were 4.53 and 66.9 mg/L, respectively. Sulfate enriched water enters the smear zone with groundwater flowing from the north of the facility and bedrock-aquifer interface in the western portions of Hooven. Groundwater flowing from the west in Hooven also contains elevated nitrate. The average sulfate concentration within the smear zone was 5.6 mg/L, with the majority of the samples reported as non-detect for sulfate. Nitrate was not detected above the reporting limit within the smear zone, with the exception of a low level (1.7 mg/L) detection at MW-93S, where the smear zone has been depleted via interim and final groundwater corrective measures. Nitrate concentrations did not show a marked rebound in the down-gradient portions of the smear zone. However, dissolved phase sulfate concentrations rebounded to 14.8 mg/L down-gradient of the smear zone, likely the result of the supply of hydrocarbons in groundwater being exhausted by biodegradation processes.

The spatial distribution of reduced species and attenuation by-products including dissolved iron, manganese, and methane are depicted on Figure 3-16. The concentration of each of these oxidation by-products was higher within the smear zone compared to up-gradient and down-gradient conditions. As reported in Table 3-1, the average dissolved iron, manganese, and methane concentrations up-gradient of the smear zone were 0.09, 0.058, and 0.01 mg/L, respectively. Average dissolved iron, manganese, and methane concentrations within the smear zone were 11.35, 0.483, and 13.36 mg/L, respectively. This increase in the concentrations of these dissolved phase products indicates iron and manganese reduction of dissolved phase petroleum hydrocarbons, as well as methanogenic processes that transform dissolved hydrocarbons to methane. Down-gradient of the smear zone dissolved iron concentrations decrease to 0.21 mg/L.

Figure 3-17 shows the concentration of dissolved phase benzene versus distance through the centerline of the smear zone with a comparison to sulfate, iron, and methane concentrations. Dissolved phase manganese was not included on these distances versus concentration plots as previous estimates suggest manganese reduction represents less than 1% of the total smear zone mass loss in the saturated zone. Additionally, nitrate was not included on this figure as denitrification is only a significant mechanism for natural attenuation in the southern portions of the smear zone. As portrayed on Figure 3-17, iron and sulfate reduction, as well as methanogenesis primarily occur within 1,000 feet down-gradient of the smear zone boundary where available electron receptors are fully reduced. Thus, the efficacy of intrinsic processes to further degrade petroleum hydrocarbons in the saturated zone is significantly reduced within several hundred feet of the smear zone boundary at the northern portion of the former refinery. Benzene concentrations rebound within the interior of the smear zone and then are reduced at the down-gradient limits of the smear zone, as methanogenic conditions prevail. These distances versus concentration plots further support that outside-in weathering of the smear zone is occurring. It should be noted that while natural attenuation mechanisms in the saturated zone are limited as oxidizers are rapidly utilized, intrinsic biodegradation within the vadose zone occurs across the entire smear zone footprint and accounts for as much as 80% of mass loss over time.

4.0 GULF PARK

A former products transfer pipeline corridor, consisting of five 6-inch diameter lines that connected the former refinery with a loading terminal on the Ohio River, was located beneath the Gulf Park property. The pipelines carried three grades of gasoline, kerosene, aviation fuel, diesel, and fuel oil during use between 1930 and the mid-1980s. Hydrocarbon-stained soil was discovered in Gulf Park in January 1993 at approximately 10 to 14 feet below grade. Several subsurface investigations to define soil and groundwater conditions and the extent of petroleum hydrocarbons were conducted between 1993 and 1994.

Based upon the findings of these investigations, a bioventing system was installed in the area that is now the westernmost soccer field at Gulf Park in 1996. It consists of 14 air injection wells designed to deliver approximately 30 to 35 standard cubic feet per minute (scfm) to each injection well, and a blower. Valve controls for the air injection wells installed in the soccer field area are located in a nearby Valve Control Shed (VCS No. 1). A bioventing system expansion was installed between August and October 2000, consisting of an additional 38 bioventing wells constructed of 2-inch diameter PVC casing and 0.010-inch slotted screen. These bioventing wells were completed below grade and connected to a separate Valve Control Shed (VCS No. 2). Figure 4-1 shows the layout of the two bioventing systems installed at Gulf Park.

There are two primary lines of evidence used to evaluate the remedy performance at Gulf Park. First, soil vapor data is collected from selected nested wells installed in the shallow and deep portions of the vadose zone to evaluate fixed gas concentrations during times when the bioventing system is active and inactive. Second, dissolved phase monitoring is conducted annually in Gulf Park to evaluate temporal and spatial trends in the dissolved phase constituents of concern, as well as natural attenuation indicators.

4.1 BIOVENT SYSTEM PERFORMANCE MONITORING

Bioventing stimulates intrinsic biodegradation of petroleum hydrocarbons in the vadose zone by injecting air at low flow rates to provide sufficient oxygen to sustain aerobic microbial activity. Airflow is injected at rates designed to maximize oxygen delivery to the subsurface while minimizing volatilization of hydrocarbon constituents, thus eliminating the necessity for vapor intrusion or ambient air pollution control measures.

Startup and shutdown criteria for the biovent system are related to groundwater trigger levels beneath Gulf Park. Historic soil vapor monitoring data indicate that higher respiration rates occur within the lower portions of the smear zone. However, this portion of the smear zone is only exposed above the groundwater table during low water table conditions. The groundwater level is typically above the trigger level elevation from January through June and below the trigger level intermittently from June through December. The period of low water table conditions is considered the seasonal bioventing operation period. Figure 4-2 presents the hydrographs from the trigger monitoring wells for 2006 through 2009. As shown, groundwater elevations fluctuated above and below the trigger level within wells GPW-5S and TH-2 from January through June 2009.

The bioventing system at Gulf Park was operated intermittently during the first half of 2009, with shut downs due to high water levels between January 5 through 13, February 11 through March 16, April 9 through April 29, and April 30 through July 7, 2009. Each bioventing well has a valve to regulate air flow and a port used for monitoring temperature, pressure, and air flow. The system monitoring activities performed during operation of the biovent system in the first half of 2009 consisted of:

- Recording operational parameters (pressure, flow rate, and temperature) periodically at the process blower in order to document the blower performance
- Measuring air flow parameters in each of the biovent wells weekly in order to document the amount of air delivered to the subsurface through each injection well
- Gauging fluid levels within the system trigger wells (GPW-5S and TH-2) on a weekly basis to determine the schedule for system startup and shutdown
- Collecting field measurements of soil vapor composition including total organic vapor, pressure, and fixed gas concentrations (O_2, CO_2, and CH_4) to qualitatively evaluate system effectiveness

4.1.1 BIOVENT SYSTEM PERFORMANCE RESULTS

During system inspections and each time air flow adjustments were made, performance parameters for active (i.e., valve not closed) injection wells were monitored within VCS No. 1 (Lines BV-1 through BV-14) and VCS No. 2 (BVW-1 through BVW-38). Biovent wells in VCS No. 1 contain analog, vane-style flow meters, which allow for measuring instantaneous flow rates. Biovent lines located in VCS No. 2 were installed with sensor ports to allow for measurement of pressure, temperature, and differential pressure in order to calculate standard air flow rate.

Pressure in the individual biovent wells in VCS No. 2 was measured using a digital manometer. Injection air temperature measurements for the biovent expansion system were collected from dedicated dial gauge thermometers installed on each vent line. Flow rates measured at individual biovent well lines were measured using a Dwyer flow sensor manufactured to measure differential pressure in a 2-inch diameter pipe. The flow sensor was connected to a digital manometer, and differential pressure values provided by the manometer were recorded. The recorded values were later converted to volumetric flow rates and corrected to standard conditions.

During the first half of 2009, biovent system control valves were periodically adjusted to deliver a target 35 scfm of air to each biovent well. Based upon average flow rates measured at the biovent wells and recorded operation times, approximately 166,929,780 standard cubic feet of process air was injected into the expanded biovent system area during the periods of operation that occurred in the first half of 2009. The biovent well performance measurements, including dates and time of operation, are presented in Appendix I.

4.1.2 SOIL VAPOR MONITORING RESULTS

Soil vapor conditions including fixed gases, total organic vapor, and pressure were measured within selected nested vapor monitoring points including VP1-25S, VP1-25D, VP1-50S, VP2-25S, VP2-50S, VP3-35S, VP3-35D, VP4-25S, VP4-25D, VP6-35S, based on access to the vapor points and water table elevation. Due to the groundwater elevation at the time of measurement, several of the deeper vapor monitoring points could not be monitored. Several other points have been destroyed or covered over time due to surface maintenance activities at Gulf Park. Soil vapor field measurements were collected while the system was active on January 5, 2009 and prior to system start-up on July 7, 2009. Results of field measurements collected from accessible vapor monitoring points during January and July 2009 are included in Appendix J.

Table 4-1 presents the results of fixed gas and total organic vapor measurements collected from soil vapor monitoring points during January and July 2009. Comparison of the fixed gas concentrations measured prior to system start-up and when the system was active indicates that bioventing has a measurable impact on subsurface vapor composition within proximity of vapor points VP2-25, VP2-50, VP4-25, and VP6-35 within the central portions of the biovent system footprint. Whereas, along the eastern portion of the system (measured using vapor points VP1-25, VP1-50, and VP3-35) O_2 concentrations were elevated prior to the start up of the system indicating that aerobic biodegradation is occurring at a slow rate in this area. This is likely associated with historical depletion of petroleum hydrocarbons in the smear zone beneath this portion of the Park. Thus, operation of the system in 2009 did not substantially increase the O_2 concentrations above the near-atmospheric concentrations that were present prior to system operation.

These field screening results may be used in the future to terminate bioventing using portions of the system where aerobic conditions prevail throughout the year and petroleum hydrocarbons have been depleted. Additional air delivery can then be supplied to those portions of the Park where petroleum hydrocarbons persist and anaerobic conditions are observed during periods when the system is inactive.

4.1.3 GROUNDWATER MONITORING RESULTS

Groundwater samples were collected from the shallow monitoring wells (GPW-1S through GPW-5S, TH-1S, TH-2, and TH-3) and intermediate groundwater monitoring wells (GPW-1I, GPW-2I, GPW-3I and TH-1I) in June 2009 for analysis of the dissolved phase constituents of concern. Monitored natural attenuation parameters were also analyzed in groundwater samples collected from each of the shallow monitoring wells. The field forms for groundwater samples collected in Gulf Park are provided in Appendix C. Groundwater analytical and data validation reports for samples collected in the first half of 2009 are included in Appendix D.

Table 4-2 presents a summary of the constituents of concern measured in groundwater samples collected between 2006 and 2009. Concentrations of the volatile constituents of concern were only detected in samples collected from TH-1S and TH-2 during this monitoring event. Dissolved phase concentrations of benzene and ethylbenzene exceeded the remedial goals (i.e., MCLs) in one or more samples collected from these two wells. Monitoring well TH-2 is situated at the southern limits of the biovent system and well TH-1S is located approximately 100 feet south of the nearest air injection point.

A comparison of total BTEX versus time for groundwater samples collected from shallow monitoring wells GPW-1S through GPW-5S is provided on Figure 4-3. A measureable concentration of total BTEX in groundwater was last reported in any of these wells in November 2007. The overall decrease in total BTEX concentrations observed in these wells installed across Gulf Park is attributable to a combination of intrinsic biodegradation and historic biovent system operations.

The total dissolved phase BTEX concentration compared to the groundwater elevation over time for monitoring wells TH-1S and TH-2 is provided as Figures 4-4 and 4-5, respectively. An overall decreasing trend has been observed in dissolved phase BTEX concentrations measured in well TH-2. This decrease is attributed to both operation of the biovent system and natural attenuation processes within the smear zone beneath this portion of the Park. Concentrations of total BTEX measured in groundwater samples collected from well TH-1S appear to be more constant over time. Well TH-1S is located outside of the influence of the biovent system.

Dissolved phase natural attenuation indicators were analyzed in the shallow wells during the June 2009 monitoring event and are summarized on Table 4-3. In addition, the spatial distribution of oxidizers and attenuation by-products measured during the first 2009 semiannual monitoring period is displayed on Figure 4-6. In general, electron acceptors including nitrate and sulfate were reported at greater concentrations within the up-gradient monitoring well TH-3 compared to concentrations measured in wells TH-1S and TH-2, situated within the area of residual hydrocarbons beneath the Park. A rebound in the nitrate and sulfate concentrations was observed within the down-gradient monitoring well GPW-2S. It should be noted that the highest concentration of sulfate was reported in well TH-2 during the June 2009 monitoring event. The sulfate measured in this well may be associated with fertilizers used to enhance the growth of grasses within the open fields in this portion of Gulf Park. Rainwater infiltrate percolating through the vadose zone may become enriched in sulfate and transport this to the upper portion of the shallow water table. The increased availability of sulfate beneath this portion of the Park may be a secondary cause of the decreasing trend in dissolved phase BTEX concentrations observed in groundwater samples collected from monitoring well TH-2 compared to well TH-1.

The spatial distribution of reduced species including dissolved iron, manganese, and methane show an inverse relationship in groundwater beneath Gulf Park with low concentrations measured in up-gradient well TH-3 and an increase of these attenuation by-products measured across the distribution of petroleum hydrocarbons present beneath the Park. The greatest concentration of iron, manganese, and methane are reported in wells TH-1S and TH-2. The concentrations of the attenuation by-products rapidly decrease down-gradient of the smear zone in samples collected from monitoring well GPW-2S.

Figure 4-7 shows the concentration of total BTEX versus distance through the centerline of the smear zone with a comparison to oxidizer (nitrate and sulfate) and attenuation by-product (iron, manganese, and methane) concentrations. It should be noted that only monitoring wells GPW-2S, GPW-5S, TH-1S, TH-2, and TH-3 were utilized for this centerline analysis. Monitoring well TH-1S is located approximately 180 feet from the centerline depicted on Figure 4-6. Anaerobic degradation of each of the preferred electron acceptors is occurring across the smear zone with utilization of sulfate and nitrate and generation of reduced species of manganese, iron, and methane across the distribution of petroleum hydrocarbons associated with the historic pipeline release. The nitrate concentrations rebound and iron, manganese, and methane concentrations decline down-gradient of the distribution of petroleum hydrocarbons associated with the release.

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TABLES

TABLE 2-1. SOUTHWEST QUAD DISSOLVED PHASE ANALYTICAL RESULTS SUMMARY (NOVEMBER 2008 TO JUNE 2009)
FIRST 2009 SEMIANNUAL MONITORING EVENT
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

Location ID		Date Sampled	Benzene (mg/L)	Chlorobenzene (mg/L)	Ethylbenzene (mg/L)	Toluene (mg/L)	Xylenes, Total (mg/L)	Arsenic, Dissolved (mg/L)	Lead, Dissolved (mg/L)
MW-26R		11/25/08	0.003 J	ND(0.0008)	ND(0.0008)	ND(0.0007)	0.0008 J	ND(0.01)	ND(0.0069)
		3/27/09	0.007	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
MW-35		11/19/08	0.13	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
	Dup	11/19/08	0.13	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
		2/17/09	0.021	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
		4/03/09	0.021	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
	Dup	4/03/09	0.021	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
		4/28/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	--	--
		5/27/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	--	--
		6/29/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-37		11/18/08	ND(0.5)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
		4/02/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
MW-94S		12/08/08	ND(0.5)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
	Dup	12/08/08	ND(0.5)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
		4/02/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
MW-115S		12/09/08	ND(0.5)	ND(0.0008)	0.0008 J	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
		4/03/09	0.009	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
MW-120		11/18/08	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
		4/01/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
MW-131		11/21/08	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	0.0155 J	0.0225
		2/18/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	0.0144 J	ND(0.0069)
		4/02/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
MW-132		11/17/08	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
		2/19/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
		3/30/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)

TABLE 2-1. SOUTHWEST QUAD DISSOLVED PHASE ANALYTICAL RESULTS SUMMARY (NOVEMBER 2008 TO JUNE 2009)
FIRST 2009 SEMIANNUAL MONITORING EVENT
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

Location ID	Date Sampled	Benzene (mg/L)	Chlorobenzene (mg/L)	Ethylbenzene (mg/L)	Toluene (mg/L)	Xylenes, Total (mg/L)	Arsenic, Dissolved (mg/L)	Lead, Dissolved (mg/L)
MW-133	11/18/08	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
	2/17/09	0.003 J	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
	4/01/09	0.11	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
	4/28/09	0.036	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	--	--
	5/26/09	0.032	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	--	--
	6/29/09	0.11	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-134	11/17/08	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
	2/19/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
	3/30/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
MW-138	3/31/09	0.005 J	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
	4/28/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	--	--
	5/28/09	0.002 J	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	--	--
	6/29/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-139	3/31/09	0.15	ND(0.0008)	ND(0.0008)	0.005 J	0.005 J	0.0122 J	ND(0.0069)
	4/28/09	0.019	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	--	--
	4/28/09	0.098	ND(0.0008)	ND(0.0008)	0.003 J	0.003 J	--	--
	5/28/09	0.085	ND(0.0008)	ND(0.0008)	0.003 J	0.003 J	--	--
	6/30/09	0.11	ND(0.0008)	0.0009 J	0.005 J	0.004 J	0.0126 J	ND(0.0069)
MW-140	3/27/09	0.35	ND(0.002)	0.43	0.041	0.55	ND(0.01)	ND(0.0069)
MW-141	4/1/09	0.51	ND(0.002)	0.06	0.013	0.039	ND(0.01)	ND(0.0069)
Dup	4/1/09	0.52	ND(0.002)	0.062	0.013	0.042	ND(0.01)	ND(0.0069)
MW-142	3/31/09	0.13	ND(0.002)	0.39	0.028	0.35	0.0166 J	ND(0.0069)
	5/28/09	0.12	ND(0.0008)	0.53	0.025	0.31	--	--
	6/30/09	0.31	ND(0.0008)	0.023	0.014	0.056	0.0212	ND(0.0069)

NOTES:

Dup - duplicate sample

J - estimated concentration

mg/L - milligram per liter

TABLE 2-2. PERIMETER, INTERIOR, AND SUPPLEMENTAL WELL GROUNDWATER ANALYTICAL RESULTS SUMMARY
FIRST 2009 SEMIANNUAL MONITORING EVENT
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

Location ID	Date Sampled	Benzene (mg/L)	Ethylbenzene (mg/L)	Toluene (mg/L)	Xylenes, Total (mg/L)	Chlorobenzene (mg/L)	Arsenic, Dissolved (mg/L)	Lead, Dissolved (mg/L)
L-1RR	4/07/09	1.6	1.8	0.25	7.7	ND(0.008)	0.0443	0.0175
L-3R	4/04/09	12	1.5	0.17	0.48	ND(0.016)	0.048	0.0077 J
MW-10	4/04/09	0.017	0.013	0.003 J	0.004 J	ND(0.0008)	ND(0.01)	ND(0.0069)
MW-17	4/14/09	9.7	0.34	0.14	0.3	ND(0.008)	0.06	ND(0.0069)
MW-18R	4/15/09	1.7	2.3	0.28	7.4	ND(0.008)	0.0397	ND(0.0069)
MW-20S	4/16/09	2.1	1.3	0.098	2.3	ND(0.002)	0.0337	ND(0.0069)
MW-21	4/14/09	0.25	2.2	0.097	1.4	ND(0.002)	ND(0.01)	0.0073 J
MW-22	4/04/09	0.024	0.69	0.022	0.51	ND(0.002)	0.0331	ND(0.0069)
MW-26R	3/27/09	0.007	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
MW-33	4/06/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
MW-48S	4/13/09	0.001 J	0.21	0.0009 J	0.47	ND(0.0008)	0.0155 J	ND(0.0069)
MW-51	4/06/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
MW-64	4/05/09	0.0008 J	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
MW-80	4/05/09	0.006	ND(0.0008)	0.003 J	0.01	ND(0.0008)	0.0378	ND(0.0069)
MW-80 Dup	4/05/09	0.007	ND(0.0008)	0.003 J	0.01	ND(0.0008)	0.0325	ND(0.0069)
MW-81S	4/23/09	0.5	0.028	0.01	0.045	ND(0.0008)	0.0111 J	0.0082 J
MW-85D	4/16/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
MW-85S	4/20/09	0.22	0.37	0.035	0.32	ND(0.002)	0.0217	ND(0.0069)
MW-85S Dup	4/20/09	0.22	0.36	0.035	0.32	ND(0.002)	0.0211	ND(0.0069)
MW-93S	4/21/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
MW-94S	4/02/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
MW-95S	4/23/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
MW-96S	4/23/09	0.67	1.1	0.025	1.3	ND(0.002)	0.0429	0.0113 J
MW-96S Dup	4/23/09	0.65	1	0.025	1.3	ND(0.002)	0.0459	0.0135 J
MW-99S	4/22/09	0.015	0.25	0.01	0.38	ND(0.0008)	0.034	ND(0.0069)
MW-100S	4/21/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
MW-104S	4/04/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
MW-115S	4/03/09	0.009	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)

NOTES:

J – estimated concentration

B - constituent reported in method blank

mg/L - milligrams per liter

ND - not detected

-- not analyzed

TABLE 2-3. DISSOLVED PHASE NATURAL ATTENUATION ANALYTICAL RESULTS SUMMARY
FIRST 2009 SEMIANNUAL MONITORING EVENT
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

Location ID	Date Sampled	Alkalinity to pH 4.5 (mg/L)	Alkalinity to pH 8.3 (mg/L)	Calcium, Total (mg/L)	Chemical Oxygen Demand (mg/L)	Chloride (mg/L)	Iron, Ferric (mg/L)	Iron, Ferrous (mg/L)
L-1RR	4/07/09	460	ND(0.46)	144	99.8	43.5	7.1	4.7
MW-18R	4/15/09	468	ND(2)	151	102	38.6	3.3	11.7
MW-20S	4/16/09	472	ND(2)	155	92.9	52 J	6.7	13.3
MW-33	4/06/09	373	ND(2)	144	ND(50)	41	0.7	3.2 J
MW-35	4/03/09	455	ND(0.46)	123	13 J	56.4	ND(0.052)	0.21
MW-38	4/20/09	457	ND(2)	211	61	773	3.2	5.4
MW-51	4/06/09	211	ND(2)	75.2	17.6 J	92.2	ND(0.2)	ND(0.1) J
MW-81S	4/23/09	562	ND(2)	169	42.7 J	90.6	4.9	11.1
MW-85S	4/20/09	532	ND(2)	168	72.4	20.5	ND(10)	27.4
MW-96S	4/23/09	570	ND(2)	166	127	234	0.7 J	29
MW-100S	4/21/09	392	ND(2)	118	17.6 J	76.1	ND(0.1)	0.11
MW-112	4/14/09	490	ND(2)	156	40.4 J	45.8 J	8	10.3
MW-114	4/22/09	434	ND(2)	164	19.9 J	145	ND(0.2)	0.11
MW-115S	4/03/09	492	ND(0.46)	137	26.7 J	72.5	0.71 J	5.6

TABLE 2-3. DISSOLVED PHASE NATURAL ATTENUATION ANALYTICAL RESULTS SUMMARY
FIRST 2009 SEMIANNUAL MONITORING EVENT
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

Location ID	Date Sampled	Nitrogen Ammonia (mg/L)	Methane (mg/L)	Manganese, Total (mg/L)	Manganese, Dissolved (mg/L)	Iron, Total (mg/L)	Nitrogen, Nitrate (mg/L)	Nitrogen, Nitrite (mg/L)
L-1RR	4/07/09	0.38 J	15	0.243	0.228	11.8	ND(0.04)	ND(0.015)
MW-18R	4/15/09	ND(0.6)	13	0.141	0.138	15	ND(0.1)	0.018 J
MW-20S	4/16/09	0.55 J	17	0.233	0.228	19.9	ND(0.1)	ND(0.05)
MW-33	4/06/09	ND(0.6)	0.072	0.79	0.789	3.93	ND(0.1)	ND(0.05)
MW-35	4/03/09	ND(0.2)	--	1.17	1.18	0.233	0.22	ND(0.015)
MW-38	4/20/09	1.1	12	0.607	0.601	8.61	ND(0.1)	ND(0.05)
MW-51	4/06/09	ND(0.6)	ND(0.015)	0.172	0.171	ND(0.2)	2.6	0.18
MW-81S	4/23/09	ND(0.6)	13	0.194	0.192	15.9	ND(0.1)	0.021 J
MW-85S	4/20/09	2.1	18	1.19	1.2	27.1	ND(0.1)	ND(0.05)
MW-96S	4/23/09	2.5	19	0.159	0.16	29.7	ND(0.1)	0.036 J
MW-100S	4/21/09	ND(0.6)	0.016	0.0026 J	0.0015 J	ND(0.2)	2.8	ND(0.05)
MW-112	4/14/09	ND(0.6)	15	0.328	0.322	18.3	ND(0.1)	ND(0.5)
MW-114	4/22/09	ND(0.6)	ND(0.015)	0.0028 J	0.0012 J	ND(0.2)	8.2	ND(0.05)
MW-115S	4/03/09	ND(0.2)	8.4	2.08	2	6.3	ND(0.04)	ND(0.015)

TABLE 2-3. DISSOLVED PHASE NATURAL ATTENUATION ANALYTICAL RESULTS SUMMARY
FIRST 2009 SEMIANNUAL MONITORING EVENT
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

Location ID	Date Sampled	Potassium, Total (mg/L)	Sodium, Total (mg/L)	Sulfate (mg/L)	Total Organic Carbon (mg/L)
L-1RR	4/07/09	2.71	24.5	ND(1.5)	7.9
MW-18R	4/15/09	2.45	27.8	1.9	9.3 J
MW-20S	4/16/09	2.76	31.9	ND(5)	8
MW-33	4/06/09	2.38	23.5	54.5	1.6
MW-35	4/03/09	5.31	33.2	14.8	1.8
MW-38	4/20/09	11.5	381	2.1 J	3.2
MW-51	4/06/09	5.07	60.9	60.3	1.7
MW-81S	4/23/09	3.62	58.6	ND(5)	15.5
MW-85S	4/20/09	2.78	13.3	1.7 J	12.9
MW-96S	4/23/09	4.85	160	ND(5)	32.8
MW-100S	4/21/09	5.93	67.4	51.4	1.2
MW-112	4/14/09	3.66	29.8	ND(5)	7.9
MW-114	4/22/09	3.51	92.2	89	1.3
MW-115S	4/03/09	2.98	51.9	ND(1.5)	3.7

NOTES:

J – estimated concentration

mg/L - milligrams per liter

ND - not detected

-- not analyzed

TABLE 2-4. LYSIMETER ANALYTICAL RESULTS SUMMARY
FIRST 2009 SEMIANNUAL MONITORING EVENT
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

Lysimeter	Dissolved Oxygen[1] (mg/L)	ORP[1]	Nitrate (mg/L)	Sulfate (mg/L)	Iron, Total (mg/L)	Iron, Dissolved (mg/L)	Manganese, Total (mg/L)	Manganese, Dissolved (mg/L)	Methane[2] (mg/L)
L-21S	3.0	211	ND(0.25)	1.6 J	1.21	ND(0.0522)	0.197	0.187	0.27
L-18S	4.2	189	ND(0.25)	1.8 J	0.319	ND(0.0522)	0.362	0.357	1.9
L-20S	2.6	208	ND(0.25)	156	0.268	ND(0.0522)	0.637	0.660	0.014
L-93S	6.0	173	14.4	124	ND(0.0522)	ND(0.0522)	0.0039 J	0.0034 J	ND(0.005)

NOTES:

[1] Dissolved Oxygen and ORP measured using field instrumentation

[2] Methane detected in trip blank at an estimated 0.0051 mg/L

J - estimated concentration

mg/L - milligrams per liter

ND(0.25) - non-detect concentrations established at the detection limit

ORP - Oxidation-Reduction Potential

TABLE 2-5a. BARRIER WALL PERFORMANCE MONITORING CONSTITUENTS OF CONCERN ANALYTICAL RESULTS SUMMARY
FIRST 2009 SEMIANNUAL MONITORING EVENT
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

Location ID		Date Sampled	Benzene (mg/L)	Ethylbenzene (mg/L)	Toluene (mg/L)	Xylenes, Total (mg/L)	Chlorobenzene (mg/L)	Arsenic, Dissolved (mg/L)	Lead, Dissolved (mg/L)
MW-135D		3/17/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
		6/22/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-135I		3/16/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
		6/22/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-135S		3/16/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
		6/22/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BMW-1D		3/18/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
		6/22/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BMW-1I		3/18/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
		6/23/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BMW-1S		3/17/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
		6/23/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BSW-1D		3/19/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	0.003 J	ND(0.0008)	ND(0.01)	ND(0.0069)
	Dup	3/19/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	0.003 J	ND(0.0008)	ND(0.01)	ND(0.0069)
		6/24/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BSW-1S		3/19/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	0.0009 J	ND(0.0008)	ND(0.01)	ND(0.0069)
		6/23/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	0.002 J	ND(0.0008)	0.0091 J	ND(0.0069)
MW-136D		3/12/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
		6/18/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-136I		3/10/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
		6/18/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-136S		3/10/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
	Dup	3/10/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
		6/11/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	0.0163 J	ND(0.0069)
BMW-2D		3/16/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
		6/09/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BMW-2I		3/16/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
		6/09/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	Dup	6/09/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BMW-2S		3/12/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
		6/11/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BSW-2D		3/20/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
		6/24/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	0.0009 J	ND(0.0008)	ND(0.0072)	ND(0.0069)
BSW-2S		3/20/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	0.003 J	ND(0.0008)	ND(0.01)	ND(0.0069)
		6/24/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	0.001 J	ND(0.0008)	0.0078 J	ND(0.0069)
	Dup	6/24/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	0.001 J	ND(0.0008)	ND(0.0072)	ND(0.0069)

TABLE 2-5a. BARRIER WALL PERFORMANCE MONITORING CONSTITUENTS OF CONCERN ANALYTICAL RESULTS SUMMARY
FIRST 2009 SEMIANNUAL MONITORING EVENT
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

Location ID		Date Sampled	Benzene (mg/L)	Ethylbenzene (mg/L)	Toluene (mg/L)	Xylenes, Total (mg/L)	Chlorobenzene (mg/L)	Arsenic, Dissolved (mg/L)	Lead, Dissolved (mg/L)
MW-137D		3/04/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
		6/15/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-137I		3/04/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
		6/15/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	Dup	6/15/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-137S		3/05/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
	Dup	3/05/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
		6/15/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	0.0103 J	ND(0.0069)
BMW-3D		3/11/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
		6/16/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BMW-3I		3/05/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
		6/16/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BMW-3S		3/11/09	0.0007 J	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
		6/16/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BSW-3D		3/20/09	ND(0.0005)	0.0009 J	ND(0.0007)	0.004 J	ND(0.0008)	ND(0.01)	ND(0.0069)
		6/18/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BSW-3S		3/20/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.01)	ND(0.0069)
		6/17/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	0.001 J	ND(0.0008)	ND(0.0072)	ND(0.0069)

NOTES:
J – estimated concentration
mg/L - milligrams per liter
ND - not detected
-- not analyzed

TABLE 2-5b. BARRIER WALL PERFORMANCE MONITORING NATURAL ATTENUATION ANALYTICAL RESULTS SUMMARY
FIRST 2009 SEMIANNUAL MONITORING EVENT
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

Location ID	Date Sampled	Alkalinity to pH 4.5, Total (mg/L CaCO^3)	Alkalinity to pH 8.3, Total (mg/L CaCO^3)	Calcium, Total (mg/L)	CO2 by Headspace (mg/L)	Chloride (mg/L)	Iron, Ferric (mg/L)
BSW-1D	6/24/09	253	ND(0.46)	73.9	13	49	0.57
MW-136D	6/18/09	317	ND(0.46)	84.9	19	40.6 J	ND(0.052)
MW-136I	6/18/09	292	ND(0.46)	86.3	24	39.1 J	ND(0.052)
MW-136S	6/11/09	521	ND(0.46)	130	70	57.9 J	ND(0.016)
BMW-2D	6/09/09	310	ND(0.46)	80.6	18	42.6	0.056 J
BMW-2I	6/09/09	216	ND(0.46)	61.5	8.5 J	35.9	0.053 J
BMW-2S	6/11/09	211	ND(0.46)	63.6	11 J	55.7 J	ND(0.052)
BSW-2D	6/24/09	195	ND(0.46)	59.4	8.7 J	43.6	0.13 J
MW-137D	6/15/09	262	ND(0.46)	92.2	15	61.3	0.1 J
MW-137I	6/15/09	236	ND(0.46)	86	14	53	ND(0.052)
MW-137S	6/15/09	466	ND(0.46)	143	87	110	ND(0.1)
BMW-3D	6/16/09	210	ND(0.46)	70.4	12	45.9	0.054 J
BMW-3I	6/16/09	216	ND(0.46)	76.1	14	52.5	ND(0.052)
BMW-3S	6/16/09	241	ND(0.46)	72.9	15	53.6	0.62
BSW-3D	6/18/09	196	ND(0.46)	59.7	10 J	57.1 J	0.11 J

NOTES:
J – estimated concentration
mg/L - milligrams per liter
ND - not detected
-- not analyzed

TABLE 2-5b. BARRIER WALL PERFORMANCE MONITORING NATURAL ATTENUATION ANALYTICAL RESULTS SUMMARY
FIRST 2009 SEMIANNUAL MONITORING EVENT
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

Location ID	Date Sampled	Iron, Ferrous (mg/L)	Nitrogen, Ammonia (mg/L)	Methane (mg/L)	Magnesium, Total (mg/L)	Manganese, Total (mg/L)	Manganese, Dissolved (mg/L)
BSW-1D	6/24/09	0.51 J	0.54 J	0.07	28.1	0.191	0.182
MW-136D	6/18/09	ND(0.01)	ND(0.2)	0.081	33.9	0.658	0.653
MW-136I	6/18/09	0.018 J	ND(0.2)	0.25	28.4	0.475	0.488
MW-136S	6/11/09	12 J	5	17	54.6	3.34	3.15
BMW-2D	6/09/09	0.036 J	ND(0.2)	0.15	31.9	0.357	0.354
BMW-2I	6/09/09	0.021 J	0.24 J	0.15	22.9	0.325	0.314
BMW-2S	6/11/09	0.017 J	ND(0.2)	0.19	23.8	0.223	0.219
BSW-2D	6/24/09	0.015 J	0.27 J	0.039	20.9	0.184	0.167
MW-137D	6/15/09	0.025 J	ND(0.2)	0.01 J	29.6	0.61	0.595
MW-137I	6/15/09	ND(0.01)	ND(0.2)	0.03	24.9	0.715	0.663
MW-137S	6/15/09	4.2 J	0.54 J	1.8	49.8	1.08	1.03
BMW-3D	6/16/09	0.019 J	ND(0.2)	0.041	19.4	0.68	0.621
BMW-3I	6/16/09	0.039 J	ND(0.2)	0.31	23.2	0.756	0.719
BMW-3S	6/16/09	0.73 J	ND(0.2)	0.61	23.1	0.8	0.81
BSW-3D	6/18/09	0.084 J	0.21 J	0.15	21.6	0.549	0.55

NOTES:
J – estimated concentration
mg/L - milligrams per liter
ND - not detected
-- not analyzed

TABLE 2-5b. BARRIER WALL PERFORMANCE MONITORING NATURAL ATTENUATION ANALYTICAL RESULTS SUMMARY
FIRST 2009 SEMIANNUAL MONITORING EVENT
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

Location ID	Date Sampled	Iron, Total (mg/L)	Nitrogen, Kjeldahl (mg/L)	Nitrogen, Nitrate (mg/L)	Nitrogen, Nitrite (mg/L)	Potassium, Total (mg/L)	Sodium, Total (mg/L)
BSW-1D	6/24/09	1.07	0.8 J	1	0.09	4.06	34
MW-136D	6/18/09	ND(0.0522)	ND(0.5)	0.07 J	ND(0.015)	4.22	29.9
MW-136I	6/18/09	ND(0.0522)	ND(0.5)	ND(0.04)	ND(0.015)	3.59	26.8
MW-136S	6/11/09	11.9	5.8	ND(0.04)	ND(0.015)	6.54	32
BMW-2D	6/09/09	0.0918 J	ND(0.5)	ND(0.04)	ND(0.015)	4.14	29.5
BMW-2I	6/09/09	0.0743 J	ND(0.5)	0.055 J	ND(0.015)	4.61	23.1
BMW-2S	6/11/09	ND(0.0522)	ND(0.5)	0.066 J	ND(0.015)	4.42	24.6
BSW-2D	6/24/09	0.144 J	ND(0.5)	0.75	0.41	4.15	28
MW-137D	6/15/09	0.127 J	ND(0.5)	2.2	0.045 J	3.9	30.9
MW-137I	6/15/09	ND(0.0522)	ND(0.5)	1.8	0.094	3.98	33.8
MW-137S	6/15/09	4.15	ND(0.5)	ND(0.04)	ND(0.015)	4.71	58.7
BMW-3D	6/16/09	0.073 J	ND(0.5)	1	0.017 J	3.71	29
BMW-3I	6/16/09	0.0576 J	ND(0.5)	0.77	ND(0.015)	4.07	30.7
BMW-3S	6/16/09	1.35	ND(0.5)	0.7	0.02 J	3.99	31.4
BSW-3D	6/18/09	0.193 J	ND(0.5)	1	ND(0.015)	3.43	25.1

NOTES:
J – estimated concentration
mg/L - milligrams per liter
ND - not detected
-- not analyzed

TABLE 2-5b. BARRIER WALL PERFORMANCE MONITORING NATURAL ATTENUATION ANALYTICAL RESULTS SUMMARY
FIRST 2009 SEMIANNUAL MONITORING EVENT
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

Location ID	Date Sampled	Sulfate (mg/L)	Total Sulfide (mg/L)	Total Inorganic Carbon (mg/L)	Total Organic Carbon (mg/L)
BSW-1D	6/24/09	39.8	ND(0.054)	71.4	2.9
MW-136D	6/18/09	39.9 J	ND(0.054)	79.6	3
MW-136I	6/18/09	38.1 J	ND(0.054)	76.3	3.4
MW-136S	6/11/09	13.3	ND(0.054)	141	7.5
BMW-2D	6/09/09	31	ND(0.054)	75.6	3.2
BMW-2I	6/09/09	35.2	ND(0.054)	55	2.6
BMW-2S	6/11/09	38.3	ND(0.054)	52	2.7
BSW-2D	6/24/09	36.2	ND(0.054)	47.8	2.8
MW-137D	6/15/09	50.2 J	ND(0.054)	66.6	1.3
MW-137I	6/15/09	46 J	ND(0.054)	64	1.7
MW-137S	6/15/09	55.5 J	ND(0.054)	130	4.3
BMW-3D	6/16/09	104 J	ND(0.054)	54.5	2.1
BMW-3I	6/16/09	40.7 J	ND(0.054)	54.5	2.6
BMW-3S	6/16/09	37.7 J	ND(0.054)	35.3	2.3
BSW-3D	6/18/09	45.5 J	ND(0.054)	47.7	3.7

NOTES:
J – estimated concentration
mg/L - milligrams per liter
ND - not detected
-- not analyzed

TABLE 2-6. VAPOR DIFFUSION COEFFICIENT ESTIMATES
FIRST 2009 SEMIANNUAL MONITORING EVENT
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

Well	Date Measured	Depth (ft bgs)	Helium Concentration (%)	t (min)	Unadjusted D^{eff} (cm^2/s)	Adjusted D^{eff} (cm^2/s)
VW-20	5/4/2009	5	0.0	--		
			29.9	0		
			15.8	20	1.9E-03	1.9E-03
			1.7	60	4.1E-03	4.1E-03
VW-20	5/4/2009	10	0.0	--		
			29.5	0		
			4.9	20	5.3E-03	5.3E-03
			1.1	60	5.5E-03	5.4E-03
VW-20	5/4/2009	15	5.4	--		
			34.2	0		
			6.8	19	5.6E-03	4.9E-03
			1.7	60	5.0E-03	4.4E-03
VW-20	5/4/2009	20	1.15	--		
			34.0	0		
			7.3	20	4.5E-03	4.3E-03
			2.0	60	4.1E-03	3.9E-03
VW-20	5/5/2009	25	3.9	--		
			38.4	0		
			20.5	20	2.1E-03	1.9E-03
			9.9	89	9.4E-04	8.4E-04
VW-20	5/5/2009	30	4.7	--		
			39.1	0		
			12.2	20	3.5E-03	3.2E-03
			7.3	85	1.3E-03	1.1E-03
VW-18	4/28/2009	5	3.0	--		
			29.9	0		
			22.6	20	1.3E-03	1.1E-03
			20.1	60	5.2E-04	4.6E-04
VW-18	4/28/2009	10	12.7	--		
			38.3	0		
			25.6	20	2.0E-03	1.4E-03
			21	60	8.2E-04	5.9E-04
VW-18	4/28/2009	15	10.3	--		
			26.5	0		
			12.6	20	2.9E-03	2.1E-03
			11.8	60	1.0E-03	7.4E-04

TABLE 2-6. VAPOR DIFFUSION COEFFICIENT ESTIMATES
FIRST 2009 SEMIANNUAL MONITORING EVENT
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

Well	Date Measured	Depth (ft bgs)	Helium Concentration (%)	t (min)	Unadjusted D^{eff} (cm^2/s)	Adjusted D^{eff} (cm^2/s)
VW-21	4/29/2009	5	0.0	--		
			25.5	0		
			15.6	20	1.6E-03	1.6E-03
			15.5	60	5.2E-04	5.2E-04
VW-21	4/29/2009	10	0.0	--		
			40.1	0		
			7.5	20	4.9E-03	4.9E-03
			3.1	60	3.3E-03	3.3E-03
VW-21	4/29/2009	15	10.1	--		
			18.1	0		
			9.0	20	3.1E-03	2.0E-03
			3.7	60	2.2E-03	1.6E-03
VW-21	4/29/2009	20	2.1	--		
			26.2	0		
			4.7	20	5.3E-03	5.1E-03
			2.0	60	3.5E-03	3.3E-03
VW-93	5/19/2009	5	0.0	--		
			33.2	0		
			5.0	20	5.9E-03	5.9E-03
			2.1	50	4.5E-03	4.5E-03
VW-93	5/19/2009	25	0.4	--		
			8.7	0		
			1.4	20	5.9E-03	5.6E-03
			1.0	24	6.2E-03	5.8E-03
VW-93	5/19/2009	50	0.0	--		
			10.2	0		
			2.0	20	4.7E-03	4.7E-03
VW-93	5/19/2009	55	0.1	--		
			10.9	0		
			0.5	22	1.3E-02	1.3E-02
			0.1	36	2.0E-02	2.1E-02
VW-99	5/7/2009	5	0.0	--		
			29.1	0		
			4.8	21	5.3E-03	5.3E-03
			2.0	52	4.1E-03	4.1E-03
VW-99	5/7/2009	25	0.4	--		
			15.9	0		
			2.5	20	5.9E-03	5.6E-03
			1.0	30	7.7E-03	7.5E-03

TABLE 2-6. VAPOR DIFFUSION COEFFICIENT ESTIMATES
FIRST 2009 SEMIANNUAL MONITORING EVENT
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

Well	Date Measured	Depth (ft bgs)	Helium Concentration (%)	t (min)	Unadjusted D^{eff} (cm^2/s)	Adjusted D^{eff} (cm^2/s)
VW-99	5/7/2009	50	3.1	--		
			11.1	0		
			3.2	20	4.2E-03	3.4E-03
VW-99	5/7/2009	55	3.9			
			10.5	0		
			3.2	20	4.3E-03	3.3E-03
VW-96	5/20/2009	5	0.0	--		
			37.7	0		
			4.5	20	7.0E-03	7.0E-03
			2.9	47	4.2E-03	4.2E-03
VW-96	5/20/2009	25	5.9	--		
			11.8	0		
			6.2	31	1.8E-03	1.2E-03
			7.0	60	8.4E-04	5.4E-04
VW-96	5/20/2009	50	3.4	--		
			14.2	0		
			6.1	20	2.9E-03	2.3E-03
			4.6	60	1.2E-03	1.0E-03
VW-96	5/20/2009	55	4.7	--		
			8.2	0		
			3.2	20	3.9E-03	2.6E-03
			4.2	45	1.3E-03	8.6E-04
GP-7	5/21/2009	10	0.0	--		
			40	0		
			11.2	21	3.4E-03	3.3E-03
			2.7	60	3.6E-03	3.6E-03
GP-7	5/21/2009	20	0.0	--		
			11.3	0		
			2.1	20	4.9E-03	4.9E-03
			1.4	60	2.3E-03	2.3E-03

$$\eta = \frac{C_s V_s}{C_o V_o} = erf(\beta^{1/2}) - \left(\frac{2\beta^{1/2}}{\sqrt{\pi}}\right) e^{-\beta}$$

$$D^{eff} = \left(\frac{\theta_v^{1/3}}{\beta}\right)\left(\frac{1}{4t_s}\right)\left(\frac{3V_s}{4\pi}\right)^{2/3}$$

All sample volumes set equal to 300 mL.
q_v assumed 0.28, as suggested in Johnson et al. 1998.

Calculations based on Johnson et al. 1998. In situ measurement of effective vapor-phase porous media diffusion coefficients. *Environmental Science and Technology*, 32, 3405-3409.

Adjusted D^{eff} calculated by subtracting pre-test helium concentration from time zero sample.

TABLE 3-1. DISTRIBUTION OF DISSOLVED PHASE CONSTITUENTS
FIRST 2009 SEMIANNUAL MONITORING EVENT
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

Constituent	Up-gradient of Smear Zone[1]	Within Smear Zone[2]	Down-gradient of Smear Zone[3]
Average TPH Concentration	0.096	14.6	No Data
Average BTEX Concentration	0.010	2.66	0.031
Average Benzene Concentration	0.003	1.19	0.027
Average Nitrate Concentration	4.53	0.172	0.220
Average Sulfate Concentration	66.9	5.6	14.8
Average Ferrous Iron Concentration	0.090	11.35	0.210
Average Dissolved Manganese Concentration	0.058	0.483	1.180
Average Methane Concentration	0.010	13.36	No Data

NOTES:

[1] - Wells Upgradient of Smear Zone include MW-51, MW-95S, MW-100S, and MW-114.

[2] - Wells within Smear Zone include L-1RR, L-3R, MW-10, MW-17, MW-18R, MW-20S, MW-21, MW-22, MW-26R, MW-38, MW-48S, MW-52, MW-57, MW-64, MW-80, MW-81S, MW-85S, MW-93S, MW-94S, MW-96S, MW-99S, MW-112, and MW-115S, MW-140, MW-141, MW-142.

[3] - Wells Downgradient of Smear Zone include MW-35, MW-37, MW-120, MW-131, MW-132, MW-133, and MW-134, MW-138, and MW-139.

Concentrations reported in milligrams per liter.

Average values estimated assuming non-detect concentrations equal one half the detection limit, or average of detection limits when all constituents are non-detect.

TABLE 4-1. SOIL VAPOR FIELD SCREENING RESULTS FOR GULF PARK
FIRST 2009 SEMIANNUAL MONITORING EVENT
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

Location ID	Oxygen (System Inactive) (%)	Oxygen (System Active) (%)	Carbon Dioxide (System Inactive) (%)	Carbon Dioxide (System Active) (%)	Methane (System Inactive) (%)	Methane (System Active) (%)	Total Organic Vapor (System Inactive) (%)	Total Organic Vapor (System Active) (%)
VP1-25S	18.1	20.7	0.1	0	0	0	0	0
VP1-25D	16.9	20.7	0.6	0	0	0	1.6	0
VP1-50S	17.7	20.7	0.2	0	0	0	0	0
VP1-50D	NS	20.5	NS	0.1	NS	0	NS	0
VP2-25S	0.7	20.1	1.1	0.3	1	0	24.5	0
VP2-50S	1.8	15.4	14.9	2.1	7.3	0.6	405	186
VP3-35S	14.9	NS	0.1	NS	0	NS	0	NS
VP3-35D	14.4	NS	0.3	NS	0	NS	0	NS
VP4-25S	22	20.2	0	0.1	0	0.2	2.7	5.3
VP4-25D	0.4	NS	0.7	NS	1.1	NS	78.9	NS
VP6-35S	1.2	20.6	3.5	0	1.7	0	28.7	0
VP7-25S	NS	20.7	NS	0	NS	0	NS	0

NOTES:
% - percent
ppmv - parts per million by volume
NS - Not Sampled due to plugging or submersion of the sample point

TABLE 4-2. GROUNDWATER QUALITY ANALYTICAL RESULTS FOR GULF PARK
FIRST 2009 SEMIANNUAL MONITORING EVENT
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

Location ID		Date Sampled	Benzene (mg/L)	Ethylbenzene (mg/L)	Toluene (mg/L)	Xylenes, Total (mg/L)	Chlorobenzene (mg/L)	Arsenic, Dissolved (mg/L)	Lead, Dissolved (mg/L)
GPW-1I		12/14/06	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	--	ND(0.0069)
	Dup	12/14/06	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	--	ND(0.0069)
		12/18/07	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	--	ND(0.0069)
		6/23/08	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0102)	ND(0.0069)
		6/25/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	Dup	6/25/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
GPW-1S		12/14/06	0.0009 J	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	--	ND(0.0069)
		6/23/08	0.001 J	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0102)	ND(0.0069)
		6/25/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
GPW-2I		12/18/06	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	--	0.0163
		12/19/07	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	--	ND(0.0069)
		6/23/08	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0102)	ND(0.0069)
		6/23/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
GPW-2S		12/18/06	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	--	0.0171
		12/19/07	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	--	ND(0.0069)
		6/23/08	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0102)	ND(0.0069)
		6/23/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
GPW-3I		12/13/06	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	--	ND(0.0069)
		12/20/07	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	--	ND(0.0069)
		6/25/08	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0102)	ND(0.0069)
		6/25/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
GPW-3S		12/13/06	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	--	ND(0.0069)
		12/20/07	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	--	ND(0.0069)
		6/25/08	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0102)	ND(0.0069)
	Dup	6/25/08	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0102)	ND(0.0069)
		6/25/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
GPW-4S		12/14/06	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	--	ND(0.0069)
		12/19/07	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	--	ND(0.0069)
		6/25/08	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0102)	ND(0.0069)
		6/24/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	Dup	6/24/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
GPW-5S		12/12/06	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	--	ND(0.0069)
		12/21/07	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	--	ND(0.0069)
		6/25/08	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0102)	ND(0.0069)
		6/24/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
TH-1I		12/15/06	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	--	ND(0.0069)
		12/20/07	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	--	ND(0.0069)
		6/26/08	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0102)	ND(0.0069)
		6/23/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
TH-1S		12/15/06	0.022	0.29	0.008	0.28	ND(0.0008)	--	ND(0.0069)
		4/09/07	0.061	0.62	0.028	1	ND(0.002)	--	0.0176
		12/20/07	0.012	0.048	0.002	0.012	ND(0.0008)	--	ND(0.0069)
	Dup	12/20/07	0.012	0.045	0.002	0.011	ND(0.0008)	--	--
		6/26/08	0.074	1	0.045	1.6	ND(0.0008)	0.0118	ND(0.0069)
		6/23/09	0.027	0.4	0.015	0.32	ND(0.0008)	ND(0.0072)	ND(0.0069)
TH-2		12/12/06	0.003 J	0.16	0.029	0.21	ND(0.0008)	--	ND(0.0069)
		4/09/07	0.004 J	0.15	0.019	0.44	ND(0.0008)	--	0.0135 J
		12/18/07	0.012	0.002	0.005	0.046	ND(0.0008)	--	ND(0.0069)
		6/26/08	0.003 J	0.3	0.021	0.89	ND(0.0008)	ND(0.0102)	ND(0.0069)
		6/24/09	0.021	0.066	0.012	0.34	ND(0.005)	0.0129 J	ND(0.0069)
TH-3		12/12/06	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	--	ND(0.0069)
		12/21/07	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	--	ND(0.0069)
		6/27/08	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0102)	ND(0.0069)
		6/23/09	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)

NOTES:

Dup - Blind Duplicate Sample
J – Value is estimated and should be used with consideration or qualitative purposes
mg/L - milligram per liter
NA - Not available
ND - Not detected

TABLE 4-3. DISSOLVED PHASE MONITORED NATURAL ATTENUATION ANALYTICAL SUMMARY FOR GULF PARK
FIRST 2009 SEMIANNUAL MONITORING EVENT
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

Location ID	Date Sampled	Chemical Oxygen Demand (mg/L)	Methane (mg/L)	Nitrogen (mg/L)	Nitrogen, Ammonia (mg/L)	Nitrogen, Nitrate (mg/L)	Nitrogen, Nitrite (mg/L)	Sulfate (mg/L)	Total Sulfide (mg/L)	Total Organic Carbon (mg/L)	Iron, Total (mg/L)	Iron, Ferrous Total	Iron, Ferric Total	Manganese, Dissolved (mg/L)	Manganese, Total (mg/L)
GPW-1I	4/28/98	ND(10)	--	--	--	--	--	--	--	--	--	--	--	--	--
	5/22/02	--	--	--	--	--	--	--	--	--	--	--	--	0.0048	--
	11/17/04	--	--	--	--	--	--	--	--	--	--	1	--	--	--
	11/17/05	2.4	0.03	ND(0.5)	ND(0.11)	1.4	0.021	51.4	ND(0.022)	1.2	ND(0.0378)	ND(0.008)	ND(0.038)	0.0045	0.0032
	12/14/06	ND(2.6)	0.03	ND(0.5)	ND(0.2)	1.1	ND(0.015)	49	ND(0.054)	ND(1)	0.122 J	0.06 J	0.063 J	--	0.0068
	12/18/07	ND(12.8)	0.0028	ND(0.5)	ND(0.2)	1.1	ND(0.015)	45.9	ND(0.054)	ND(1)	0.195	0.15	ND(0.052)	0.0076	0.0115
GPW-1S	4/25/95	41	--	--	--	3	--	60	--	--	4.88	--	--	0.388	0.478
	2/22/96	ND(10)	--	--	--	0.02	--	6	--	--	13.1	--	--	0.645	0.601
	10/30/96	55	--	--	--	ND(0.01)	--	ND(0.2)	--	--	31.7	--	--	0.634	0.997
	5/06/97	--	--	--	--	2.71	--	48	--	--	1.2	--	--	0.335	0.335
	11/13/97	--	--	--	--	0.02	--	ND(1)	--	--	14.7	--	--	0.485	0.542
	4/29/98	ND(10)	--	--	--	0.75	--	34	--	--	11.5	--	--	0.56	0.59
	11/03/98	--	--	--	--	ND(0.03)	--	8.8	--	--	11.6	--	--	0.5	0.46
	4/21/99	--	--	--	--	0.11	--	61.4	--	--	10	--	--	0.58	0.6
	11/04/99	--	--	--	--	ND(0.03)	--	18	--	--	11	--	--	0.49	0.5
	4/26/00	--	--	--	--	0.6	--	28.7	--	--	0.25	--	--	1.1	1.1
	11/15/01	--	--	--	--	ND(0.05)	--	17.9	--	--	3.66	--	--	0.85	0.922
	5/22/02	--	--	--	--	ND(0.05)	--	ND(5)	--	--	4.13	--	--	0.887	0.937
	11/19/02	--	--	--	--	ND(0.05)	0.0088	60.2	--	--	5.94	--	--	1.01	0.972
	11/17/04	11.6	1.8	ND(0.5)	--	ND(0.04)	ND(0.015)	1.8	ND(0.022)	4.9	13.1	13.9	ND(0.4)	0.761	1.02
	11/17/05	4	0.11	ND(0.5)	ND(0.11)	3.2	ND(0.015)	40.2	ND(0.022)	2.4	0.0515	0.046	ND(0.038)	0.402	0.431
	12/14/06	9.8	0.25	ND(0.5)	0.32 J	ND(0.04)	ND(0.015)	32.1	ND(0.054)	2.9	4.04	4.1	ND(0.16)	--	0.675
	6/25/09	ND(12.8)	0.24	ND(0.5)	0.72	ND(0.04)	ND(0.015)	10 J	--	2.4	1.34	1.2 J	0.13 J	0.526	0.533
GPW-2I	4/29/98	ND(10)	--	--	--	--	--	--	--	--	--	--	--	--	--
	5/22/02	--	--	--	--	--	--	--	--	--	--	--	--	ND(0.03)	--
	11/17/04	3.2	ND(0.002)	ND(0.5)	--	5.4	ND(0.015)	41.5	ND(0.022)	2.3	ND(0.0495)	0.012	ND(0.05)	0.0151	0.0016
	11/16/05	8.3	0.067	ND(0.5)	ND(0.11)	2.1	ND(0.015)	41.7	ND(0.022)	1.5	ND(0.0378)	0.012	ND(0.038)	ND(0.00096)	0.0032
	12/18/06	16.8	0.0049 J	ND(0.5) J	ND(0.2)	5.4	ND(0.015)	48.2	ND(0.054)	1.2 J	ND(0.0522)	ND(0.008)	ND(0.052)	--	0.0011 J
	12/19/07	16.2	ND(0.002)	ND(0.5)	ND(0.2)	4.4	ND(0.015)	46.8	ND(0.054)	ND(1)	ND(0.0522)	0.065	ND(0.052)	0.0033	0.0042
GPW-2S	4/25/95	27	--	--	--	0.95	--	50	--	--	3.64	--	--	0.554	0.594
	2/22/96	ND(10)	--	--	--	1.42	--	41	--	--	24.5	--	--	1.04	1.13
	10/30/96	21	--	--	--	0.06	--	21.3	--	--	12.2	--	--	0.668	0.779
	5/06/97	--	--	--	--	1.98	--	75	--	--	0.7	--	--	0.662	0.749
	11/14/97	--	--	--	--	0.03	--	4	--	--	11.4	--	--	0.769	0.809
	4/29/98	ND(10)	--	--	--	0.017	--	34.6	--	--	2.3	--	--	0.98	1
	11/02/98	--	--	--	--	0.041	--	49.6	--	--	4.8	--	--	0.81	0.81
	4/20/99	--	--	--	--	2.3	--	57.9	--	--	0.74	--	--	0.71	0.67
	11/04/99	--	--	--	--	0.09	--	41	--	--	6.4	--	--	0.84	0.95
	11/15/01	--	--	--	--	0.196	--	16.6	--	--	0.778	--	--	1.06	1.02
	5/22/02	--	--	--	--	1.2	--	37	--	--	0.122	--	--	1.05	1.11
	11/19/02	--	--	--	--	1.62	0.03	40.7	--	--	0.989	--	--	0.996	1.06
	11/17/04	20.3	0.23	ND(0.5)	--	0.98	ND(0.015)	31.8	ND(0.022)	2.6	15.5	2	13.5	0.904	1.17
	11/16/05	ND(2.1)	0.0046	ND(0.5)	ND(0.11)	2.6	0.034	35.8	ND(0.022)	1.8	0.522	0.59	ND(0.038)	0.916	0.944
	12/18/06	3.2 J	0.0027 J	ND(0.5) J	ND(0.2)	1.9	ND(0.015)	45.1	ND(0.054)	1.3 J	0.202	0.031 J	0.17 J	--	0.931
	12/19/07	ND(12.8)	ND(0.002)	ND(0.5)	ND(0.2)	5.2	ND(0.015)	53.6	ND(0.054)	1.5	ND(0.0522)	ND(0.008)	ND(0.052)	0.0117	0.0305
	6/23/09	15.3 J	0.078	ND(0.5)	ND(0.2)	1.4	ND(0.015)	33.8 J	--	4.1	0.0526 J	0.026 J	ND(0.052)	0.507	0.558

TABLE 4-3. DISSOLVED PHASE MONITORED NATURAL ATTENUATION ANALYTICAL SUMMARY FOR GULF PARK
FIRST 2009 SEMIANNUAL MONITORING EVENT
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

Location ID	Date Sampled	Chemical Oxygen Demand (mg/L)	Methane (mg/L)	Nitrogen (mg/L)	Nitrogen, Ammonia (mg/L)	Nitrogen, Nitrate (mg/L)	Nitrogen, Nitrite (mg/L)	Sulfate (mg/L)	Total Sulfide (mg/L)	Total Organic Carbon (mg/L)	Iron, Total (mg/L)	Iron, Ferrous Total	Iron, Ferric Total	Manganese, Dissolved (mg/L)	Manganese, Total (mg/L)
GPW-3I	4/24/95	14	--	--	--	3.2	--	56	--	--	1.8	--	--	0.011	0.048
	2/21/96	ND(10)	--	--	--	4.52	--	50	--	--	7.81	--	--	ND(0.005)	0.122
	10/28/96	13	--	--	--	4.41	--	56	--	--	0.14	--	--	ND(0.005)	0.007
	5/05/97	--	--	--	--	3.6	--	44	--	--	0.88	--	--	ND(0.005)	0.019
	11/13/97	--	--	--	--	4.48	--	15	--	--	ND(0.1)	--	--	ND(0.005)	0.005
	4/28/98	ND(10)	--	--	--	5.3	--	31.1	--	--	0.65	--	--	ND(0.0002)	0.014
	11/03/98	--	--	--	--	5.9	--	60.9	--	--	0.51	--	--	ND(0.0003)	0.011
	4/21/99	--	--	--	--	3.1	--	45.1	--	--	0.68	--	--	ND(0.0002)	0.012
	11/04/99	--	--	--	--	5.2	--	44.3	--	--	0.26	--	--	ND(0.00025)	0.0086
	4/25/00	--	--	--	--	5.5	--	64.7	--	--	4.1	--	--	0.011	0.062
	11/14/01	--	--	--	--	1.29	--	31.4	--	--	--	--	--	--	--
	5/21/02	--	--	--	--	--	--	--	--	--	--	--	--	0.00066	--
	11/18/04	ND(2.1)	ND(0.002)	ND(0.5)	--	3.6	ND(0.015)	46.3	ND(0.022)	1.8	ND(0.0495)	ND(0.008)	ND(0.05)	0.0042	0.0015
	11/17/05	ND(2.1)	0.026	ND(0.5)	ND(0.11)	3.1	ND(0.015)	44.4	ND(0.022)	1.4	ND(0.0378)	ND(0.008)	ND(0.038)	ND(0.00096)	ND(0.00096)
	12/13/06	3.1 J	0.024	ND(0.5)	ND(0.2)	2.4	ND(0.015)	43.9	ND(0.054)	ND(1)	ND(0.0522)	0.018 J	ND(0.052)	--	0.0013 J
	12/20/07	ND(12.8)	ND(0.002)	ND(0.5)	ND(0.2)	2.2	ND(0.015)	44	ND(0.054)	ND(1)	ND(0.0522)	ND(0.008)	ND(0.052)	ND(0.00084)	ND(0.00084)
GPW-3S	4/24/95	73	--	--	--	0.06	--	56	--	--	12.9	--	--	1.07	1.55
	2/21/96	19	--	--	--	0.1	--	48	--	--	33	--	--	0.534	1.1
	10/29/96	ND(10)	--	--	--	0.99	--	64	--	--	2.28	--	--	0.855	1.04
	5/05/97	--	--	--	--	0.02	--	44	--	--	10.6	--	--	1.12	1.25
	11/13/97	--	--	--	--	0.13	--	22	--	--	2.96	--	--	0.962	1.08
	4/28/98	22.2	--	--	--	18	--	62.8	--	--	0.7	--	--	0.72	0.33
	11/03/98	--	--	--	--	0.45	--	67.8	--	--	2.8	--	--	0.89	0.9
	4/21/99	--	--	--	--	0.87	--	108	--	--	1.5	--	--	1.2	1.2
	11/04/99	--	--	--	--	0.2	--	379	--	--	13.3	--	--	3.3	3.5
	4/25/00	--	--	--	--	6.9	--	80.9	--	--	3.8	--	--	1.1	1
	11/14/01	--	--	--	--	1.52	--	39.7	--	--	0.869	--	--	0.544	0.551
	5/20/02	--	--	--	--	6.2	--	39.3	--	--	0.358	--	--	0.274	0.289
	11/19/02	--	--	--	--	1.41	0.02	39.6	--	--	0.667	--	--	0.959	0.956
	11/18/04	ND(2.1)	0.023	ND(0.5)	--	0.66	0.019	37.3	ND(0.022)	1.9	0.236	0.2	ND(0.05)	0.907	0.912
	11/17/05	5.1	0.039	ND(0.5)	ND(0.11)	1.8	ND(0.015)	30.1	ND(0.022)	2.2	0.36	0.3	0.064	0.189	0.212
	12/13/06	3.5 J	0.045	ND(0.5)	ND(0.2)	7.1	ND(0.015)	37.4	ND(0.054)	1.2 J	ND(0.0522)	0.076 J	ND(0.052)	--	0.364
	12/20/07	46.3	0.05	ND(0.5)	ND(0.2)	1	ND(0.015)	51.4	ND(0.054)	1.5	ND(0.0522)	ND(0.008)	ND(0.052)	0.199	0.264
	6/25/09	ND(12.8)	0.035	ND(0.5)	ND(0.2)	0.66	ND(0.015)	30.1 J	--	1	0.355	0.3 J	0.053 J	0.487	0.494
GPW-4S	2/21/96	ND(10)	--	--	--	0.11	--	12	--	--	64.1	--	--	0.644	2.87
	10/29/96	49	--	--	--	ND(0.01)	--	29	--	--	11.3	--	--	0.716	1.61
	5/06/97	--	--	--	--	1.04	--	66	--	--	5.26	--	--	0.455	0.522
	11/13/97	--	--	--	--	0.02	--	6	--	--	11.1	--	--	0.498	0.871
	4/28/98	ND(10)	--	--	--	5.1	--	39	--	--	0.71	--	--	0.18	0.18
	11/03/98	--	--	--	--	ND(0.03)	--	20.1	--	--	7.7	--	--	0.45	0.58
	4/20/99	--	--	--	--	0.039	--	109	--	--	6.3	--	--	0.72	0.84
	11/04/99	--	--	--	--	0.049	--	13.9	--	--	7.8	--	--	0.38	0.49
	4/26/00	--	--	--	--	2.1	--	95.6	--	--	1.4	--	--	0.47	0.34
	11/15/01	--	--	--	--	0.238	--	11.6	--	--	5.01	--	--	0.546	0.564
	5/20/02	--	--	--	--	3.67	--	21.1	--	--	0.867	--	--	0.217	0.228
	11/18/02	--	--	--	--	0.38	0.0088	6.3	--	--	3.36	--	--	0.648	0.65
	11/17/04	6.8	2.3	ND(0.5)	--	ND(0.04)	ND(0.015)	6.6	0.031	2.7	5.27	4.7	0.53	0.714	0.695
	11/17/05	6.3	2.1	ND(0.5)	ND(0.11)	ND(0.04)	ND(0.015)	5	ND(0.022)	2.6	5.64	5.2	0.48	0.831	0.87
	12/14/06	5.1 J	1.5	ND(0.5)	ND(0.2)	2	ND(0.015)	30.4	ND(0.054)	1.6 J	0.574	0.57	ND(0.052)	--	0.387
	12/19/07	ND(12.8)	0.76	ND(0.5)	ND(0.2)	3.4	0.021	37	ND(0.054)	1	0.0905	0.12	ND(0.052)	0.0951	0.105
	6/24/09	15.3 J	2.5	ND(0.5)	0.27 J	0.078 J	ND(0.015)	9.4	--	1.3	0.8	0.78 J	ND(0.052)	0.53	0.544

TABLE 4-3. DISSOLVED PHASE MONITORED NATURAL ATTENUATION ANALYTICAL SUMMARY FOR GULF PARK
FIRST 2009 SEMIANNUAL MONITORING EVENT
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

Location ID	Date Sampled	Chemical Oxygen Demand (mg/L)	Methane (mg/L)	Nitrogen (mg/L)	Nitrogen, Ammonia (mg/L)	Nitrogen, Nitrate (mg/L)	Nitrogen, Nitrite (mg/L)	Sulfate (mg/L)	Total Sulfide (mg/L)	Total Organic Carbon (mg/L)	Iron, Total (mg/L)	Iron, Ferrous Total	Iron, Ferric Total	Manganese, Dissolved (mg/L)	Manganese, Total (mg/L)
GPW-5S	2/21/96	16	--	--	--	ND(0.01)	--	43	--	--	78.3	--	--	0.777	2.8
	10/29/96	57	--	--	--	0.03	--	271	--	--	5.91	--	--	0.786	1.93
	5/05/97	--	--	--	--	0.19	--	52	--	--	2.34	--	--	1.11	1.07
	11/13/97	--	--	--	--	0.03	--	78	--	--	1.86	--	--	0.983	1.23
	4/28/98	ND(10)	--	--	--	6.9	--	94.4	--	--	0.059	--	--	0.16	0.065
	11/03/98	--	--	--	--	0.15	--	179	--	--	0.49	--	--	1.2	1.3
	4/20/99	--	--	--	--	0.14	--	78.5	--	--	1.2	--	--	1.5	1.2
	11/04/99	--	--	--	--	0.022	--	16.4	--	--	1.9	--	--	1.6	2.1
	4/25/00	--	--	--	--	0.38	--	195	--	--	1.1	--	--	1.7	1.6
	11/15/01	--	--	--	--	0.675	--	26.7	--	--	0.437	--	--	0.963	1.05
	5/20/02	--	--	--	--	0.621	--	39.2	--	--	1.19	--	--	0.988	1.03
	11/18/02	--	--	--	--	0.07	ND(0.01)	14.5	--	--	0.739	--	--	0.829	0.833
	11/17/04	4	0.047	ND(0.5)	--	0.087	ND(0.015)	14.1	0.58	2.5	0.322	0.36	ND(0.05)	0.794	0.793
	11/16/05	5.5	0.22	ND(0.5)	ND(0.11)	ND(0.04)	ND(0.015)	8.8	0.039	2.5	0.722	0.73	ND(0.038)	0.688	0.76
	12/12/06	2.8 J	0.0043 J	ND(0.5) J	ND(0.2)	0.58	ND(0.015)	52.1 J	0.14 J	1.3 J	--	0.11	--	--	--
	12/21/07	ND(12.8)	ND(0.002)	ND(0.5) J	ND(0.2)	4.2	ND(0.015)	92.3	ND(0.054)	ND(1)	ND(0.0522)	ND(0.008)	ND(0.052)	ND(0.00084)	ND(0.00084)
	6/24/09	19.9 J	0.011 J	ND(0.5)	0.21 J	0.44	ND(0.015)	29.7	--	1	0.171 J	0.15 J	ND(0.052)	0.448	0.466
TH-1I	4/28/98	ND(10)	--	--	--	--	--	--	--	--	--	--	--	--	--
	5/21/02	--	--	--	--	--	--	--	--	--	--	--	--	0.00071	--
	11/17/04	ND(2.1)	ND(0.002)	ND(0.5)	--	3.9	ND(0.015)	46.2	0.035	2	ND(0.0495)	ND(0.008)	ND(0.05)	ND(0.00084)	ND(0.00084)
	11/17/05	ND(2.1)	ND(0.002)	ND(0.5)	ND(0.11)	3.6	ND(0.015)	46.8	ND(0.022)	1.2	ND(0.0378)	ND(0.008)	ND(0.038)	ND(0.00096)	ND(0.00096)
	12/15/06	4.4 J	ND(0.002)	ND(0.5)	ND(0.2) J	4	ND(0.015) R	50.4	ND(0.054)	1 J	ND(0.0522)	ND(0.008)	ND(0.052)	--	ND(0.00036)
	12/20/07	ND(12.8)	ND(0.002)	ND(0.5)	ND(0.2)	4.3	ND(0.015)	49.2	ND(0.054)	ND(1)	ND(0.0522)	0.0095	ND(0.052)	ND(0.00084)	ND(0.00084)
TH-1S	4/24/95	75	--	--	--	ND(0.01)	--	3	--	--	6.8	--	--	0.465	0.483
	2/22/96	ND(10)	--	--	--	0.01	--	65	--	--	15.5	--	--	0.433	0.501
	10/29/96	23	--	--	--	ND(0.01)	--	2.06	--	--	2.7	--	--	0.428	0.482
	5/06/97	--	--	--	--	0.09	--	16	--	--	5.62	--	--	0.383	0.408
	11/14/97	--	--	--	--	0.02	--	4	--	--	1.9	--	--	0.437	0.51
	4/29/98	ND(10)	--	--	--	0.024	--	11.6	--	--	20.2	--	--	0.66	0.69
	4/20/99	--	--	--	--	ND(0.03)	--	10.9	--	--	5.4	--	--	0.51	0.5
	11/04/99	--	--	--	--	ND(0.03)	--	9.8	--	--	2	--	--	0.58	0.63
	4/26/00	--	--	--	--	ND(0.15)	--	25	--	--	16.8	--	--	0.71	0.75
	11/14/01	--	--	--	--	ND(0.05)	--	7.4	--	--	13.4	--	--	0.725	0.757
	5/21/02	--	--	--	--	ND(0.05)	--	29.6	--	--	10.4	--	--	0.626	0.686
	11/19/02	--	--	--	--	ND(0.05)	0.0088	ND(5)	--	--	25.6	--	--	0.934	0.972
	11/17/04	6.4	0.26	ND(0.5)	--	ND(0.04)	ND(0.015)	13.3	0.13	2.5	2.76	2.8	ND(0.05)	0.44	0.452
	11/17/05	4.8	0.39	ND(0.5)	0.24	ND(0.04)	ND(0.015)	15.4	0.089	2.2	1.7	1.8	ND(0.04)	0.496	0.525
	12/15/06	18.8	0.43	0.76 J	0.46 J	ND(0.04)	ND(0.015) R	34.6	0.083 J	4.7	11.3	11.5	ND(0.4)	--	0.628
	12/20/07	25.5	0.55	ND(0.5)	ND(0.2)	ND(0.04)	ND(0.015)	241	0.16	3.8	6.35	6.4	ND(0.2)	1.22	1.26
	6/23/09	40.8 J	0.54	0.76 J	ND(0.2)	ND(0.04)	0.052	13.5 J	--	3.6	21.1	21.9 J	ND(1)	0.545	0.565

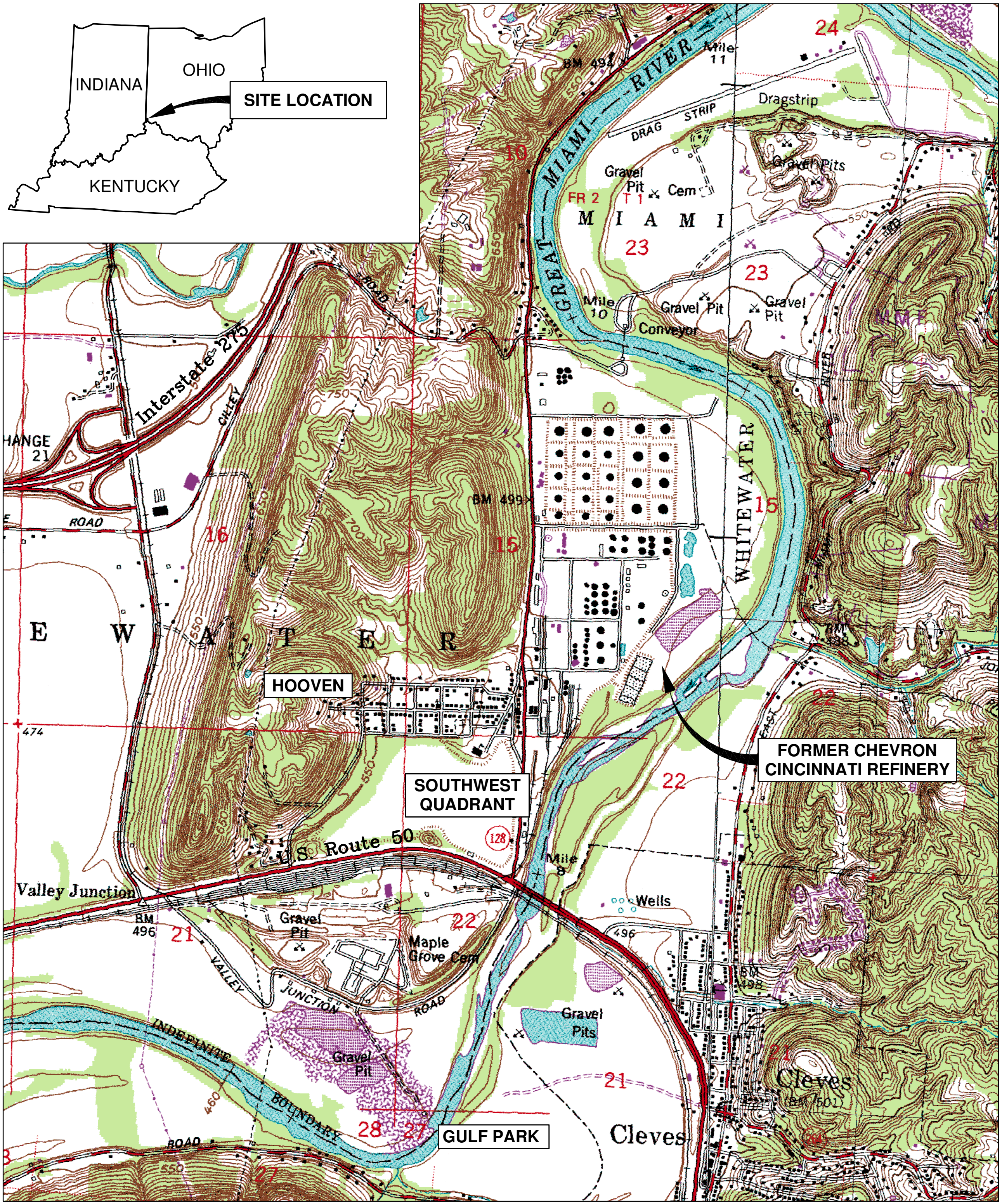
TABLE 4-3. DISSOLVED PHASE MONITORED NATURAL ATTENUATION ANALYTICAL SUMMARY FOR GULF PARK
FIRST 2009 SEMIANNUAL MONITORING EVENT
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

Location ID	Date Sampled	Chemical Oxygen Demand (mg/L)	Methane (mg/L)	Nitrogen (mg/L)	Nitrogen, Ammonia (mg/L)	Nitrogen, Nitrate (mg/L)	Nitrogen, Nitrite (mg/L)	Sulfate (mg/L)	Total Sulfide (mg/L)	Total Organic Carbon (mg/L)	Iron, Total (mg/L)	Iron, Ferrous Total	Iron, Ferric Total	Manganese, Dissolved (mg/L)	Manganese, Total (mg/L)
TH-2	4/25/95	105	--	--	--	0.04	--	8	--	--	30.7	--	--	0.64	1.25
	2/22/96	41	--	--	--	0.01	--	5	--	--	21.8	--	--	0.391	0.744
	10/30/96	64	--	--	--	0.03	--	ND(0.2)	--	--	33.2	--	--	0.342	1.37
	5/06/97	--	--	--	--	0.03	--	16	--	--	32.6	--	--	0.653	0.847
	11/14/97	--	--	--	--	0.08	--	ND(1)	--	--	15.8	--	--	0.357	0.506
	4/29/98	ND(10)	--	--	--	0.028	--	7.5	--	--	14.1	--	--	0.45	0.46
	11/02/98	--	--	--	--	ND(0.03)	--	13.8	--	--	18.3	--	--	0.42	0.49
	4/20/99	--	--	--	--	ND(0.03)	--	4.1	--	--	19.4	--	--	0.5	0.52
	11/04/99	--	--	--	--	0.024	--	7.4	--	--	17.5	--	--	0.38	0.63
	4/26/00	--	--	--	--	0.057	--	7	--	--	17.8	--	--	0.48	0.49
	11/14/01	--	--	--	--	ND(0.05)	--	ND(5)	--	--	14.6	--	--	0.41	0.46
	5/21/02	--	--	--	--	ND(0.05)	--	ND(5)	--	--	10.4	--	--	0.314	0.34
	11/19/02	--	--	--	--	ND(0.05)	0.0088	ND(5)	--	--	20.1	--	--	0.78	0.889
	11/17/04	81.3	8.6	2.1	--	ND(0.04)	ND(0.015)	18	0.26	21.6	18.6	18.6	ND(0.4)	1.49	1.03
	11/16/05	16.3	1.1	0.65	0.71	ND(0.04)	ND(0.015)	ND(1.5)	0.06	3.8	9.35	10.1	ND(0.2)	0.349	0.366
	12/12/06	24	13	ND(0.5) J	ND(0.2)	ND(0.04)	ND(0.015)	13.1 J	ND(0.054)	4.5	9.13	9.3	ND(0.2)	--	0.325
	12/18/07	39.4	6.5	1.2	ND(0.2)	7	0.097	299	ND(0.054)	11.7	0.318	0.2	0.12	1.16	1.23
	6/24/09	38.4 J	7.7	0.79 J	0.72	ND(0.04)	ND(0.015)	80.4	--	6.2	5.46	5.5 J	ND(0.25)	0.828	0.854
TH-3	4/24/95	86	--	--	--	5.1	--	62	--	--	7.04	--	--	ND(0.005)	0.323
	2/21/96	ND(10)	--	--	--	6.81	--	55	--	--	22.7	--	--	0.017	0.838
	10/30/96	17	--	--	--	4.42	--	44	--	--	4.23	--	--	0.046	0.319
	5/05/97	--	--	--	--	5.3	--	63	--	--	8.28	--	--	0.106	0.183
	11/13/97	--	--	--	--	8.12	--	11	--	--	0.36	--	--	0.101	0.167
	4/28/98	ND(10)	--	--	--	0.45	--	24.9	--	--	1.7	--	--	0.0005	0.034
	11/02/98	--	--	--	--	4.4	--	45.8	--	--	0.18	--	--	0.11	0.14
	4/20/99	--	--	--	--	4.3	--	42.3	--	--	1.5	--	--	0.0034	0.042
	11/04/99	--	--	--	--	3	--	45.9	--	--	0.12	--	--	0.017	0.034
	4/25/00	--	--	--	--	9	--	41.2	--	--	4.3	--	--	0.023	0.084
	11/14/01	--	--	--	--	3.78	--	33.9	--	--	0.186	--	--	0.0055	0.0059
	5/21/02	--	--	--	--	2.72	--	37.6	--	--	0.105	--	--	0.0222	0.0218
	11/18/02	--	--	--	--	3.96	ND(0.01)	42.5	--	--	0.122	--	--	0.0027	0.0036
	11/18/04	5.2	ND(0.002)	ND(0.5)	--	4.2	ND(0.015)	41	ND(0.022)	2.7	1.98	0.2	1.8	0.0348	0.0581
	11/17/05	2.4	ND(0.002)	ND(0.5)	0.24	2.3	ND(0.015)	38	ND(0.022)	1.9	ND(0.0378)	0.015	ND(0.038)	0.0036	0.0018
	12/12/06	5.9 J	0.0063	ND(0.5) J	ND(0.2)	2.1	0.018 J	153 J	ND(0.054)	2.5	0.153 J	0.021 J	0.13 J	--	0.0048 J
	12/21/07	ND(12.8)	ND(0.002)	ND(0.5) J	ND(0.2)	1.4	ND(0.015)	35.7	ND(0.054)	1.3	0.0684	0.019	ND(0.052)	0.0068	0.0219
	6/23/09	15.3 J	ND(0.005)	ND(0.5)	ND(0.2)	2.8	ND(0.015)	34.2 J	--	1.4	0.502	0.075 J	0.43	0.0043 J	0.0082

NOTES:

J – Value is estimated and should be used with consideration or qualitative purposes
mg/L - milligram per liter
-- - Not available
ND - Not detected

FIGURES



Basemap: U.S.G.S 7.5' Quadrangles, Hooven and Addyston, Ohio, 1996

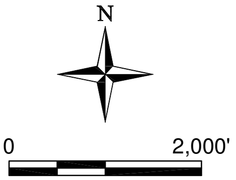


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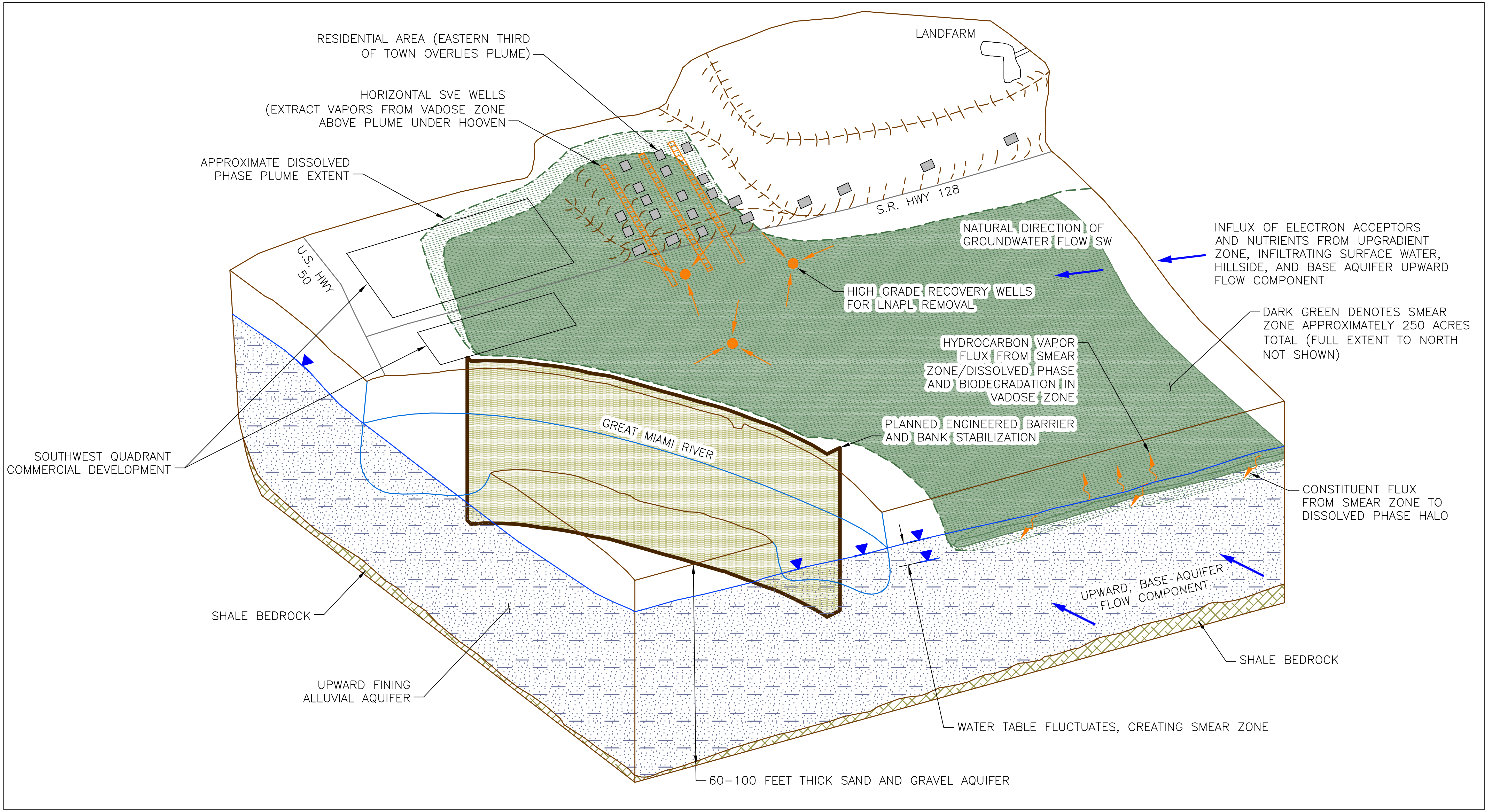
FIGURE 1-1

SITE LOCATION MAP

FIRST 2009 SEMIANNUAL MONITORING EVENT
CHEVRON CINCINNATI FACILITY
HOOVEN, OHIO

Drawn By: DVS	Checked By: PM	Scale: 1" = 2,000'	Date: 12/15/09	File: 500USGSSITE200912



Source: Provided by Chevron Cincinnati.

EXPLANATION

✳	HIGH-GRADE PUMPING TARGETED AREAS WITH HIGHEST RESIDUAL LNAPL SATURATION.
▼	WATER LEVEL
▨	DISSOLVED PHASE PLUME EXTENT
🟩	SMEAR ZONE EXTENT

N

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FIGURE 1-2

GROUNDWATER CONCEPTUAL SITE MODEL

FIRST 2009 SEMIANNUAL MONITORING EVENT
CHEVRON CINCINNATI FACILITY
HOOVEN, OHIO

Drawn By: REP | Checked By: KR | Scale: NONE | Date: 7/10/09 | File: 500GWCONCMODEL-200912