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FIRST 2010 SEMIANNUAL MONITORING REPORT

CHEVRON CINCINNATI FACILITY

HOOVEN, OHIO

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PREPARED BY: Trihydro Corporation

1252 Commerce Drive, Laramie, Wyoming 82070

SUBMITTED BY: Chevron Environmental Management Company

Chevron Cincinnati Facility, 5000 State Route 128, Cleves, Ohio 45002

Trihydro CORPORATION

ENGINEERING SOLUTIONS. ADVANCING BUSINESS.

Home Office | 1252 Commerce Drive | Laramie, WY 82070 | phone 307/745.7474 | fax 307/745.7729 | www.trihydro.com

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EXECUTIVE SUMMARY

This report presents results of the routine monitoring conducted by Chevron Environmental Management Company (Chevron) between January 1, 2010 and June 30, 2010 at the former Gulf Oil refinery situated approximately 20 miles west of Cincinnati, Ohio. Monitoring during this semiannual period was performed following the methods described in the *Remedy Implementation Plan for Final Groundwater Remedy, Chevron Cincinnati Facility* (*RIP*, Trihydro 2007a) and the *Operation, Maintenance, and Monitoring Plan for Final Groundwater Remedy, Chevron Cincinnati Facility* (*OMM Plan*, Trihydro 2007b), in fulfillment of requirements provided in the 2006 Administrative Order on Consent (2006 AOC, Docket No. RCRA-05-2007-0001). Monitoring that was performed during the first 2010 semiannual period include:

- Fluid level gauging including continuous monitoring using pressure transducers as well as weekly, monthly, and bimonthly manual measurements to track hydraulic gradients and LNAPL occurrence
- Groundwater sampling to demonstrate dissolved phase plume stability and efficacy of monitored natural attenuation
- Lysimeter monitoring to collect data regarding precipitation infiltrate to assist in understanding electron acceptor flux into the upper portions of the saturated zone
- ROST to confirm stability of the LNAPL plume at the lateral edge of the smear zone
- River monitoring to evaluate groundwater and surface water quality adjacent to, beneath, and within the Great Miami River

Monitoring results continue to demonstrate that the final groundwater remedy at the former refinery is progressing as anticipated and will meet remedial goals while ensuring that sensitive receptors remain protected. The USEPA has established performance monitoring criteria for remedies incorporating intrinsic natural attenuation processes (USEPA 1999, USEPA 2003). These performance monitoring criteria have been used to evaluate the progress of the final groundwater remedy at the Chevron Cincinnati Facility. Specifically the data collected at the Chevron Cincinnati Facility demonstrate the following:

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1. Dissolved phase natural attenuation indicators continue to demonstrate that intrinsic biodegradation is occurring within the saturated zone at facility and off-site properties including Gulf Park. Nested vapor monitoring was not performed in Hooven or on the facility during the first semiannual period in 2010, in accordance with the schedule provided within the *OMM Plan* (Trihydro 2007b). Evidence of natural attenuation processes occurring in the vadose zone will be presented in the second semiannual report for 2010.

2. Dissolved phase data collected during the first half of 2010 continue to demonstrate that the concentrations of constituents of concern in groundwater are decreasing over time. Soil vapor, LNAPL, and soil core analytical results collected from the facility prior to 2010 also show a continued decrease in the smear zone mass and petroleum hydrocarbon concentrations over time.

3. Decreasing dissolved phase constituent 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, 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 within the interior of the smear zone. These observations are consistent with the expectation of outside-in attenuation of petroleum hydrocarbons within the smear zone.

4. ROST and dissolved phase monitoring results verify that the LNAPL and dissolved phase plume were stable beneath the Southwest Quad and on the facility. Localized changes in dissolved phase conditions were identified at the point of compliance boundary in the Southwest Quad in November 2008 with benzene reported in groundwater samples collected from sentinel monitoring well MW-35 and point of compliance well MW-133. These changes have been associated with a localized release(s) in the Southwest Quad. Fluid level and groundwater monitoring results collected in the first half of 2010 confirm that constituents from the plume are not migrating to the point of compliance boundary. In March 2010, long-term operations and monitoring were reverted to the schedule outlined in the *OMM Plan* (Trihydro 2007b) following six months of monitoring with no additional detections of benzene in groundwater samples collected from wells MW-35 and MW-133. An understanding of the effects of these localized sources will be considered during future implementation of the final corrective measures for groundwater.

5. Dissolved phase monitoring conducted along the west bank of the Great Miami River showed that constituents of concern present in the smear zone are not migrating beneath the partial penetrating barrier wall. The surface water screening standards were not exceeded in any of the hyporheic or surface water samples collected during the first half of 2010 and sensitive receptors along the river bank remain protected.

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1.0 INTRODUCTION

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 groundwater cleanup standards. Achieving this objective was estimated to take up to 42 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 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 performed from March 2009 until March 2010)
- 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 December 2007 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

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- 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 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 *RIP* (Trihydro 2007a) and the *OMM Plan* (Trihydro 2007b).

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 assessment and routine monitoring results collected during the first half of 2010. 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 more than 3.5 million gallons of LNAPL.

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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, is composed of dominantly coarse sediment, and is referred to as the Great Miami 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.

The Buried Valley Aquifer pinches out beneath the western portions of Hooven (west of monitoring wells MW-113 and MW-129). During investigation activities conducted in 2005 during high-water table conditions, saturated sediments were not observed during installation of the soil boring completed as monitoring well MW-130. This soil boring was installed approximately two feet within the weathered portions of the Ordovician-age shale bedrock at a total depth of 65 ft-bgs. Monitoring well MW-130 is located approximately 325 feet west of well MW-129. Groundwater has been measured between 62.37 feet and 63.43 ft-bgs in well MW-130 since July 2005. Groundwater measured in this monitoring well is thought to be “trapped” within the screened portion of the well set in the weathered bedrock and does not reflect saturated conditions in the Buried Valley Aquifer. The depth to groundwater measured in monitoring well MW-129 is typically more than ten feet below the bottom of the screen interval in well MW-130. Monitoring wells MW-129 and MW-130 are situated at nearly the same ground surface elevation.

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 east for periods ranging from days to weeks dependent 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

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"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 individual constituents from many families, including aliphatics, aromatics, paraffins, isoparaffins, olefins, and naphthalenes. Each constituent has somewhat different physical, chemical, and toxicological properties. Some of these constituents are sufficiently 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 approximately 100 to 200 feet down-gradient from the LNAPL plume boundary.

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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 pumping that was performed for more than two decades. It was anticipated that the dissolved phase plume stability would become re-established during the first few years after pumping was discontinued. As discussed further in Section 2.2, detections of dissolved phase benzene in samples collected from the sentinel well MW-35 and point of compliance well MW-133 were observed in early 2009. Dissolved phase benzene was not measured in any of the monthly groundwater samples collected from these two wells from September 2009 though the first half of 2010. The detections of benzene in groundwater are not believed to be associated with re-distribution of the dissolved phase hydrocarbons associated with the former refinery at the southern limits of the plume. The benzene detected in these two wells was likely derived from an alternate source in the Southwest Quad, as the measured dissolved phase concentrations did not follow trends that would be expected if contaminants were migrating down-gradient from the smear zone limits to the point of compliance well and benzene has not been detected during recent sampling events, also indicative of a localized source.

The primary driver for plume stability is believed to be active biodegradation along the boundaries of the smear zone (i.e., up- and down-gradient limits of the smear zone, lower reaches of the smear zone within the saturated zone, and upper contact of the smear zone within the unsaturated zone). 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 slower rate compared with aerobic degradation.

The pathway for migration of petroleum hydrocarbons 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 constituents 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.

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Microbiological degradation can also occur in the absence of O_2 within the vadose zone, 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 if 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 atmospheric and dissolved O_2 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 LNAPL and dissolved phase 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 vapors coming from the smear zone or dissolve phase plume 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,

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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. Two independent investigations performed between 2008 and 2009 by the USEPA and Chevron confirmed that the vapor intrusion pathway is incomplete beneath Hooven and the Southwest Quad, and there is not a health risk to any occupants within homes, businesses, or the school associated with the smear zone or dissolved phase constituents beneath the community.

1.1.5 ALTERNATE SOURCES

There are multiple potential alternate sources of LNAPL, vapor phase, 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 diesel and gasoline underground storage tanks removed in 1991, the Kroger gasoline and diesel service station, underground storage tanks removed at the Hooven Elementary School and Hooven Fire Station, dry wells installed in the Southwest Quad, the Whitewater Reclamation (formerly Golsch) construction and demolition landfill, surface releases associated with vehicles travelling on Ohio State Route 128 and United States Highway 50, surface releases from vehicles located in parking lots across the Southwest Quad, commercial businesses (e.g., automotive repair, long-haul trucking, and construction lay down yards) located within Hooven and the Southwest Quad, as well as local point sources associated with residential, municipal and commercial activities in the Southwest Quad and Hooven. In addition, each of the

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residences and other occupied structures in Hooven maintained an individual septic system to treat wastewater prior to extension of a municipal sanitary sewer system into the community in 2006. Several studies including DeWalle et al. (1985) and Conn and Seigrist (2009) have documented releases of volatile petroleum related constituents from septic systems.

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 constituents 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 sources similar to those described above. Therefore, hydrocarbon vapors are present in the vadose zone and indoor air in Hooven and the Southwest Quad associated with releases from these alternate 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, 2010 to June 30, 2010. This report will also provide a summary of additional assessment and operational activities performed during the first half of 2010 including implementation of contingency measures and cessation of hydraulic control activities in the Southwest Quad following detection of dissolved phase benzene in the sentinel and point of compliance monitoring network in early 2009. The remainder of this report is organized into the following sections:

- Section 2.0 – Describes the infrastructure, methods, and results of monitoring activities conducted during the first semiannual reporting period in 2010.
- 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.

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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
- River monitoring to evaluate groundwater and surface water quality adjacent to, beneath, and 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, 2010. 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

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daily or more frequent basis. Groundwater elevation data recorded using pressure transducers are provided in Appendix A.

Pressure transducers were deployed in an expanded network (including wells MW-4, MW-10, MW-17, MW-18R, MW-19, MW-20S, MW-21, MW-26R, MW-35, MW-44S, MW-81S, MW-85S, MW-93S, MW-94S, MW-96S, MW-99S, MW-101S, MW-112, MW-131, PROD_15, PROD_19, PROD_20, and RBGP-44) across the site, Hooven, and Southwest Quad. Fluid levels were continuously monitored using the pressure transducers to measure the effectiveness of hydraulic controls through early March 2010 and the restored hydraulic gradients after continuous pumping was terminated. Section 2.2 provides a further explanation of the hydraulic controls at the down-gradient limits of the facility and termination of continuous pumping following agency approval in March 2010.

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 LNAPL thickness. The number of wells included in the weekly fluid level monitoring was increased both onsite and in the Southwest Quad following the resumption of hydraulic control using production wells PROD_15 and PROD_24 in accordance with the submitted *Work Plan for Contingency Measures in the Southwest Quad* (Trihydro 2009d). Upon termination of high-grade pumping on December 14, 2009 through the approval of the Contingency Measures work plan on March 4, 2010, fluid levels were gauged on a weekly basis in select monitoring wells (including wells GPW-5S, 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, PROD_24, RBGP-44 and TH-2) in support of evaluating hydraulic controls.

Appendix B provides manual fluid level gauging data collected during the first half of 2010. Potentiometric surface maps for January, March, and May 2010 generated using data collected during bimonthly monitoring are provided as Figures 2-2 through 2-4. Groundwater flow in the Buried Valley Aquifer is generally to the south under non-stressed (i.e., non-pumping) conditions. The potentiometric surface map generated using fluid level data collected on January 14, 2010 shows that groundwater flow was predominantly towards the depressions created through groundwater recovery using production wells PROD_15 and PROD_24 in the southern portions of the facility and Southwest Quad.

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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 200 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 (Fe^{3+}), ferrous iron (Fe^{2+}), total iron, dissolved manganese, total manganese, CH_4, 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 2010 are included in Appendix C. Laboratory analytical reports for groundwater samples collected during the first 2010 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 2010.

2.2.1 SENTINEL AND POINT OF COMPLIANCE MONITORING

There are three sentinel wells (MW-35, MW-131, and MW-132) and four point of compliance monitoring wells (MW-37, MW-120, MW-133, and MW-134) located at the down-gradient edge of the dissolved phase plume in the Southwest Quad. The sentinel and point of compliance monitoring networks are presented on Figure 2-5. Groundwater samples were collected from the sentinel and point of compliance monitoring wells during May 2010, as part of semiannual monitoring activities in accordance with the schedule described in the *OMM Plan* (Trihydro 2007b).

Groundwater analytical results for the dissolved phase constituents of concern are provided on Table 2-1. Dissolved arsenic was detected in samples collected from sentinel well MW-131 and point of compliance wells MW-37 and MW-134 in May 2010 at estimated concentrations of 0.0252 (determined to be a false positive in duplicate sample), 0.0086, and 0.0104 mg/L, respectively. 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),

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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.

Dissolved phase benzene was not detected in sentinel or point of compliance wells during the first half of 2010. Due to historic detections of benzene in sentinel well MW-35 (November 2008, February 2009, and April 2009) and point of compliance well MW-133 in monthly samples collected from February 2009 through August 2009, additional monitoring was performed within selected sentinel and point of compliance wells in the Southwest Quad, hydraulic controls were resumed using production wells PROD_15 and PROD_24, five monitoring wells were installed up-gradient of sentinel well MW-35, and the work plan for contingency measures was submitted and approved by USEPA. A discussion of these activities conducted in response to the dissolved phase benzene measured in the sentinel and point of compliance wells is provided in the following subsection.

2.2.1.1 RESPONSE TO DISSOLVED PHASE BENZENE DETECTIONS

Upon termination of 2009 high-grade pumping, hydraulic control of groundwater in the Southwest Quad was re-initiated via pumping from production wells PROD_15 and PROD_24. From December 15, 2009 to February 25, 2010, groundwater was primarily extracted from production well PROD_15 (average rate of 1,000 gpm) and secondarily from well PROD_24 (average pumping rate of 400 gpm). From February 25 to March 9, 2010, production well PROD_23 was then operated at an average pumping rate of 400 gpm. The USEPA approved discontinuance of hydraulic containment beneath the Southwest Quad and return to ambient groundwater conditions on March 4, 2010.

As reported in the *First 2009 Semiannual Monitoring Report, Chevron Cincinnati Facility, Hooven, Ohio* (Trihydro 2009e), five additional groundwater monitoring wells (MW-138 through MW-142) were installed in March 2009 up-gradient of sentinel well MW-35 to characterize the relationship between the dissolved phase detections reported in this monitoring well, point of compliance well MW-133, and those detected in the up-gradient portions of the smear zone in the Southwest Quad. 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 point of compliance 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. In addition, 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

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MW-142 since the first semiannual monitoring event. Finally, groundwater samples were collected from monitoring well MW-141 as part of the quarterly monitoring activities.

Groundwater samples were analyzed for the dissolved phase constituents of concern. Groundwater analytical results are summarized on Table 2-1 (since November 2008) and Figure 2-6 (since July 2009). Dissolved phase petroleum hydrocarbon constituents have not been detected in any of the sentinel or point of compliance monitoring wells since August 2009, including those samples collected following deactivation of hydraulic controls in March 2010.

As depicted on Figure 2-6, well MW-139 is the nearest up-gradient well where benzene has been reported in samples collected since August 2009. Monitoring well MW-139 is located more than 400 feet up-gradient of point of compliance 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 have shown a consistent and continual decreasing trend in the down-gradient direction, with additional detections of benzene in samples collected from monitoring wells MW-35 and MW-138. As constituent concentrations have not behaved in this manner in the Southwest Quad, this suggests a localized alternate source was responsible for the transient detections of benzene in samples collected from the point of compliance well MW-133.

On October 1, 2009 Chevron submitted the *Work Plan for Contingency Measures in the Southwest Quad, Chevron Cincinnati Facility, Hooven, Ohio* (Trihydro 2009d). The work plan was approved on March 4, 2010 pending modifications. Chevron submitted the modified work plan on April 1, 2010. This work plan describes the nature of the dissolved phase constituents measured in the Southwest Quad and the lines of evidence supporting an alternate source for benzene measured in samples collected from sentinel well MW-35 and point of compliance well MW-133. In accordance with this work plan, groundwater was monitored monthly in wells within and down-gradient from the smear zone to closely track the dissolved phase constituent distribution as ambient groundwater conditions become re-established. Fluid level and groundwater monitoring results confirm that constituents from the plume are not migrating to the point of compliance, therefore long-term operations and monitoring were reverted to the protocols outlined in the *OMM Plan* (Trihydro 2007b) following six months of monitoring following termination of hydraulic controls in March 2010.

If future monitoring results indicate that (1) dissolved phase constituents of concern are present in monitoring wells from the smear zone in a continuous trend down-gradient to the point of compliance boundary, (2) concentrations of dissolved phase constituents measured in the sentinel and point of compliance wells are in good agreement with the

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expected concentrations based on the effective solubility of constituents present within the smear zone, and (3) the concentration of a dissolved phase constituent of concern listed on Table 1 of the *2006 AOC* exceeds the USEPA Maximum Contaminant Level (MCL, USEPA 2009), contingency measures will be implemented.

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 dissolved 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 eleven 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 2010 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 2010 include wells L-1RR, MW-21, MW-51, MW-64, and MW-80.

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-37,

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MW-38, MW-51, MW-81S, MW-85S, MW-96S, MW-100S, MW-112, MW-114, MW-115S, and MW-131. Groundwater analytical results for the dissolved phase natural attenuation indicators are included on Table 2-3.

2.3 LYSIMETERS

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 well above the smear zone and the second set at an 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 24, 2010. Subsequently, on June 3, 2010, the rainwater infiltrate was collected from the shallow lysimeters. Samples were not collected from the deep lysimeter at each location due to sufficient recovery in the shallow lysimeter. Infiltrating precipitation collected from the lysimeters was analyzed for dissolved O_2 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 CH_4.

Field forms for samples collected from the lysimeters in June 2010 are included in Appendix C. Laboratory analytical reports for the lysimeter samples are provided in Appendix D-1 and data validation reports for each of the analytical packages provided by the laboratory are included in Appendix D-2. 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. The concentrations of electron acceptors measured in the infiltrate collected from lysimeter L-21S (northernmost location) and lysimeter L-18S (central portion of the smear zone) were generally low or not detected, with the exception of a

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relatively high dissolved O_2 concentration observed in the sample from L-21S (6.0 mg/L). Reduced byproducts including dissolved manganese and CH_4 were elevated within the samples collected from these locations. This may be an indication of ongoing attenuation of petroleum hydrocarbons, and subsequent partitioning of CH_4 and volatile petroleum hydrocarbons from soil vapor to pore water within the vadose zone.

In the southern portions of the smear zone, the pore water generally contains higher levels of electron acceptors with elevated sulfate and manganese concentrations measured in lysimeter L-20S and elevated O_2, nitrate, and sulfate measured in lysimeter L-93S. Reduced by-products were reported as non-detect or relatively low concentrations in the infiltrate samples collected from these two lysimeters, with the exception of elevated dissolved manganese (1.92 mg/L) measured in the sample collected from lysimeter L-20S. Based on these results it appears that there is a higher flux of electron acceptors into the saturated portions of the smear zone along the southern portion of the site.

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 negative assimilative capacity, indicating that precipitation infiltrate at these locations does not have the potential to further degrade hydrocarbons within the saturated zone. 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) is much higher.

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 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

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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).

ROST monitoring could not be conducted in June 2010 as originally scheduled due to malfunctioning equipment and maintenance required by the subcontractor. A letter dated July 1, 2010 was sent to USEPA providing notice of the delay. Monitoring within the ROST network was conducted between July 13 and 16, 2010. The tool was advanced from approximately 5 feet above the water table to approximately 5 feet below the water table in each of the monitoring location. Multiple attempts were made at each monitoring location, if necessary, until the target depth of approximately 45 feet below ground surface was reached. ROST monitoring results are provided in Appendix E. Data collected during the July 2010 event 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 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 *Performance Monitoring Plan, Sheet Pile Barrier Along Great Miami River, Chevron Cincinnati Facility, Hooven, Ohio* (Trihydro 2007c). This work plan 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 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, Ohio* (Trihydro 2009b).

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2.5.1 FLUID LEVEL MONITORING

Pressure transducers were deployed on December 1, 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 groundwater and surface water elevations at a four-hour frequency. High frequency groundwater elevation data recorded using the pressure transducers are provided in Appendix A. Manual fluid level gauging was also conducted on May 26, 2010 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 during this gauging event. 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). Along the northern transect (shown on Figure 2-9), the groundwater elevation on the interior of the wall was generally lower than the surface water elevation from January to March 14, 2010, which corresponds to the peak of a flood event. Following this flood event, the groundwater elevation on the interior of the wall was generally higher than the surface water elevation. There is a consistent downward gradient on both sides of the wall leading up to the mid-March flood event. Following the flood event, there is generally a downward gradient on the inside of the wall and a corresponding upward gradient observed on the outboard side of the wall through June 2010. These results indicate that rapid and large fluctuations to surface water elevations can alter gradients and flow paths along the barrier. In addition, following flood events groundwater may continue to discharge back into the river for several months. The pathway for groundwater discharging back into the river has been altered as designed by installation of the barrier wall. Groundwater discharging into the river must first travel beneath the partially penetrating wall before making its way back into the river. It should be noted that this bank discharge beneath the wall typically makes up a small component of the overall flow within the aquifer, as the primary flow direction for groundwater is generally parallel to the riverbank.

At the southern transect (shown on Figure 2-10), groundwater elevations are generally higher than surface water elevations with brief reversals during rapid rises in river stage. Generally, there is a downward gradient observed on the outboard side of the partially penetrating sheet pile wall that briefly reverses during river stage increases. On the interior portions of the wall there was essentially no vertical gradient observed during the first 2010 semiannual monitoring period, with the exception of a small upward gradients observed during rapid rises in the river stage. The

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data collected during the first half of 2010 show that during episodic increases in the river elevations, surface water may be discharging into the aquifer along the southern portion of the barrier wall.

2.5.2 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 May 2010 were analyzed for the dissolved phase constituents of concern. In addition, samples collected from the middle and southern transects in May 2010 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, respectively. During the March and May 2010 monitoring events, there were low level, estimated concentrations of toluene and dissolved phase arsenic measured in samples collected from inboard monitoring wells (MW-136S & MW-137S) and a low level, estimated concentration of total xylenes measured in a single sample collected from the outboard monitoring well BSW-3D. In no case were detected constituents present on both sides of the barrier, indicating that constituents of concern present in the smear zone along the west bank of the river are not migrating beneath the barrier. The surface water screening standards were not exceeded in any of the hyporheic or surface water samples collected during the first half of 2010.

The March and May 2010 barrier performance monitoring results are similar to those observed during all previous barrier sampling events (i.e., infrequent low-level or estimated concentrations at a small number of wells not indicative of contaminant migration beneath the barrier). Thus, there does not appear to be a dissolved phase or LNAPL source near the inboard or outboard portions of the barrier wall. Without the presence of a dissolved phase or LNAPL source it is not expected that there will be any significant changes to the natural attenuation indicators as petrophyllic bacteria require a hydrocarbon source to proliferate and cause alterations to groundwater geochemistry.

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2.6 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 2010. Samples were collected from the nested vapor monitoring wells in Hooven during August 2010 and will be reported in the *Second 2010 Semiannual Monitoring Report.*

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3.0 INTERPRETATION

Data collected during the first half of 2010 and included herein continue to demonstrate that the intrinsic processes are degrading petroleum hydrocarbons in the smear zone. 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 2010. 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 nested vapor monitoring wells VW-93, VW-96, VW-99, VW-128, and VW-129 in Hooven in August 2010 in accordance with the *OMM Plan* (Trihydro 2007b). Additionally, soil vapor samples have been collected from the 10, 20, 30, and 40 foot intervals in nested wells VW-96 and VW-99 monthly since startup of the HSVE system in August 2010. An update regarding attenuation processes within the vadose zone and evaluation of the soil vapor conditions beneath Hooven during operation of the HSVE system will be provided in the *Second 2010 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., USEPA 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 (Section 3.3) demonstrate indirectly that 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 2010 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

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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 2010 continue to support that the smear zone is stable based on the laser induced fluorescence measurements in the three ROST monitoring transects conducted between July 13 and 16, 2010. Additionally, LNAPL was not measured in any of the sentinel or point of compliance monitoring wells installed in the Southwest Quad. 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

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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 indicated in Section 2.2.1, benzene was detected in the groundwater sample collected from sentinel well MW-35 and point of compliance well MW-133 at concentrations exceeding the USEPA MCL (0.005 mg/L) between November 2008 and August 2009. During monitoring conducted in the first half of 2010, none of the constituents of concern, including benzene were measured in any of the sentinel or point of compliance wells installed in the Southwest Quad. Benzene has not been measured above detection limits in samples collected from sentinel well MW-35 since April 2009 or in point of compliance well MW-133 since August 2009. As described in the *Work Plan for Contingency Measures in the Southwest Quad, Chevron Cincinnati Facility, Hooven, Ohio* (Trihydro 2009d), there are several lines of evidence indicating that the dissolved phase benzene detected in sentinel well MW-35 and point of compliance well MW-133 is associated with alternate sources within the Southwest Quad. Thus, the detections of benzene in wells MW-35 and MW-133 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) and the mole fraction of benzene in smear

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zone soil cores samples (SZ-18, SZ-20, SZ-21, SZ-58, SZ-96 and SZ-NTF1) collected in 2008 and 2009 on a logarithmic-linear scale. This figure also shows the decline in the average benzene mole fraction 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 is being conducted to provide a means of measuring LNAPL composition, with the first coring events performed in 2008 and 2009. The benzene mole fractions estimated within the soil cores collected during these initial events were compared to the benzene mole fraction 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 benzene mole fraction 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 in 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 a LNAPL saturation of approximately 5.6% (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 system 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 SZ-96, where LNAPL is still present. Smear zone soil coring will be conducted on five year intervals with the next event slated to occur between 2013 and 2014.

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3.2.2 DISSOLVED PHASE CONSTITUENT TRENDS

The distribution of total benzene, toluene, ethylbenzene, and total xylenes (BTEX) in groundwater as well as total petroleum hydrocarbons concentrations for samples collected during the first 2010 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, (e.g., 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-10, 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 four remaining interior plume monitoring wells (MW-17, MW-22, MW-81S and MW-93S) are provided on Figures 3-3 through 3-6. Monitoring well MW-17 is located in the interior of the smear zone, where dissolved phase benzene concentrations continue to be measured at concentrations above remedial goals. There is a

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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 and MW-93S is located in the central portion of Hooven adjacent to the elementary school. Dissolved phase constituent concentrations in these two wells show a clear decreasing trend between 1996 and 2010. This trend is likely associated with groundwater and LNAPL recovery as well as HSVE system operations starting between 1999 and 2000.

Of the nine supplemental groundwater monitoring wells (L-1RR, L-3R, MW-21, MW-33, MW-38, MW-51, MW-64, MW-80, and MW-99), wells L-1RR, L-3R, MW-21, MW-33, MW-38, 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 3-7 through 3-10, dissolved phase benzene concentrations reported in supplemental monitoring wells L-1RR, L-3R, MW-21, and MW-38 showed a first order degradation rate over time. These wells are generally located outside of the footprint of engineered 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, L-3R and MW-38, 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 3-11) and MW-99S (Figure 3-12) 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). Moreover, dissolved phase trends observed in monitoring well MW-99 reflect mass loss through engineered recovery like the other wells situated in Hooven.

Temporal analysis of the dissolved phase results can also be conducted for two additional monitoring wells (MW-85S 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. MW-115S (Figure 3-13) is located outside the influence of historic remedial efforts in the Southwest Quad. Dissolved phase benzene shows a decreasing trend over time within samples collected from this well, which can be considered indicative of natural attenuation processes.

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Monitoring well MW-85S (Figure 3-13) has historically shown a decreasing trend, which was slightly reversed with inclusion of the result from the groundwater sample collected during the first half of 2010. It is possible that installation of the partially penetrating barrier wall along the west bank of the Great Miami River during 2007 has subsequently limited the transport of electron acceptors such as dissolved oxygen to this portion of the smear zone along the river. Future groundwater monitoring will help resolve short term and long term dissolved phase benzene trends in this well and other monitoring wells installed along the west bank of the river within the smear zone.

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-38, MW-22, MW-64, MW-81S, MW-93S, MW-99S, and MW-115S) is approximately 6.91×10^{-4} per year (MW-85S was excluded due to positive trend). 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 2010. 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. Dissolved phase benzene was not detected in samples collected from monitoring wells up-gradient and down-gradient of the smear zone, while the average concentration of dissolved phase benzene within the smear zone was 0.31 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 3-15. Dissolved phase concentrations reported during monitoring conducted in 2002, 2004, 2008, 2009 and 2010 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 2010, 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,

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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 within 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 reaching remedial goals (i.e., USEPA MCLs).

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, dissolved O_2 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. In other words, petrophyllic bacteria that utilize the electron acceptor that offers the most energy during consumption of the petroleum hydrocarbon source will proliferate over other bacteria until they exhaust that electron acceptor and then another bacteria that uses that uses the next most favorable electron acceptor (based on availability in groundwater) thrives. The general order of preference for anaerobic hydrocarbon biodegradation based on the Gibb's energy of the reaction is:

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- Denitrification (reduction of nitrate), with the eventual production of molecular nitrogen
- Reduction of manganese from Mn^{4+} to Mn^{2+}
- Reduction of ferric iron (Fe^{3+}) to ferrous iron (Fe^{2+})
- Sulfate reduction, with eventual production of sulfide
- Reduction of carbon dioxide (CO_2) and generation of CH_4

These microbial processes generally segregate into distinct zones dominated by O_2, nitrate, ferric iron, sulfate, and CO_2 reduction. Furthermore, given the different electron acceptors consumed and final by-products it is theoretically possible to differentiate the "zones" of microbial processes across the smear zone.

If dissolved O_2 is present in groundwater above 0.5 mg/L, then aerobic biodegradation of petroleum hydrocarbons is the dominant process. If dissolved O_2 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 O_2, nitrate, and nitrite; but concentrations of ferrous iron or total manganese are greater than 0.5 mg/L then iron and/or manganese reduction will be the dominant biodegradation process. If groundwater is depleted in ferrous iron and manganese 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 CH_4 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 several of the by-products of microbial metabolism (such as ferric iron, hydrogen sulfide, and CH_4) are readily transported down-gradient. Based on data collected in 2008 (Trihydro 2009b), sulfate reduction and methanogenesis account for more than 90% of smear zone attenuation within the saturated zone.

The spatial distribution of electron acceptors measured during the first 2010 semiannual monitoring period is displayed on Figure 3-16. 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 4.8 and 52.1 mg/L, respectively. Sulfate and nitrate 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. The average sulfate concentration within the smear zone was 5.2 mg/L, while nitrate was not detected above the reporting limit within the smear zone. Nitrate concentrations showed a slight rebound in the down-gradient portions of

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the smear zone. However, dissolved sulfate concentrations rebounded to 29.9 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 CH_4 are depicted on Figure 3-17. 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 CH_4 concentrations up-gradient of the smear zone were 0.035, 0.038, and 0.008 mg/L, respectively. Average dissolved iron, manganese, and CH_4 concentrations within the smear zone were 15.5, 0.57, and 12.6 mg/L, respectively. The increase in the concentration of these biodegradation by-products indicates iron and manganese reduction, as well as methanogenic processes, are degrading petroleum hydrocarbons. Down-gradient of the smear zone, dissolved iron and CH_4 concentrations decrease to 2.0 and 0.073 mg/L, respectively.

Figure 3-18 shows the concentration of dissolved phase benzene versus distance through the centerline of the smear zone with a comparison to sulfate, iron, and CH_4 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 3-18, iron and sulfate reduction, as well as methanogenesis primarily occur within 2,000 feet down-gradient of the smear zone boundary where available electron receptors are reduced. There is a rapid increase in benzene, CH_4, and dissolved iron concentrations with an associated decrease in sulfate. These trends reverse toward the down-gradient edge of the smear zone. The concentration versus distance 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.

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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.

In order to isolate petroleum hydrocarbons present in the smear zone along the east bank of the Great Miami River in Gulf Park, a partially penetrating sheet pile barrier and river bank stabilization measures were installed along the northern portion of the smear zone during the second half of 2009. The sheet pile barrier placement was selected based on smear zone morphology with the objective of eliminating potential petroleum hydrocarbon flux towards the river. A summary of the sheet pile installation and river bank stabilization measures performed along the northern transect were presented in the *Second 2008 Semiannual Monitoring Report, Chevron Cincinnati Facility, Hooven, Ohio* (Trihydro 2009b). A second section of the sheet pile wall and bank stabilization measures were proposed along the southern transect in the Park. Installation and stabilization measures were not completed in 2009 along the southern

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transect due to refusal of a third-party property owner to allow access to this portion of the river bank. Additional assessment activities were performed during the second half of 2010 to evaluate alternate options along the southern limits of the smear zone.

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 O_2 to sustain aerobic microbial activity. Airflow is injected at rates designed to maximize O_2 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 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 January 2006 through June 2010. As shown, groundwater elevations were generally below the trigger levels within wells GPW-5S and TH-2 from June until the end of November 2009. Thereafter, the water levels rebounded and then fluctuated above and below the trigger elevation during the first half of 2010.

The bioventing system at Gulf Park was operated continuously during the second half of 2009 through March 2, 2010, with only minor shut downs due to power outages. 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 2010 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

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- 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 2010, 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 160,000,000 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 2010 between January 1 and March 2, 2010. The biovent well performance measurements, including dates and time of operation, are presented in Appendix F.

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, VP1-50S, VP2-25S, VP2-50S, VP3-35S, VP4-25S, and 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 were submerged and could not be monitored. Soil vapor field measurements were collected a day before shutting down the system on March 1, 2010 and during four additional

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events after shutdown terminating on March 4, 2010. Results of field measurements collected from accessible vapor monitoring points during March 2010 are included in Appendix G.

Table 4-1 presents the results of fixed gas and total organic vapor measurements collected from soil vapor monitoring points while the system was still active on March 1, 2010 and following approximately 48 hours of inactivity on March 4, 2010. Comparison of the fixed gas concentrations measured during system operation and following shutdown indicates that bioventing has a measurable impact on portions of the vadose zone situated within the smear zone. There was a measureable decrease in the concentrations observed in monitoring wells VP2-25S, VP2-50S, and VP6-35S, with a corresponding increase in CO_2. CH_4 concentrations were not observed to rebound after 48 hours of system inactivity.

Additional evaluation of the O_2 consumption coupled with CO_2 and CH_4 production following shut down of the biovent system was performed across an expanded monitoring network during the second half of 2010. The results of this evaluation will be reported in the next semiannual monitoring report. The historic and expanded field screening results may be used to support termination of bioventing beneath 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 2010 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 2010 are included in Appendix D.

Table 4-2 presents a summary of the constituents of concern measured in groundwater samples collected between 2006 and June 2010. Concentrations of the volatile constituents of concern were only detected in samples collected from TH-1S and TH-2 during the June 2010 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.

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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 any of the dissolved phase constituents of concern was last reported in these five 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.

Dissolved phase natural attenuation indicators were analyzed in the shallow wells during the June 2010 monitoring event and are summarized on Table 4-3. In addition, the spatial distribution of oxidizers and attenuation by-products measured during the first 2010 semiannual monitoring period is displayed on Figure 4-6. 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.

The spatial distribution of reduced species including dissolved iron 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. Some of the highest concentrations of iron and methane are reported in wells TH-1S and TH-2. The concentrations of theses 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) concentrations, attenuation by-product (iron, manganese, and methane) concentrations, and ORP. 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

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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 and sulfate concentrations rebound while iron and methane concentrations decline down-gradient of the distribution of petroleum hydrocarbons associated with the release. This is further evidenced by the inverse relationship between BTEX concentrations and ORP observed along the centerline of the smear zone.

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TABLES

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TABLE 2-1. SOUTHWEST QUAD DISSOLVED PHASE ANALYTICAL RESULTS SUMMARY (NOVEMBER 2008 TO JUNE 2010)
FIRST 2010 SEMIANNUAL MONITORING PERIOD
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)
		11/12/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
		5/11/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	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)
		4/3/09	0.021	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
	Dup	4/3/09	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)
		7/21/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
		8/11/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
		9/14/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
		10/12/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	Dup	10/12/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
		11/17/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	--	--
		12/11/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	--	--
		1/12/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	--	--
		2/23/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
		3/29/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
		4/21/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
		5/4/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	Dup	5/4/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
		6/15/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0098)	ND(0.0069)
MW-37		11/18/08	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
		4/2/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
		10/20/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	0.003 JB	ND(0.0069)
		5/5/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	0.0086 J	ND(0.0069)

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TABLE 2-1. SOUTHWEST QUAD DISSOLVED PHASE ANALYTICAL RESULTS SUMMARY (NOVEMBER 2008 TO JUNE 2010)
FIRST 2010 SEMIANNUAL MONITORING PERIOD
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-94S	12/8/08	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
Dup	12/8/08	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
	4/2/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
	5/6/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	0.0166/ND(0.0166)U*	ND(0.0069)
MW-115S	12/9/08	ND(0.0005)	ND(0.0008)	0.0008 J	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
	4/3/09	0.009	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
	10/12/09	0.0008 J	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	0.0109 J	ND(0.0069)
	5/5/10	0.011	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	0.0185 J	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)
	4/1/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
	10/7/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	3/29/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
Dup	3/29/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	4/20/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	5/5/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	6/14/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0098)	ND(0.0069)
Dup	6/14/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0098)	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)
	4/2/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.01)	ND(0.0069)
	7/23/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	0.01 J	ND(0.0069)
	10/20/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	0.0266/ND(0.0266)U*	ND(0.0069)
	5/6/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	0.0252 JB	ND(0.0069)
Dup	5/6/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	0.0174/ND(0.0174)U*	ND(0.0069)

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TABLE 2-1. SOUTHWEST QUAD DISSOLVED PHASE ANALYTICAL RESULTS SUMMARY (NOVEMBER 2008 TO JUNE 2010)
FIRST 2010 SEMIANNUAL MONITORING PERIOD
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-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)
	7/20/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
Dup	7/20/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	10/5/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	5/5/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
Dup	5/5/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
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)
	4/1/09	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)
	7/21/09	0.051	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	8/11/09	0.031	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	9/14/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	10/8/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	11/17/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	--	--
	12/11/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	--	--
	1/12/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	--	--
	2/23/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	3/29/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	4/20/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	5/4/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	6/14/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0098)	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)
	7/20/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	10/5/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	5/5/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	0.0104 J	ND(0.0069)

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TABLE 2-1. SOUTHWEST QUAD DISSOLVED PHASE ANALYTICAL RESULTS SUMMARY (NOVEMBER 2008 TO JUNE 2010)
FIRST 2010 SEMIANNUAL MONITORING PERIOD
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-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)
	7/21/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	8/12/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	9/15/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	10/7/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	11/18/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	--	--
	12/14/09	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	--	--
	1/13/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	--	--
	2/23/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	3/30/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	4/21/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	5/4/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	6/14/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0098)	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)
	7/21/09	0.12	ND(0.0008)	0.001 J	0.006	0.005 J	0.0175 J	ND(0.0069)
	8/12/09	0.12	ND(0.0008)	ND(0.0008)	0.006	0.005 J	0.0164 J	ND(0.0069)
	9/15/09	0.048	ND(0.0008)	ND(0.0008)	0.002 J	0.0009 J	0.0097 J	ND(0.0069)
	10/7/09	0.017	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	0.0131 J	ND(0.0069)
	11/18/09	0.002 J	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	--	--
	12/14/09	0.004 J	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	--	--
	1/13/10	0.0009 J	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	--	--
	2/24/10	ND(0.0005)	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	0.0095 J	ND(0.0069)
	3/30/10	0.004 J	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	4/21/10	0.007	ND(0.0008)	0.001 J	ND(0.0007)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	5/4/10	0.009	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	0.0117 J	ND(0.0069)
	6/14/10	0.002 J	ND(0.0008)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0098)	ND(0.0069)

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TABLE 2-1. SOUTHWEST QUAD DISSOLVED PHASE ANALYTICAL RESULTS SUMMARY (NOVEMBER 2008 TO JUNE 2010)
FIRST 2010 SEMIANNUAL MONITORING PERIOD
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-140	3/27/09	0.35	ND(0.002)	0.43	0.041	0.55	ND(0.01)	ND(0.0069)
	7/10/09	33 J	ND(2)	2000 J	30 J	--	--	--
	6/15/10	0.12	ND(0.0008)	0.013	0.004 J	0.033	ND(0.0098)	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)
	7/23/09	0.4	ND(0.0008)	0.017	0.011	0.016	ND(0.0072)	ND(0.0069)
	10/13/09	0.29	ND(0.0008)	0.045	0.01	0.032	0.0131 J	ND(0.0069)
	2/24/10	0.19	ND(0.0008)	0.014	0.006	0.015	ND(0.0072)	ND(0.0069)
Dup	2/24/10	0.18	ND(0.0008)	0.014	0.006	0.015	ND(0.0072)	ND(0.0069)
	5/5/10	0.14	ND(0.0008)	0.019	0.008	0.024	0.0094 J	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)
	7/23/09	0.27	ND(0.0008)	0.045	0.015	0.061	0.0254	ND(0.0069)
	8/12/09	0.21	ND(0.002)	0.31	0.022	0.21	0.0172 J	ND(0.0069)
	9/15/09	0.15	ND(0.0008)	0.15	0.019	0.13	0.0219	ND(0.0069)
	10/13/09	0.11	ND(0.0008)	0.19	0.021	0.17	0.0211	ND(0.0069)
	11/18/09	0.043	ND(0.002)	0.052	0.011 JB	0.058	--	--
	12/14/09	0.035	ND(0.0008)	0.12	0.013	0.13	--	--
	1/13/10	0.084	ND(0.002)	0.023	0.006 J	0.027	--	--
Dup	1/13/10	0.085	ND(0.002)	0.023	0.006 J	0.027	--	--
	2/24/10	0.09	ND(0.0008)	0.2	0.017	0.11	0.0211	ND(0.0069)
	3/30/10	0.066	ND(0.0008)	0.039	0.009	0.042	0.0194 J	ND(0.0069)
	4/20/10	0.13	ND(0.0008)	0.061	0.014	0.073	0.0267	ND(0.0069)
Dup	4/20/10	0.13	ND(0.0008)	0.061	0.013	0.074	0.0249	ND(0.0069)
	5/4/10	0.12	ND(0.002)	0.18	0.016	0.15	0.0203	ND(0.0069)
	6/15/10	0.16	ND(0.0008)	0.036	0.013	0.062	0.0192 J	ND(0.0069)

NOTES:
The method detection limit was used as the reporting limit.
-- - Not analyzed
Dup - Duplicate sample
J - Estimated concentration
JB - Estimated concentration due to detection of analyte within the method blank.
mg/L - milligram per liter
ND - Not detected at the indicated laboratory reporting limit or the method detection limit.
* - The first result represents the laboratory reported concentration. The second result was evaluated to be undetected at the reported concentration during validation due to detection of the analyte within the method blank.

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TABLE 2-2. PERIMETER, INTERIOR, AND SUPPLEMENTAL WELL GROUNDWATER ANALYTICAL RESULTS SUMMARY
FIRST 2010 SEMIANNUAL MONITORING PERIOD
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	5/03/10	1.1	2.2	0.22	8.8	ND(0.004)	0.0472	0.0113 J
MW-10	5/03/10	0.008	0.012	0.002 J	0.004 J	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-17 Dup	5/10/10	8.3 J	0.62 J	0.11	0.31	ND(0.008)	0.0569	ND(0.0069)
MW-17	5/10/10	1.7 J	0.13 J	0.12	0.34	ND(0.002)	0.0588	ND(0.0069)
MW-18R	5/10/10	2.1 J	2.6 J	0.29	8.3	ND(0.008)	0.0379	0.0128 J
MW-20S	5/11/10	1.7	2.2	0.099	2.5	ND(0.004)	0.0358	ND(0.0069)
MW-21	5/03/10	0.15	1.9	0.073	1.1	ND(0.002)	0.0116 J	ND(0.0069)
MW-22	5/07/10	0.009 J	0.38 J	0.006 J	0.16	ND(0.002)	0.0263	ND(0.0069)
MW-26R	5/11/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-33	5/10/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	0.001 J	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-48S	5/13/10	ND(0.0005)	0.068	ND(0.0007)	0.14	ND(0.0008)	0.0151 J	ND(0.0069)
MW-51	5/06/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-64	5/10/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-80 Dup	5/13/10	0.043	ND(0.0008)	0.006	0.009	ND(0.0008)	0.0394	ND(0.0069)
MW-80	5/13/10	0.042	ND(0.0008)	0.005	0.009	ND(0.0008)	0.0378	ND(0.0069)
MW-81S	5/06/10	0.2	0.001 J	0.004 J	0.009	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-85D	5/11/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-85S Dup	5/11/10	0.16	0.16	0.018 J	0.17	ND(0.004)	0.0234	ND(0.0069)
MW-85S	5/11/10	0.17	0.17	0.018 J	0.18	ND(0.004)	0.0239	ND(0.0069)
MW-93S	5/10/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-94S	5/06/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	0.0166J/ND(0.0166)U*	ND(0.0069)
MW-95S	5/11/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-96S	5/10/10	0.33 J	0.66 J	0.03	1.3	ND(0.0008)	0.0235	0.0128 J
MW-100S	5/04/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-104S	5/03/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	0.001 J	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-115S	5/05/10	0.011	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	0.0185 J	ND(0.0069)

NOTES:
The method detection limit was used as the reporting limit.
-- - Not analyzed
Dup - Duplicate sample
J - Estimated concentration
JB - Estimated concentration due to detection of analyte within the method blank.
mg/L - milligram per liter
ND - Not detected at the indicated laboratory reporting limit or the method detection limit.
* - The first result represents the laboratory reported concentration. The second result was evaluated to be undetected at the reported concentration during validation due to detection of the analyte within the method blank.

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TABLE 2-3. DISSOLVED PHASE NATURAL ATTENUATION ANALYTICAL RESULTS SUMMARY
FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

Location ID	Date Sampled	Alkalinity to pH 4.5 (mg/L)	Alkalinity to pH 8.3 (mg/L)	Chemical Oxygen Demand (mg/L)	Iron, Ferric (mg/L)	Iron, Ferrous (mg/L)	Methane (mg/L)	Manganese, Total (mg/L)
L-1RR	5/03/10	480	ND(0.46)	117	ND(0.5)	13.5 J	20	0.168
MW-18R	5/10/10	495	ND(0.46)	125	ND(0.25)	15.8 J	21	0.156
MW-20S	5/11/10	520	ND(0.46)	100	ND(1)	19.4 J	14	0.215
MW-33	5/10/10	383	ND(0.46)	13.3 J	0.76 J	2.6 J	0.028	0.764
MW-35	5/04/10	422	ND(0.46)	16.5 J	0.26	0.028 J	0.012 J	0.983
MW-37	5/05/10	456	ND(0.46)	ND(12.8)	ND(0.052)	0.021 J	ND(0.005)	0.002 J
MW-38	5/10/10	430	ND(0.46)	139	0.2 J	6.4 J	15	0.469
MW-51	5/06/10	213	ND(0.46)	ND(12.8)	ND(0.052)	ND(0.01)	ND(0.005)	0.232
MW-81S	5/06/10	456	ND(0.46)	17.9 J	ND(0.5)	9.6 J	14	0.244
MW-85S	5/11/10	538	ND(0.46)	97.8	ND(1)	38.4 J	10	1.43
MW-96S	5/10/10	615	ND(0.46)	155	ND(0.5)	21.6 J	12	0.378
MW-100S	5/04/10	388	ND(0.46)	14.4 J	0.089 J	0.029 J	ND(0.005)	0.0024 J
MW-112	5/04/10	532	ND(0.46)	55.9	ND(1)	19 J	20	0.296
MW-114	5/05/10	456	ND(0.46)	ND(12.8)	ND(0.052)	0.027 J	ND(0.005)	0.0023 J
MW-115S	5/05/10	474	ND(0.46)	ND(12.8)	ND(0.2)	7 J	0.86	1.66
MW-131	5/06/10	480	ND(0.46)	13.3 J	1.2	4 J	0.2	2.44

NOTES:
The method detection limit was used as the reporting limit.
J - Estimated concentration
mg/L - milligram per liter
ND - Not detected at the indicated laboratory reporting limit or the method detection limit.

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TABLE 2-3. DISSOLVED PHASE NATURAL ATTENUATION ANALYTICAL RESULTS SUMMARY
FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

Location ID	Date Sampled	Manganese, Dissolved (mg/L)	Iron, Total (mg/L)	Nitrogen, Nitrate (mg/L)	Nitrogen, Nitrite (mg/L)	Sulfate (mg/L)	Total Organic Carbon (mg/L)
L-1RR	5/03/10	0.165	12.9	ND(0.04)	ND(0.015)	ND(1.5)	7.4
MW-18R	5/10/10	0.154	15.7	ND(0.04)	0.025 J	ND(1.5)	9.8
MW-20S	5/11/10	0.205	20	ND(0.04)	ND(0.015)	ND(1.5)	10.3
MW-33	5/10/10	0.769	3.37	ND(0.04)	ND(0.015)	27.2	2.6
MW-35	5/04/10	0.937	0.292	ND(0.04)	ND(0.015)	19.2	1.9
MW-37	5/05/10	ND(0.00084)	ND(0.0522)	0.32	ND(0.015)	47.8	1.6
MW-38	5/10/10	0.494	6.63	ND(0.04)	ND(0.015)	5.1	2.5
MW-51	5/06/10	0.224	ND(0.0522)	0.66	ND(0.015)	47.1	1.9
MW-81S	5/06/10	0.244	9.18	ND(0.04)	ND(0.015)	2.4 J	5.3
MW-85S	5/11/10	1.39	38.3	ND(0.04)	ND(0.015)	ND(1.5)	13
MW-96S	5/10/10	0.379	21.7	ND(0.04)	0.03 J	ND(1.5)	30.9
MW-100S	5/04/10	0.001 J	0.118 J	6.1	ND(0.015)	58.2	1.4
MW-112	5/04/10	0.284	17.8	ND(0.04)	0.017 J	ND(1.5)	6.2
MW-114	5/05/10	0.0014 J	ND(0.0522)	7.5	ND(0.015)	51.1	1.4
MW-115S	5/05/10	1.65	6.98	ND(0.04)	ND(0.015)	2.2 J	2.7
MW-131	5/06/10	2.41	5.18	ND(0.04)	ND(0.015)	22.8	2.6

NOTES:
The method detection limit was u
J - Estimated concentration
mg/L - milligram per liter
ND - Not detected at the indicate

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TABLE 2-4. LYSIMETER ANALYTICAL RESULTS SUMMARY
FIRST 2010 SEMIANNUAL MONITORING PERIOD
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 (mg/L)
L-21S	6.0	67	ND(0.25)	ND(1.5)	1.02	ND(0.0522)	0.148	0.145	2.2
L-18S	2.0	45	ND(0.25)	ND(1.5)	2.38	ND(0.0522)	0.256	0.259	2.7
L-20S	2.0	86	ND(0.25)	59.6	1.15	ND(0.0522)	1.99	1.92	0.011 J
L-93S	6.0	101	14.6	45.5	0.0813 J	ND(0.0522)	0.0036 J	0.0014 J	ND(0.005)

NOTES:
[1] Dissolved oxygen and ORP measured using field titration methodology
J - estimated concentration
mg/L - milligrams per liter
ND(0.25) - non-detect at the laboratory reporting limit
ORP - Oxidation-reduction potential

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TABLE 2-5A. BARRIER WALL PERFORMANCE MONITORING CONSTITUENTS OF CONCERN ANALYTICAL RESULTS SUMMARY
FIRST 2010 SEMIANNUAL MONITORING PERIOD
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	3/08/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	5/20/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-135I	3/08/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	5/20/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-135S	3/08/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-135S Dup	3/08/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-135S	5/20/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BMW-1D	3/08/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	5/24/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BMW-1I	3/09/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	5/24/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BMW-1S	3/09/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	5/24/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BSW-1D	3/23/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	5/24/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BSW-1S	3/23/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	5/24/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-136D	3/11/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	5/17/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-136I	3/11/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	5/17/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-136S	3/11/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	0.0125 J	ND(0.0069)
MW-136S Dup	3/11/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	0.0126 J	ND(0.0069)
MW-136S	5/17/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	0.0145 J	ND(0.0069)
MW-136S Dup	5/17/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	0.0144 J	ND(0.0069)
BMW-2D	3/09/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	5/25/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BMW-2I	3/09/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	5/18/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BMW-2S	3/09/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	5/18/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)

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TABLE 2-5A. BARRIER WALL PERFORMANCE MONITORING CONSTITUENTS OF CONCERN ANALYTICAL RESULTS SUMMARY
FIRST 2010 SEMIANNUAL MONITORING PERIOD
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)
BSW-2D	3/23/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BSW-2D Dup	3/23/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BSW-2D	5/19/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BSW-2S	3/23/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	5/19/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BSW-2S Dup	5/19/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-137D	3/19/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	5/18/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-137I	3/19/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	5/25/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-137S	3/19/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-137S Dup	3/19/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
MW-137S	5/25/10	ND(0.0005)	ND(0.0008)	0.002 J	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BMW-3D	3/10/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BMW-3D Dup	3/10/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BMW-3D	5/17/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BMW-3I	3/10/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	5/17/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BMW-3S	3/10/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	5/18/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BMW-3S Dup	5/18/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
BSW-3D	3/24/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	5/25/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	0.001 J	ND(0.0008)	ND(0.0072)	ND(0.0069)
BSW-3S	3/24/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	5/25/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)

NOTES:
The method detection limit was used as the reporting limit.
Dup - Duplicate sample
J - Estimated concentration
mg/L - milligram per liter
ND - Not detected at the indicated laboratory reporting limit or the method detection limit.

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TABLE 2-5B. BARRIER WALL PERFORMANCE MONITORING NATURAL ATTENUATION ANALYTICAL RESULTS SUMMARY
FIRST 2010 SEMIANNUAL MONITORING PERIOD
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)	Chloride (mg/L)	Iron, Ferric (mg/L)	Iron, Ferrous (mg/L)	Nitrogen, Ammonia (mg/L)	Methane (mg/L)	Magnesium, Total (mg/L)	Manganese, Total (mg/L)
MW-136D	5/17/10	228	ND(0.46)	70.3	72.2	ND(0.052)	ND(0.01)	ND(0.2)	ND(0.005)	28.7	0.364
MW-136I	5/17/10	328	ND(0.46)	83.5	60.4	ND(0.052)	0.039 J	ND(0.2)	0.66	33.5	0.486
MW-136S	5/17/10	547	ND(0.46)	131	37.3	ND(1)	25.9 J	5	10	54.7	3.81
BMW-2D	5/25/10	238	ND(0.46)	70.6	67.6	ND(0.052)	0.033 J	ND(0.2)	0.04	28.7	0.245
BMW-2I	5/18/10	233	ND(0.46)	70	68.6	ND(0.052)	0.03 J	ND(0.2)	ND(0.005)	28.4	0.278
BMW-2S	5/18/10	235	ND(0.46)	68.1	66.2	ND(0.052)	0.018 J	ND(0.2)	ND(0.005)	27.7	0.343
BSW-2D	5/19/10	267	ND(0.46)	77.4	66.1	0.098 J	0.057 J	ND(0.2)	ND(0.005)	29.7	0.0992
MW-137D	5/18/10	242	ND(0.46)	80.3	62.1	ND(0.052)	0.037 J	ND(0.2)	ND(0.005)	22.7	0.424
MW-137I	5/25/10	247	ND(0.46)	80.4	62.9	ND(0.052)	0.056 J	ND(0.2)	0.21	22.2	0.831
MW-137S	5/25/10	482	ND(0.46)	143	50.1	0.13 J	2.4 J	ND(0.2)	0.33	43	1.46
BMW-3D	5/17/10	240	ND(0.46)	83.9	64.9	ND(0.052)	0.014 J	ND(0.2)	0.0065 J	24.1	0.391
BMW-3I	5/17/10	239	ND(0.46)	85.7	63.5	0.26	0.029 J	ND(0.2)	0.0051 J	24.9	0.485
BMW-3S	5/18/10	245	ND(0.46)	82.6	59.2	0.1 J	0.073 J	ND(0.2)	0.097	22.3	0.594
BSW-3D	5/25/10	217	ND(0.46)	69.3	46.9	0.14 J	0.055 J	ND(0.2)	0.048	23.4	0.206

NOTES:
The method detection limit was used as the reporting limit.
J - Estimated concentration
mg/L - milligram per liter
ND - Not detected at the indicated laboratory reporting limit or the method detection limit.

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TABLE 2-5B. BARRIER WALL PERFORMANCE MONITORING NATURAL ATTENUATION ANALYTICAL RESULTS SUMMARY
FIRST 2010 SEMIANNUAL MONITORING PERIOD
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)	Sulfate (mg/L)	Total Sulfide (mg/L)	Total Organic Carbon (mg/L)
MW-136D	5/17/10	ND(0.0522)	ND(0.5)	0.46	ND(0.015)	4.12	42	50.1	ND(0.054)	2.3
MW-136I	5/17/10	ND(0.0522)	ND(0.5)	ND(0.04)	ND(0.015)	4.19	38.9	14.9	ND(0.054)	2.7
MW-136S	5/17/10	24.1	5.4	ND(0.04)	ND(0.015)	7.11	24.1	14.5	ND(0.054)	8.3
BMW-2D	5/25/10	ND(0.0522)	ND(0.5)	0.38	ND(0.015)	4.1	40.7	49.8	ND(0.054)	1.7 J
BMW-2I	5/18/10	ND(0.0522)	ND(0.5)	0.62	0.015 J	4.14	41.3	48	ND(0.054)	1.5
BMW-2S	5/18/10	ND(0.0522)	ND(0.5)	0.35	0.016 J	3.96	40.9	47.8	ND(0.054)	1.8
BSW-2D	5/19/10	0.155 J	ND(0.5)	ND(0.04)	ND(0.015)	4.45	41.5	37.6	ND(0.054)	2
MW-137D	5/18/10	0.0616 J	0.57 J	0.087 J	0.02 J	3.73	36.6	42	ND(0.054)	1.4
MW-137I	5/25/10	0.106 J	ND(0.5)	ND(0.04)	ND(0.015)	3.69	36	34.3	ND(0.054)	1.6 J
MW-137S	5/25/10	2.51	0.64 J	ND(0.04)	ND(0.015)	5.23	29.1	39.8	ND(0.054)	5.5 J
BMW-3D	5/17/10	ND(0.0522)	ND(0.5)	0.098 J	ND(0.015)	3.78	37.8	41.2	ND(0.054)	1.6
BMW-3I	5/17/10	0.288	0.57 J	0.16	ND(0.015)	3.82	38.4	43.1	ND(0.054)	1.5
BMW-3S	5/18/10	0.174 J	ND(0.5)	0.14	0.046 J	3.48	36.6	40.1	ND(0.054)	1.8
BSW-3D	5/25/10	0.192 J	ND(0.5)	3.3	ND(0.015)	4.17	27.4	36.7	ND(0.054)	4.2 J

NOTES:
The method detection limit was
J - Estimated concentration
mg/L - milligram per liter
ND - Not detected at the indicat

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TABLE 3-1. DISTRIBUTION OF DISSOLVED PHASE CONSTITUENTS
FIRST 2010 SEMIANNUAL MONITORING PERIOD
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	0.073	5.8	No Data
Average BTEX Concentration	0.010	1.3	0.010
Average Benzene Concentration[4]	0.0025	0.31	0.0025
Average Nitrate Concentration	4.8	0.050	0.14
Average Sulfate Concentration	52.1	5.2	29.9
Average Ferrous Iron Concentration	0.035	15.5	2.0
Average Dissolved Manganese Concentration	0.038	0.57	1.1
Average Methane Concentration	0.008	12.6	0.073

NOTES:
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.
[1] - Wells Upgradient of Smear Zone include MW-51, MW-95S, MW-100S, MW-113, MW-114, and MW-129
[2] - Wells within Smear Zone include L-1RR, MW-10, MW-17, MW-18R, MW-20S, MW-21, MW-22, MW-26R, MW-33, MW-38, MW-48S, MW-52, MW-64, MW-80, MW-81S, MW-85S, MW-93S, MW-94S, MW-96S, MW-104S, MW-112, MW-115S, MW-124, MW-139, MW-141, and MW-142
[3] - Wells Downgradient of Smear Zone include MW-35, MW-37, MW-120, MW-131, MW-132, MW-133, MW-134, and MW-138
[4] - All up-gradient and down-gradient wells were non-detect for benzene. Concentration (0.0025 mg/L) represents one half the detection limit.

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TABLE 4-1. SOIL VAPOR FIELD SCREENING RESULTS FOR GULF PARK
FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

Location ID	Oxygen (System Active) (%)	Oxygen (System Inactive) (%)	Carbon Dioxide (System Active) (%)	Carbon Dioxide (System Inactive) (%)	Methane (System Active) (%)	Methane (System Inactive) (%)	Total Organic Vapor (System Active) (%)	Total Organic Vapor (System Inactive) (ppm)
VP1-25S	20.8	20.7	0.0	0.0	0.0	0.0	0.0	0.0
VP1-50S	21.0	20.9	0.0	0.0	0.0	0.0	0.0	0.0
VP2-25S	21.1	19.2	0.0	0.1	0.0	0.0	0.0	3.0
VP2-50S	20.8	16.3	0.0	0.5	0.0	0.0	0.0	2.8
VP3-35S	21.2	20.9	0.0	0.0	0.0	0.0	0.0	0.0
VP4-25S	20.8	20.7	0.0	0.1	0.0	0.0	0.0	0.0
VP6-35S	20.8	18.4	0.0	0.2	0.0	0.0	0.0	0.1

NOTES:
% - percent
ppmv - parts per million by volume
Fixed gas monitoring could not be performed in vapor probes VP1-25D, VP1-50D, VP3-35D, VP4-25D, and VP7-25S due to immersion below the water table.

TABLE 4-2. GROUNDWATER QUALITY ANALYTICAL RESULTS FOR GULF PARK
FIRST 2010 SEMIANNUAL MONITORING PERIOD
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)
		6/08/10	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)
		6/08/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)
	Dup	6/08/10	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)
		6/09/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0098)	ND(0.0069)
	Dup	6/09/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0098)	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)
		6/08/10	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)
		6/10/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0098)	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)
		6/10/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0098)	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)
		6/08/10	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)
		6/08/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)

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TABLE 4-2. GROUNDWATER QUALITY ANALYTICAL RESULTS FOR GULF PARK
FIRST 2010 SEMIANNUAL MONITORING PERIOD
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)
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)
	6/10/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0098)	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	1.0	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	0.045	1.6	ND(0.0008)	0.0118	ND(0.0069)
	6/23/09	0.027	0.40	0.015	0.32	ND(0.0008)	ND(0.0072)	ND(0.0069)
	6/10/10	0.023	0.44	0.015	0.41	ND(0.0008)	ND(0.0098)	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(0.0008)	0.0129 J	ND(0.0069)
Dup	6/24/09	--	--	--	--	--	0.0127 J	ND(0.0069)
	6/08/10	0.002 J	0.043	0.01	0.33	ND(0.0008)	0.008 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)
	6/08/10	ND(0.0005)	ND(0.0008)	ND(0.0007)	ND(0.0008)	ND(0.0008)	ND(0.0072)	ND(0.0069)

NOTES:
The method detection limit was used as the reporting limit.
-- - Not analyzed
Dup - Duplicate sample
J - Estimated concentration
mg/L - milligram per liter
ND - Not detected at the indicated laboratory reporting limit or the method detection limit.

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TABLE 4-3. DISSOLVED PHASE MONITORED NATURAL ATTENUATION ANALYTICAL SUMMARY FOR GULF PARK
FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

Location ID	Date Sampled	Chemical Oxygen (mg/L)	Methane (mg/L)	Nitrogen (mg/L)	Nitrogen, Ammonia (mg/L)	Nitrogen, Nitrate (mg/L)	Nitrogen, Nitrite (mg/L)	Sulfate (mg/L)
GPW-1I	12/14/06	ND(2.6)	0.03	ND(0.5)	ND(0.2)	1.1	ND(0.015)	49
	12/18/07	ND(12.8)	0.0028	ND(0.5)	ND(0.2)	1.1	ND(0.015)	45.9
GPW-1S	12/14/06	9.8	0.25	ND(0.5)	0.32 J	ND(0.04)	ND(0.015)	32.1
	6/25/09	ND(12.8)	0.24	ND(0.5)	0.72	ND(0.04)	ND(0.015)	10 J
	6/08/10	--	0.3	--	ND(0.4)	ND(0.04)	ND(0.015)	4.6 J
GPW-2I	12/18/06	16.8	0.0049 J	ND(0.5) J	ND(0.2)	5.4	ND(0.015)	48.2
	12/19/07	16.2	ND(0.002)	ND(0.5)	ND(0.2)	4.4	ND(0.015)	46.8
GPW-2S	12/18/06	3.2 J	0.0027 J	ND(0.5) J	ND(0.2)	1.9	ND(0.015)	45.1
	12/19/07	ND(12.8)	ND(0.002)	ND(0.5)	ND(0.2)	5.2	ND(0.015)	53.6
	6/23/09	15.3 J	0.078	ND(0.5)	ND(0.2)	1.4	ND(0.015)	33.8 J
	6/08/10	--	0.26	--	ND(0.2)	0.9	ND(0.015)	34.1
GPW-3I	12/13/06	3.1 J	0.024	ND(0.5)	ND(0.2)	2.4	ND(0.015)	43.9
	12/20/07	ND(12.8)	ND(0.002)	ND(0.5)	ND(0.2)	2.2	ND(0.015)	44
GPW-3S	12/13/06	3.5 J	0.045	ND(0.5)	ND(0.2)	7.1	ND(0.015)	37.4
	12/20/07	46.3	0.05	ND(0.5)	ND(0.2)	1	ND(0.015)	51.4
	6/25/09	ND(12.8)	0.035	ND(0.5)	ND(0.2)	0.66	ND(0.015)	30.1 J
	6/10/10	--	0.021	--	ND(0.4)	0.24	ND(0.015)	28.6
GPW-4S	12/14/06	5.1 J	1.5	ND(0.5)	ND(0.2)	2	ND(0.015)	30.4
	12/19/07	ND(12.8)	0.76	ND(0.5)	ND(0.2)	3.4	0.021	37
	6/24/09	15.3 J	2.5	ND(0.5)	0.27 J	0.078 J	ND(0.015)	9.4
	6/08/10	--	0.39	--	0.3 J	ND(0.04)	ND(0.015)	15.8
GPW-5S	12/12/06	2.8 J	0.0043 J	ND(0.5) J	ND(0.2)	0.58	ND(0.015)	52.1 J
	12/21/07	ND(12.8)	ND(0.002)	ND(0.5) J	ND(0.2)	4.2	ND(0.015)	92.3
	6/24/09	19.9 J	0.011 J	ND(0.5)	0.21 J	0.44	ND(0.015)	29.7
	6/08/10	--	0.0079 J	--	ND(0.2)	0.041 J	ND(0.015)	32.5
TH-1I	12/15/06	4.4 J	ND(0.002)	ND(0.5)	ND(0.2) J	4	ND(0.015)	50.4
	12/20/07	ND(12.8)	ND(0.002)	ND(0.5)	ND(0.2)	4.3	ND(0.015)	49.2
TH-1S	12/15/06	18.8	0.43	0.76 J	0.46 J	ND(0.04)	ND(0.015)	34.6
	12/20/07	25.5	0.55	ND(0.5)	ND(0.2)	ND(0.04)	ND(0.015)	241
	6/23/09	40.8 J	0.54	0.76 J	ND(0.2)	ND(0.04)	0.052	13.5 J
	6/10/10	--	1.2	--	0.78 J	ND(0.04)	ND(0.015)	17.2
TH-2	12/12/06	24	13	ND(0.5) J	ND(0.2)	ND(0.04)	ND(0.015)	13.1 J
	12/18/07	39.4	6.5	1.2	ND(0.2)	7	0.097	299
	6/24/09	38.4 J	7.7	0.79 J	0.72	ND(0.04)	ND(0.015)	80.4
	6/08/10	--	7.1	--	0.34 J	ND(0.04)	ND(0.015)	ND(1.5)
TH-3	12/12/06	5.9 J	0.0063	ND(0.5) J	ND(0.2)	2.1	0.018 J	153 J
	12/21/07	ND(12.8)	ND(0.002)	ND(0.5) J	ND(0.2)	1.4	ND(0.015)	35.7
	6/23/09	15.3 J	ND(0.005)	ND(0.5)	ND(0.2)	2.8	ND(0.015)	34.2 J
	6/08/10	--	ND(0.005)	--	ND(0.2)	1.7	ND(0.015)	34.3

NOTES:

The method detection limit was used as the reporting limit.

-- - Not analyzed

Dup - Duplicate sample

J - Estimated concentration

mg/L - milligram per liter

ND - Not detected at the indicated laboratory reporting limit or the method detection limit.

US EPA ARCHIVE DOCUMENT

TABLE 4-3. DISSOLVED PHASE MONITORED NATURAL ATTENUATION ANALYTICAL SUMMARY FOR GULF PARK
FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

Location ID	Date Sampled	Total Sulfide (mg/L)	Total Organic (mg/L)	Iron, Total (mg/L)	Iron, Ferrous (mg/L)	Iron, Ferric Total (mg/L)	Manganese, Dissolved (mg/L)	Manganese, Total (mg/L)
GPW-1I	12/14/06	ND(0.054)	ND(1)	0.122 J	0.06 J	0.063 J	--	0.0068
	12/18/07	ND(0.054)	ND(1)	0.195	0.15	ND(0.052)	0.0076	0.0115
GPW-1S	12/14/06	ND(0.054)	2.9	4.04	4.1	ND(0.16)	--	0.675
	6/25/09	--	2.4	1.34	1.2 J	0.13 J	0.526	0.533
	6/08/10	ND(0.054)	2.7	2.31	2.2 J	0.11 J	0.609	0.612
GPW-2I	12/18/06	ND(0.054)	1.2 J	ND(0.0522)	ND(0.008)	ND(0.052)	--	0.0011 J
	12/19/07	ND(0.054)	ND(1)	ND(0.0522)	0.065	ND(0.052)	0.0033	0.0042
GPW-2S	12/18/06	ND(0.054)	1.3 J	0.202	0.031 J	0.17 J	--	0.931
	12/19/07	ND(0.054)	1.5	ND(0.0522)	ND(0.008)	ND(0.052)	0.0117	0.0305
	6/23/09	--	4.1	0.0526 J	0.026 J	ND(0.052)	0.507	0.558
	6/08/10	ND(0.054)	1.2	0.591	0.056 J	0.53	0.551	0.838
GPW-3I	12/13/06	ND(0.054)	ND(1)	ND(0.0522)	0.018 J	ND(0.052)	--	0.0013 J
	12/20/07	ND(0.054)	ND(1)	ND(0.0522)	ND(0.008)	ND(0.052)	ND(0.00084)	ND(0.00084)
GPW-3S	12/13/06	ND(0.054)	1.2 J	ND(0.0522)	0.076 J	ND(0.052)	--	0.364
	12/20/07	ND(0.054)	1.5	ND(0.0522)	ND(0.008)	ND(0.052)	0.199	0.264
	6/25/09	--	1	0.355	0.3 J	0.053 J	0.487	0.494
	6/10/10	ND(0.054)	1	0.225	0.2 J	ND(0.052)	0.363	0.37
GPW-4S	12/14/06	ND(0.054)	1.6 J	0.574	0.57	ND(0.052)	--	0.387
	12/19/07	ND(0.054)	1	0.0905	0.12	ND(0.052)	0.0951	0.105
	6/24/09	--	1.3	0.8	0.78 J	ND(0.052)	0.53	0.544
	6/08/10	ND(0.054)	1.3	3.47	3.6 J	ND(0.2)	0.747	0.754
GPW-5S	12/12/06	0.14 J	1.3 J	--	0.11	--	--	--
	12/21/07	ND(0.054)	ND(1)	ND(0.0522)	ND(0.008)	ND(0.052)	ND(0.00084)	ND(0.00084)
	6/24/09	--	1	0.171 J	0.15 J	ND(0.052)	0.448	0.466
	6/08/10	0.077 J	1.1	0.188 J	0.21 J	ND(0.052)	0.753	0.759
TH-1I	12/15/06	ND(0.054)	1 J	ND(0.0522)	ND(0.008)	ND(0.052)	--	ND(0.00036)
	12/20/07	ND(0.054)	ND(1)	ND(0.0522)	0.0095	ND(0.052)	ND(0.00084)	ND(0.00084)
TH-1S	12/15/06	0.083 J	4.7	11.3	11.5	ND(0.4)	--	0.628
	12/20/07	0.16	3.8	6.35	6.4	ND(0.2)	1.22	1.26
	6/23/09	--	3.6	21.1	21.9 J	ND(1)	0.545	0.565
	6/10/10	0.12 J	2.9	24.2	23.2 J	1 J	0.549	0.558
TH-2	12/12/06	ND(0.054)	4.5	9.13	9.3	ND(0.2)	--	0.325
	12/18/07	ND(0.054)	11.7	0.318	0.2	0.12	1.16	1.23
	6/24/09	--	6.2	5.46	5.5 J	ND(0.25)	0.828	0.854
	6/08/10	0.066 J	2.5	3.74	3.7 J	ND(0.2)	0.257	0.262
TH-3	12/12/06	ND(0.054)	2.5	0.153 J	0.021 J	0.13 J	--	0.0048 J
	12/21/07	ND(0.054)	1.3	0.0684	0.019	ND(0.052)	0.0068	0.0219
	6/23/09	--	1.4	0.502	0.075 J	0.43	0.0043 J	0.0082
	6/08/10	ND(0.054)	1.1	0.0616 J	0.064 J	ND(0.01)	0.0047 J	0.008

NOTES:

The method detection limit was used as the reporting limit.

-- - Not analyzed

Dup - Duplicate sample

J - Estimated concentration

mg/L - milligram per liter

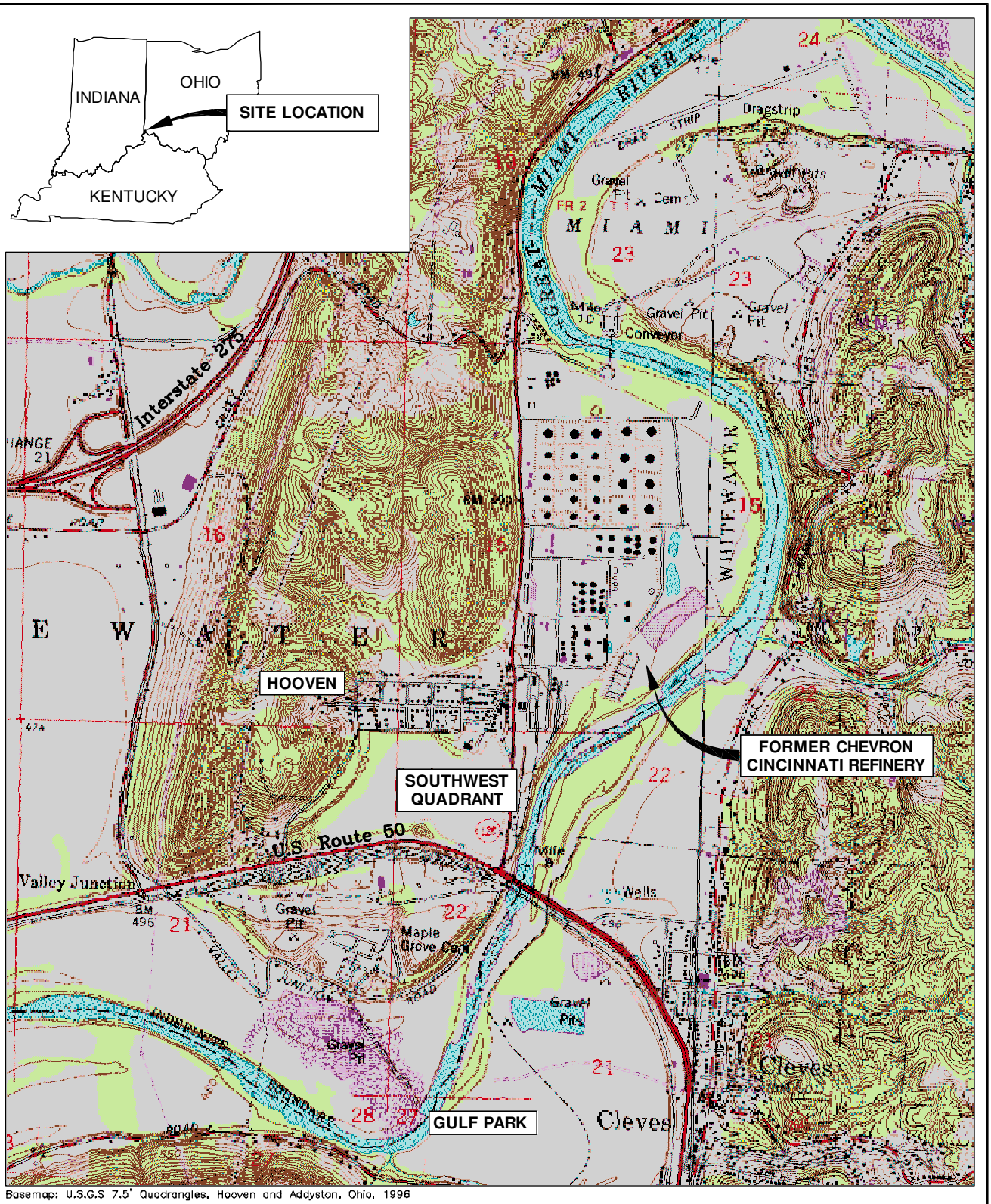
ND - Not detected at the indicated laboratory reporting limit or the method detection limit.

US EPA ARCHIVE DOCUMENT

US EPA ARCHIVE DOCUMENT

FIGURES

US EPA ARCHIVE DOCUMENT



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

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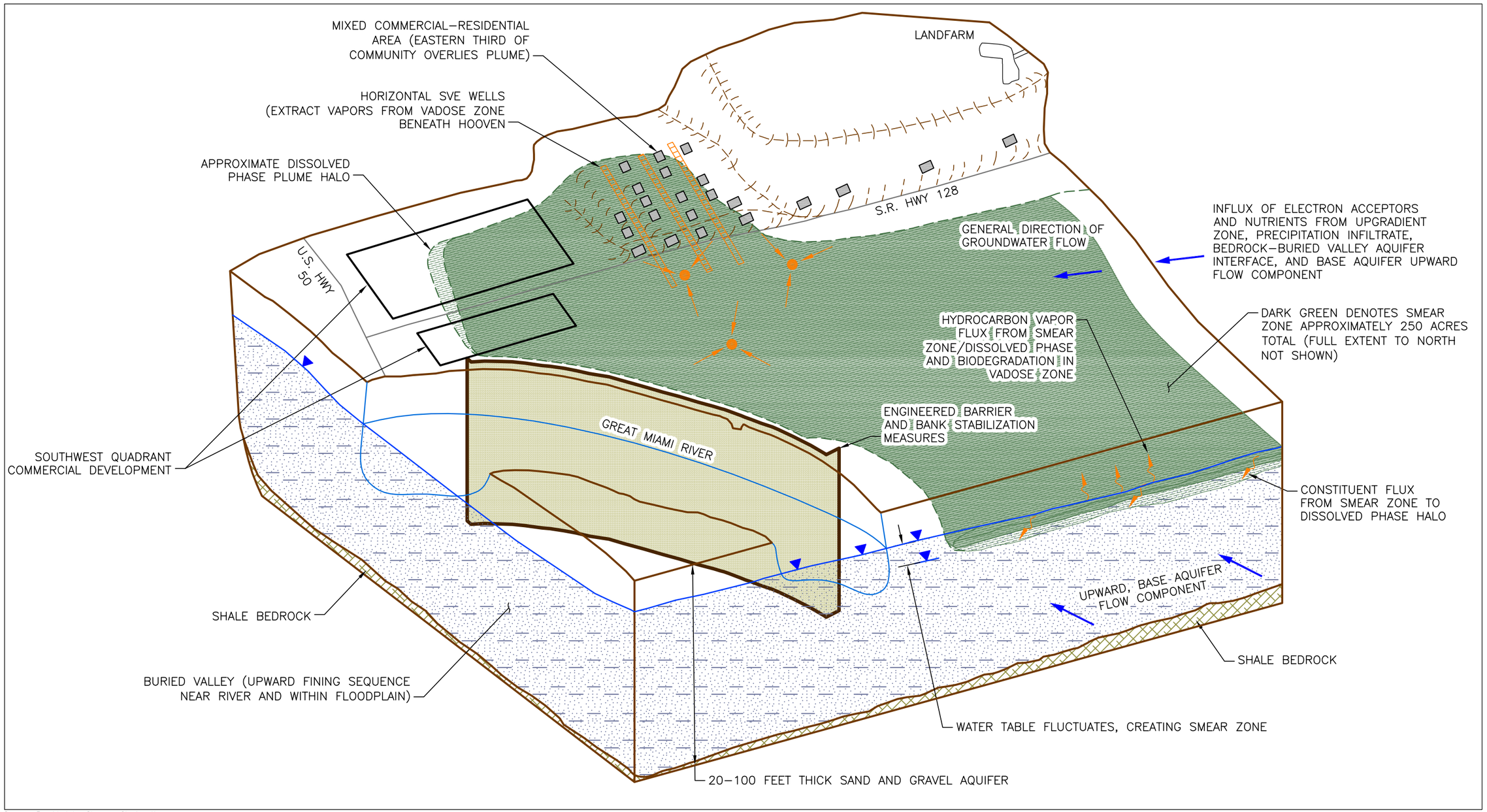
FIGURE 1-1

SITE LOCATION MAP

FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY
HOOVEN, OHIO

Drawn By: REP	Checked By: JP	Scale: 1" = 2,000'	Date:1/13/2011	File: 500USGSSITE201011

US EPA ARCHIVE DOCUMENT



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

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FIGURE 1-2

GROUNDWATER CONCEPTUAL SITE MODEL

FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY
HOOVEN, OHIO

Drawn By: REP	Checked By: JP	Scale: NONE	Date: 11/19/2010	File: 500GWCONCMODEL-201011

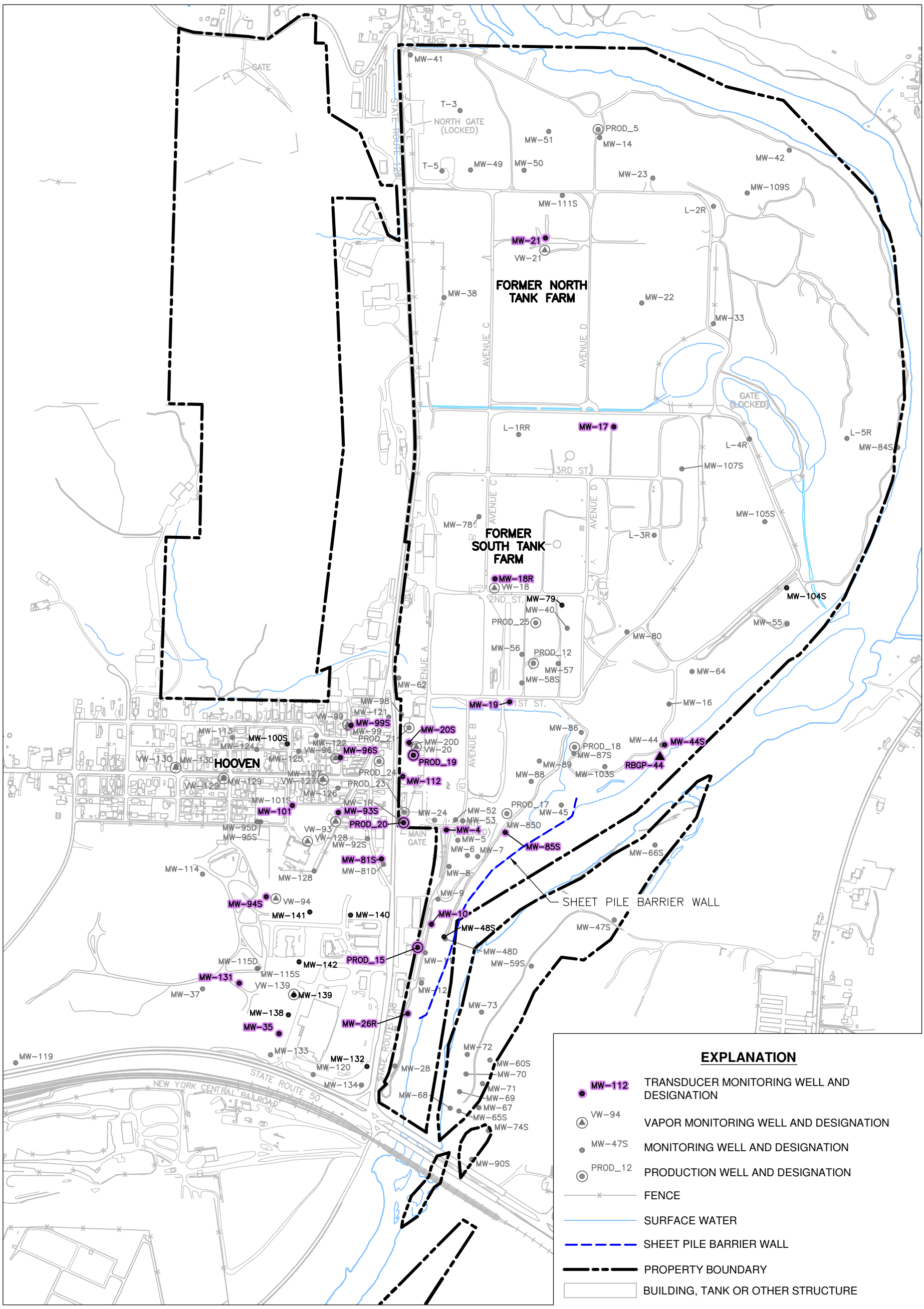

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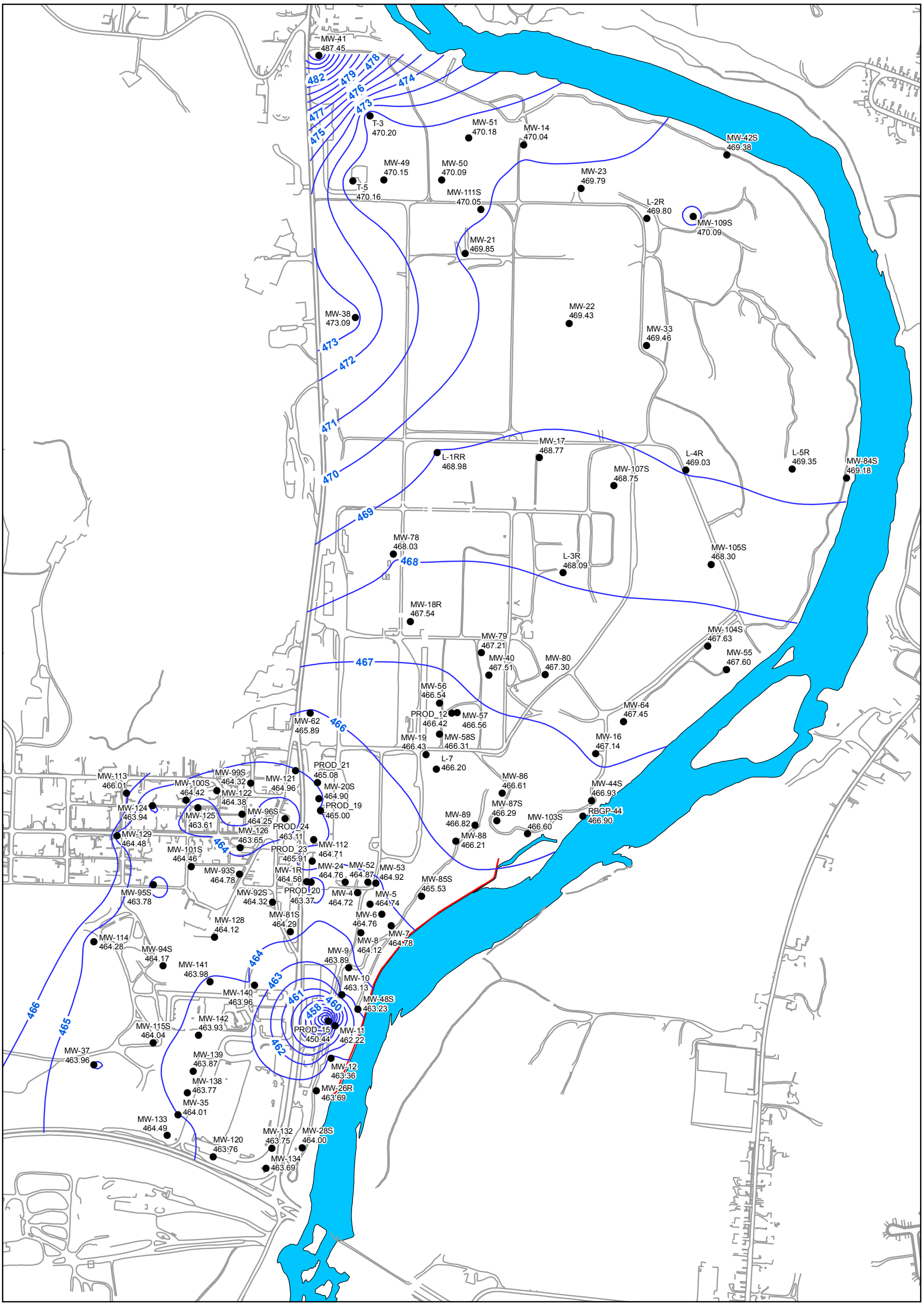
FIGURE 2-1

TRANSDUCER MONITORING WELLS

FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY
HOOVEN, OHIO

Drawn By: REP	Checked By: JP	Scale: 1" = 650'	Date: 11/19/2010	File: 500TRANMONWELLS201011

US EPA ARCHIVE DOCUMENT



EXPLANATION

EQUIPOTENTIAL CONTOUR LINE
Elevation In Feet Above Mean Sea Level
Contour Interval is 1.0 feet
(Line dashed where approximate)

NOTE: RBGP-44 (RIVER ELEVATION) WAS NOT USED FOR CONTOURING.

N

0 600'

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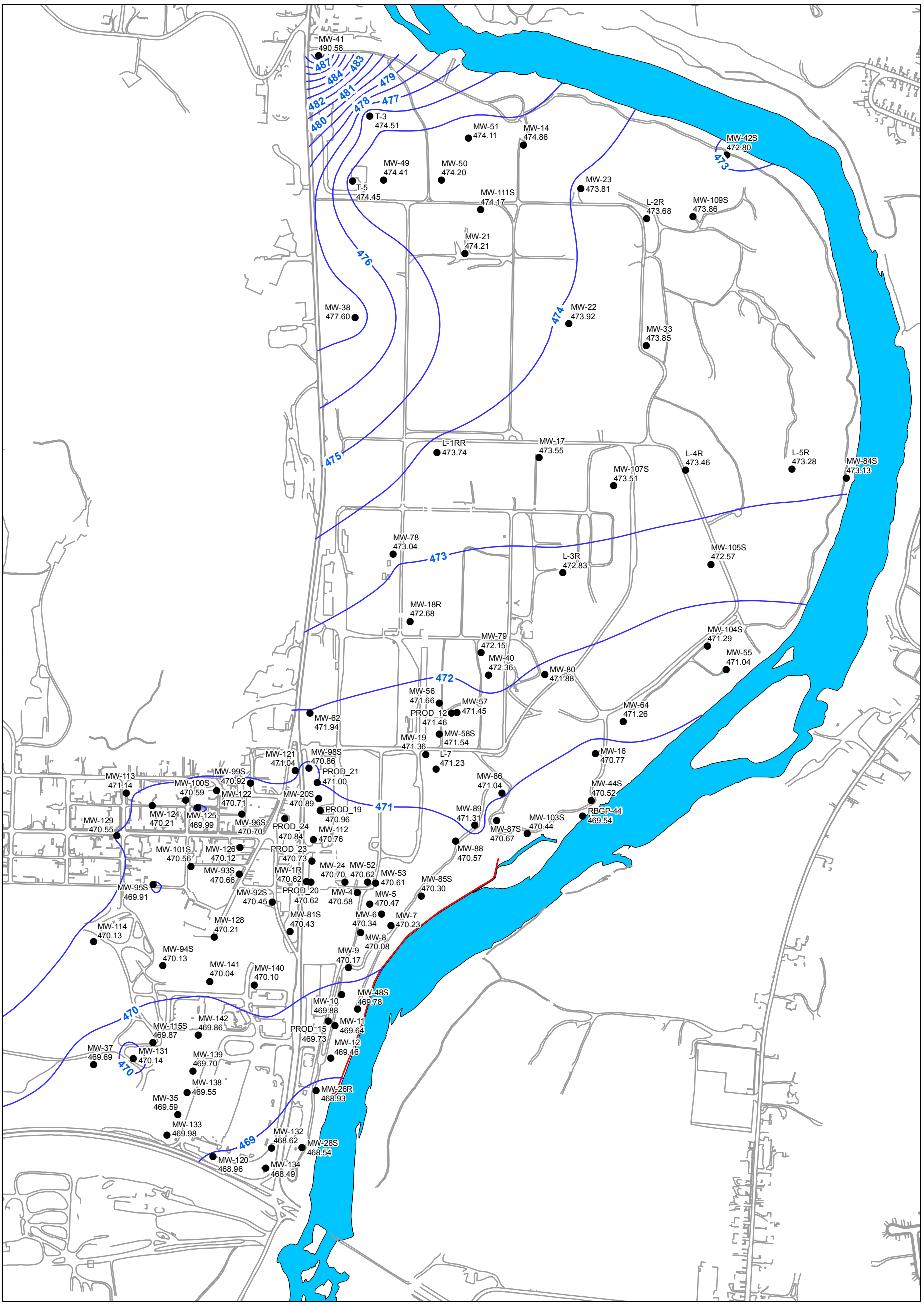
FIGURE 2-2

POTENTIOMETRIC SURFACE MAP
JANUARY 14, 2010

FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY
HOOVEN, OHIO

Drawn By: BR	Checked By: PM	Scale: 1" = 600'	Date: 11/1/10	File: Jan_14_2010_Potsurface.mxd

US EPA ARCHIVE DOCUMENT



EXPLANATION

EQUIPOTENTIAL CONTOUR LINE
Elevation In Feet Above Mean Sea Level
Contour Interval is 1.0 feet
(Line dashed where approximate)

NOTE: RBGP-44 (RIVER ELEVATION) WAS NOT USED FOR CONTOURING.

N

0 600'

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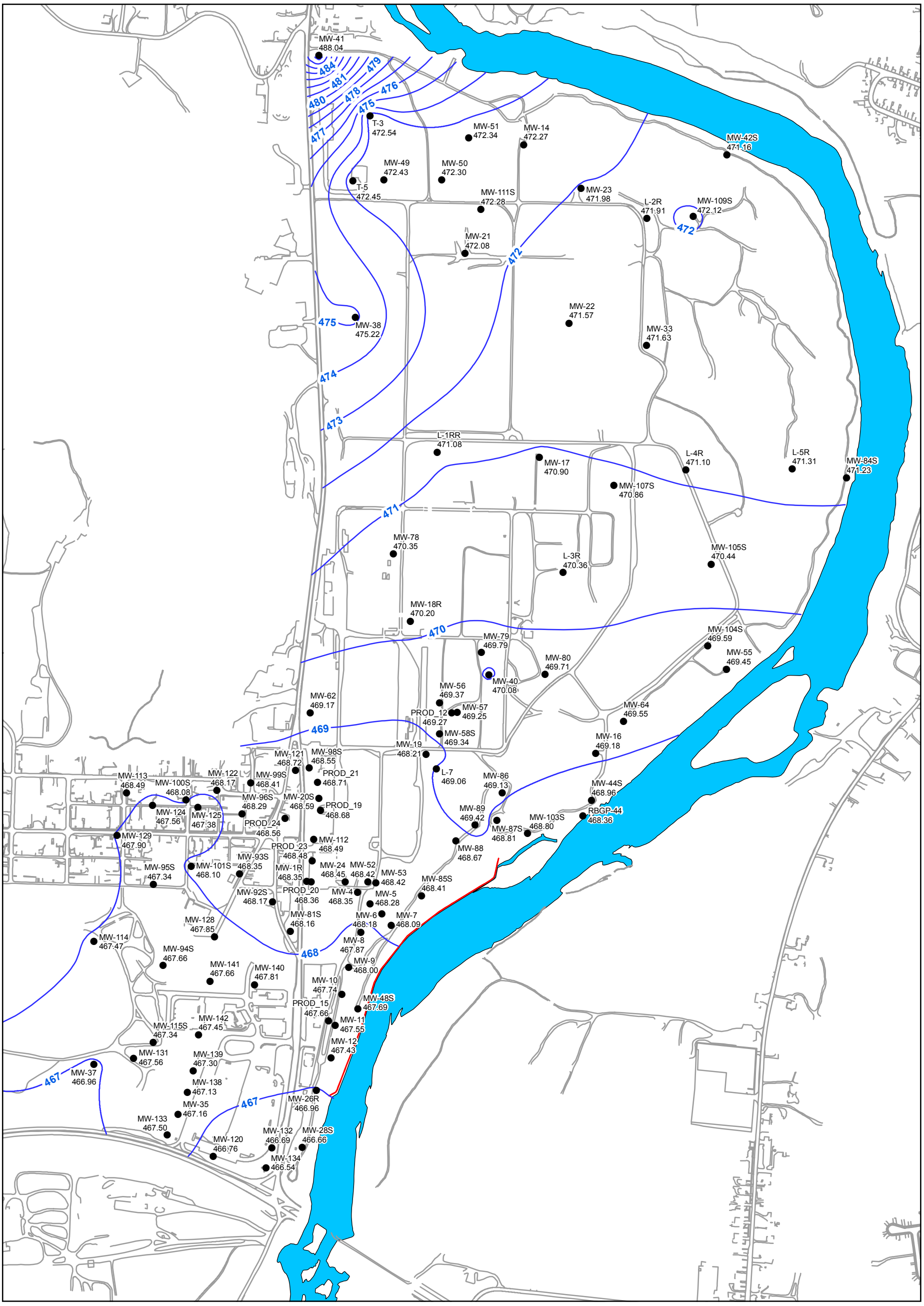
FIGURE 2-3

POTENTIOMETRIC SURFACE MAP
MARCH 25, 2010

FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY
HOOVEN, OHIO

Drawn By: BR	Checked By: PM	Scale: 1" = 600'	Date: 11/1/10	File: March_25_2010_Potsurface.mxd

US EPA ARCHIVE DOCUMENT



EXPLANATION

EQUIPOTENTIAL CONTOUR LINE
Elevation In Feet Above Mean Sea Level
Contour Interval is 1.0 feet
(Line dashed where approximate)

NOTE: RBGP-44 (RIVER ELEVATION) WAS NOT USED FOR CONTOURING.

N

0 600'

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FIGURE 2-4

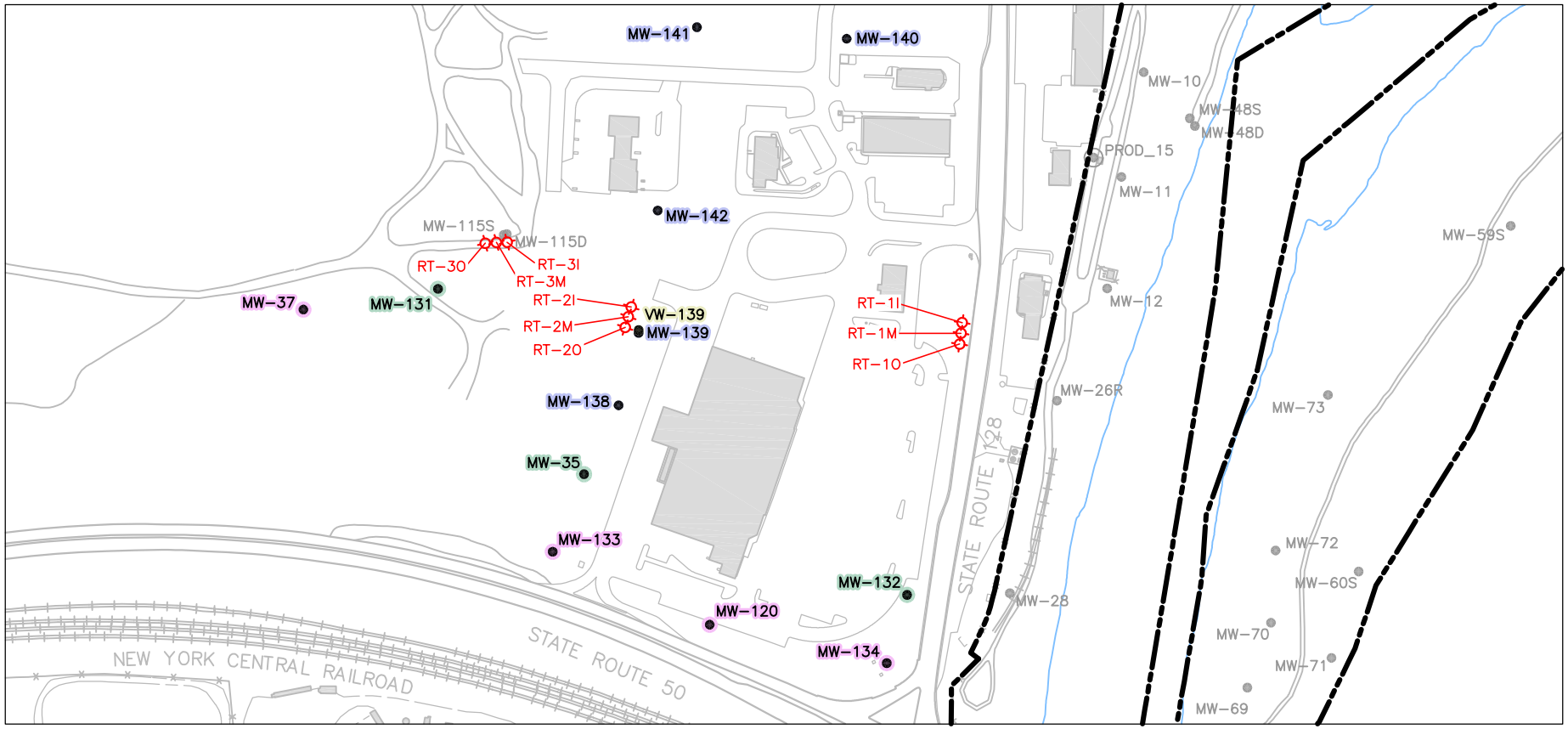
POTENTIOMETRIC SURFACE MAP
MAY 26, 2010

FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY
HOOVEN, OHIO

Drawn By: BR	Checked By: PM	Scale: 1" = 600'	Date: 11/1/10	File: May_26_2010_Potsurface.mxd

US EPA ARCHIVE DOCUMENT

US EPA ARCHIVE DOCUMENT



EXPLANATION

RT-2O, RT-2M, RT-2I — PERMANENT ROST TRANSECT AND DESIGNATION (I-INNER, M-MIDDLE, O-OUTER)

MW-138 — MONITORING WELL AND DESIGNATION (INSTALLED MARCH 2009)

MW-35 — SENTINEL MONITORING WELL AND DESIGNATION

MW-37 — POINT OF COMPLIANCE MONITORING WELL AND DESIGNATION

VW-139 — NESTED VAPOR WELL AND DESIGNATION

MW-47S — MONITORING WELL AND DESIGNATION

PROD_12 — PRODUCTION WELL AND DESIGNATION

SURFACE WATER

PROPERTY BOUNDARY

BUILDING, TANK OR OTHER STRUCTURE

N

0 300'

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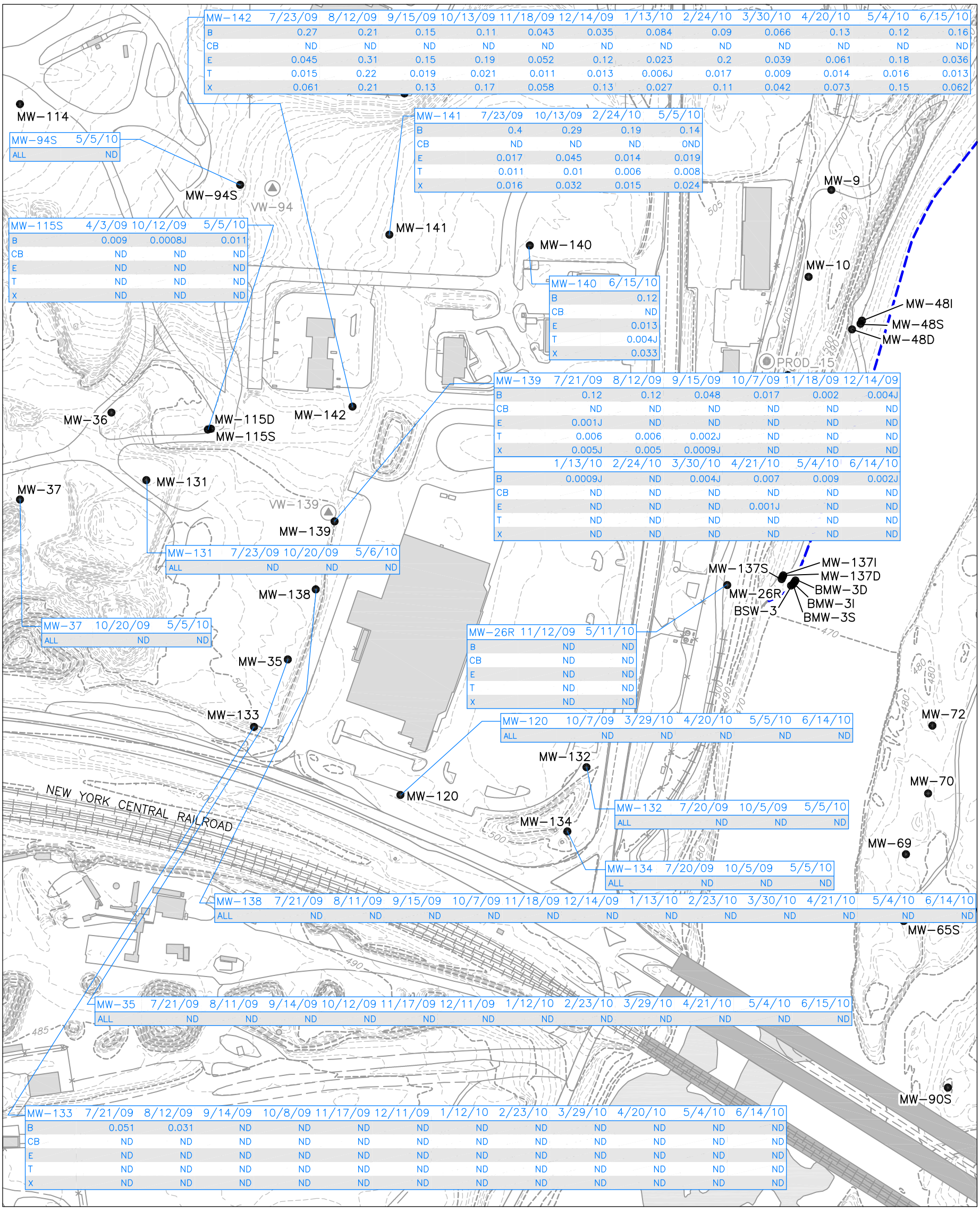
FIGURE 2-5

SENTINEL, POINT OF COMPLIANCE, AND ROST MONITORING NETWORK

FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY
HOOVEN, OHIO

Drawn By: REP	Checked By: JP	Scale: 1"=300'	Date: 11/19/2010	File: 500ROST-TRANSECTS201011



MW-142	7/23/09	8/12/09	9/15/09	10/13/09	11/18/09	12/14/09	1/13/10	2/24/10	3/30/10	4/20/10	5/4/10	6/15/10
B	0.27	0.21	0.15	0.11	0.043	0.035	0.084	0.09	0.066	0.13	0.12	0.16
CB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
E	0.045	0.31	0.15	0.19	0.052	0.12	0.023	0.2	0.039	0.061	0.18	0.036
T	0.015	0.22	0.019	0.021	0.011	0.013	0.006J	0.017	0.009	0.014	0.016	0.013
X	0.061	0.21	0.13	0.17	0.058	0.13	0.027	0.11	0.042	0.073	0.15	0.062

MW-94S	5/5/10
ALL	ND

MW-141	7/23/09	10/13/09	2/24/10	5/5/10
B	0.4	0.29	0.19	0.14
CB	ND	ND	ND	0ND
E	0.017	0.045	0.014	0.019
T	0.011	0.01	0.006	0.008
X	0.016	0.032	0.015	0.024

MW-115S	4/3/09	10/12/09	5/5/10
B	0.009	0.0008J	0.011
CB	ND	ND	ND
E	ND	ND	ND
T	ND	ND	ND
X	ND	ND	ND

MW-140	6/15/10
B	0.12
CB	ND
E	0.013
T	0.004J
X	0.033

MW-139	7/21/09	8/12/09	9/15/09	10/7/09	11/18/09	12/14/09
B	0.12	0.12	0.048	0.017	0.002	0.004J
CB	ND	ND	ND	ND	ND	ND
E	0.001J	ND	ND	ND	ND	ND
T	0.006	0.006	0.002J	ND	ND	ND
X	0.005J	0.005	0.0009J	ND	ND	ND

	1/13/10	2/24/10	3/30/10	4/21/10	5/4/10	6/14/10
B	0.0009J	ND	0.004J	0.007	0.009	0.002J
CB	ND	ND	ND	ND	ND	ND
E	ND	ND	ND	0.001J	ND	ND
T	ND	ND	ND	ND	ND	ND
X	ND	ND	ND	ND	ND	ND

MW-131	7/23/09	10/20/09	5/6/10
ALL	ND	ND	ND

MW-37	10/20/09	5/5/10
ALL	ND	ND

MW-26R	11/12/09	5/11/10
B	ND	ND
CB	ND	ND
E	ND	ND
T	ND	ND
X	ND	ND

MW-120	10/7/09	3/29/10	4/20/10	5/5/10	6/14/10
ALL	ND	ND	ND	ND	ND

MW-132	7/20/09	10/5/09	5/5/10
ALL	ND	ND	ND

MW-134	7/20/09	10/5/09	5/5/10
ALL	ND	ND	ND

MW-138	7/21/09	8/11/09	9/15/09	10/7/09	11/18/09	12/14/09	1/13/10	2/23/10	3/30/10	4/21/10	5/4/10	6/14/10
ALL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

MW-35	7/21/09	8/11/09	9/14/09	10/12/09	11/17/09	12/11/09	1/12/10	2/23/10	3/29/10	4/21/10	5/4/10	6/15/10
ALL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

MW-133	7/21/09	8/12/09	9/14/09	10/8/09	11/17/09	12/11/09	1/12/10	2/23/10	3/29/10	4/20/10	5/4/10	6/14/10
B	0.051	0.031	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
E	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
T	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
X	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

EXPLANATION

- BSW-3D — BARRIER MONITORING WELL AND DESIGNATION
- MW-27 — MONITORING WELL AND DESIGNATION
- VW-94 — NESTED SOIL VAPOR MONITORING WELL AND DESIGNATION
- PROD_15 — PRODUCTION WELL AND DESIGNATION
- SHEET PILE BARRIER WALL
- FENCE
- BUILDING, TANK OR OTHER STRUCTURE
- 480 — GROUND SURFACE CONTOURS (INTERVAL= 5')

CONSTITUENT TABLE EXPLANATION

WELL DESIGNATION	MW-133	6/14/10	SAMPLE DATE
Benzene	B	0.5	
Chlorobenzene	CB	0.8	
Ethylbenzene	E	0.8	
Toluene	T	0.7	
Xylenes, Total	X	0.8	

N

0 200'

NOTES:

1. ALL VALUES ARE IN MILLIGRAMS PER LITER (mg/L)
2. J = ESTIMATED CONCENTRATION

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FIGURE 2-6
SOUTHWEST QUAD DISSOLVED PHASE RESULTS SUMMARY (JULY 2009 THROUGH JUNE 2010)
FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY
HOOVEN, OHIO

Drawn By: REP	Checked By: MM	Scale: 1" = 200'	Date: 11/22/2010	File: 500-SW-BTEX-201011

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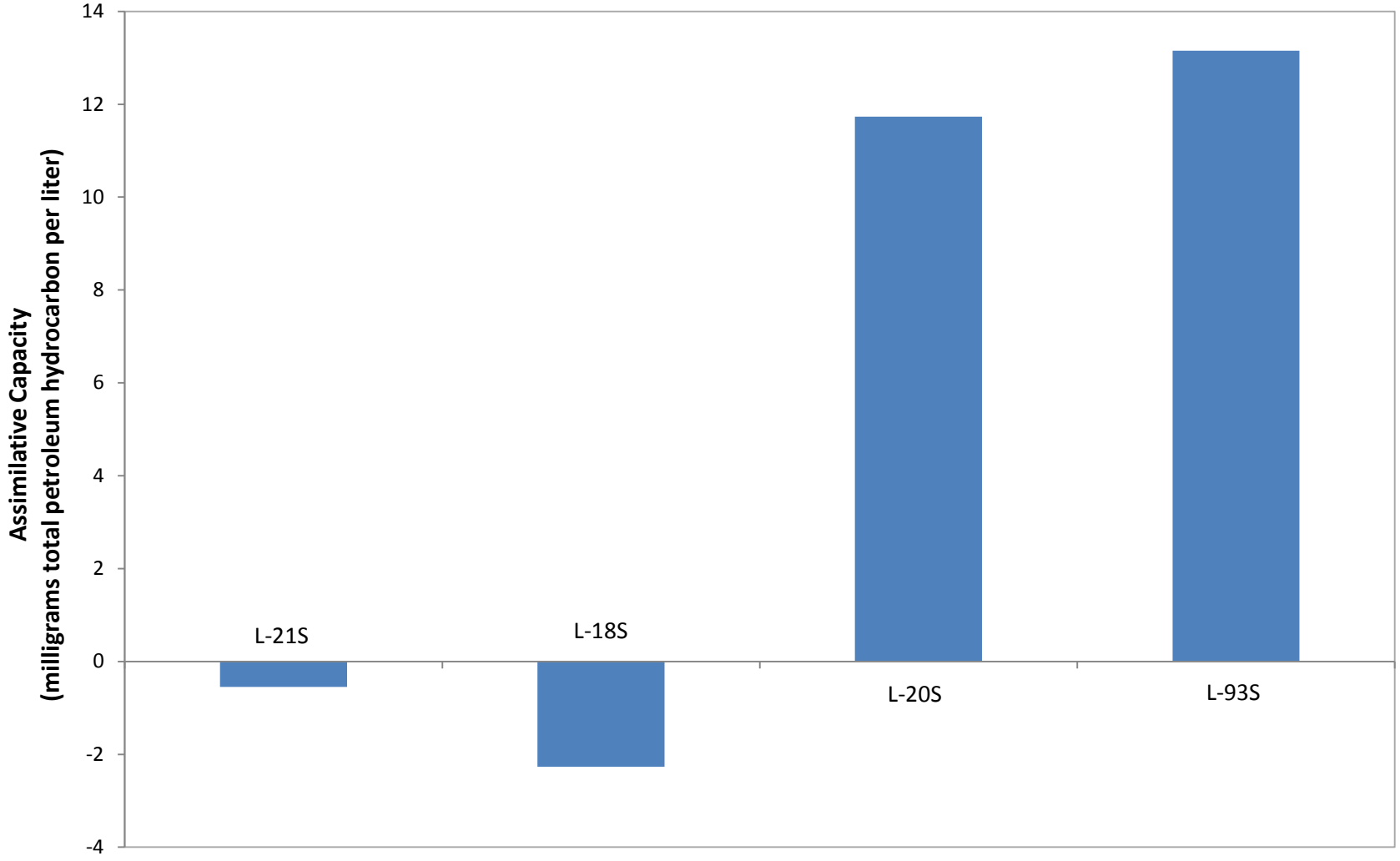
FIGURE 2-7. PORE WATER ASSIMILATIVE CAPACITY
FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY
HOOVEN, OHIO



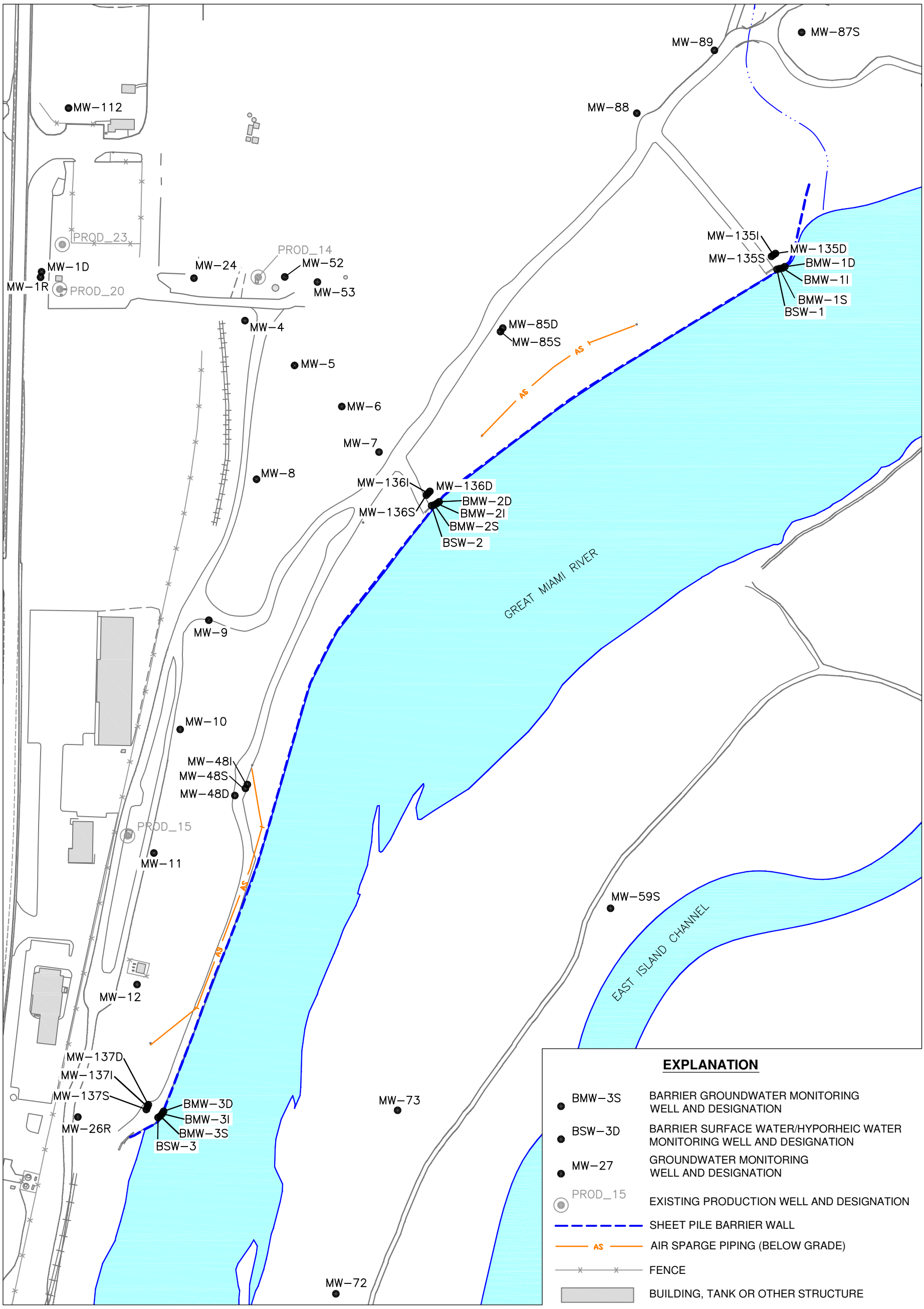


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FIGURE 2-8

BARRIER PERFORMANCE AIR SPARGE AND MONITORING WELL NETWORK

FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY
HOOVEN, OHIO

Drawn By: REP	Checked By: JP	Scale: 1" = 150'	Date:1/13/11	File: 500ASBUILTMONNET-201011

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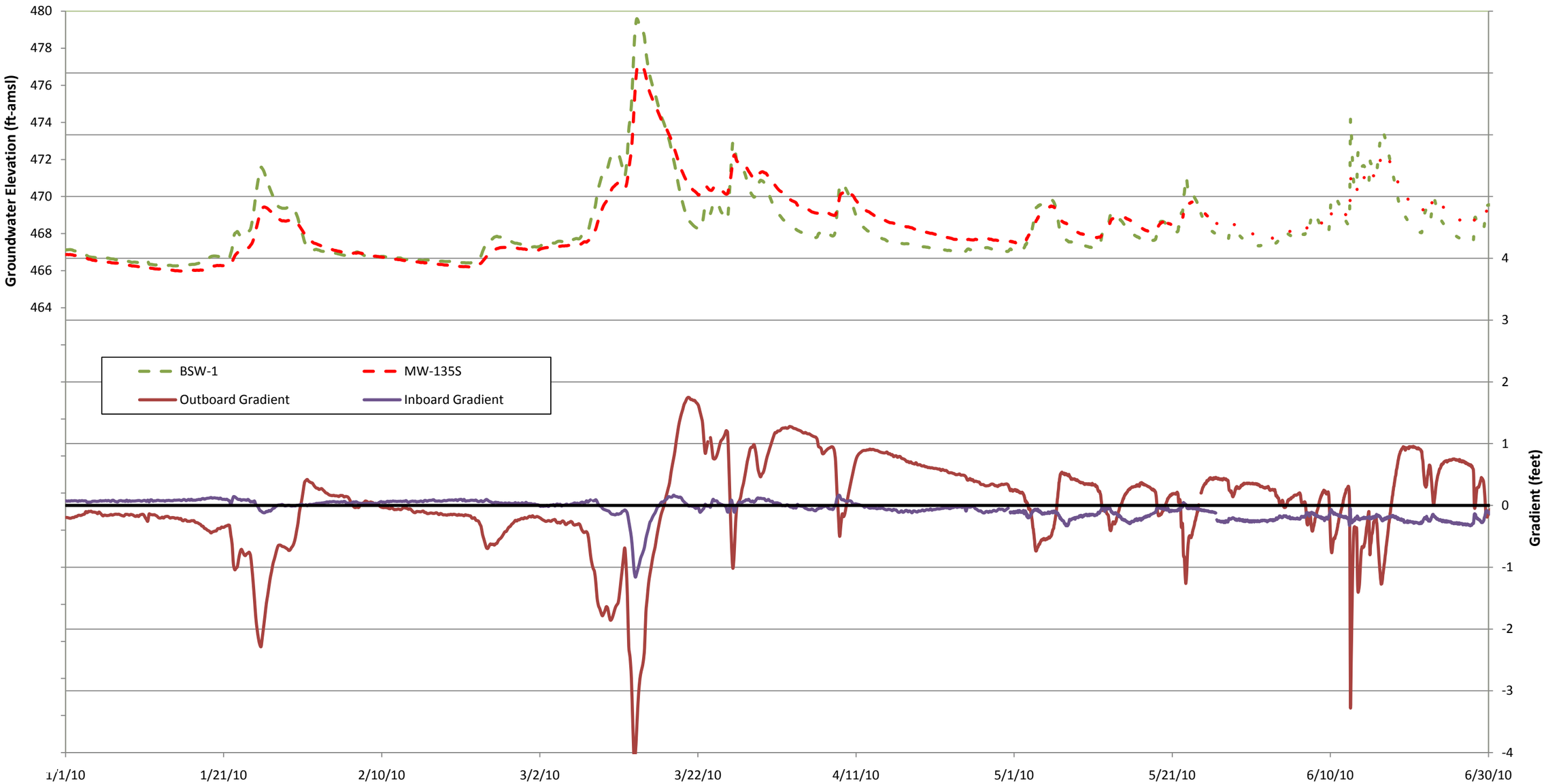
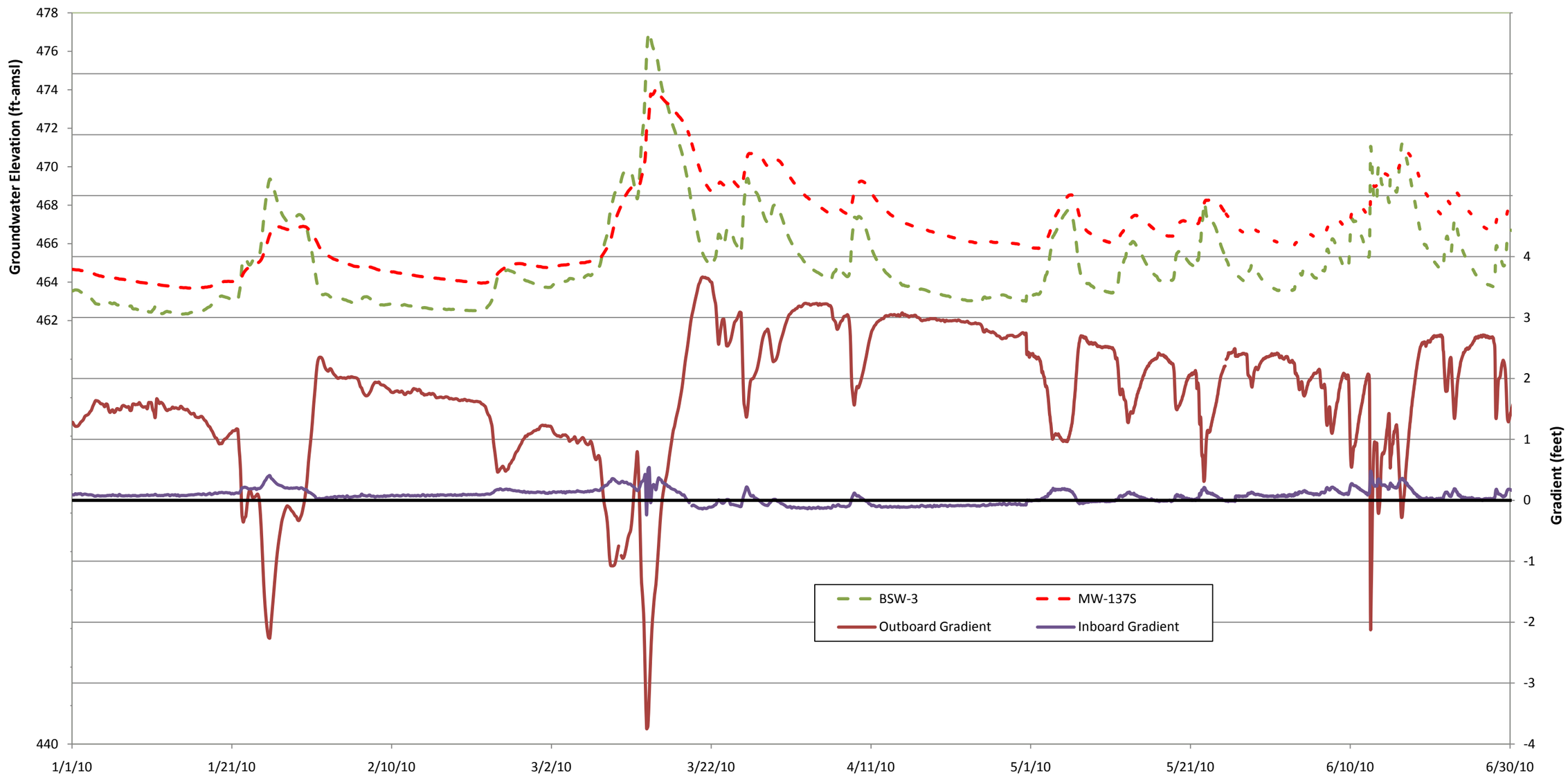
FIGURE 2-9. BARRIER WALL NORTH TRANSECT VERTICAL GRADIENTS
FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO



EXPLANATION
Outboard Gradient - Groundwater elevation at BMW-1D minus the surface water elevation at BSW-1.
Inboard Gradient - Groundwater elevation at MW-135D minus the groundwater elevation at MW-135S.
Upward vertical gradient shown as positive values, downward vertical gradient shown as negative values.

US EPA ARCHIVE DOCUMENT

FIGURE 2-10. BARRIER WALL SOUTH TRANSECT VERTICAL GRADIENTS
FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO



EXPLANATION
Outboard Gradient - Groundwater elevation at BMW-3D minus the surface water elevation at BSW-3.
Inboard Gradient - Groundwater elevation at MW-137D minus the groundwater elevation at MW-137S.
Upward vertical gradient shown as positive values, downward vertical gradient shown as negative values

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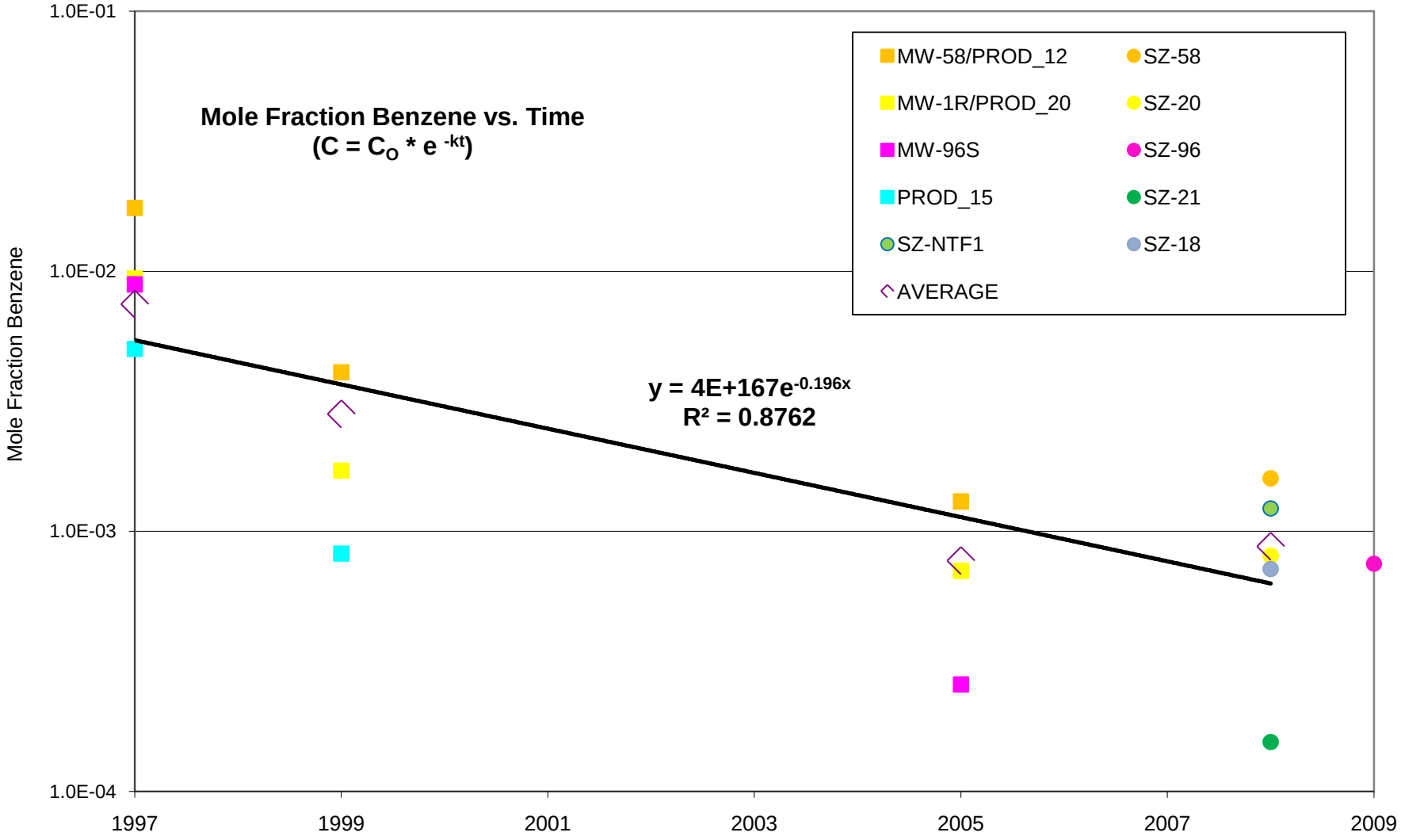
FIGURE 3-1. BENZENE MOLE FRACTION VERSUS TIME IN LNAPL AND SOIL CORE SAMPLES
FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO



EXPLANATION

1. SZ DESIGNATION INDICATES SMEAR ZONE SOIL CORES COLLECTED IN 2008 AND 2009 WHERE MOLE FRACTION BENZENE ARE AVERAGED FOR EACH OF THE SAMPLES COLLECTED FROM THE MIDDLE OF THE SMEAR ZONE AT EACH LOCATION.
2. MOLE FRACTION BENZENE FOR ALL OTHER EVENTS CALCULATED USING LNAPL ANALYTICAL RESULTS

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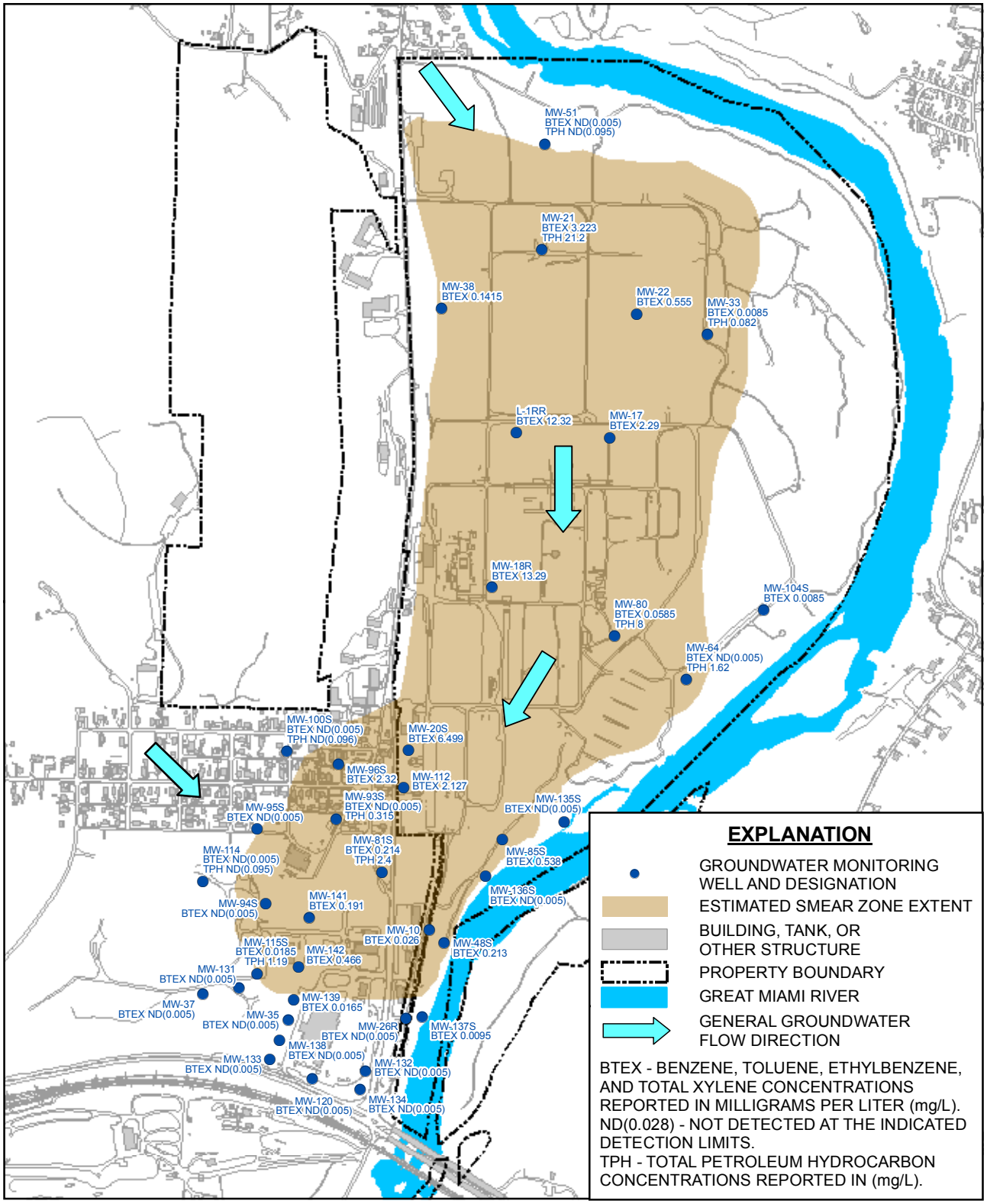

N

0 1,000'

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FIGURE 3-2

DISSOLVED PHASE CONSTITUENT CONCENTRATIONS

FIRST SEMIANNUAL 2010 MONITORING PERIOD
CHEVRON CINCINNATI FACILITY
HOOVEN, OHIO

Drawn By: BLM	Checked By: JP	Scale: 1" = 1000'	Date: 03/02/10	File: 201004_QI_TPHTrends.mxd

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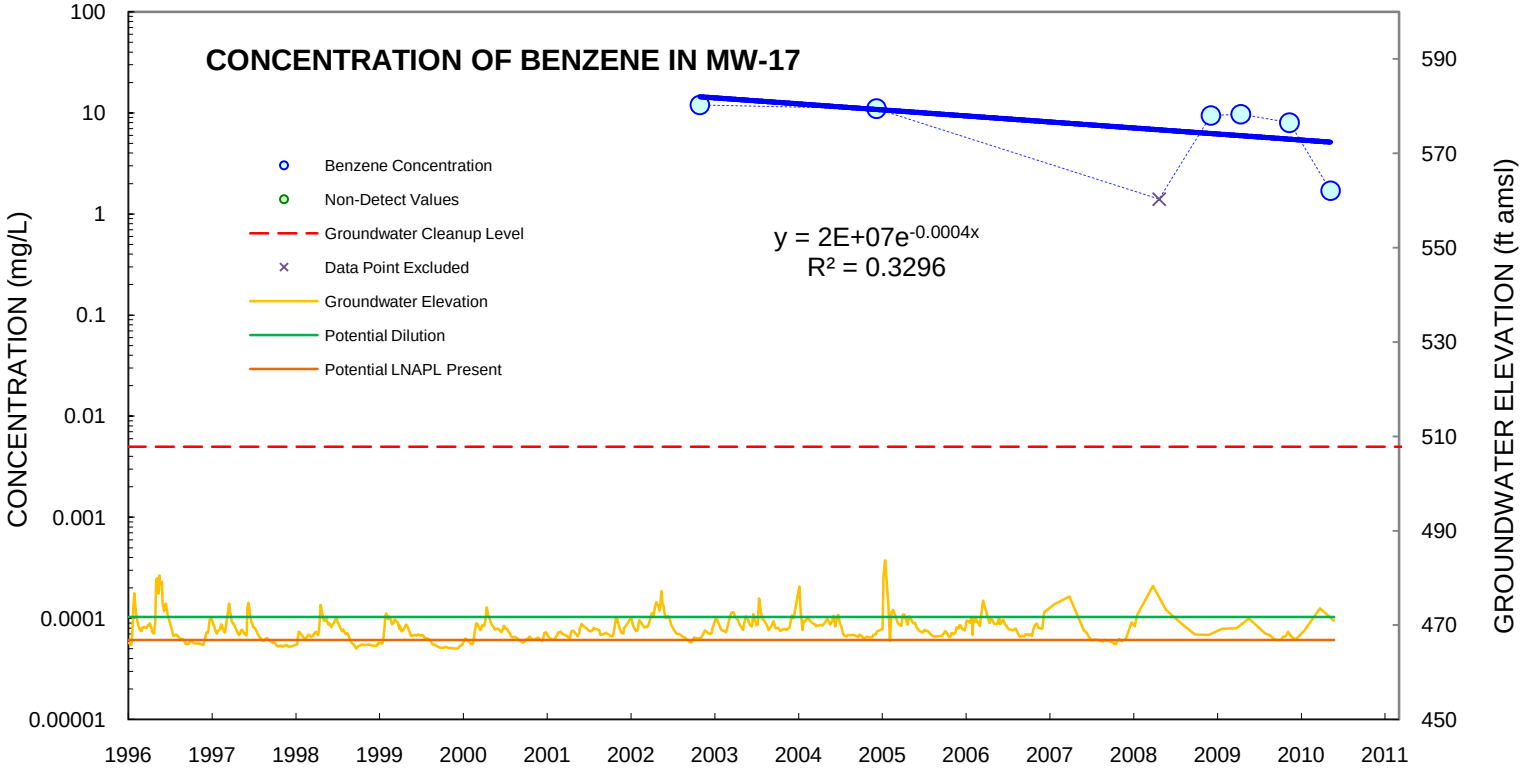
FIGURE 3-3. GROUNDWATER CONSTITUENT CONCENTRATIONS VERSUS TIME, MONITORING WELL MW-17
FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO



EXPLANATION

WATER LEVELS PRESENTED FOR POSSIBLE EXCLUSION OF DATA POINTS BASED ON POTENTIAL DILUTION OR PRESENCE OF LNAPL.

ONE DATA POINT EXCLUDED (4/23/08)

FT AMSL - FEET ABOVE MEAN SEA LEVEL

mg/L - MILLIGRAMS PER LITER

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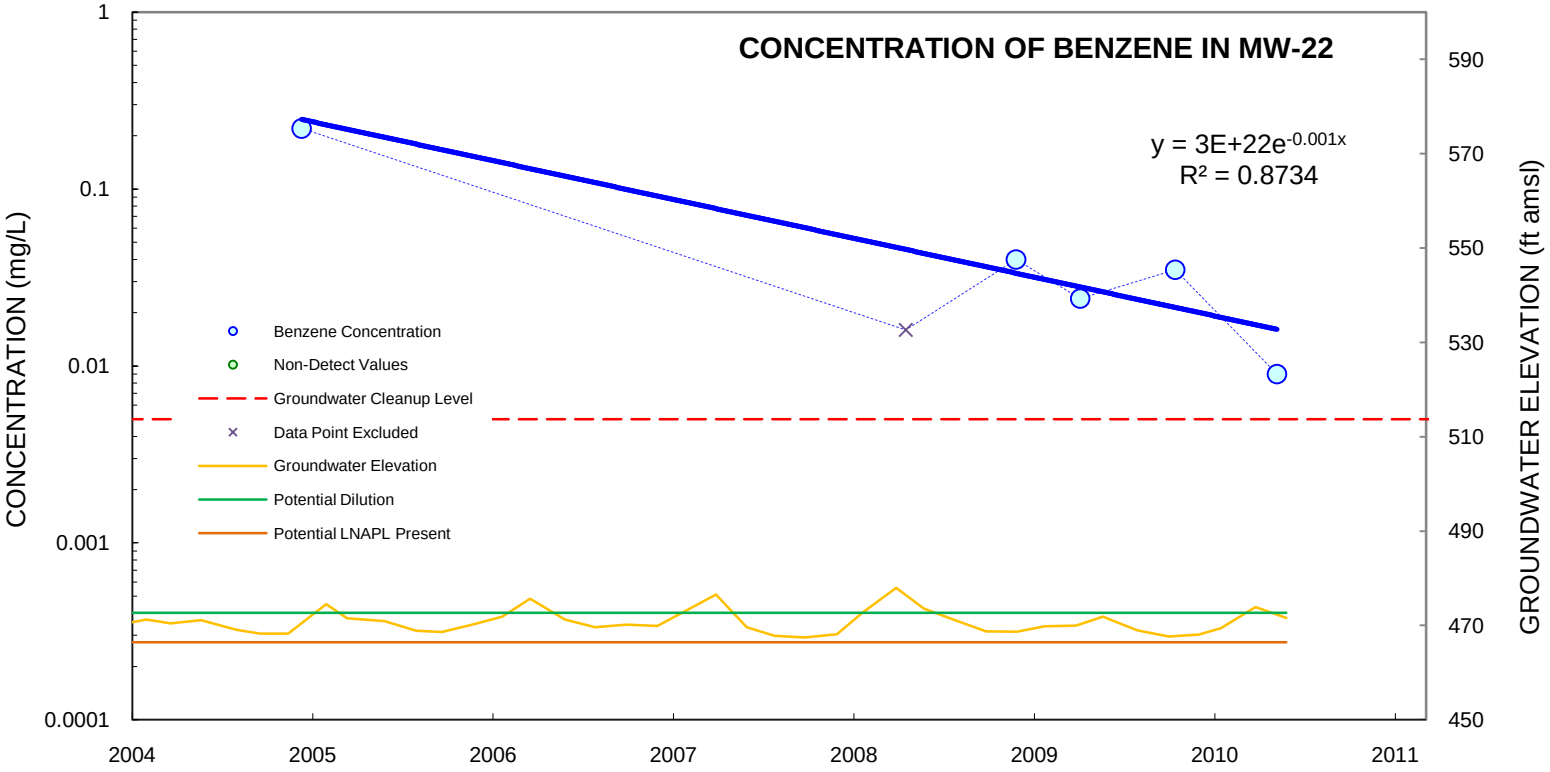
FIGURE 3-4. GROUNDWATER CONSTITUENT CONCENTRATIONS VERSUS TIME, MONITORING WELL MW-22
FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

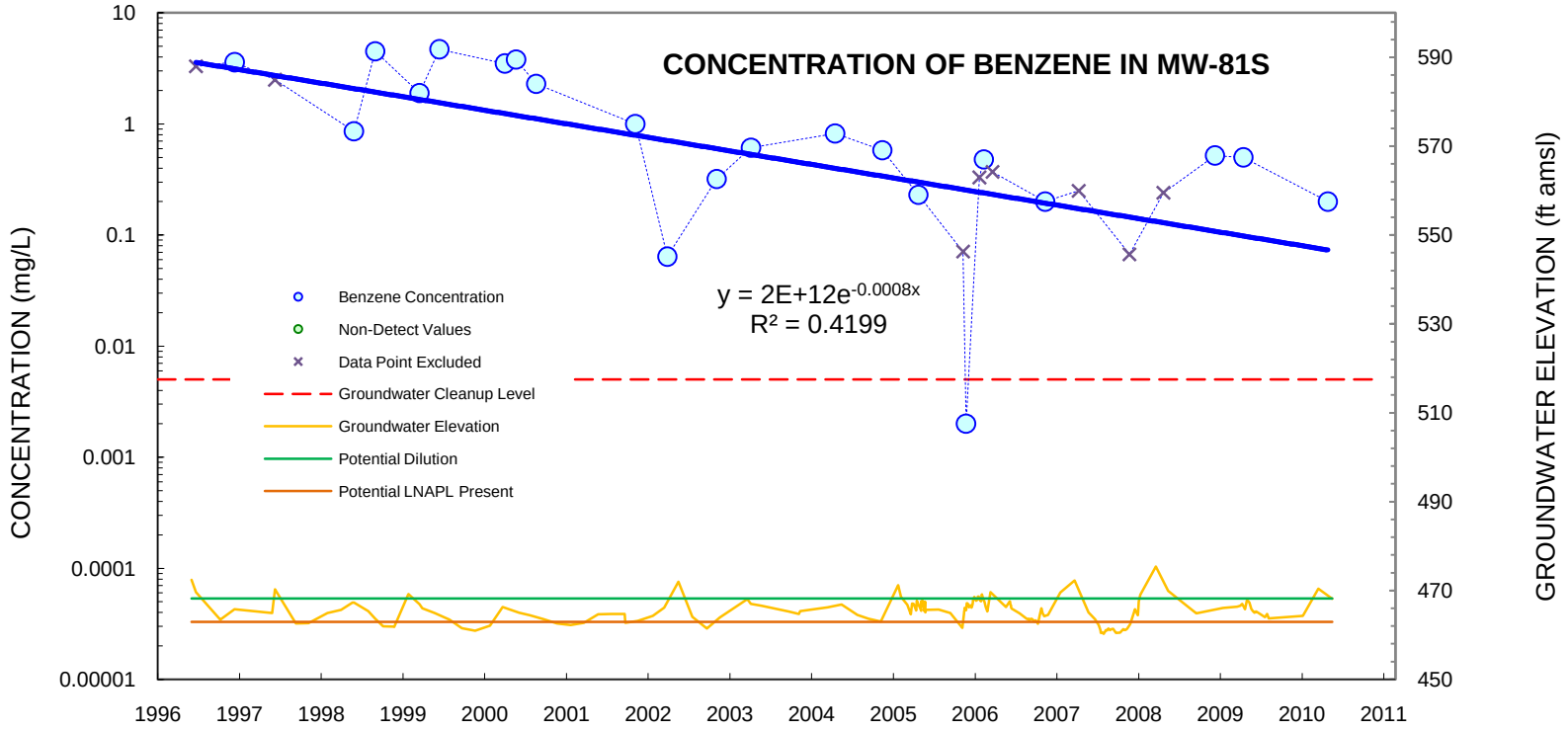


EXPLANATION

WATER LEVELS PRESENTED FOR POSSIBLE EXCLUSION OF DATA POINTS BASED ON POTENTIAL DILUTION OR PRESENCE OF LNAPL.
ONE DATA POINT EXCLUDED (4/16/08)
FT AMSL - FEET ABOVE MEAN SEA LEVEL
mg/L - MILLIGRAMS PER LITER

US EPA ARCHIVE DOCUMENT

FIGURE 3-5. GROUNDWATER CONSTITUENT CONCENTRATIONS VERSUS TIME, MONITORING WELL MW-81S
FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO



EXPLANATION

WATER LEVELS PRESENTED FOR POSSIBLE EXCLUSION OF DATA POINTS BASED ON POTENTIAL DILUTION OR PRESENCE OF LNAPL.

NO ANALYTICAL DATA AVAILABLE FOR FALL 2009 BECAUSE LNAPL WAS PRESENT IN THE WELL.

EIGHT DATA POINTS EXCLUDED (6/20/96, 6/9/97, 4/1/02, 11/15/05, 11/28/05, 12/29/05, 4/30/08)

FT AMSL - FEET ABOVE MEAN SEA LEVEL

mg/L - MILLIGRAMS PER LITER

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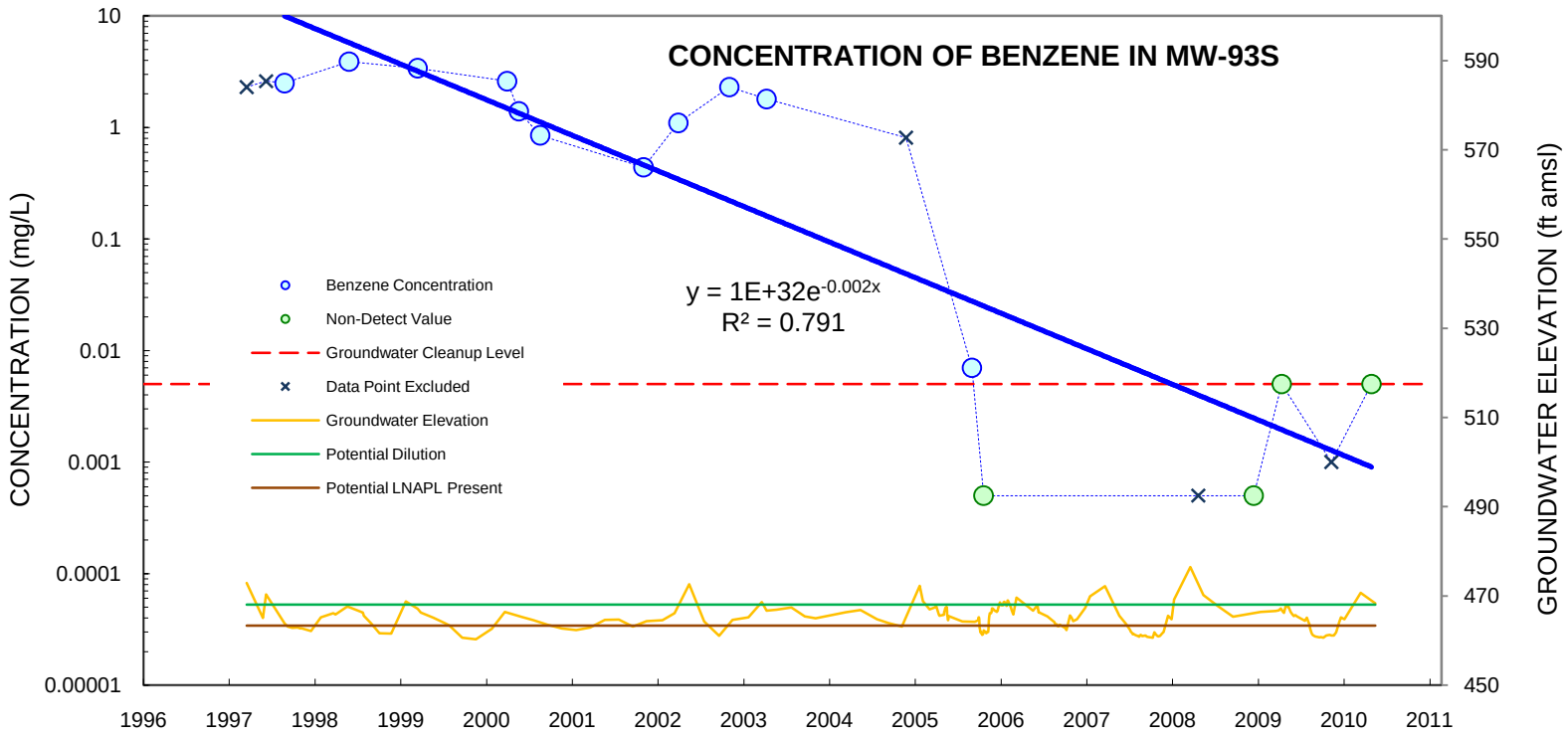
FIGURE 3-6. GROUNDWATER CONSTITUENT CONCENTRATIONS VERSUS TIME, MONITORING WELL MW-93S
FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO



EXPLANATION

WATER LEVELS PRESENTED FOR POSSIBLE EXCLUSION OF DATA POINTS BASED ON POTENTIAL DILUTION OR PRESENCE OF LNAPL.

FIVE DATA POINTS EXCLUDED (3/18/97, 6/9/97, 11/30/04, 4/30/08, AND 11/19/09)

FT AMSL - FEET ABOVE MEAN SEA LEVEL

mg/L - MILLIGRAMS PER LITER

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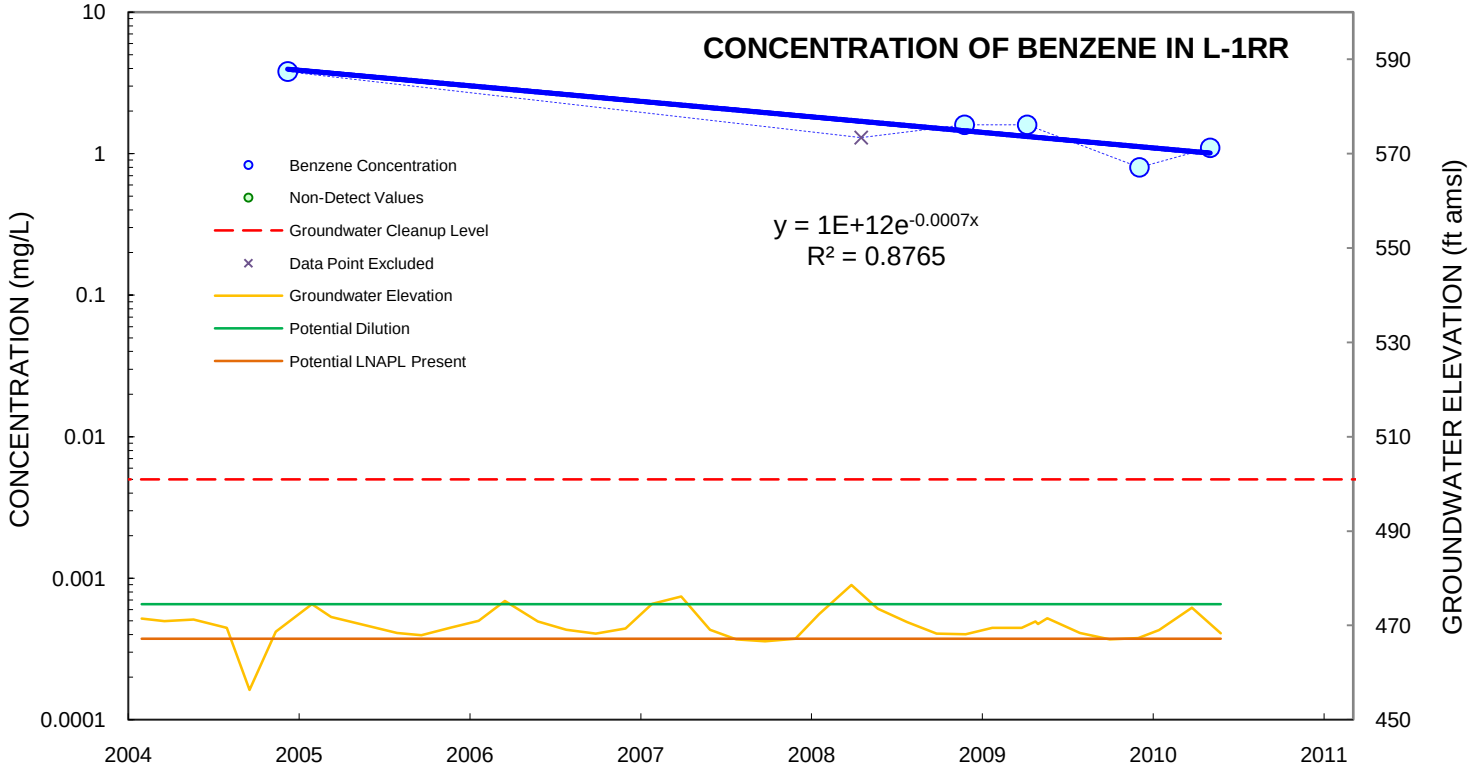
FIGURE 3-7. GROUNDWATER CONSTITUENT CONCENTRATIONS VERSUS TIME, MONITORING WELL L-1RR
FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO



EXPLANATION

WATER LEVELS PRESENTED FOR POSSIBLE EXCLUSION OF DATA POINTS BASED ON POTENTIAL DILUTION.
ONE DATA POINT EXCLUDED (4/17/08)
FT AMSL - FEET ABOVE MEAN SEA LEVEL
mg/L - MILLIGRAMS PER LITER

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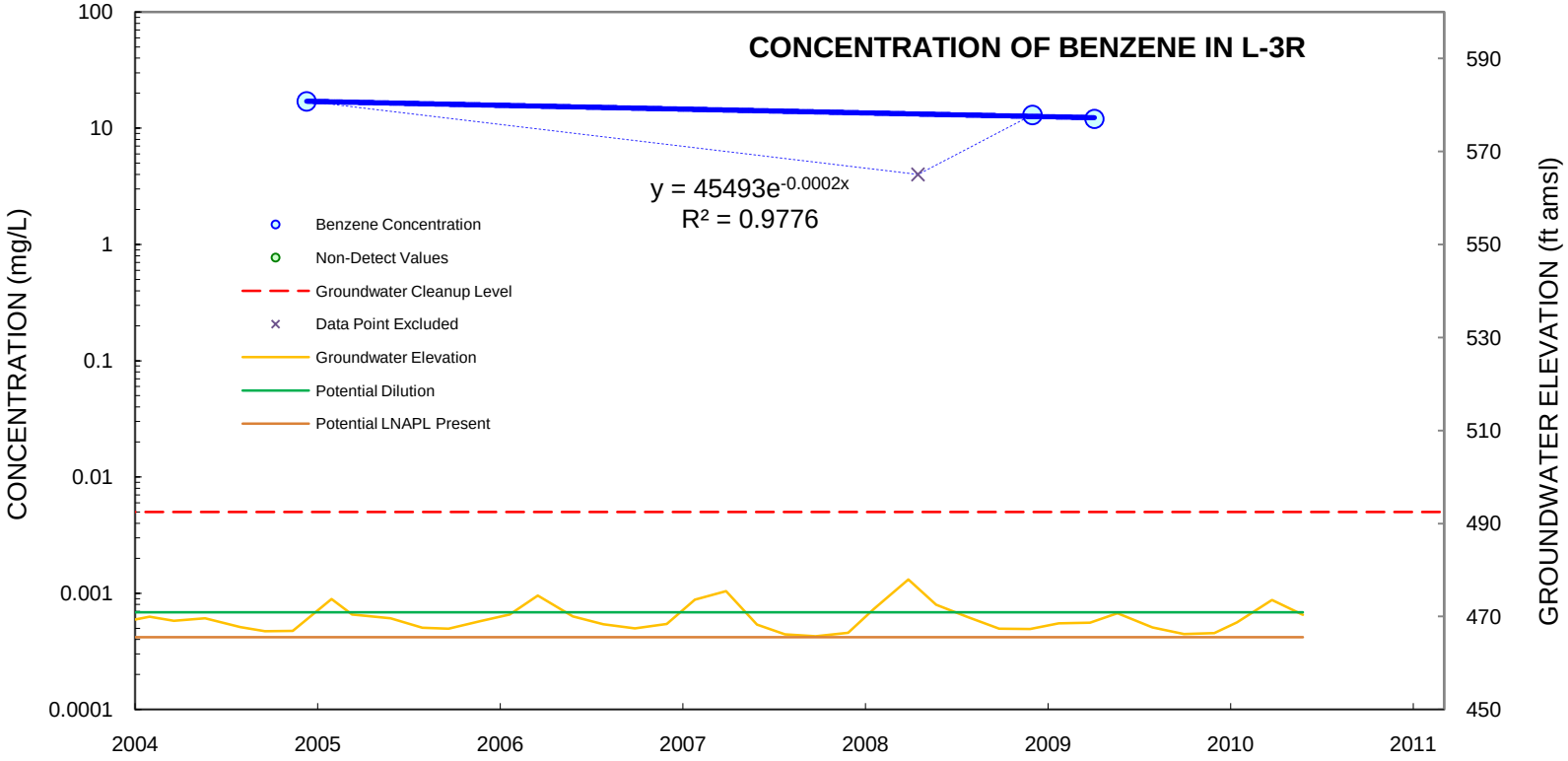
FIGURE 3-8. GROUNDWATER CONSTITUENT CONCENTRATIONS VERSUS TIME, MONITORING WELL L-3R
FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

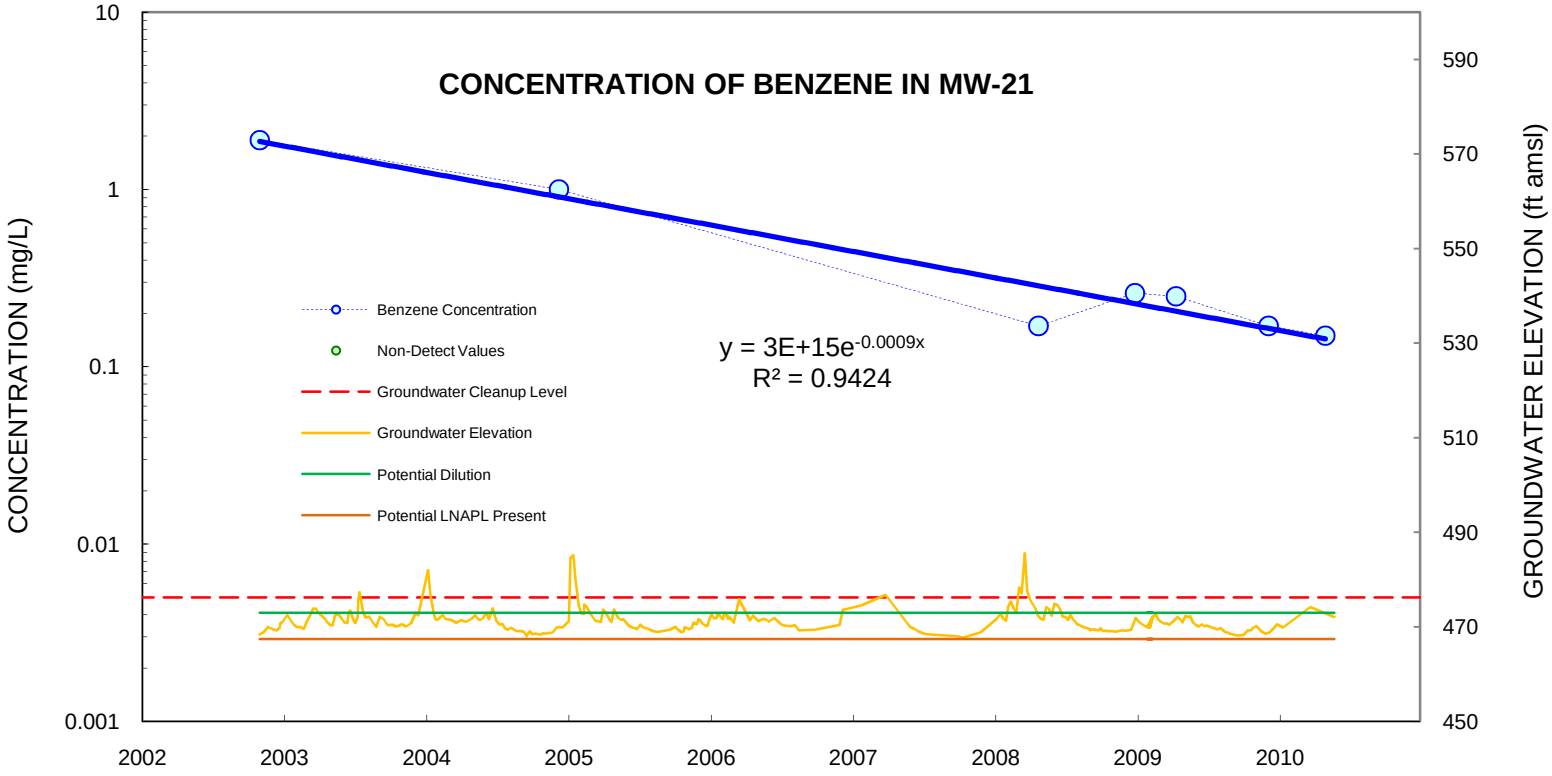


EXPLANATION

WATER LEVELS PRESENTED FOR POSSIBLE EXCLUSION OF DATA POINTS BASED ON POTENTIAL DILUTION OR PRESENCE OF LNAPL.
NO ANALYTICAL DATA AVAILABLE FOR FALL 2009 OR SPRING 2010 DUE TO LNAPL PRESENCE IN WELL.
ONE DATA POINT EXCLUDED (4/16/08)
FT AMSL - FEET ABOVE MEAN SEA LEVEL
mg/L - MILLIGRAMS PER LITER

US EPA ARCHIVE DOCUMENT

FIGURE 3-9. GROUNDWATER CONSTITUENT CONCENTRATIONS VERSUS TIME, MONITORING WELL MW-21
FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO



EXPLANATION

WATER LEVELS PRESENTED FOR POSSIBLE EXCLUSION OF DATA POINTS BASED ON POTENTIAL DILUTION OR PRESENCE OF LNAPL.
NO DATA POINTS EXCLUDED
FT AMSL - FEET ABOVE MEAN SEA LEVEL
mg/L - MILLIGRAMS PER LITER

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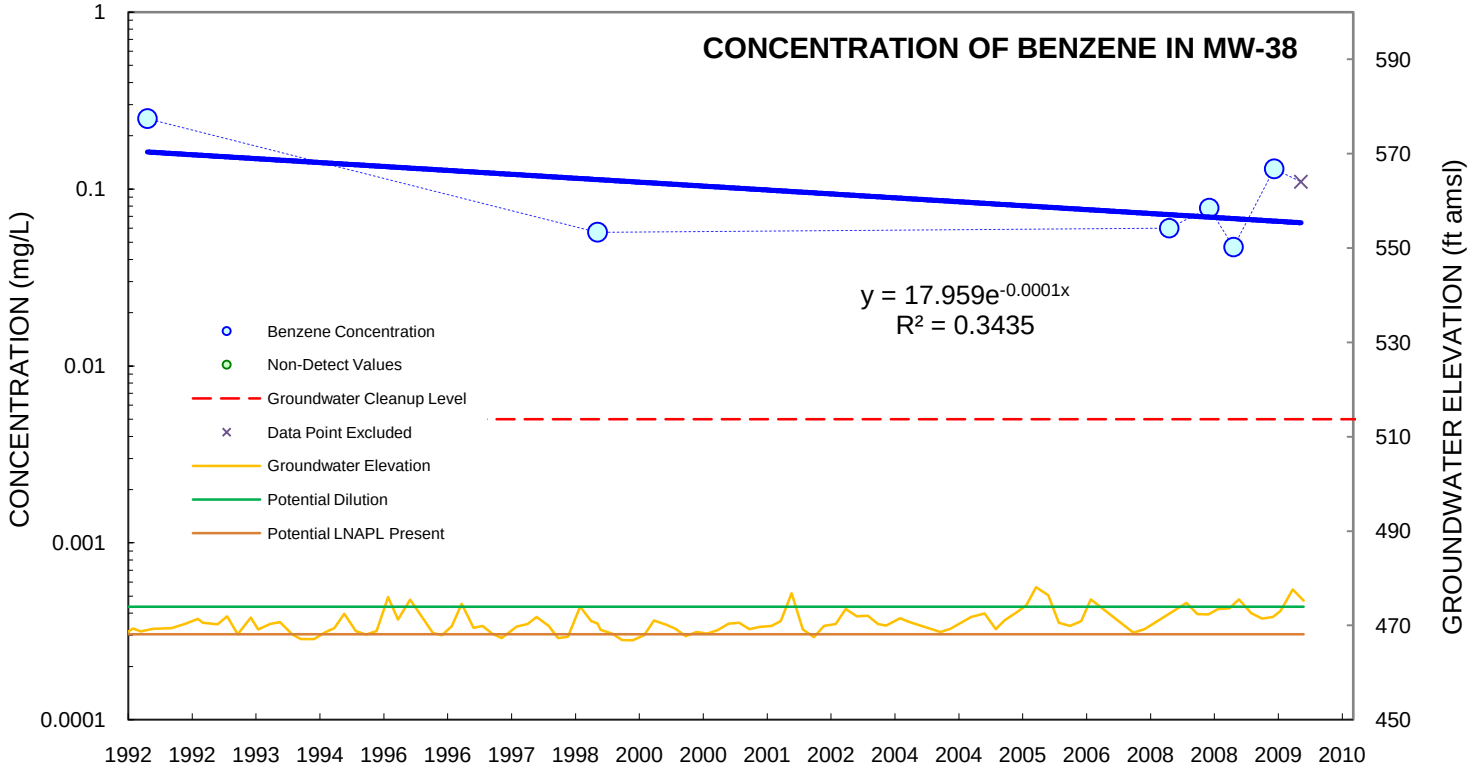
FIGURE 3-10. GROUNDWATER CONSTITUENT CONCENTRATIONS VERSUS TIME, MONITORING WELL MW-38
FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

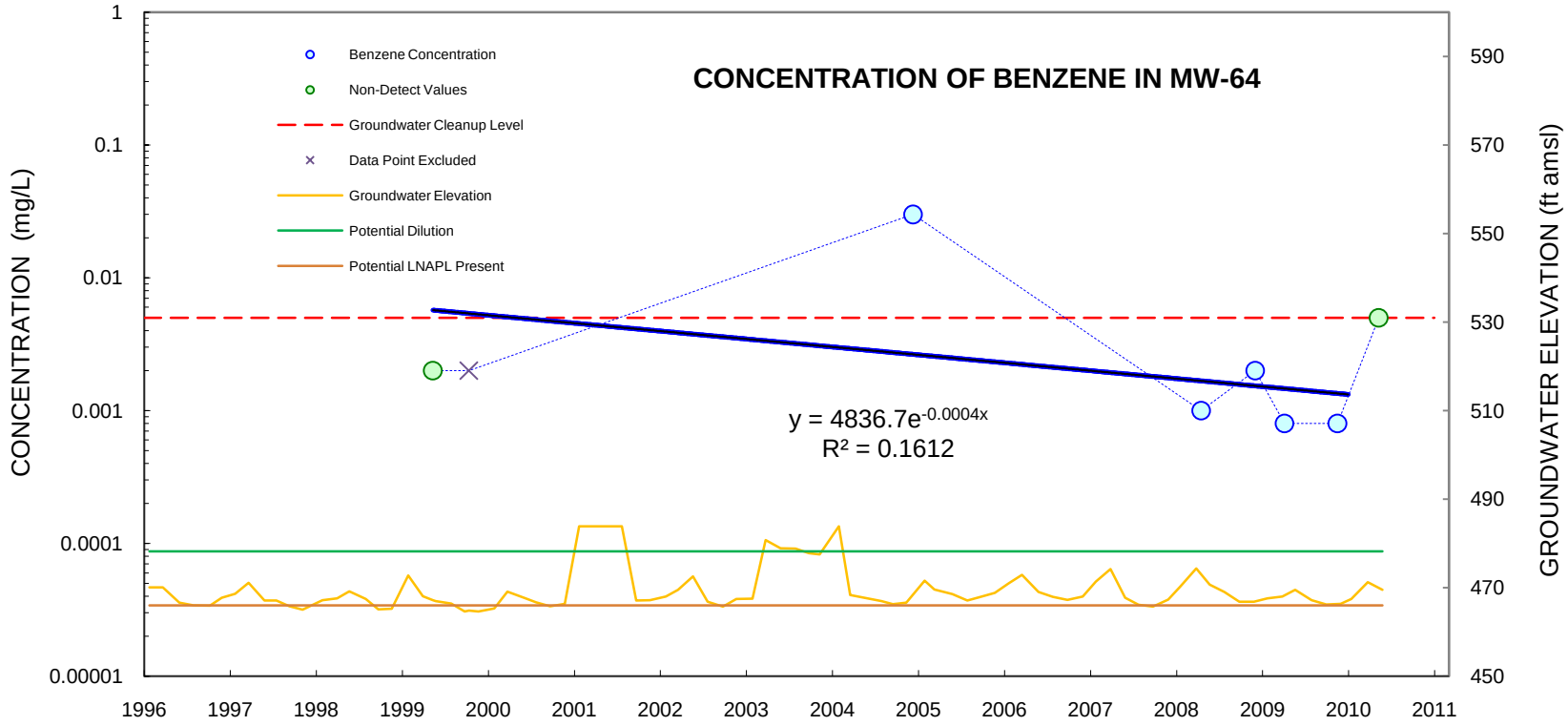


EXPLANATION

WATER LEVELS PRESENTED FOR POSSIBLE EXCLUSION OF DATA POINTS BASED ON POTENTIAL DILUTION OR PRESENCE OF LNAPL.
ONE DATA POINT EXCLUDED (5/10/10)
FT AMSL - FEET ABOVE MEAN SEA LEVEL
mg/L - MILLIGRAMS PER LITER

US EPA ARCHIVE DOCUMENT

FIGURE 3-11. GROUNDWATER CONSTITUENT CONCENTRATIONS VERSUS TIME, MONITORING WELL MW-64
FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO



EXPLANATION

WATER LEVELS PRESENTED FOR POSSIBLE EXCLUSION OF DATA POINTS BASED ON POTENTIAL DILUTION OR PRESENCE OF LNAPL.
ONE DATA POINT EXCLUDED (10/12/99)
FT AMSL - FEET ABOVE MEAN SEA LEVEL
mg/L - MILLIGRAMS PER LITER

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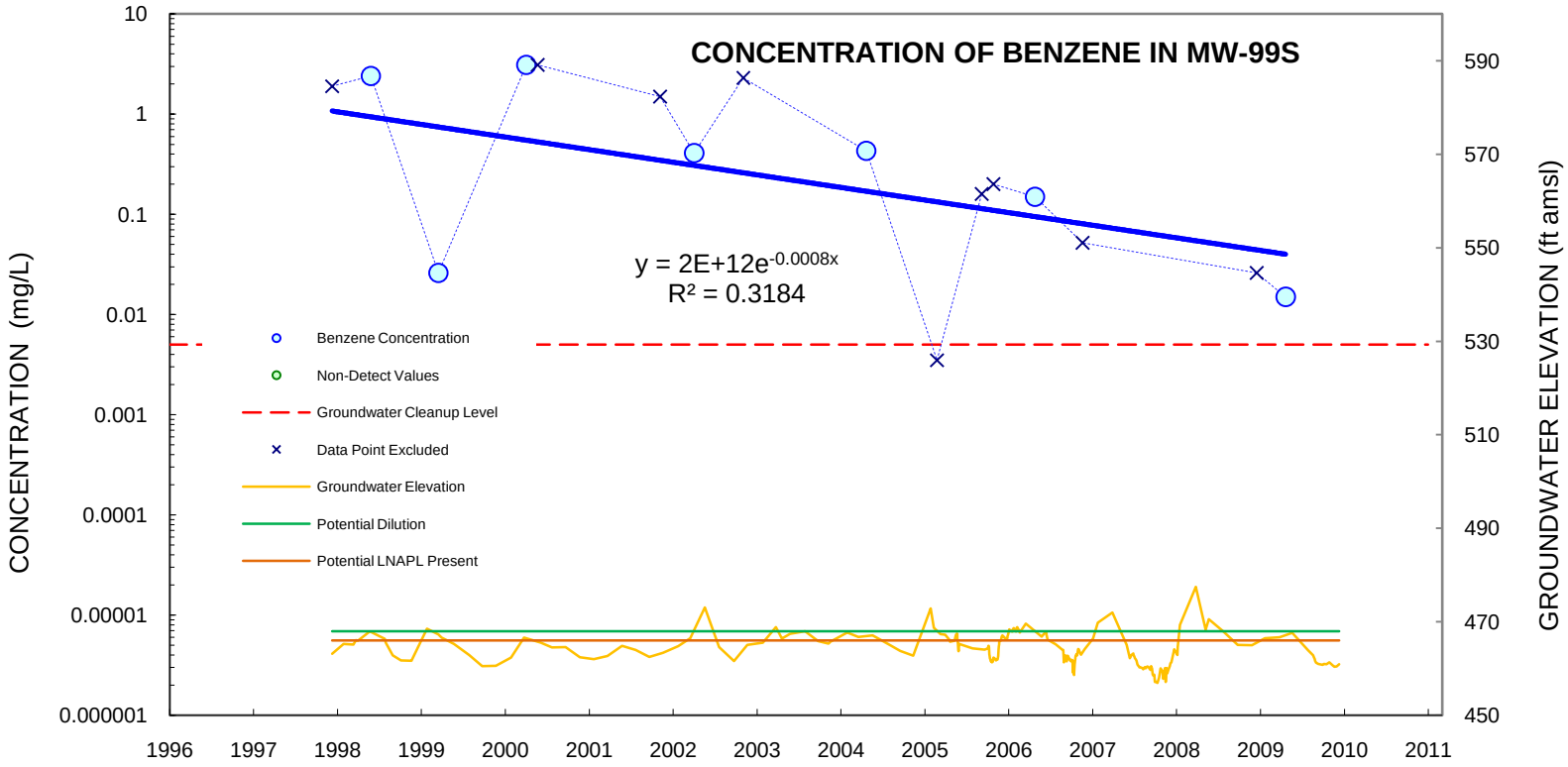
FIGURE 3-12. GROUNDWATER CONSTITUENT CONCENTRATIONS VERSUS TIME, MONITORING WELL MW-99S
FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO



EXPLANATION:

WATER LEVELS PRESENTED FOR POSSIBLE EXCLUSION OF DATA POINTS BASED ON POTENTIAL DILUTION OR PRESENCE OF LNAPL.
NINE DATA POINTS EXCLUDED (12/10/97, 4/3/00, 5/23/00, 11/7/01, 11/4/02, 2/24/05, 9/7/05, 10/28/05, and 11/20/06).
WELL NOT SAMPLED IN SPRING 2010 DUE TO LNAPL PRESENCE IN WELL.
FT AMSL - FEET ABOVE MEAN SEA LEVEL
mg/L - MILLIGRAMS PER LITER

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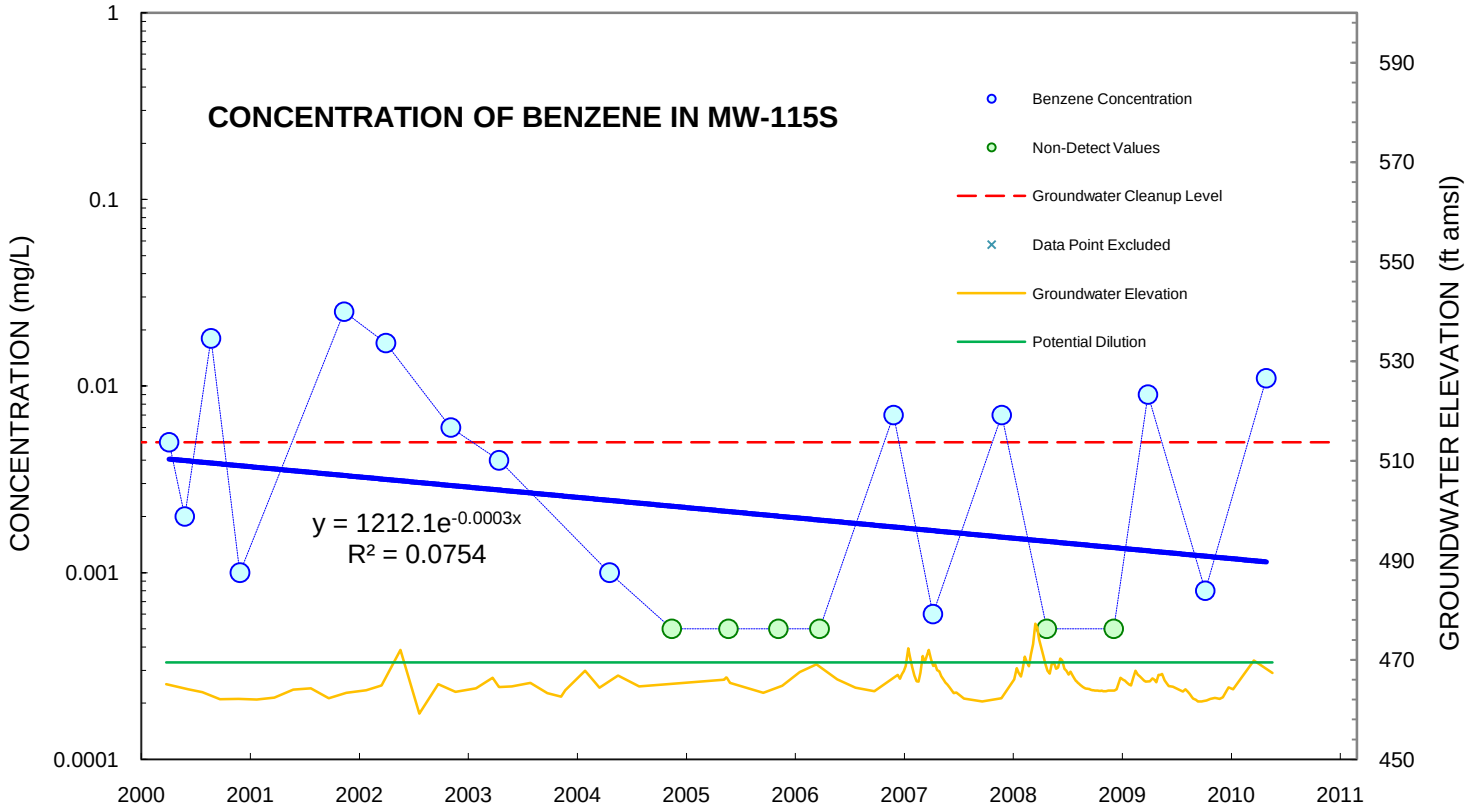
FIGURE 3-13. GROUNDWATER CONSTITUENT CONCENTRATIONS VERSUS TIME, MONITORING WELL MW-115S
FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO



EXPLANATION

WATER LEVELS PRESENTED FOR POSSIBLE EXCLUSION OF DATA POINTS BASED ON POTENTIAL DILUTION.

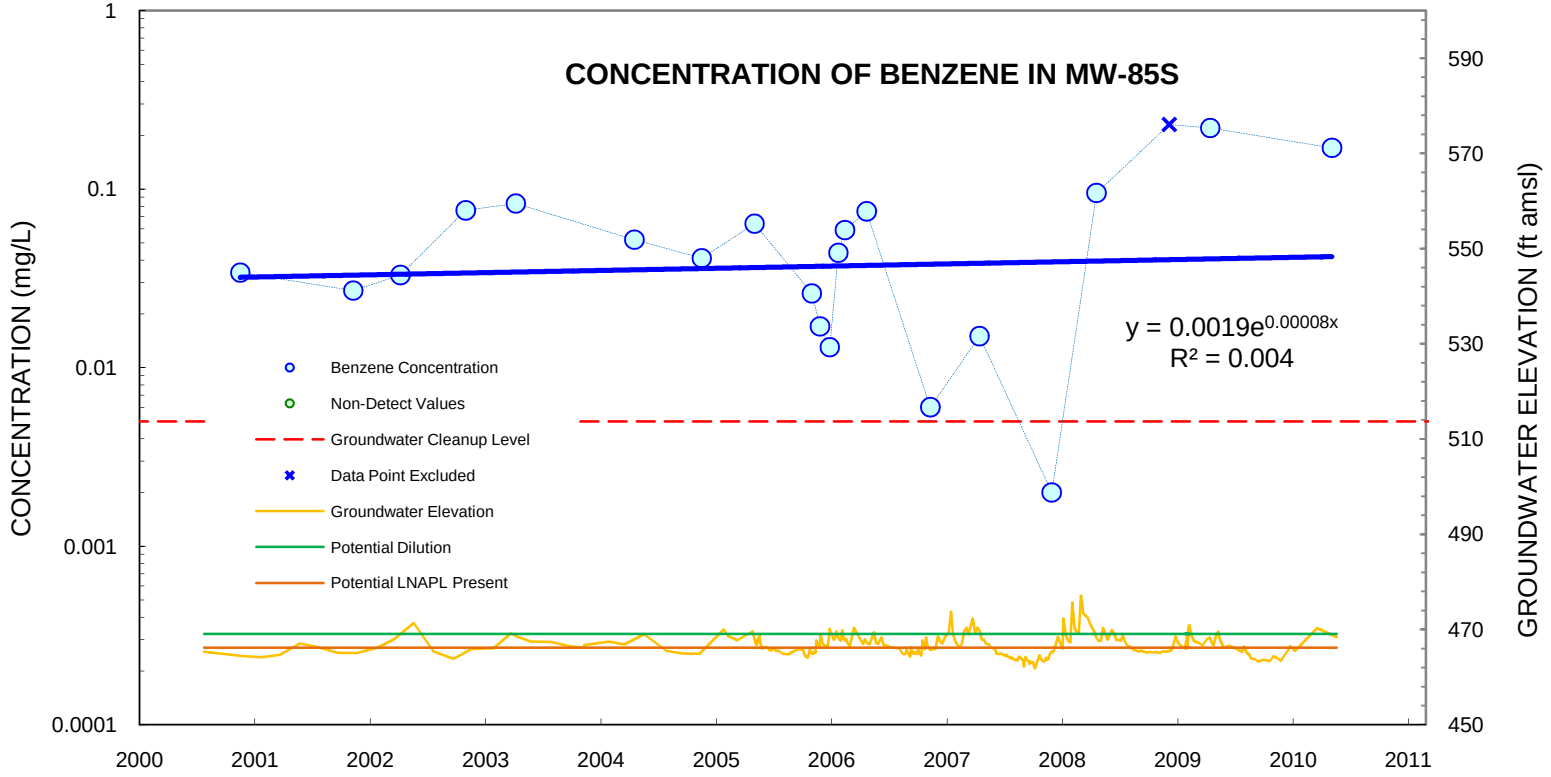
NO DATA POINTS EXCLUDED

FT AMSL - FEET ABOVE MEAN SEA LEVEL

mg/L - MILLIGRAMS PER LITER

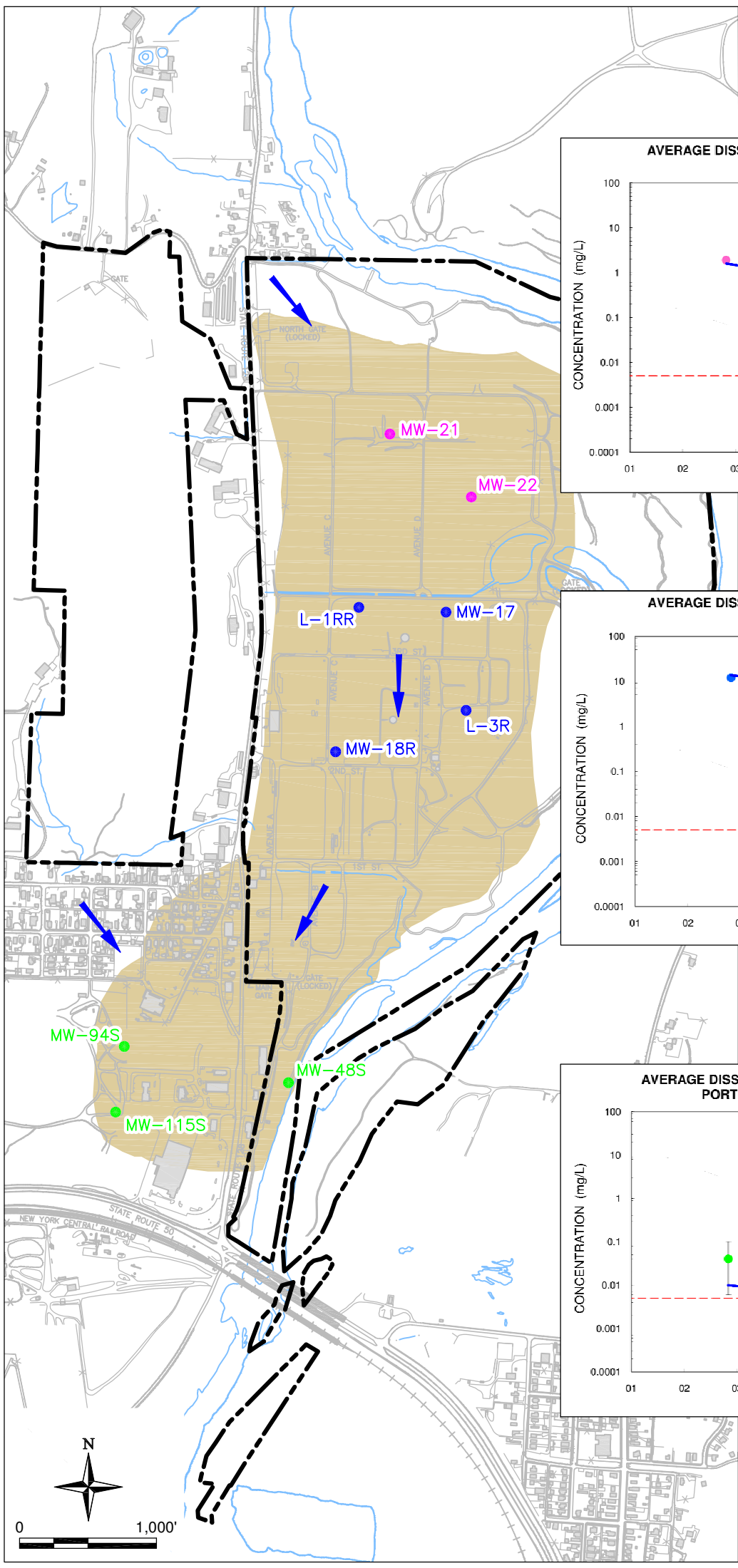
US EPA ARCHIVE DOCUMENT

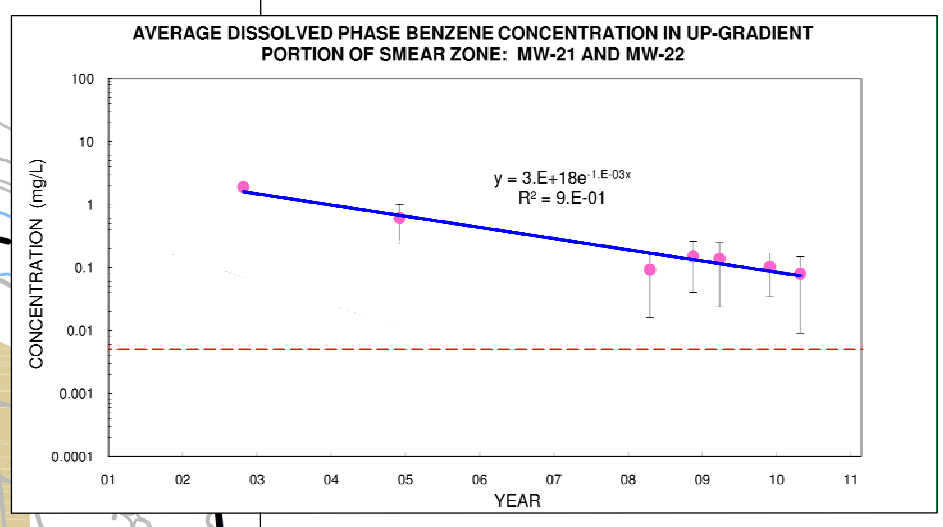
FIGURE 3-14. GROUNDWATER CONSTITUENT CONCENTRATIONS VERSUS TIME, MONITORING WELL MW-85S
FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO

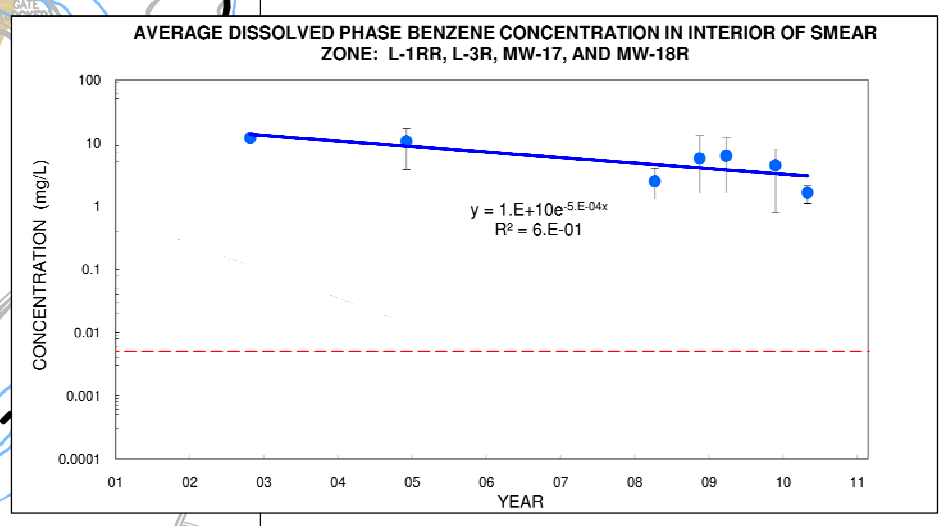


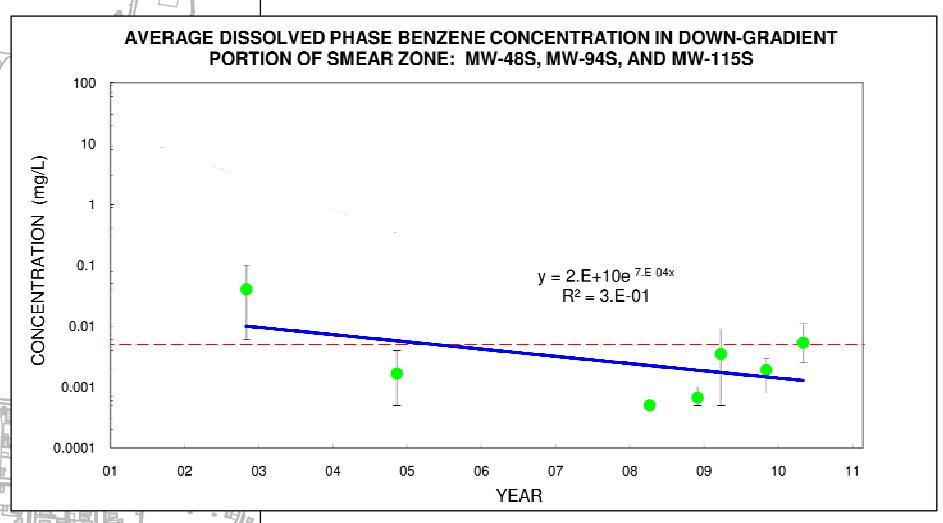
EXPLANATION

WATER LEVELS PRESENTED FOR POSSIBLE EXCLUSION OF DATA POINTS BASED ON POTENTIAL DILUTION OR PRESENCE OF LNAPL.
ONE DATA POINT EXCLUDED (12/11/08)
FT AMSL - FEET ABOVE MEAN SEA LEVEL
mg/L - MILLIGRAMS PER LITER









EXPLANATION

- MW-22 UPGRADIENT MONITORING WELL AND DESIGNATION
- MW-17 INTERIOR MONITORING WELL AND DESIGNATION
- MW-48S DOWNGRADIENT MONITORING WELL AND DESIGNATION
- PROPERTY BOUNDARY
- FENCE
- STREAM
- GROUNDWATER CLEANUP LEVEL
- GENERAL GROUNDWATER FLOW DIRECTION
- BUILDING, TANK OR OTHER STRUCTURE
- SMEAR ZONE

NOTES:

1. ERROR BARS REPRESENT MINIMUM AND MAXIMUM CONCENTRATIONS MEASURED DURING SAMPLING EVENT.
2. NON-DETECT CONCENTRATIONS SET TO REPORTING LIMIT FOR AVERAGING.
3. SAMPLING EVENTS DISPLAYED: FALL 2002, FALL 2004, SPRING 2008, FALL 2008, SPRING 2009, FALL 2009, AND SPRING 2010.

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FIGURE 3-15

AVERAGE DISSOLVED PHASE BENZENE TRENDS ACROSS THE SMEAR ZONE

FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY
HOOVEN, OHIO

Drawn By: REP	Checked By: JGP	Scale: AS SHOWN	Date: 11/30/10	File: 500SPATIO201011

US EPA ARCHIVE DOCUMENT

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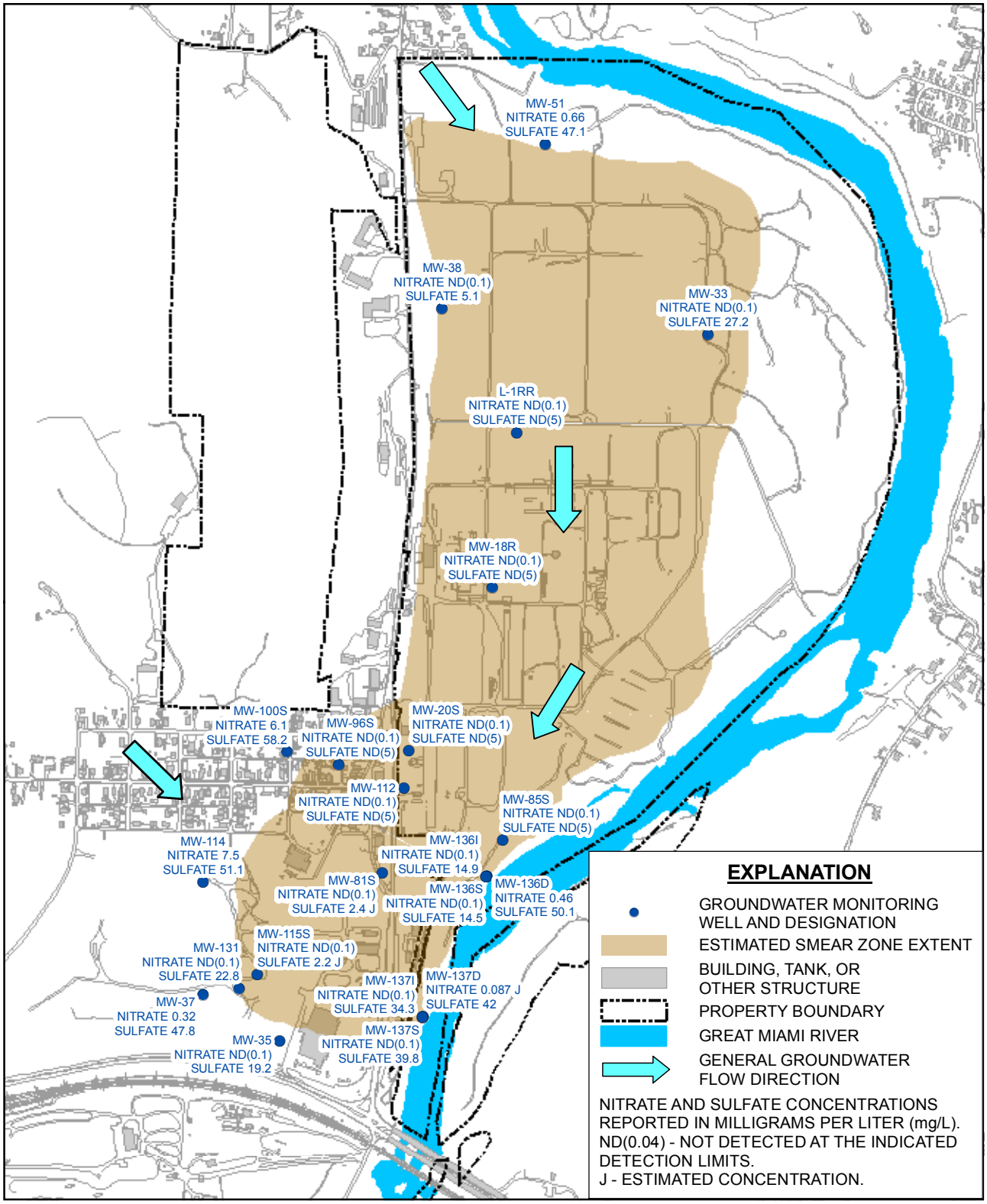

N

0 1,000'

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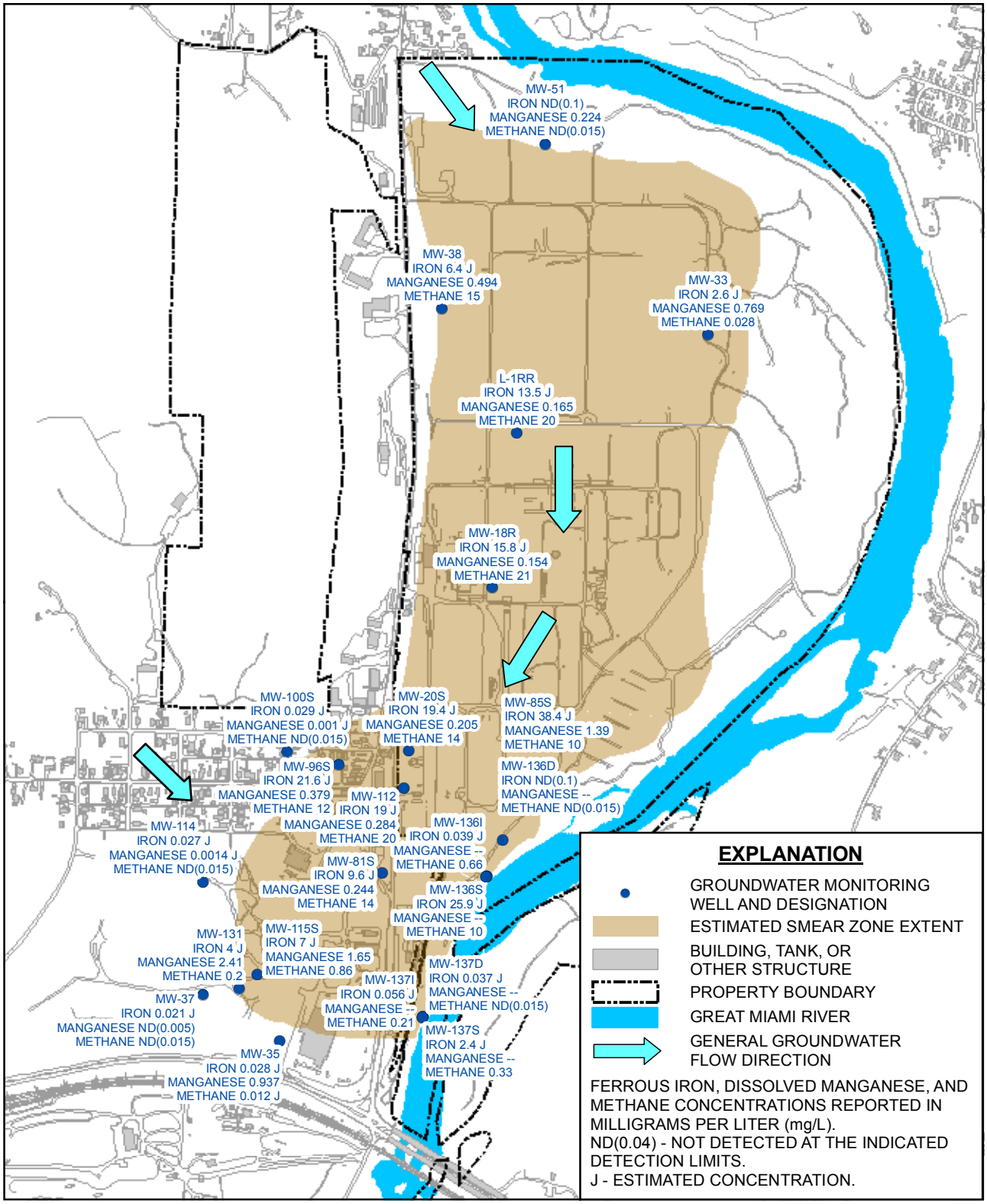
FIGURE 3-16

DISSOLVED PHASE NITRATE AND SULFATE CONCENTRATIONS

FIRST SEMIANNUAL 2010 MONITORING PERIOD
CHEVRON CINCINNATI FACILITY
HOOVEN, OHIO

Drawn By: BLM	Checked By: JP	Scale: 1" = 1000'	Date: 03/02/10	File: 201004_QI_EAccept_OxTrends.mxd

US EPA ARCHIVE DOCUMENT



N

0 1,000'

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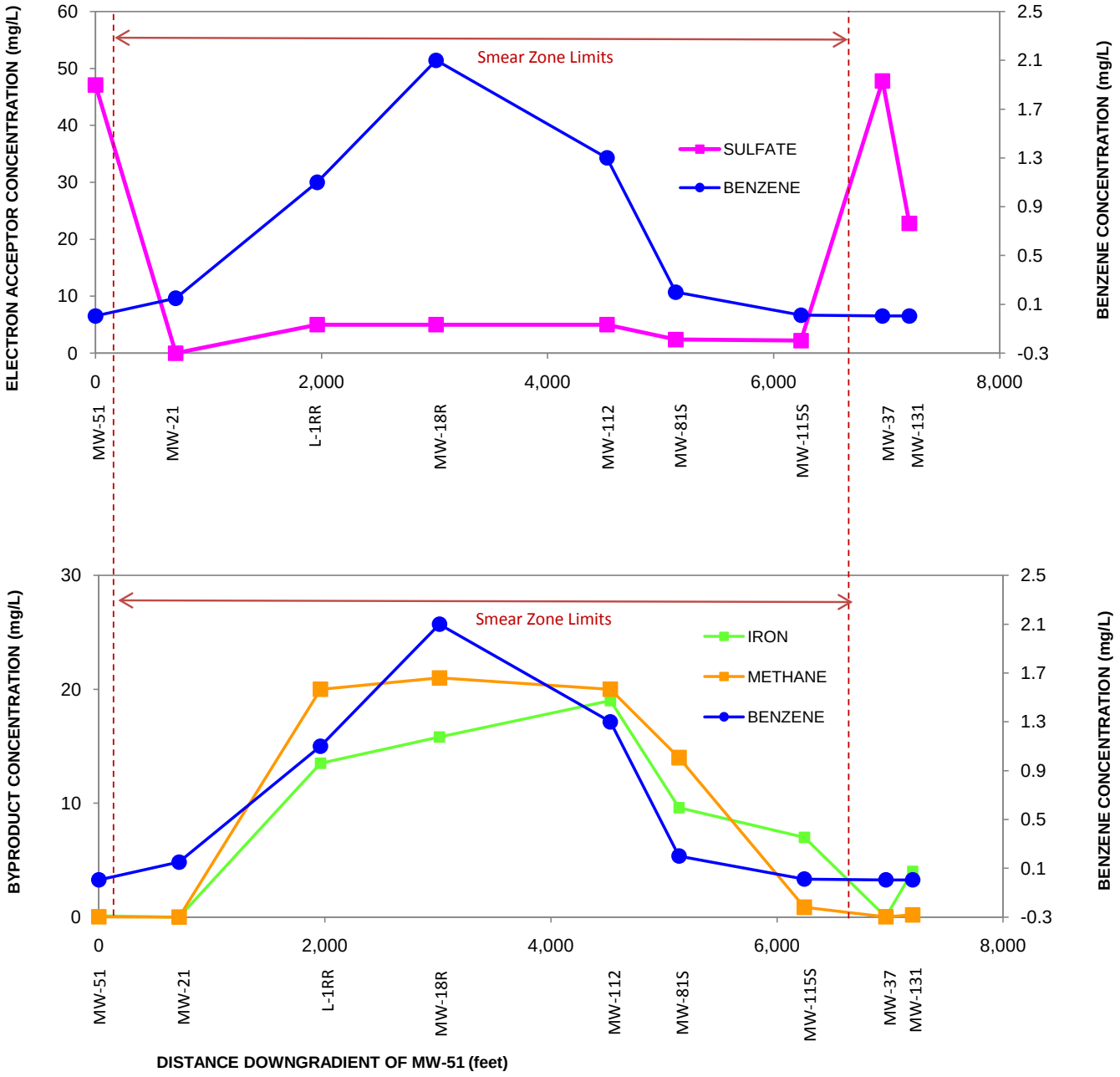
FIGURE 3-17

DISSOLVED PHASE IRON, MANGANESE, AND AND METHANE CONCENTRATIONS

FIRST SEMIANNUAL 2010 MONITORING PERIOD
CHEVRON CINCINNATI FACILITY
HOOVEN, OHIO

Drawn By: BLM	Checked By: JP	Scale: 1" = 1000'	Date: 03/02/10	File: 201004_QI_EAccept_RedTrends.mxd

FIGURE 3-18. DISSOLVED PHASE BENZENE & NATURAL ATTENUATION INDICATOR CONCENTRATIONS VERSUS DISTANCE
FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY, HOOVEN, OHIO



EXPLANATION

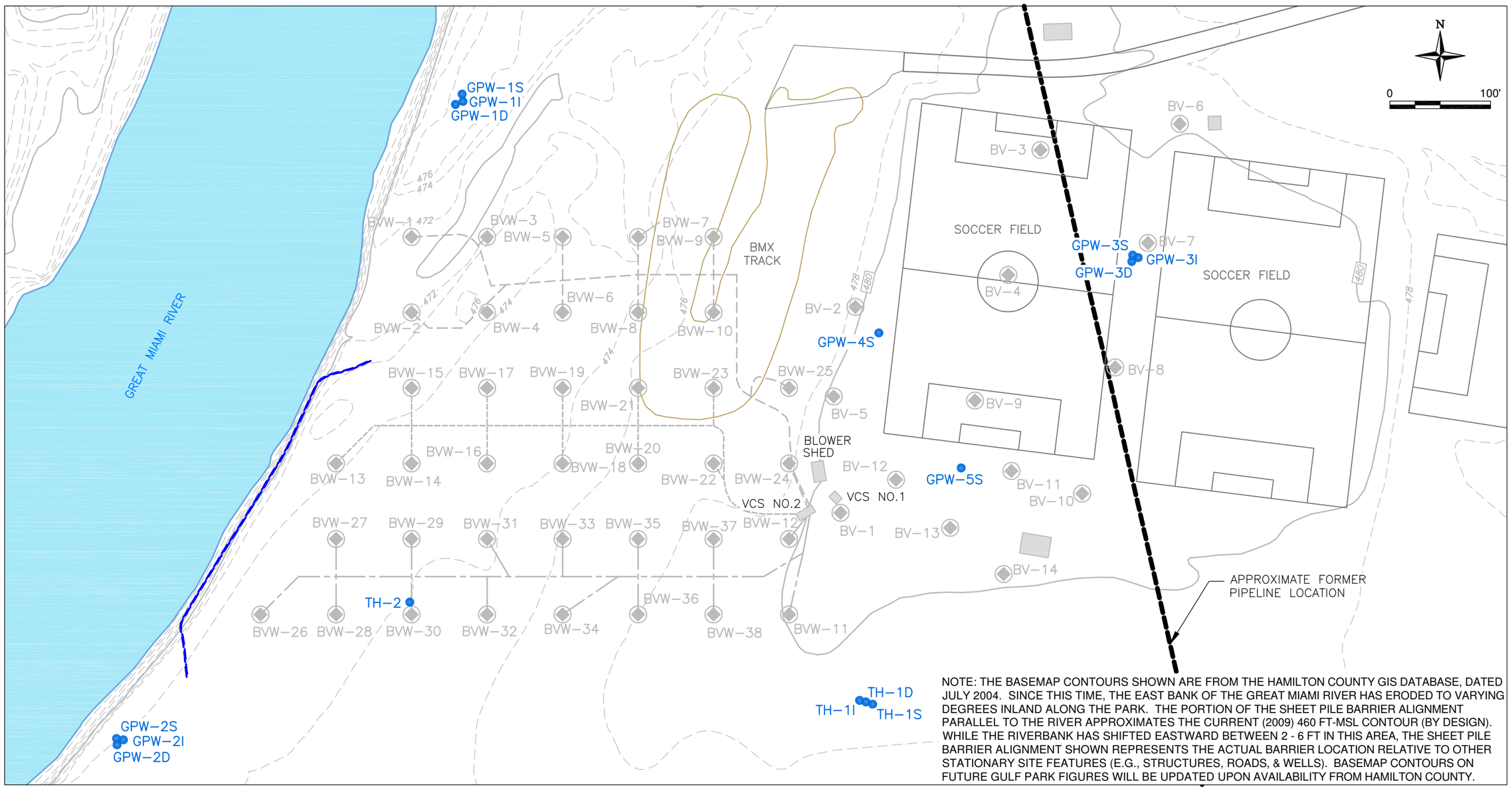
NON-DETECTED REPORTING LIMITS SET AT ONE HALF THE DETECTION LIMIT

IRON DISPLAYED AS FERROUS IRON

mg/L - MILLIGRAMS PER LITER

US EPA ARCHIVE DOCUMENT

US EPA ARCHIVE DOCUMENT



NOTE: THE BASEMAP CONTOURS SHOWN ARE FROM THE HAMILTON COUNTY GIS DATABASE, DATED JULY 2004. SINCE THIS TIME, THE EAST BANK OF THE GREAT MIAMI RIVER HAS ERODED TO VARYING DEGREES INLAND ALONG THE PARK. THE PORTION OF THE SHEET PILE BARRIER ALIGNMENT PARALLEL TO THE RIVER APPROXIMATES THE CURRENT (2009) 460 FT-MSL CONTOUR (BY DESIGN). WHILE THE RIVERBANK HAS SHIFTED EASTWARD BETWEEN 2 - 6 FT IN THIS AREA, THE SHEET PILE BARRIER ALIGNMENT SHOWN REPRESENTS THE ACTUAL BARRIER LOCATION RELATIVE TO OTHER STATIONARY SITE FEATURES (E.G., STRUCTURES, ROADS, & WELLS). BASEMAP CONTOURS ON FUTURE GULF PARK FIGURES WILL BE UPDATED UPON AVAILABILITY FROM HAMILTON COUNTY.

EXPLANATION

- GPW-2D — GROUNDWATER MONITORING WELL AND DESIGNATION
- BVW-26 — BIOVENT WELL AND DESIGNATION
- EXPANDED BIOVENTING SYSTEM PIPE RUN #1
- EXPANDED BIOVENTING SYSTEM PIPE RUN #2
- EXPANDED BIOVENTING SYSTEM PIPE RUN #3
- SHEET PILE BARRIER WALL
- 480 — GENERAL TOPOGRAPHIC CONTOUR (FT-AMSL, INTERVAL 2 FEET, DASHED WHERE INFERRED)
- BUILDING, TANK OR OTHER STRUCTURE
- ROAD
- VCS — VALVE CONTROL SHED
- FT AMSL — FEET ABOVE MEAN SEA LEVEL

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Laramie, Wyoming 82070
www.trihydro.com
(P) 307/745.7474 (F) 307/745.7729

FIGURE 4-1

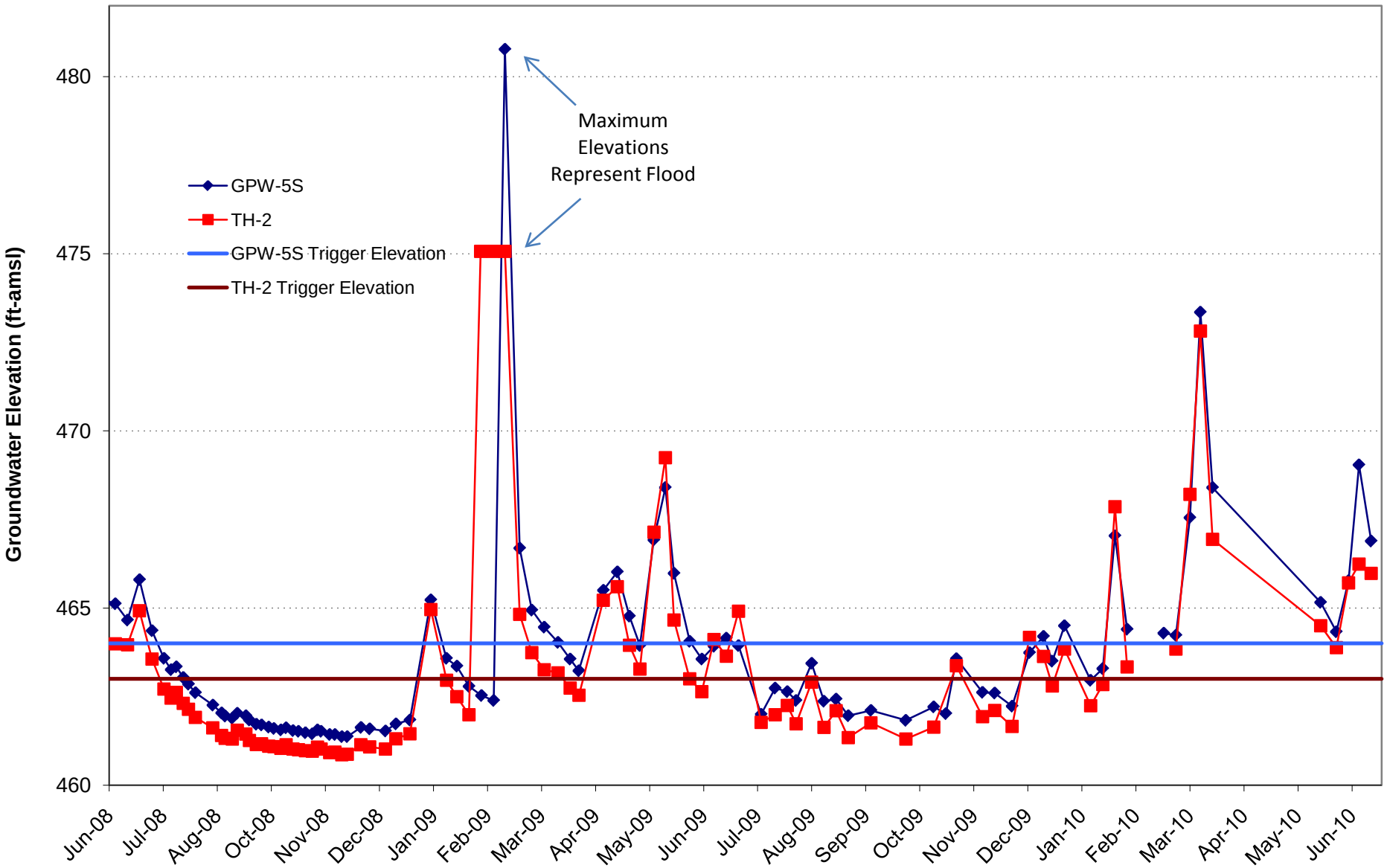
GULF PARK LAYOUT

FIRST 2010 SEMIANNUAL MONITORING PERIOD
CHEVRON CINCINNATI FACILITY
HOOVEN, OHIO

Drawn By: REP	Checked By: JP	Scale: 1"=100'	Date: 1/13/2011	File: 500GP_LAYOUT201011

US EPA ARCHIVE DOCUMENT

FIGURE 4-2. HYDROGRAPHS AND TRIGGER LEVELS FOR TH-2 AND GPW-5S (JUNE 2008-JUNE 2010)
FIRST 2010 SEMIANNUAL MONITORING PERIOD
GULF PARK, CLEVES, OHIO



201103_TriggerHydrograph_FIG-4-2

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FIGURE 4-3. TOTAL BTEX CONCENTRATION VERSUS TIME FOR MONITORING WELLS GPW-1S, GPW-2S, GPW-3S, GPW-4S, GPW-5S
FIRST 2010 SEMIANNUAL MONITORING PERIOD
GULF PARK, CLEVES, OHIO

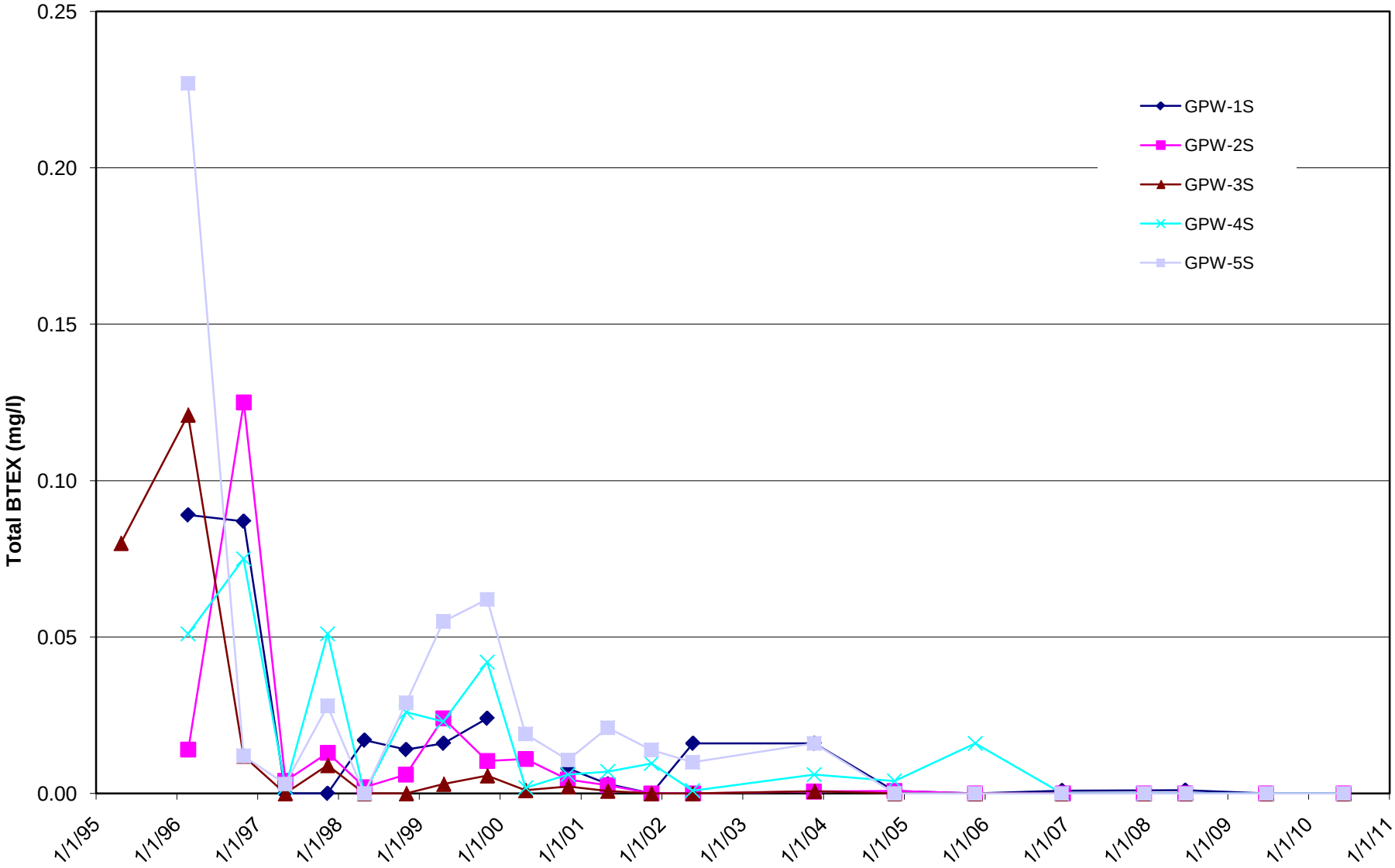

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FIGURE 4-4. TOTAL BTEX CONCENTRATION VERSUS TIME FOR MONITORING WELL TH-1S
FIRST 2010 SEMIANNUAL MONITORING PERIOD
GULF PARK, CLEVES, OHIO

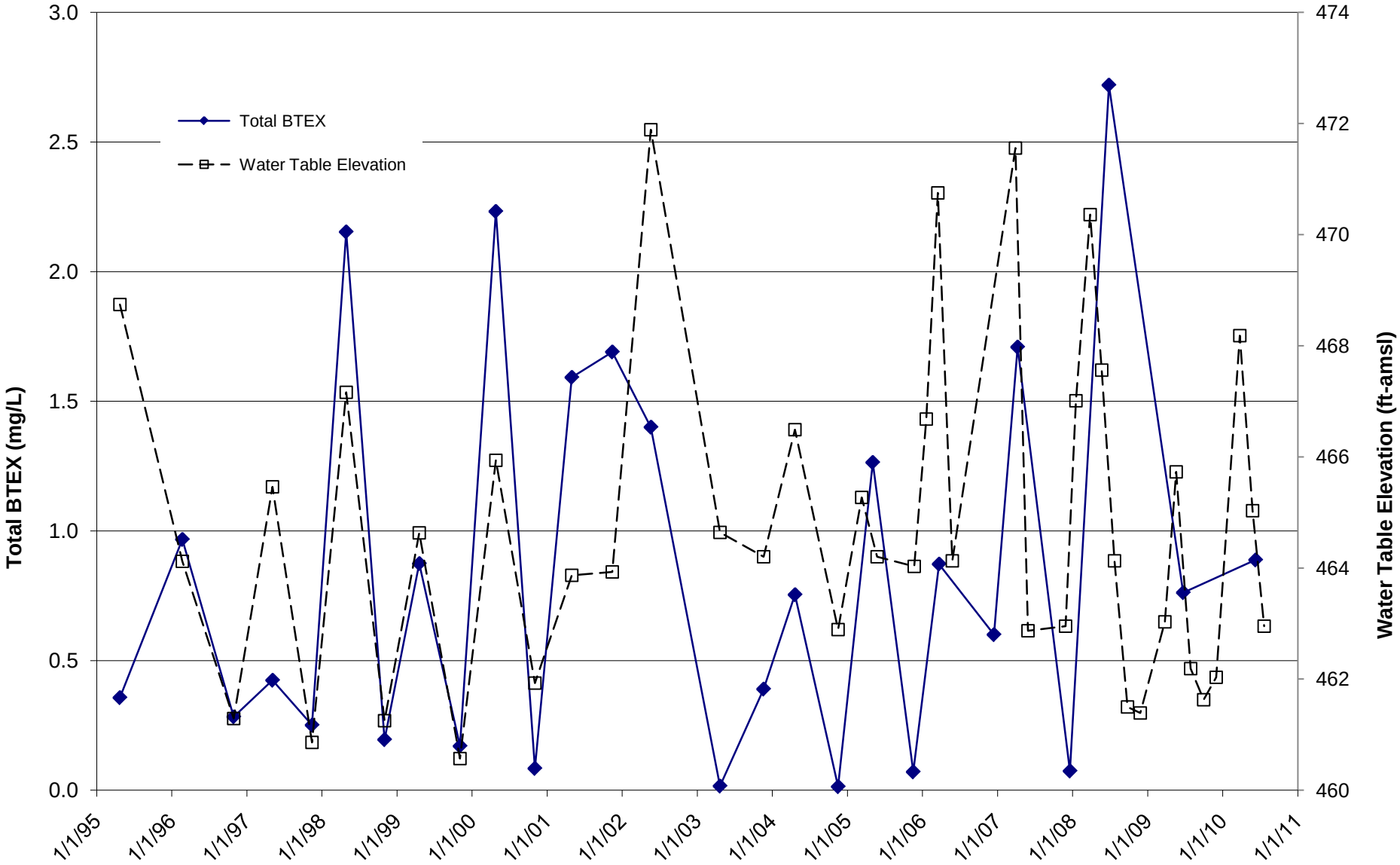

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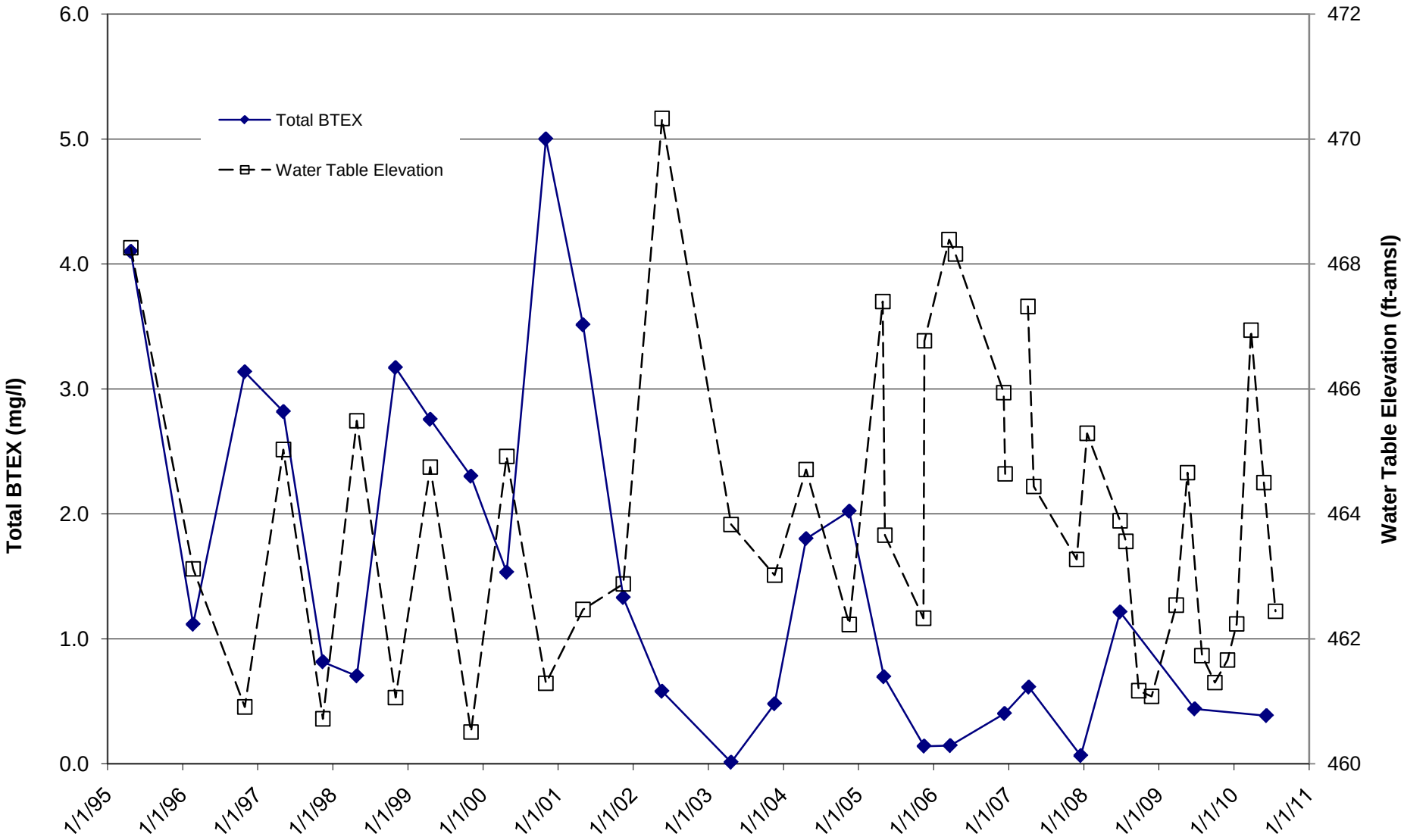
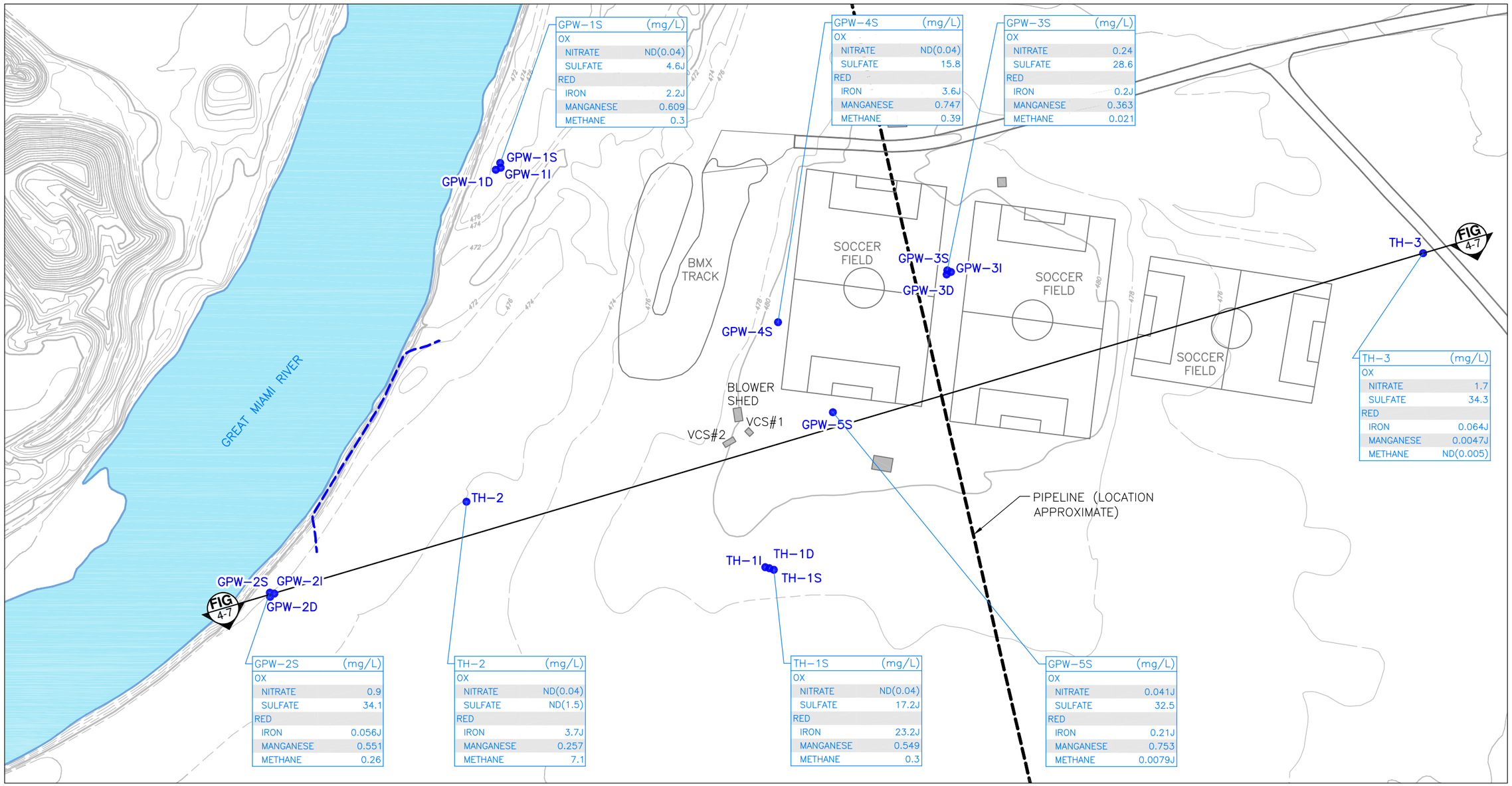
FIGURE 4-5. TOTAL BTEX CONCENTRATION VERSUS TIME FOR MONITORING WELL TH-2
FIRST 2010 SEMIANNUAL MONITORING PERIOD
GULF PARK, CLEVES, OHIO



US EPA ARCHIVE DOCUMENT



EXPLANATION

GPW-2S	SHALLOW GROUNDWATER MONITORING WELL AND DESIGNATION
	STRUCTURE
	ROAD
	SHEET PILE BARRIER WALL
480	GENERAL TOPOGRAPHIC CONTOUR (FT AMSL, INTERVAL 2', DASHED WHERE INFERRED)

FT AMSL	FEET ABOVE MEAN SEA LEVEL
mg/L	MILLIGRAMS PER LITER
VCS	VALVE CONTROL SHED

N

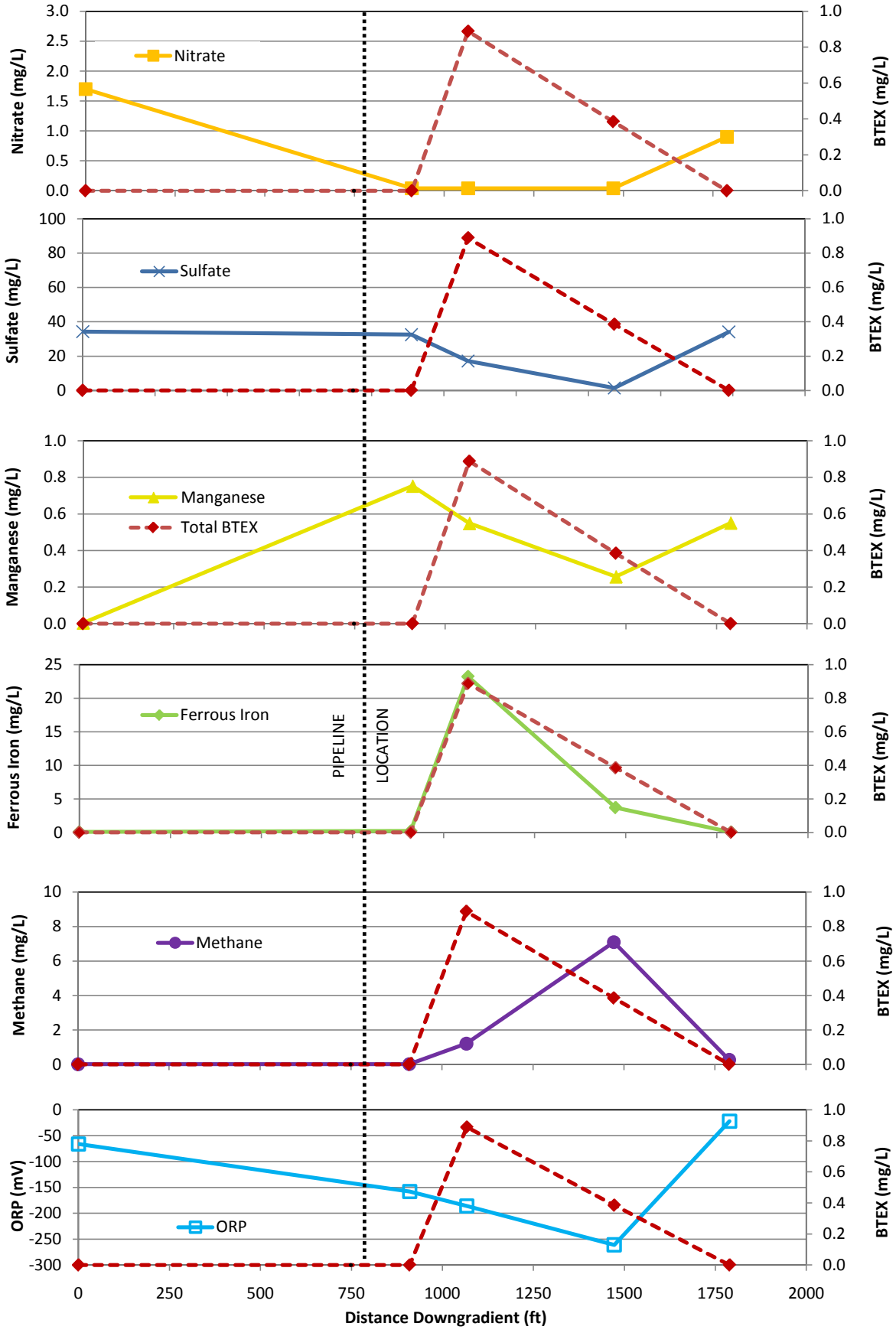
0 150'

Trihydro CORPORATION
1252 Commerce Drive
Laramie, Wyoming 82070
www.trihydro.com
(P) 307/745.7474 (F) 307/745.7729

FIGURE 4-6
SUMMARY OF GROUNDWATER OXIDATION AND REDUCTION TRENDS (JUNE 2010)
FIRST 2010 SEMIANNUAL MONITORING PERIOD
GULF PARK
CLEVES, OHIO

Drawn By: REP	Checked By: JP	Scale: 1" = 150'	Date:11/22/2010	File: 500GP_2009_OXRED201011

FIGURE 4-7. TOTAL BTEX AND NATURAL ATTENUATION INDICATOR CONCENTRATION VERSUS DISTANCE
FIRST 2010 SEMIANNUAL MONITORING PERIOD
GULF PARK, CLEVES, OHIO



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APPENDICES A THROUGH G

(PLEASE SEE ATTACHED CD)