OPERATION, MAINTENANCE AND MONITORING PLAN FOR

FINAL GROUNDWATER REMEDY

CHEVRON CINCINNATI FACILITY

HOOVEN, OHIO

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PREPARED BY: Trihydro Corporation

1252 Commerce Drive, Laramie, WY 82070

SUBMITTED BY: Chevron Environmental Management Company

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

Trihydro CORPORATION

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1.0 INTRODUCTION

This Operation, Maintenance, and Monitoring (OMM) Plan, in combination with the Remediation Implementation Plan (RIP), details plans and schedules for long-term operation of the final groundwater remedy at the Chevron Cincinnati Facility (Facility) in Hooven, Ohio. A general layout of the former refinery and surrounding area is shown in Figure 2-1. Chevron and the United States Environmental Protection Agency (USEPA) executed an Administrative Order on Consent for implementation of the Final Groundwater Remedy on November 1, 2006 (2006 Order). This Plan is intended to satisfy Paragraph 11 of the 2006 Order by detailing long-term procedures that will be followed to operate, maintain, and monitor the remediation systems and overall cleanup progress. The RIP describes the physical systems and infrastructure that will be constructed in the short term (e.g. over the next six to 12 months) in order to accomplish the remedy.

In accordance with the 2006 Order, this OMM Plan specifies requirements for operation, maintenance and monitoring of components of the groundwater remedy at the Facility, including well locations, monitoring parameters, pumping rates, and sampling schedules necessary to conduct groundwater remedy components specified herein. As such, this Plan is arranged in sections representative of selected remedy components, rather than functional areas, and is intended as a work plan which will serve as an operational tool for those performing work directed by remedy agreements summarized in the RIP. This Plan has been prepared with the input of those experienced with the site remedial history, and in operating, maintaining, and monitoring the systems and components addressed herein.

Sampling and analysis conducted in accordance with this Plan, under direction of the approved 2006 Order, will be performed in accordance with the USEPA approved, amended Quality Assurance Project Plan Policy (QAPP) for the site. Alterations from the methodology specified in the QAPP will be noted in routine reports submitted under this Plan, and amendments to the QAPP may be requested in writing to the USEPA, from time to time as warranted by changes in the site conditions or standard industry practices.

Routine operations and monitoring at the site has to date been conducted under a 1993 Order. That Order terminated and was superseded with issuance of the 2006 Order, but routine monitoring and reporting have continued under the terms of the 1993 Order while the combined RIP/OMM Plan was being prepared and reviewed. Upon USEPA approval of the combined RIP/OMM Plan, work will thereafter be performed under requirements set forth therein. Furthermore, the groundwater containment pumping and granular activated carbon (GAC) water treatment system will cease continuous operation upon USEPA approval of this RIP/OMM Plan. Should implementation of the contingencies covered in this plan direct resumption of the site-wide groundwater recovery system, the system will be operated under the parameter shown to be effective in the past. Operation of the site-wide groundwater recovery system currently entails production of 1000 to 1600 gallons per minute, including from one or more production wells in the southwest area of the plume plus a production well located in the northern portion of the refinery for supply of supplemental oxygen-rich water to the GAC. In recent years, production well #20 has been operated most often for groundwater recovery due to its location in the extreme southwest corner of the refinery property. However, production wells #15, #19, #21, #23, and proposed production well #24 will also be available for use. The groundwater recovery production well(s) will be selected based on their potential to carry out the contingency which has triggered resumption of the system, and as needed to resume overall hydraulic control at the down-gradient edge of the plume.

It is anticipated that there may then be a transition period while new infrastructure systems are being constructed, during which new wells or other infrastructure will not yet be available for operation or testing. During that period, existing infrastructure will be sampled during a given event. New infrastructure will be sampled or operated as soon as construction is complete. Construction of most of the monitoring infrastructure described in the RIP is expected to be completed within three to six months of USEPA approval of the combined RIP/OMM Plan.

Site background and a brief history of regulatory documentation pertaining to the Facility are presented in the RIP. The RIP also includes a summary discussion regarding the liquid non-aqueous phase liquid (LNAPL)/Groundwater plume Conceptual Site Model (CSM), which is a key framing element to the operations, maintenance and monitoring approach described in this Plan.

2.0 GROUNDWATER REMEDY APPROACH

As detailed in the RIP, the groundwater remedy has been designed to be protective of human health and the environment, the long-term objective being the restoration of groundwater to its maximum beneficial uses by achieving drinking water MCLs throughout the area of contaminated groundwater. Groundwater will be monitored for dissolved contaminants of concern (COCs) listed in Table 2-1 for compliance with Maximum Contaminant Level (MCL) standards. The principal contaminant of concern in groundwater is benzene, although the other constituents in Table 2-1 have also periodically been detected in site groundwater. Because achieving this long-term objective will take many years, a series of interim objectives have been developed. These include:

- Protect human health and the environment
- Monitor soil vapor concentrations and prevent unacceptable indoor air exposures
- Maintain plume control to prevent migration of either LNAPL or dissolved phase constituents
- Remove recoverable LNAPL to the extent practicable
- Stabilize the Great Miami River riverbank to prevent erosion of LNAPL impacted soil

These remedial objectives are interrelated and are to be achieved through implementation of the various remedy components detailed in this Plan. This OMM Plan is arranged in sections representative of selected remedy components to be implemented in accordance with regulatory agreements presented in the RIP to monitor the stability of LNAPL and dissolved contaminant plumes and implement corrective measures should monitoring indicate plume migration. Components of the groundwater remedy are as follows:

- LNAPL and Dissolved Phase Plume Monitoring
- Seasonal High-Grade Pumping
- Granular Activated Carbon (GAC) System Operation
- Horizontal Soil Vapor Extraction (HSVE) System Operation
- Vapor Monitoring

Details for implementation, operation, maintenance, monitoring, and measuring these remedy components are presented in the following sections. Results obtained from sampling and monitoring events detailed herein will be submitted to USEPA on a semi-annual basis as detailed in the Remedy Schedule, which is attached as Appendix A to the RIP.

It is worth noting that two of the COCs listed in Table 2-1, arsenic and lead, are not subject to intrinsic biodegradation. However, the dissolved phase concentrations of these two metals is expected to decline over time to background levels. In general, the dissolved phase arsenic and lead concentrations only slightly exceed MCLs currently in the wells located within the interior portions of the plume. The concentrations will decline over time via dispersion and reduction in conjunction with anaerobic degradation of the organic constituents in the LNAPL/dissolved phase plume.

3.0 NAPL AND DISSOLVED PHASE PLUME MONITORING

3.1 COMPONENT DESCRIPTION

This component of the groundwater remedy seeks to monitor for potential migration of the dissolved-phase contamination plume, track the depletion of dissolved-phase contaminants in groundwater at the Facility, and monitor for the migration of LNAPL. Constituents consist primarily of those derived from petroleum products released at the site, including those listed in Table 2-1. Benzene is the contaminant detected most frequently above the MCL, with concentrations as high as 5,000 micrograms per liter in groundwater beneath the facility. Dissolved benzene is generally not detected more than a few hundred feet outside the area containing LNAPL (smear zone) because of an active zone of biodegradation in the oxygen-rich groundwater around the plume periphery. LNAPL is the primary source of dissolved-phase benzene observed in groundwater underneath the facility. Constituents dissolve out of the LNAPL and into the groundwater as it flows through the LNAPL smear zone.

To ensure accurate interpretation of dissolved-phase contamination data, monitoring will be performed by the following methods:

- Perimeter plume monitoring, for both LNAPL and dissolved phase stability
- Interior plume monitoring
- Monitored Natural Attenuation (MNA) monitoring
- River monitoring
- Fluid level monitoring

The following sections detail plans for monitoring of dissolved-phase constituents by these methods.

3.2 COMPONENT INSTALLATION/OPERATION

The vast majority of monitoring wells necessary for monitoring of dissolved-phase constituents is already in place. Four additional groundwater wells and three Rapid Optical Screen Tool (ROST) push boring transects will be installed in accordance with the RIP to complete the network that will allow for long-term tracking of the down-gradient plume behavior under natural flow conditions.

As described in the RIP, three groupings (transects) consisting of three ROST borings are proposed for installation perpendicular to the leading edge of the LNAPL plume, as shown in Figure 3-1. ROST technology has been identified as the preferred tool for monitoring the potential for LNAPL migration at the leading edge of the plume. ROST is designed to provide rapid sampling and real-time analysis of the physical and chemical characteristics of subsurface soil to distinguish between contaminated (primarily petroleum fuels) and non-contaminated areas. However, due to previous efforts to deploy ROST technology at the site experiencing difficulties with the tool encountering large cobbles, causing refusal or deflection of the ROST tool, installation of conventional monitoring wells having screens installed at the smear zone altitude is considered an alternative to ROST technology. ROST technology and installation methodology is presented in greater detail in the RIP. The ROST transects will be monitored for signs of LNAPL plume migration in accordance with the following subsections.

A network of three monitoring wells will be established at the current down-gradient boundary of the dissolved contaminant plume to constitute a sentinel monitoring system that will provide an early warning of potential down-gradient migration. One existing monitoring well, MW-35, and two proposed monitoring wells, MW-131 and MW-132, will be positioned to act as the sentinel monitoring system, as shown in Figure 3-1. A containment Point of Compliance (POC) well will be established down-gradient from each sentinel well, also shown in Figure 3-1. One existing monitoring well, MW-37, and two proposed monitoring wells, MW-133 and MW-134, will be established down-gradient from each sentinel well to serve as POC wells. In addition to the three POC wells which will serve as companions to sentinel wells, existing well MW-120 will serve as a fourth POC well. The location of MW-120 is ideal for a POC well, but land use restrictions do not permit the installation of a companion sentinel well. Sentinel and POC wells will be monitored for signs of LNAPL and dissolved-phase plume migration in accordance with the following paragraphs.

In support of long-term attenuation monitoring, a number of new remedy components are proposed for installation at various locations throughout the plume. These installations will all take place at the four grouped media sample locations shown in Figure 2-1. Three additional nested vapor wells (VW-21, VW-18, and VW-20) will be installed at grouped media sample locations 21, 18 and 20. Four nested groundwater monitoring wells (NW-21, NW-18, NW-20, and NW-93) will be installed at the corresponding grouped media sample locations. In addition, lysimeters will be installed at each of the four grouped media sample locations. Installations will be performed in accordance with details presented in the RIP.

With regard to the river monitoring systems, a separate plan was submitted to the USEPA in accordance with the 2006 Order requirement to evaluate and design alternatives for engineered controls and recommendations necessary to stabilize the bank of the Great Miami River at the refinery to prevent the river from eroding into LNAPL-contaminated soils. The Engineering Options Evaluation Report was approved by USEPA in a letter dated June 15, 2007. Detailed designs for construction of the proposed River bank stabilization measures, including a River Monitoring Plan, were submitted to USEPA on December 6, 2007.

A similar evaluation of the options to stabilize the river bank along an area of hydrocarbon impacts in Gulf Park was submitted to USEPA on February 28, 2007. Upon USEPA approval of the engineering option analyses, detailed stabilization measure(s) will be designed, and submitted for USEPA approval. Plans for River Monitoring at Gulf Park will be included with the detailed designs for bank stabilization measures at that location. Upon USEPA approval of the detailed designs, the long-term river monitoring plans at both locations will be incorporated into this OMM Plan.

3.3 SAMPLING/MONITORING

This section presents requirements for the following five sampling and monitoring components:

- LNAPL and dissolved-phase perimeter plume monitoring
- Interior plume monitoring
- Monitored Natural Attenuation (MNA) monitoring
- River monitoring
- Fluid level monitoring

3.3.1 LNAPL AND DISSOLVED PHASE PERIMETER PLUME MONITORING

Down-gradient plume monitoring will be performed on a semiannual basis for the first five years, annually for the next five years (staggered for seasonality), biennially for the next ten years, and every five years thereafter. The exception to this schedule is any newly installed groundwater monitoring well, which will be monitored on a quarterly basis for the first two years following installation in order to develop an initial data set. Monitoring will be performed on three ROST transects, sentinel and POC monitoring wells, and general perimeter plume groundwater monitoring wells.

ROST technology will be utilized to monitor the LNAPL plume stability at its down-gradient edge. At the ROST transects shown on Figure 3-1, ROST technology will be utilized to screen for the presence of petroleum compounds at each well during each sampling event. The tool will be advanced from approximately 5 feet above the water, to approximately 5 feet below the water table. The anticipated water table elevation will be estimated at the ROST wells during each sampling event using either the ROST tool, or based on measured levels at a nearby groundwater monitoring well.

Water table data can be collected from ROST borings through piezocone penetration testing by conducting pore pressure dissipation testing. The cone is stopped at a suitable point while advancing the CPT, and the pore pressure is allowed to dissipate to hydrostatic pressure. A suitable soil would be a sand or silty soil. In sands a typical dissipation test can be completed in a few minutes. While it is possible to do dissipation testing in clays it is not practical as it can take from several hours to several days for the pore pressure to fully dissipate. However, the soil throughout the area of testing in the Southwest Quadrant is primarily sand and gravel, so this method will be attempted to verify the water table elevation during each sampling event. If this method proves ineffective, then water table elevations will be inferred from measurement with a fluid level probe in the nearest groundwater monitoring well. The ROST screen results will provide an indication of the presence/absence of LNAPL at each location.

The ROST is a Tunable Dye Laser pumped by an ND-Yag Laser. The yag laser generates a pulsed light at 532 nm wavelength. Light is produced using a flash lamp which acts like a strobe. As the flash lamp ages the amount of light energy it produces decreases. The average usable life time of a flash lamp is 30 to 40 million flashes.

The tunable dye laser produces light at 580 nm which is doubled to 290 nm then filtered to remove visible light. The 290 nm light is transmitted down the hole through a fiber optic line to the ROST window. When the photons of light strike a ringed hydrocarbon molecule the photons are absorbed by the molecule, raising the energy state of the molecule. It returns to its natural state by releasing energy in the form of photons. Some of the photons are captured by a second fiber optic line and returned to the equipment on the surface. A monochrometer breaks the light (photons) into individual wavelengths of light and sends four wavelengths (340nm, 390nm, 440nm and 490nm) to a photomultiplier which converts the light into an electrical signal which can be measured with a digital oscilloscope. The digital signal is sent to the computer during testing.

Prior to each test the fluorescence signature of a standard mixture of synthetic motor oil is recorded. The standard has a known fluorescence signature and is used to standardize the ROST test. The power output of the laser can change due to environmental conditions (i.e. temperature, humidity, etc.) and aging of the components of the system. Use of the standard normalizes the data. The area of the waveform for the M1 Standard becomes 100% fluorescence intensity for that test. The area of each waveform taken during a test is given as a percentage of the area of the M1 Standard waveform.

The ROST probe is ideally advanced into the soil at a rate of 2 cm per second. Readings are taken at 1 second intervals. The readings are displayed on the computer monitor in real time and saved to disk. The computer displays two graphs, fluorescence intensity vs. depth and current fluorescence waveform. The fluorescence waveform graph updates every second during the test. Background fluorescence is generally 1 to 1.5 percent or less.

Prior to testing at a site, a sample of products present at the site is tested on the ROST window in the laboratory to determine the signature of the product and the intensity of fluorescence. Different fuels have different signatures. Pure gasoline and diesel fuels generally have fluorescence intensities of 100% or more. Intensities between 100% and 1000% have been observed in free product plumes at various diesel sites around the country. Because the age of the fuel can influence the signature and intensity, smear zones are generally below 100%. Each site is different and requires verification locally.

The ROST equipment will be operated by the ROST contractor, according to their standard operating procedures. Because ROST equipment operation is an evolving science, there are not currently detailed written protocols available that can be incorporated into the site QAPP. Chevron will work with the ROST contractor to develop a SOP that can be integrated to the QAPP at a future date.

Sentinel monitoring wells located down-gradient of the plume, as listed in Table 3-1 and shown on Figure 3-1, will be monitored for the presence of LNAPL and sampled according to frequencies stated above and analyzed for groundwater COCs listed in Table 2-1 for comparison to MCL standards. Primarily, sentinel wells are intended as an “early warning” of the potential for dissolved-phase contaminant migration. However, sentinel well monitoring results may require interpretation relative to the conditions at the time of sampling. In general, if the migration of LNAPL or dissolved-phase plumes is indicated in a sentinel well by the detection of a COC at a concentration above the MCL, the sentinel well will be re-sampled along with the paired down-gradient point-of-compliance (POC) well. If an MCL exceedence in a sentinel is confirmed, contingencies will be implemented, as detailed in subsection 3.4.1.

Similarly, POC monitoring wells, as listed in Table 3-1 and shown on Figure 3-1, will be sampled on the same frequency and analyzed per the same criteria described above for sentinel wells. General perimeter plume monitoring wells listed in Table 3-1 and shown in Figure 3-2 will also be sampled semiannually for the first five years, annually for the next five years (staggered for seasonality), biennially for the next ten years, and every five years thereafter and analyzed for groundwater COCs listed in Table 2-1 for comparison against MCL standards.

3.3.2 INTERIOR PLUME MONITORING

Interior plume monitoring will be performed at monitoring wells listed in Table 3-2 and shown in Figure 3-3 to collect data to track degradation trends in dissolved-phase groundwater COCs listed in Table 2-1. Sampling will be conducted on a semiannual basis for the first four sampling events in order to establish COC baseline data. Thereafter, interior plume sampling will be performed annually for the next ten years, and then biennially thereafter.

3.3.3 MONITORED NATURAL ATTENUATION (MNA) MONITORING

Section 2.2 of the RIP provides a discussion of the Groundwater Conceptual Site Model. Figures 2-2 and 2-3 from the RIP are also included in this Plan, for reference relative to an overall understanding of the CSM. The MNA monitoring program is framed around the CSM, as discussed further below.

The Facility's MNA program will sample for the COCs and parameters listed in Table 3-3. These constituents are summarized from the USEPA Region 5 guidance for MNA for sites where the contaminant is petroleum hydrocarbons and the primary mechanism for MNA is biological degradation under either oxygenated or anoxic conditions. As additional background regarding the rational for MNA monitoring plans, Table 3-4 summarizes the rationale for use for various MNA parameters, also summarized from Region 5 MNA Guidance. Table 3-4 represents a comprehensive list of MNA parameters that is included in this work plan for reference purposes only. Not all of the parameters listed in Table 3-4 will be monitored, and it is anticipated that revisions to Table 3-3 may be proposed in the future based on ongoing results and evaluations. The overall MNA monitoring program involves a number of monitoring parameters and strategies, some of which have yet to be tested at the site. The intent is to begin collecting the information outlined in this Plan, making adjustments as warranted based on initial results. The optimal target media, type of collection and analyses, locations, and/or interpretation methodology for supplemental monitoring addressed herein may change over time based on analysis relative to tracking overall plume remedy progress and evolving industry practices. If Chevron identifies improvements to the monitoring plan, it will submit them for USEPA approval as an amendment to this Plan.

The primary attenuation pathways linked to the plume degradation are as follows:

1. Dissolution of COCs from LNAPL in smear zone soils and subsequent biodegradation. Aerobic biodegradation is expected to be an important process at the periphery of the smear zone. Anaerobic biodegradation is expected to be the dominant process within the smear zone, and within the transition zone immediately down-gradient of the smear zone. This trend of aerobic to anaerobic biodegradation is expected to occur in both the lateral and vertical dimensions:

    - Lateral dimension – groundwater up-gradient of the smear zone will provide water with significant dissolved oxygen. This oxygen will be consumed via aerobic biodegradation as groundwater moves laterally into the smear zone. Subsequently, anaerobic processes will occur. A previous natural attenuation study identified sulfate reduction, nitrate reduction, ferric iron reduction, and methanogenesis as anaerobic processes occurring at the site.

    - Vertical dimension – infiltrating groundwater from the ground surface, especially following precipitation events, will provide additional dissolved oxygen to the groundwater within the smear zone. Therefore, COCs in the upper portion of the aquifer will undergo aerobic biodegradation to some extent. Below the smear zone, it is not anticipated that aerobic processes will be important. This is because previous sampling of "deep" groundwater has measured low dissolved oxygen concentrations.

2. Volatilization of COCs from LNAPL in smear zone soils and subsequent biodegradation in overlying soil gas. Degradation in this phase is thought to be primarily aerobic.

The natural attenuation rates are expected to show some seasonal variation, with the primary driver of this variation being water table elevations. In periods when the water table is high, then the amount of groundwater entering the smear zone from upgradient will be larger than when the water table is low. This will tend to increase the amount of partitioning of COCs to groundwater and the supply of electron acceptors, leading to increased biodegradation. However, during these periods when the water table is high, the amount of smear zone exposed to soil gas will be small compared to when the water table is low. This will have the effect of decreasing the amount of volatilization of COCs to soil vapor and subsequent biodegradation.

Finally, the amount of COCs that are depleted from the smear zone is expected to change over the long term. Many models simplify natural attenuation as a first-order process, meaning that the amount of attenuation of a COC at any given time is proportional to the concentration of the COC at that time. While this is a simplification of the complex partitioning/degradation system, it does provide for a general picture of the future of natural attenuation processes at the site. At some point in the future, the amount of COCs that are attenuated from the smear zone will be small compared to that in previous years. This is because the COC concentrations will have decreased in the LNAPL and the vapor and groundwater "daughter" phases. However, the COC concentrations will continue to decrease, though at a lower rate, indicating continued natural attenuation processes. Only when COC concentrations are extremely low (presumably when they are lower than MCLs in groundwater) would natural attenuation no longer be a viable process.

Attenuation processes via both the groundwater and the vapor pathway will be monitored under this Plan. In groundwater, COCs and geochemical parameters will be monitored in wells up-gradient, within the smear zone, in the transition zone, and down-gradient near US 50. In soil gas, vapor concentrations will be monitored in nested wells installed in the vadose zone. Below is a discussion of DQOs for monitoring these natural attenuation pathways.

Step 1 – State the Problem

Monitored natural attenuation processes must be tracked. Attenuation occurs as COCs partition from LNAPL in the smear zone and are subsequently consumed via aerobic and anaerobic biodegradation in both the aqueous and vapor phases.

Step 2 – Identify the Decision

Qualitative evidence of natural attenuation and quantitative estimates of natural attenuation rates of COCs are desired.

Step 3 – Identify Inputs to the Decision

Because natural attenuation in groundwater and vapor occurs via multiple steps (dissolution of COCs from smear zone soils, followed by biodegradation of COCs in groundwater, and volatilization of COCs from exposed smear zone soils and dissolved phase groundwater into vadose zone soil and subsequent biodegradation), multiple sets of data will be collected. The first data set is dissolved COCs in groundwater, as listed in Table 2-1. The second data set is geochemical parameters in groundwater, as listed in Table 3-3. The third data set is COCs and related indicator parameters in soil vapor. The COC data can be used directly to identify natural attenuation processes; decreasing COC concentrations in groundwater within the smear zone over time are indicators of natural attenuation. The COCs concentrations can also be used in conjunction with geochemical data. The rate of dissolution of COCs can be estimated by comparison of COC concentrations up-gradient and within the smear zone. Similarly, the rate of consumption of electron acceptors, and generation of reduced species, can be estimated by comparison of geochemical trends up-gradient to within the smear zone. Taken together, the sum of these processes provides an estimate of the natural attenuation rate.

Step 4 – Define the Boundaries of the Study

Lateral dimension – Up-gradient of the smear zone, groundwater supplies electron acceptors for biodegradation. Within the smear zone, COCs will partition to groundwater. The electron acceptors provided by the up-gradient water are used in biodegradation processes. Immediately down-gradient of the smear zone (i.e., the "transition zone"), COCs no longer partition to groundwater. In this transition zone, biodegradation processes continue until the COCs are consumed. Down-gradient of the transition zone, biodegradation processes no longer occur as the COC concentrations have been depleted.

Vertical dimension – Above the smear zone, water infiltrates vadose zone soil during precipitation events. Some of this water migrates to the top of the groundwater. This water is expected to supply electron acceptors, especially dissolved oxygen, that are used in biodegradation processes. Below the smear zone, some groundwater may enter the smear zone during periods of water table rise. Based on previous investigations, this water is not expected to supply significant dissolved oxygen. However, it may provide other electron acceptors that are used in anaerobic biodegradation processes.

Step 5 – Develop a Decision Rule

Spatial trends in geochemical parameters will be used to qualitatively demonstrate that natural attenuation is occurring. Because each of the geochemical parameters listed in Table 3-3 plays a different role in natural attenuation processes, the decision rule for each parameter is also different. The decision rules for the individual parameters have been added as Table 3-5.

The decision rule for all organic COCs is the same. To demonstrate natural attenuation processes qualitatively, COC concentrations up-gradient of the smear zone should be low/non-detect. Within the smear zone, COC concentrations should be higher than any other concentrations in the study area. Within the transition zone, COC concentrations should be intermediate to low. Down-gradient of the transition zone, COC concentrations should be low/non-detect.

The rate of natural attenuation will be estimated for each sample event based on the spatial distributions of geochemical parameters and COCs. Both sets of data will be input to the calculation so that the rate of dissolution and the rate of subsequent biodegradation can be estimated. The rate of natural attenuation will also be estimated by plotting COC concentrations vs. time.

Step 6 – Specify Tolerable Limits to Decision Errors

Natural attenuation will be demonstrated qualitatively by consideration of spatial trends in geochemical parameters and COCs. Natural attenuation rates will also be estimated quantitatively using both approaches described in Step 5 above. Also, though not discussed in detail here, natural attenuation processes will also be monitored by measurement of LNAPL composition in smear zone soils. All of these approaches considered together will be used to provide a weight of evidence of natural attenuation processes. Natural attenuation will not be considered to be a viable remedy if none of these approaches demonstrates ongoing natural attenuation.

Step 7 – Optimize the Design for Obtaining Data

The spatial distribution of monitoring wells is based on the Conceptual Site Model, which holds that groundwater COC concentrations are expected to be non-detect up-gradient of the smear zone, relatively high within the smear zone, intermediate within the transition zone, and non-detect down-gradient of the transition zone, near US 50. The MNA plan has been designed to monitor COC concentrations in wells in each of these areas.

Note that sampling wells have been added to those proposed in the original draft OMM plan in order to ensure adequate characterization of each zone. Recognizing that groundwater generally flows north to south-southwest, wells were selected to provide multiple samples from up-gradient to down-gradient. In addition, multiple wells are located along some east-west transects, allowing for evaluation of groundwater COC concentrations in areas where groundwater flow deviates from the general north to south-southwest trajectory. Groundwater COC concentrations will be monitored to provide a complete picture of spatial trends as one line of evidence relative to natural attenuation.

In addition, the groundwater COC concentrations within the smear zone will be analyzed for temporal trends. Chevron has monitored groundwater BTEX concentrations within smear zone wells since 1989 on at least a semi-annual basis. The BTEX concentrations have been plotted versus time and are presented in Appendix B. For most wells, BTEX concentrations have decreased during this period. Trend graphs will be continue to be updated and BTEX degradation rates calculated for wells included in this Plan.

Because semi-annual monitoring of BTEX concentrations has already been performed for many of the smear zone wells, and the general weight of evidence indicates decreasing concentrations with time, the existing data set appears adequate to provide baseline trend information specified in the Region 5 MNA Framework. As described in later sections, these wells will be sampled for the COCs in Table 2-1 on a semi-annual basis for the first two years. This will allow for the continued calculation of BTEX half-lives and tracking of COC degradation trends. After the first two years of the MNA program, sufficient data will have been collected to characterize seasonal variations in these trends.

As described in this plan, Chevron anticipates that wells pertinent to tracking attenuation will be sampled for evaluation of geochemical parameters and COCs at both high and low water table elevations. The water table elevations and groundwater flow directions, important inputs to quantitative estimates of natural attenuation rates, will be determined by the semi-annual fluid level gauging. After the first two years, it is anticipated that the effect of different water table elevations will be sufficiently characterized. Thus, after the first two years, the sampling frequency will be reduced to annually for the next 10 years, and then to biennially thereafter.

As discussed in Section 2.2 of the RIP, the Conceptual Site Model holds that the monitoring programs outlined herein will further demonstrate that the LNAPL and dissolve-phase plume is stable and is naturally degrading over time. Remaining LNAPL is gradually depleting through several mass loss mechanisms, including biodegradation, dissolution into groundwater and subsequent dispersion and biodegradation, as well as volatilization from the top of the smear zone into the overlying vadose zone. As such, there are several lines of evidence that can be accumulated to track and document these processes over time, including:

1. MNA tracking
2. Supplemental Plume-wide dissolved-phase extent monitoring
3. Soil Core LNAPL GC fingerprinting
4. Core-plume vapor profile monitoring
5. Vertical profile dissolved-phase monitoring
6. Baseline vapor diffusion coefficient soil sampling
7. Lysimeter sampling

While it is not feasible to specify precise degradation milestones that will occur in the future, it is expected that the five-year MNA reviews will provide an overall indication of long-term contaminant mass loss. The primary mass loss mechanisms will initially be quantified and tracked following the protocol described in a recent paper by Johnson and Lundegard, and Liu titled "Source Zone Natural Attenuation at Petroleum Hydrocarbon Spill Sites—I: Site-Specific Assessment Approach", in Ground Water Monitoring & Remediation 26, no. 4/ Fall 2006/pages 82–92. Based on the results of this methodology, it is anticipated that at the first five-year review (2011) it will be feasible to estimate the total mass loss rate that is occurring, and to prepare an updated estimate of the total time that will be required to reach the end remedy goals. The overriding regulatory document for consistency of MNA analysis remains the USEPA Region 5 Framework for Natural Attenuation Decisions for Groundwater, 2000, as stated in paragraph 11(f) of the 2006 Order. The updated estimate will be compared to the Order timeframe to ensure that natural attenuation is on track, and interim goals for future 5-year reviews will be developed.

3.3.3.1 MNA TRACKING

Wells to be monitored in the MNA program are listed in Table 3-6 and shown in Figure 3-4. MNA sampling will be conducted on a semiannual basis for the first two years in order to establish COC baseline data. MNA sampling will be performed annually for the next ten years and biennially thereafter.

3.3.3.2 SUPPLEMENTAL DISSOLVED-PHASE EXTENT MONITORING

Supplemental wells listed in Table 3-7 and illustrated on Figure 3-4 will be sampled semiannually for the first two years, annually for the next ten years, and biennially thereafter. Samples will be analyzed for TPH and COCs listed in Table 2-1 in accordance with the protocol in this Plan and the site QAPP, as needed to provide a more detailed snapshot of the dissolved phase nature and extent. Efforts will be made to sample at various groundwater elevations to account for impacts that seasonal groundwater fluctuations may have on sample results. Revisions to the supplemental dissolved-phase monitoring program may be proposed to the USEPA at a future date, depending on developing needs of the project and the results of initial data interpretation.

3.3.3.3 SOIL CORE LNAPL GC FINGERPRINTING

The intent of LNAPL fingerprinting will be to track changes in remaining hydrocarbon composition over time, in particular with regard to total petroleum hydrocarbon (TPH) and COCs identified in Table 1 of the 2006 Order, as listed in Table 2-1. The time-sequenced fingerprint results will be compared to evaluate ongoing rates of LNAPL degradation. Because the natural degradation process takes many years to demonstrate statistically meaningful changes, samples will generally be collected once every five years, preceding the five-year progress reviews specified in the Final Remedy. A baseline data set will be established with the first full round of monitoring. Thus, an initial set of LNAPL samples will be collected once USEPA approves this Plan. Subsequent sample sets will be collected approximately six months before the first five-year review, and then every five years thereafter. Efforts will be made to sample at various groundwater elevations to account for impacts that seasonal groundwater fluctuations may have on sample results.

LNAPL fingerprinting will target three depth intervals vertically across the smear zone (e.g. near the top, middle and bottom of smear zone) at four locations horizontally across the plume axis. The four locations correspond to the approximate locations of existing monitoring wells MW-21, MW-18R, MW-20S, and MW-93S, as shown on Figure 3-4. Vapor and vertical dissolved-phase profiles later discussed in this Plan will also be collected at these locations, termed grouped media sample locations. Grouped media sample locations are shown in Figure 2-1 and listed in Table 3-8.

LNAPL will generally be sampled by collecting soil samples from targeted depth intervals within the smear zone. The exact depth intervals at each location will initially be based on field observations regarding the location of the smear zone. If scheduling and logistics permit, ROST pushes may be performed at soil sampling locations during the first sampling event to better identify the smear zone intervals. Once initial sample sets are collected, subsequent sampling events will target the same depth intervals at each location, so that results can be compared over time relative to conditions at the same approximate locations.

LNAPL-impacted soil samples will be transferred in the field from a split-spoon or similar type sampler, directly into appropriate sample containers. Samples will be collected in a manner which will minimize headspace in the sample container to prevent loss of volatiles. The lid on each sample container will be tightly secured and the sample label filled out completely, recording sample identification, date and time of collection, project name, client name, field personnel initials, and requested analyses. Sample containers will be placed on ice and proper custody maintained. Glass containers will be protected against breakage during transport to the laboratory.

Actual LNAPL samples will be extracted from soil samples at the laboratory through centrifuge, or other appropriate means. Caution will be exercised during lab extraction to limit the potential for volatile losses. LNAPL GC fingerprinting will be obtained through analysis of VOCs via USEPA Method 8260B and SVOCs via USEPA Method 8270C, with a request for a full chromatographic run to be provided with results. Samples will be submitted to Lancaster Laboratories, Inc. in Lancaster, Pennsylvania, or another lab accredited for the analyses. Selected LNAPL samples may also be submitted for analysis of hydrocarbon characterization, viscosity, and API gravity to Energy Laboratories in Billings, Montana, or to another accredited laboratory qualified to provide results comparable to historical LNAPL API characteristics analysis.

The primary use of LNAPL GC fingerprinting analysis will be to track changes in the mole fraction of COCs listed in Table 2-1 in LNAPL over time, with primary emphasis on benzene. Thus, benzene concentration results will generally be converted to mole fraction and graphed relative to past results. Additional forensic comparisons may be undertaken to track changes over time, such as comparison of chromatographic signatures.

To the extent feasible, Chevron will attempt to extract LNAPL from the soil samples. This will allow for direct conversion of COC concentrations to mole fractions in LNAPL. These mole fractions will be plotted vs. time to estimate the rate of natural attenuation of the COCs. This will be a line of evidence for natural attenuation that will be considered along with trends in groundwater and vapor. Because the attenuation of COCs in LNAPL is expected to take many years to demonstrate statistically meaningful changes, samples will generally be collected once every five years, preceding the five-year progress reviews specified in the Final Remedy.

It is expected that, as the amount of LNAPL decreases in smear zone soils over time, it may become infeasible to extract sufficient volume of LNAPL from the soil samples for laboratory analysis. In these cases, the soil samples will be analyzed directly for the COCs and modified TPH. Issues of heterogeneity of soil samples may mean that, at best, these results will be useful as qualitative evidence of natural attenuation. Valid quantitative estimates of natural attenuation rates may not be practicable for these soil sampling results.

3.3.3.4 CORE PLUME VAPOR PROFILE MONITORING

Vapor monitoring will be performed to document LNAPL mass loss across the plume and subsequent biodegradation through the vapor phase. A nested vapor well will be constructed at each grouped media sample location as detailed in the RIP for LNAPL GC fingerprinting (e.g. near groundwater wells MW-21, MW-18R, MW-20S, and MW-93S), as illustrated in Figure 3-4. Nested vapor wells listed in Table 3-9 will be constructed with vapor sampling points at 5 to 10 foot intervals from five-feet below the ground surface, down to just above the groundwater table. All points will be sampled during the first analysis, followed by streamlining of the depth profile to every 10 feet for subsequent sampling events, based on results from the first event. Nested vapor wells will be constructed and sampled according to methodology described in the Report titled "Subsurface Investigation Field Activities Report and Human Health Risk Assessment, Chevron Cincinnati Facility, Hooven, Ohio, October 2005", by Trihydro and GeoSyntec.

Vapor profiles will be sampled with the initial data collection effort following USEPA approval of this Plan, and every five years thereafter, with the timing of sampling aligned such that the results will be available for review and interpretation in preparing the 5-year remedy progress reviews. As with the GC fingerprint analysis, adjustments to the sampling locations and frequencies may be proposed over time if interpretation of results indicates that data collected from other locations or at other frequencies will be beneficial to the overall tracking and understanding of plume attenuation over time. Efforts will be made to sample at various groundwater elevations to account for impacts that seasonal groundwater fluctuations may have on sample results.

Vapor samples will be analyzed in the field for oxygen, carbon dioxide, and methane, and will be submitted to Air Toxics or a similarly qualified laboratory for analysis of oxygen, carbon dioxide, and methane using ASTM D-1946, and for analysis of TPH and for vapor COCs listed in Table 2-1 by Method TO-15. Laboratory analysis for fixed gases will generally be the preferred result for data evaluation, while field analyses will be kept as a cross-check and for immediate review and analysis, when warranted. Vapor analyses results will be used to estimate the total vapor mass loss occurring from the plume over time, and may be used for planning engineering and institutional controls as appropriate relative to redevelopment at the site. Vapor mass loss will initially be estimated by the method described in the paper "Source Zone Natural Attenuation at Petroleum Hydrocarbon Spill Sites—I: Site-Specific Assessment Approach", by Paul Johnson, Paul Lundegard, and Zhuang Liu, in Ground Water Monitoring & Remediation 26, no. 4/ Fall 2006/pages 82–92. The means of estimating vapor mass loss from the plume may be modified in the future, based on initial results and evolving industry methodology.

3.3.3.5 VERTICAL PROFILE DISSOLVED-PHASE MONITORING

The intent of dissolved-phase vertical profiles will be to evaluate potential differences in the rate of LNAPL mass loss and degradation in the dissolved phase at different depths across the smear zone/groundwater table. Vertically nested groundwater monitoring wells listed in Table 3-10 will be constructed at grouped media sample locations as detailed in the RIP (e.g. near groundwater wells MW-21, MW-18R, MW-20S, and MW-93S), as shown in Figure 3-4. Vertical groundwater sampling intervals will be established with one to two feet long screen intervals, targeted for the approximate top of the groundwater table, the middle and bottom of the smear zone, and below the current smear zone, as illustrated in Figure 3-5. Vertical spacing of sample intervals will vary across the plume, depending on the thickness of the smear zone. Smear zone and dissolved-phase profiles will be evaluated to determine optimum vertical spacing. As noted in the RIP, while ROST equipment is on site for installation of perimeter plume ROST borings, ROST pushes may be performed at these grouped media sampling locations to aid in establishing vertical groundwater sampling intervals and spacing.

Vertically nested groundwater wells will be sampled with the initial data collection effort upon USEPA approval of this Plan, and then every five years thereafter, with the timing of sampling aligned such that the results will be available for review and interpretation in preparing the 5-year remedy progress reviews. In addition, nearby standard monitoring wells MW-21, MW-18R, MW-20S, and MW-93S will be sampled in conjunction with nested well sampling. Efforts will be made to sample at various groundwater elevations to account for impacts that seasonal groundwater fluctuations may have on sample results. As with GC fingerprinting and vertical profile analyses, adjustments to sample locations and frequencies may be proposed over time if interpretation of results indicates that data collected from other locations or at other frequencies will be beneficial to the overall tracking and understanding of plume attenuation.

Vertical nested groundwater samples will be collected according to the protocol outlined in this Plan and site QAPP. Best available sampling technologies and practices will be deployed in order to make every effort to ensure that groundwater samples are not contaminated with NAPL. Samples will be analyzed for constituents specified in the 2006 Order, as listed in Table 2-1, and for the MNA monitoring and indicator parameters identified in Tables 4-2 and 4-3 of the this Plan. The results of these analyses will be interpreted relative to demonstrating overall plume degradation activity, including via methods described in the Lundegard, Johnson and Liu paper referenced above.

3.3.3.6 BASELINE VAPOR DIFFUSION COEFFICIENT SOIL SAMPLING

In conjunction with the initial LNAPL fingerprint sampling discussed above in Section 3.3.3.3, soil samples from the same locations will also be sent to a lab and analyzed for porosity and soil moisture, which will aid in the calculation of the vapor diffusion coefficient. Each lithology type will be sampled in each borehole and the general moisture profile will be developed. This will be a baseline analysis that will only be performed once.

3.3.3.7 LYSIMETER SAMPLING

Lysimeters will be installed as detailed in the RIP at the four grouped media sample locations shown Figure 3-4 in order to collected data regarding surface water infiltration at various locations across the plume. Previous aquifer water budget data concluded that the average infiltration potential for the site is approximately seventeen inches per year. If all of this surface water infiltrated from the ground surface to the smear zone, the volume of water would be comparable to the amount of water that entered the smear zone laterally as groundwater. While not all ground surface water infiltrates into the smear zone, previous aquifer water budget data suggests that much of the potential infiltration water does indeed infiltrate. An indication of this is that river levels don't directly follow precipitation trends, suggesting that the amount of runoff may be relatively small.

Each lysimeter will be a small diameter (approximately 2-inch) ceramic cup placed into a borehole just above the capillary fringe. The cup will be connected to a receptacle (6, 12, 24, or 36 inches tall) having two polyethylene tube running up to the ground surface. The ceramic cup will wick soil moisture which can be pulled to the ground surface through one of the tubes by using a hand pump. Infiltrating groundwater will be sampled semiannually for the first two years, annually for the next ten, and biennially thereafter, with each sampling event targeted to follow a precipitation event. Samples will be analyzed for dissolved oxygen content for use in calculating natural attenuation rates. Lysimeters have not been previously installed on this site. The intent is that the data collected will assist in understanding plume attenuation.

3.3.4 RIVER MONITORING

River monitoring will be conducted in two phases: a short-term program prior to riverbank stabilization and a long-term program following riverbank stabilization. In addition to the dissolved phase sampling and river observation and sampling described in this section, fluid level monitoring discussed below in section 3.3.5 also relates to river monitoring and protection.

Short-Term Monitoring

Three existing monitoring wells have been selected for monitoring conditions along the river under short-term river monitoring due to their locations along the southeastern edge of the plume, adjacent to the Great Miami River. These wells, MW-26R, MW-48S, and MW-85S, are also included in semiannual perimeter plume monitoring (shown in Figure 3-2) and are therefore captured under that program. In addition to monitoring of these wells, river surface water samples will be collected on the same frequency from locations immediately adjacent to each of the three groundwater wells. Sample locations will be marked in the field using painted t-posts or otherwise denoted to ensure consistency in sample locations. Sampling methodology will ensure the safety of field technicians and limit sample volatilization. As with samples collected from monitoring wells, surface water samples will be analyzed for groundwater COCs listed in Table 2-1. Finally, weekly observations for sheening will be conducted at the riverbank/smear zone interface where the river borders hydrocarbon-impacted soil at the facility property, including Gulf Park. These observations will be conducted daily when groundwater is below the 464.8 msl trigger level at monitoring well MW-20S and during rapidly dropping river levels following flood events, as these are the only conditions under which sheening has been observed in the past. Note that the 464.8 msl trigger level at monitoring well MW-20S will become lower with time as the source zone is depleted from the top down and less hydrocarbon is available due to recovery and/or chemical changes in the plume. Adjustments to the trigger level will be provided with future semiannual monitoring reports.

Long-Term Monitoring

Long-term dissolved-phase river monitoring will be developed in conjunction with the River bank engineering controls design. In addition to continued monitoring of wells MW-26R, MW-48S, and MW-85S under the perimeter plume monitoring program, the long-term River Monitor Plan includes monitoring of paired groundwater, hyporheic zone, and surface water monitoring transects located at the upstream, midstream, and downstream end of the proposed stabilization/control structures. A long-term River Monitoring Plan has been submitted along with the River bank stabilization measures design package, and will ultimately be incorporated into this Plan upon USEPA approval of the proposed monitoring procedures.

3.3.5 FLUID LEVEL MONITORING

Fluid level monitoring in support of groundwater gradient mapping will consist of the deployment of transducer groundwater level data logging probes in monitoring wells listed in Table 3-11 and shown in Figure 3-5. Monitoring wells primarily down-gradient of the LNAPL and dissolved-phase plumes were selected for the deployment of data logging probes for purposes of monitoring potential down-gradient migration of the plumes. An exception to this plan will be during high-grade pumping periods, when some of the transducers will be moved to wells near the high-grade pumping center to allow close tracking of high-grade performance. Transducers will be programmed to log data on a daily basis with at least a quarterly download of the data. The transducer memory capacity is 1MB of storage, and the download frequency will be sufficient so as not to exceed storage capacity. Data collected by data logging probes in support of plume monitoring will be used to map groundwater gradients, radius of influence during production well operations, and drawdown to calculate specific capacity of production wells. Data will be mapped on a semiannual basis, concurrent with collection and analysis of dissolved-phase data, and will continue following the monitoring schedule for the dissolved phase. In addition, manual fluid level gauging will be performed to record LNAPL (if present) and groundwater elevations in monitoring wells at the Facility and at Gulf Park as listed in Table 3-12 and shown on Figures 3-6 and 3-7. Gauging will be performed on a bi-monthly basis, with the frequency increased to monthly when groundwater is below the 464.8 feet above mean sea level trigger level at monitoring well MW-20S. As previously stated, the 464.8 msl trigger level at monitoring well MW-20S will become lower with time as the source zone is depleted from the top down and less hydrocarbon is available due to recovery and/or chemical changes in the plume.

With regard to fluid level monitoring along the river near the former refinery, river bank stabilization measures are expected to eliminate the potential for LNAPL introduction into the river. Fluid levels will be measured monthly in wells and piezometers listed in Table 3-13 and shown on Figure 3-8, during the interim period between when continuous groundwater pumping and treatment is discontinued and river bank stabilization measures are implemented. The frequency of fluid level monitoring and mapping along the river will be decreased to semiannually once river bank stabilization measures are implemented.

3.4 PERFORMANCE METRICS AND CONTINGENCIES

This section presents performance metrics for evaluation of remedy component performance sampling and monitoring in accordance with the previous sections, as well as contingencies should performance metrics be exceeded.

3.4.1 LNAPL AND DISSOLVED PHASE PERIMETER PLUME MONITORING

If perimeter plume LNAPL and dissolved-phase monitoring shows that groundwater in a sentinel well contains LNAPL or concentrations of a COC listed in Table 2-1 exceeding the MCL, the sentinel well and its paired down-gradient point-of-compliance well will be re-sampled within two months. If re-sampling confirms the presence of LNAPL or the exceedance of an MCL, operation of the site-wide groundwater recovery system will resume. If subsequent analysis indicates that the confirmed exceedance was due to an anomalous low water table condition, and not actual plume migration, Chevron will follow up with USEPA to discuss rational and seek approval to discontinue groundwater recovery pumping. Regardless, Chevron will obtain USEPA concurrence prior to discontinuing the site-wide recovery system following its resumption as a Final Remedy contingency, following analysis indicating that pumping is no longer necessary or beneficial.

If monitoring in a POC well confirms the presence of LNAPL or concentrations of a COC listed in Table 2-1 exceeding the MCL, operation of the site-side groundwater recovery system will resume and additional corrective measures will be evaluated to prevent the migration of LNAPL and/or dissolved-phase contaminants above MCLs beyond the containment POC. Chevron will submit a report for USEPA approval describing measures evaluated and recommended corrective measures within six months of the sampling event demonstrating the exceedance.

If ROST or fluid level monitoring detects LNAPL in an inner ROST boring located outside the current smear zone boundary, then operation of the site-wide groundwater recovery system will be resumed. Within six months of the sampling event indicating the presence of LNAPL constituents, a report will be submitted for USEPA approval detailing measures evaluated (including focused aggressive source removal technologies) to ensure containment of the LNAPL plume at the current smear zone boundary. The report will describe measures evaluated and recommended corrective measures.

In general, the LNAPL and dissolved phase perimeter plume monitoring results will need to be evaluated in context with all of the information available at the time. MCLs will be exceeded for many years to come in the interior plume wells; however, tracking of their long-term trends will provide additional data regarding the activity of attenuation processes. Monitoring results will be graphed, and a continued long-term declining trend in COC concentrations will be taken as an indication of attenuation progress. If a persistent increasing concentration trend is noted in any of the general plume monitoring wells at the second 5-year review, additional corrective actions in the area of the affected well will be evaluated and proposed to USEPA.

3.4.2 INTERIOR PLUME MONITORING

The interior plume dissolved-phase monitoring results will be used primarily for overall, long-term plume degradation monitoring. These wells are already known to be impacted and are expected to contain constituents at concentrations above standards until the later years of the remedy, so they will not be utilized for direct comparison against MCLs over the first few decades of the remedy. Results from these wells will be used to track progress toward the overall plume natural attenuation goals, as discussed in subsection 3.4.3.

3.4.3 MONITORED NATURAL ATTENUATION MONITORING

As discussed in the CSM section in the RIP, the plume has been and will continue to naturally attenuate through multiple mass loss mechanisms over the next several decades. The MNA monitoring program will be designed to track degradation progress. Mass loss rate goals for future five-year reviews will be established to serve as a metric for evaluation of the success achieved from natural attenuation at subsequent five-year reviews.

3.4.4 RIVER MONITORING

Performance metrics and contingencies related to river monitoring are divided into two categories: short-term prior to riverbank stabilization and long-term after riverbank stabilization.

Short-Term Monitoring

Both the dissolved phase groundwater and river inspection results will be evaluated for evidence of substantial changes relative to historical results, and will be maintained in the facility record and provided to USEPA with routine monitoring reports. The short-term monitoring will not trigger the additional corrective measures evaluation required under the 2006 Order, as the need for implementation of additional corrective measures along the river bank is recognized and already underway.

The results of fluid level monitoring from wells located within approximately 50 feet of the river bank will be tracked with special regard to river protection. During the interim period after the continuous groundwater pump and treatment system is shut down and before river bank stabilization measures are implemented, fluid level results from along the river will be collected and mapped on a monthly basis. If LNAPL is detected in these wells at a thickness of greater than 15% from the previous thickness observed at a similar water table elevation (plus or minus two feet), or LNAPL is detected in a distal monitoring well where it has not been previously detected, continuous pumping of groundwater in this area will resume until river bank stabilization measures are constructed.

Long-Term Monitoring

Plans for contingency actions arising from long-term River monitoring results will be included with the River Monitoring Plan, which is being developed in conjunction with the River bank stabilization engineered design specifications, and which will ultimately be integrated into this Plan upon USEPA approval.

3.4.5 FLUID LEVEL MONITORING

Over the long-term, the primary metric for evaluating the LNAPL measurements will be to track plume stability on down-gradient margins of the plume under Hooven and the Southwest Quadrant. The confirmed presence of LNAPL in a sentinel or POC monitoring well, where LNAPL has not previously been detected, will be taken as an indication that the LNAPL plume is migrating, and will trigger the resumption of continuous groundwater pumping to maintain an inward gradient, and the evaluation of additional corrective measures in the area.

As discussed above, LNAPL thickness measurements from near the Great Miami River will be used to monitor plume stability in this area during the interim period until the river bank is stabilized. Thereafter, LNAPL thickness monitoring results in existing wells in this area will be evaluated relative to overall plume tracking goals described below.

It is anticipated that new groundwater/fluid level monitoring wells will be constructed on the in-board side of the planned river bank stabilization measure, in soil placed during construction which has not been previously impacted by LNAPL. It is anticipated that the contingency for LNAPL detection in these wells will be to resume continuous groundwater pumping to maintain an inward gradient and evaluate additional corrective measures in the area. However, plans for long-term monitoring along the river will be amended in this plan following USEPA approval of river bank stabilization and long-term River monitoring plans.

LNAPL thicknesses (when present) across the rest of the site will be used in the preparation of semiannual LNAPL contour maps, which will be tracked relative to overall plume degradation, but will not otherwise be tied to short-term compliance. The results of LNAPL thickness and extent monitoring will be tied into the five-year progress reviews. In accordance with the 2006 Order, additional details regarding proposed progress metrics related to LNAPL thickness monitoring results and the long-term plan for high-grade operations as it relates to the timeframe for reaching the groundwater cleanup standards will be addressed in the plan that Chevron will submit to the USEPA by October 31, 2008.

4.0 HIGH-GRADE PUMPING

The high-grade pumping component of the groundwater remedy focuses on seasonal source removal of LNAPL from the lower reaches of the smear zone where the highest remaining LNAPL saturations persist. Although extensive LNAPL characterization and groundwater monitoring and short-term testing suggest that the LNAPL plume is stable, long-term stability of the LNAPL plume will be more definitively demonstrated by long-term monitoring programs detailed in this Plan. Additional high-grade recovery will provide further assurance against potential LNAPL mobility at the lowest natural water table conditions and will further reduce the overall mass of remaining LNAPL available for long-term dissolution of contaminants into the groundwater.

4.1 COMPONENT DESCRIPTION

LNAPL recovery will be undertaken during low water table conditions, based on historical trends and field observations during seasonally dry periods. LNAPL appears in wells and is recoverable as a function of water table elevations (triggers) as they relate to the smear zone. The water table must be low enough to expose the approximate bottom third of the smear zone before LNAPL will enter wells for recovery. The goal of high-grade pumping is to use groundwater extraction to maximally expose the smear zone for hydrocarbon drainage and recovery during the seasonal low water table period that occurs in most years. Maximal exposure of the smear zone occurs when the water table is drawn down to just below the previous depth of maximum exposure. The previous depth of maximum exposure can be approximated as the minimum historical water table elevation at monitoring locations within the smear zone. Thus, the minimum historical water table elevation is used to establish targets for high-grade pumping. Prior to high-grade pumping, the pumping target in a given monitoring well is the historical low water table elevation on record, most of which occurred during the drought in 1999. With each successful high-grade event, the depth of maximum smear zone exposure will be lowered slightly to induce hydrocarbon drainage, thereby establishing new, lower pumping targets for high-grade pumping in the following year.

Historical fluid level trends and operational data suggest that hydrocarbon recovery via high-grade pumping will only be possible in years when pumping lowers the water table elevation below the pumping targets. Pumping triggers will be used to determine when high-grade pumping can be expected to achieve pumping and recovery targets. Pumping target levels are defined by the following equation:

Pumping Trigger = $PT_i + s_{i,j}$

Where:

PT_i = Pumping target of the i^{th} monitoring well location; value is the historical minimum water table elevation in feet above mean sea level

$s_{i,j}$ = Expected drawdown at the i^{th} monitoring well location caused by pumping at the j^{th} production well

As noted by the subscripts in the above equation, pumping triggers are location-specific with respect to the monitoring location and the high-grade pumping well. Prior to each high-grade season, new pumping triggers will be calculated as follows. First, pumping targets will be established by analyzing the fluid level data from the preceding high-grade event. New pumping targets will be established at locations where the water table was lowered to a new minimum elevation. Otherwise, pumping targets from the preceding year will be carried forward. The expected drawdown will be based on fluid level monitoring during prior high-grade pumping events. Drawdown created by PROD_20 and PROD_19 has been measured during the 2005 and 2006 high-grade tests, respectively. Other pumping locations will require a pumping event to estimate drawdown. For example, trigger level calculations for the 2007 monitoring locations listed in Table 4-1 are designed for the southwestern portion of the plume near Hooven for high-grade pumping at PROD_20 or PROD_19. Trigger levels for a given production wells will be established at these and other nearby monitoring wells following the first successful high-grade event at that well. Until triggers have been established for each production well, the pumping triggers listed in Table 4-1, as updated annually, will be used globally.

In pumping groundwater to enhance LNAPL recovery, each seasonal high-grade event will collect and treat several million gallons of groundwater contaminated with dissolved-phase contaminants. This water is pumped directly to the on-site GAC and subsequent constructed treatment wetlands for final treatment prior to discharge to the Great Miami River under an Ohio EPA administered NPDES Permit. Operation of the GAC system, whether in support of high-grade pumping or otherwise, is addressed in Section 5.0 of this Plan.

In addition to operation of the GAC system, high-grade pumping activities will involve operation of the HSVE system to remove volatile petroleum constituents from the LNAPL smear zone. Operation of the HSVE, whether in conjunction with high-grade pumping or otherwise, is addressed in Section 6.0 of this Plan.

4.2 COMPONENT INSTALLATION/OPERATION

As demonstrated by historical data, the high-grade pumping remedy component will remain dynamic and adaptable due to continued reduction in remaining LNAPL saturation and ongoing degradation of its chemical constituents. As a result, a number of factors will be considered in selecting which production well will be operated during seasonal high-grade events. Fluid level data, as well as operational factors, will be considered in selecting which production well will optimize LNAPL recovery during high-grade pumping.

The primary operational parameters for high-grade operation are the production well(s) water table elevation and oil recovery rate. Each year, the production well(s) will be selected based on historical performance and current well conditions (i.e. need for well rehabilitation, pump condition, etc). Prior to each high-grade season (generally summer-fall), operational plans will be presented in the preceding semi-annual progress report to summarize the preceding high-grade pumping event and present draft plans for the upcoming event. Draft plans may include proposed production well(s) to be operated, updated pumping trigger levels, planned system modifications, and other pertinent information.

Each seasonal high-grade pumping event will be initiated once established trigger levels have been met in at least 50% of monitoring wells, typically in late summer. The selected production well(s) will be operated such that the water table is lowered below the historical maximum water table elevation at the monitoring locations while also maximizing the oil recovery rate. It is anticipated that this will require pumping rates of approximately 1,000 to 3,000 gallons per minute (gpm), depending on hydrological conditions and the pumping targets at the time of the event. The high-grade production well(s) will be operated at the maximum pumping rate sustainable by all system components, or at a pumping rate that provides drawdown in the production well to the bottom of the smear zone. Typical high-grade pumping rates range between 1,700 and 2,700 gpm, depending on a number of factors, include the nature of the plume and formation in the location of the production well, the condition of the production well screen, the performance of recovery pumps and screens, and operating parameters at the GAC.

Once high-grade pumping has been initiated, the water table will eventually rise in response to recharge events. Such events can cause the water table to rise above target elevations and may also reduce product recovery rates or preclude product recovery altogether. In some cases, this effect will be short-lived and will be overcome through continued pumping. In other cases, the pumping targets will not be reached again that year and/or oil recovery will decline to unacceptably low rates despite continued pumping. Given these conditions, a clear decision framework is needed to determine when to terminate the high-grade event during each season. The decision framework is as follows.

Upon seasonal startup, high-grade pumping will continue for a minimum of thirty days. The following performance criteria will be used to determine when high-grade pumping will be terminated.

- Pumping Targets
  - High-grade pumping may be terminated if pumping targets at 50% or more of the monitoring locations are not met during a period lasting more than two weeks.
- Oil Recovery
  - High-grade pumping may be terminated if a two-week running average oil recovery rate of 500 gallons per day (gpd) cannot be sustained at the production well.

In general, throughout the typical dry season, efforts will be made to keep the infrastructure required to resume high-grade pumping operational, so that high-grade LNAPL recovery can quickly resume if suitable conditions re-occur.

Each seasonal high-grade event will also involve operation and sampling/monitoring of both the GAC and HSVE systems. Prior to the start-up of high-grade pumping, GAC operation will begin to ensure the operational effectiveness of the GAC system in support of high grade. Operation of the HSVE system will begin after hi-grade operations commence and after soil vapor monitoring has been completed, if required. Operation of the GAC and HSVE systems are addressed in more detail in Sections 5.0 and 6.0 of this Plan, respectively.

Each successful high-grade event will reduce the volume of recoverable hydrocarbon, decrease product mobility, and will successively lower the pumping target elevations. Ultimately, high-grade pumping will reach a practical endpoint when either hydrocarbon recovery has become negligible and/or pumping targets are too deep to achieve with existing infrastructure. Chevron expects that two to three high-grade events under low water table conditions will be needed to achieve these endpoints in each of the two concentrated high-grade pumping areas (Chevron, 2005). Based on historical records, Chevron expects that this will occur in six to ten years in each area (Chevron, 2005). After successful high-grade events have been completed under low water table conditions, Chevron expects that it will be fairly self-evident that final endpoints have been met based on the results of one or more subsequent, unproductive high-grade seasons having been conducted during years of average or below average precipitation. A plan will be submitted to USEPA by October 31, 2008, to define criteria for permanent shutdown of high-grade pumping.

4.3 SAMPLING/MONITORING

Seasonal sampling/monitoring protocols will be in accordance with those established and demonstrated effective in grading pumping results during the most recent 2006 high-grade pumping event. Four types of sampling/monitoring efforts will be performed during high-grade pumping: preparatory monitoring, fluid level monitoring, HSVE sampling/monitoring, and GAC sampling/monitoring.

4.3.1 PREPARATORY MONITORING

Prior to initiation of high-grade pumping, transducers will be deployed in selected monitoring wells in order to collect data to define maximum drawdown and radius of influence during initial operation of the chosen production/recovery well. Rather than monitor against high-grade trigger levels, the deployment of transducers just prior to and during high-grade pumping provides a complete picture of drawdown, radius of influence, and well specific capacity. Manual gauging in order to log operational baseline data and measure against the pertinent trigger level(s) is conducted on a weekly basis as part of routine facility operations. The list of monitoring wells gauged weekly is routinely revised as operational data needs change. For example, weekly gauging in the spring may include proposed high-grade wells and surrounding monitoring wells as the site strategizes for the next high-grade event.

Two categories of monitoring wells, Key Transducer and Select Transducer wells, will be established based on proximity to the selected production/recovery well. Transducers will be deployed in Key Transducer monitoring wells proximal to the production well (see Figure 4-1, Key and Select Transducer Monitoring Well Locations for Production Well PROD_19), and data logged on 1-minute intervals for the first three days of high-grade pumping, then on 10-minute intervals until completion of high-grade pumping. In addition, transducers will be deployed in Select Transducer monitoring wells located farther away from the production/recovery well (see Figure 4-1), and data logged on 10 minute intervals from the start of high-grade pumping until completion. Key and Select Transducer monitoring wells for one possible high-grade scenario, that in which PROD_19 is the high-grade production well, are listed in Table 4-2 and shown on Figure 4-1. As noted on Figure 4-1, it should be emphasized that this figure illustrates Key and Select Transducer monitoring well locations for one possible high-grade scenario. Key and Select Transducer monitoring wells will be revised as needed to correspond to the production well selected for each high-grade event. Five Key and eight Select Transducer monitoring wells will be established radially away from the operating high-grade well, with the well spacing designed to define maximum drawdown and radius of influence during initial operation of the chosen production/recovery well. Well spacing will be based on past groundwater model calibration results, and potentially also on any local variations in hydraulic conductivity or other aquifer parameters or response to the pumping.

4.3.2 FLUID LEVEL MONITORING

The depth of groundwater and LNAPL (if present), will be recorded in two groups of gauging wells, Key Fluid and Select Fluid, based on proximity to the production/recovery well and frequency of monitoring. Key Fluid wells represent a concentrated cluster of wells proximal to the location of the production well, considered to be more indicative of high-grade performance. Select Fluid wells represent a broader sample of fluid level data from distal on-site and off-site wells surrounding the selected production well. Key and Select Fluid monitoring wells for one possible high-grade scenario, that in which PROD_19 is the high-grade production well, are listed in Table 4-3 and shown on Figure 4-2. As noted on Figure 4-2, it should be emphasized that this figure illustrates Key and Select Fluid monitoring well locations for one possible high-grade scenario. Key and Select Fluid monitoring wells will be revised as needed to correspond to the production well selected for each high-grade event. Five Key and 20 Select Fluid monitoring wells will be established radially away from the operating high-grade well, with well spacing designed to monitor overall drawdown and NAPL thicknesses resulting from high-grade pumping. Spacing will be based on past groundwater model calibration results, and potentially also on any local variations in hydraulic conductivity or other aquifer parameters or response to the pumping.

Key Fluid wells will be monitored for groundwater and LNAPL elevations daily upon start up of high-grade pumping, until pumping operations have stabilized and operating limits have been established (equilibration), or for a minimum of one week. Thereafter, Key Fluid well fluid levels will generally be monitored twice weekly. If a given set of operating conditions should persist for an extended period of time, the monitoring frequency may be further reduced until conditions resume changing. If the conditions are rapidly changing, more frequent monitoring may be warranted. Events which may warrant additional monitoring include, but are not limited to, large precipitation events and significant changes in operational parameters. Overall, the high-grade implementation program will require flexibility to optimize a relatively novel approach to LNAPL recovery, in a dynamic aquifer. Key Fluid well fluid level data will be recorded on the Key Well Fluid Level Log shown in Figure 4-3. As shown on the field log, additional LNAPL and groundwater flow data will be recorded for the applicable production/recovery well. This data will be obtained from flow meters mounted at the production/recovery well. However, groundwater flow data will be checked weekly against operational logs at the GAC and LNAPL flow data will be checked weekly against actual recovery volumes in collection tanks #291 and #50.

Select Fluid wells will be monitored for groundwater and LNAPL elevations twice weekly upon start up of high-grade pumping until equilibration of the system, or for a minimum of one week. Thereafter, Select Fluid well fluid levels will be monitored weekly, independent of weather or operational events. Select Fluid well fluid level data will be recorded on the Key and Select Well Fluid Level Log shown in Figure 4-4. This field log combines both Key and Select Fluid wells because there should be no event where Select Fluid wells are gauged without gauging Key Fluid wells. Located farther away from production/recovery well operations, these wells yield data regarding a broader radius of influence due to pumping operations.

4.4 PERFORMANCE METRICS AND CONTINGENCIES

4.4.1 PREPARATORY MONITORING

There are no specific performance metrics or contingencies associated with data collected from Key and Select Transducer wells during high-grade pumping. This data is intended for evaluation of the performance of high-grade pumping and analysis of plume dynamics during high-grade events, rather than an indicator for initiating additional control measures. The results of LNAPL and groundwater elevation gauging in response to high-grade pumping will be utilized to fine-tune and update the Groundwater Conceptual Site Model over time, and will ultimately tie into the decision to discontinue high-grade operations altogether.

4.4.2 FLUID LEVEL MONITORING

Fluid level data will be extensively analyzed to map changes in product thickness during and between each high-grade pumping event in order to track long-term effectiveness of the remedy component. In addition, fluid level data will be tracked on a weekly basis to ensure that high-grade trigger levels are being met. Performance metrics and contingencies are those related specifically to the operation or shutdown of the high-grade remedy component. Seasonal data will be evaluated against criteria for seasonal operation or shutdown, while historical data will be evaluated against criteria for permanent operation or shutdown.

5.0 GRANULAR ACTIVATED CARBON (GAC) SYSTEM OPERATION

5.1 COMPONENT DESCRIPTION

The groundwater containment pumping and GAC water treatment system will cease continuous operation upon USEPA approval of this Plan. However, the GAC will resume seasonal operation in support of high-grade pumping for LNAPL recovery in accordance with Section 4.0.

The GAC system is one component of the site wastewater treatment system, including a sedimentation pond and constructed treatment wetlands, which provides treatment of wastewater for compliance with the site's NPDES permit at the point of discharge to surface water. The GAC is specifically designed to treat gasoline-contaminated groundwater, the four primary contaminants of which are benzene, toluene, ethylbenzene, and xylene, or BTEX. The GAC is designed and intended to treat a very dilute, single phase solution of BTEX and water, rather than a two phase mixture of undissolved concentrated BTEX and water.

Figure 5-1 shows a plan view of the GAC system, including influent lines, the treatment unit, effluent lines, as well as ponds and wetlands. Contaminated groundwater is pumped to the GAC for treatment from one or more production wells located at the Facility. The influent groundwater enters the plant through a strainer, in order to remove any large or fibrous material which may be harmful to or settle out in the plant components or piping system. The influent stream is then split into substreams, each substream entering one of the process "trains". Within each train, the influent groundwater is mixed with part of the treated effluent recycled from the fluid bed bioreactor. The mixed stream enters the suction side of the fluidization pump. The system hydraulics and valving are such that as the influent flow increase, the recycle flow decreases, thus allowing the flow through the fluidization pump to remain essentially constant over a wide range of influent flow.

The pressurized water leaving the fluidization pumps enters the oxygen-dissolution circuit. The circuit is designed around a downflow bubble contractor which consists of a cone with its open end pointed downward, through which the full stream of water flows. Oxygen (90-95% pure) is introduced as fine bubbles below the cone. As the bubbles contact the water, oxygen begins to dissolve into the liquid phase, while dissolved nitrogen diffuses from the water into the bubbles. These shrinking bubbles rise into the cone, flowing counterflow to the direction of the water, thereby assuring that the effluent water will contact oxygen bubbles of highest purity.

The primary stream of water exits the bubble contactor carrying dissolved oxygen. A stream of nutrients is injected to provide “food” for microbial growth within the fluid bed before the fluid reaches the fluid bed reactor.

The water stream is injected at the bottom of the fluid bed reactor vessel through an arrangement of multiple nozzles, operating in parallel via a manifold system. The nozzles assure that the water flow is distributed evenly under the fluidized bed.

The fluid bed vessel contains a bed of granular activated carbon (GAC), completely immersed in water. The GAC serves two functions: 1) it provides a surface to anchor the microbes, enabling them to remain in place in a flowing water stream which would otherwise carry them out of the system, and 2) it absorbs and concentrates BTEX molecules for the microbes to break down. GAC is used as the solid media because the very porous solid particles of carbon have up to 900 square meters of internal surface area per gram. The porosity of GAC gives it the ability to absorb and hold a large amount of BTEX contaminants from a dilute solution in water. The larger internal passages also serve as additional surface on which to anchor and grow biomass.

As water pushes upward through the bed of GAC, it gently lifts and separates the particles, causing the bed to expand and increase in height. As the water flow is increased, the bed eventually fluidizes, so that each particle of GAC is essentially free floating within the bed, completely surrounded by water and not resting on any other particles. As wastewater is introduced to the fluidized bed, microorganisms begin to attach themselves to the GAC media and form a film. As microbial growth continues, the film grows in thickness, causing the GAC particles to become lighter in overall density, causing the bed to further expand and rise. When the bed reaches a predetermined height in the reactor (typically 4 feet below the water line) the biomass pump is triggered to start. The biomass pump suction positioned approximately 6 feet below the water line pulls a stream of carbon, biomass, and water through the pump. The centrifugal action of the pump and pinched discharge valve shears some of the biomass from the carbon particles. The carbon, biomass, and water mixture is then discharged back into the reactor. The cell mass, being lighter than the carbon particles, flows out of the reactor and is discharged with the clean effluent water. The clean GAC particles fall back into the active bed for continued use.

5.2 COMPONENT INSTALLATION/OPERATION

At this time, there are no plans for additional infrastructure necessary for operation of the GAC system. The system will be operated in support of high-grade pumping for LNAPL recovery in accordance with existing system manuals.

5.3 SAMPLING/MONITORING

Operation of the GAC system involves extensive operational monitoring. Daily operations of the system are recorded around the clock at set intervals to record proper operating parameters. For purposes of this Plan, discussion will be limited to monitoring related to the groundwater remedy, specifically high-grade pumping.

Sampling at the wetlands outfall is collected on a weekly basis to ensure compliance with NPDES permit requirements. A composite sample is created by an automated sampler that collects a small sample every 45 minutes over a 24-hour period. The composite sample is picked up by an independent laboratory and analyzed to ensure the site is in compliance with the discharge requirements set forth in the NPDES permit issued by the State of Ohio.

5.4 PERFORMANCE METRICS AND CONTINGENCIES

GAC monitoring is used for evaluation of system performance in support of high-grade recovery operations. Monitoring data analysis allows for checks of system efficiencies and provides information for adjustments to enhance system performance. Operating parameters may be adjusted to correct undesirable findings or to increase performance efficiencies related to the high-grade event. Operational adjustments will be made with input from the system operators and site management. Samples collected at the wetlands outfall are analyzed against requirements set forth in the site's NPDES permit.

6.0 HORIZONTAL SOIL VAPOR EXTRACTION (HSVE) SYSTEM OPERATION

6.1 COMPONENT DESCRIPTION

This component of the groundwater remedy focuses on operation of the Horizontal Soil Vapor Extraction (HSVE) system to remove volatile petroleum constituents from the LNAPL smear zone, thus contributing to overall mass reduction in the southwest portion of the plume. As documented in the Remedial Action Plan dated June 3, 1999, the HSVE was implemented to remove hydrocarbon mass and mitigate potential upward migration of vapors beneath off-site residential properties. The initial phase of this project consisted of an 830-foot horizontal soil vapor extraction well (Well #1) extending from the former refinery property westward under State Route 128 and Hooven Avenue. Phase two of this project expanded the system by adding two additional extraction wells, Well #2 extending 829 feet from the Chevron property westward under Brotherhood Avenue and Well #3 extending 760 feet from the property westward under Ohio Avenue. Modeling, engineering, and practical considerations were used in identifying the optimal location, placement, and construction of each HSVE well. To facilitate the installation of each well, the horizontal location was targeted to a path that would provide maximum adequate coverage while requiring the least amount of disruption to the public and permit and access agreements. As such, the location of each well is underneath and along the length of an east-west street within Hooven. A minor exception to this is Well #2, where Chevron acquired an easement to install the western end of the well under the Hooven Elementary School playground. An overhead view of the existing HSVE system, consisting of the three horizontal wells, process blower, and associated thermal oxidation unit with ancillary equipment, is shown in Figure 6-1.

The HSVE system extracts subsurface hydrocarbon vapors from beneath Hooven and conveys it to the Facility by creating a negative pressure in the slotted extraction well lines. Recovered hydrocarbon vapors are then destroyed via thermal oxidation technology. Thermal oxidation (also referred to as combustion) converts volatile organic compounds (VOCs), in the presence of oxygen, to carbon dioxide and water. This process results in the release of a large quantity of energy and the formation of a flame at vapor temperatures ranging from 1400^{o}F to 1800^{o}F in the combustion zone. As detailed in later sections, monitoring of the soil vapor and the treated off-gases will be performed to ensure system effectiveness and compliance with applicable permit limitations.

To address reduced hydrocarbon recovery due to remediation efforts or long-term reduction in hydrocarbon recovery as a result of a lengthy cycle of fluctuating groundwater conditions, the HSVE system has the capability to supplement recovered vapors with natural gas during periods of reduced recovery to ensure efficient combustion and to maintain a combustion zone temperature of at least 1400°F. The maximum capacity of the process blower and the air treatment unit is 3,500 standard cubic feet per minute (scfm). The recovered vapors will be combusted with a minimum 98% destruction efficiency in thermal oxidizer mode.

6.2 COMPONENT INSTALLATION/OPERATION

At this time, there are no plans for additional infrastructure necessary for operation of the HSVE system. Day to day operation of the system will be in accordance with existing system manuals and manufacturer's recommendations.

The system will commence operation after start-up of the high-grade pumping to remove vapor-phase hydrocarbons from subsurface soils beneath the town of Hooven, as the smear zone is exposed. If soil vapor samples are scheduled to be collected, start-up of the HSVE system will be delayed until completion of soil vapor sampling. Soil vapor sampling is described in more detail in Section 7.0.

Vapor extraction will focus on the horizontal well closest to the operating high-grade well and be adjusted as needed to optimize vapor recovery and to minimize supplemental gas requirements. One or two lines may be closed at times to focus recovery from the line closest to the high-grade recovery area (where the greatest amount of smear zone will be exposed), or where the highest vapor concentrations are being recovered. It is anticipated that the HSVE system will be operated in conjunction with high-grade recovery operations. However, there may be times when the groundwater levels are below the HSVE trigger elevation, and high-grade pumping is not operating. Therefore, in addition to high-grade pumping events, the HSVE system will be operated when fluid level gauging shows the groundwater elevation at monitoring well MW-96S to be 465.9 feet above mean sea level or lower, and regional weather conditions are such that the groundwater elevation is expected to stay at or below this level. MW-96S is centrally located in Hooven between Well #1 and Well #3 and will provide groundwater level conditions and smear zone exposure in the area of the screened interval of the HSVE wells. Past HSVE performance has indicated that meaningful hydrocarbon mass removal is only accomplished when the middle and lower reaches of the smear zone are exposed. The MW-96S trigger level corresponds with the elevation to expose the middle and lower portions of the smear zone. As previously noted, the trigger elevation for operation of the HSVE system is expected to decline over time, as continued mass removal and natural degradation continually reduces the remaining LNAPL that is amenable to removal through vapor recovery.

The HSVE system will be shut down when supplemental natural gas exceeds 58,000 cubic feet per day, when high-grade pumping ceases, or when groundwater is above the trigger level. Permanent shutdown of the system will be proposed to USEPA at a later date, likely once high-grade operations have been completed, and when a period of two or more years have passed when conditions have not been amenable to the system accomplishing significant additional LNAPL mass removal.

6.3 SAMPLING/MONITORING

HSVE sampling and monitoring involves influent/effluent and system efficiency tracking during operation. Individual HSVE influent lines (1-3) will be monitored for flow, vacuum, and constituent concentrations. A pitot tube will be inserted into the sampling port on each open influent line and extended to the center of the influent line until the reading has equilibrated and an approximate reading can be obtained. In addition, combined influent data will be collected prior to the blower. This monitoring will be performed once daily and recorded on the HSVE Field Screening Log (Figure 6-2) until stabilization of the system is observed, then twice per week thereafter.

Sampling will commence at start-up and continue bi-weekly during system operation. SUMA can samples will be collected from the combined (lines 1-3) sample inlet port and at the stack effluent port. This data will help verify the effectiveness of the thermal oxidizer, document vapor mass removal, and measure relative flow from individual lines. Stack effluent data is collected to ensure compliance with the unit's Permit to Operate issued by Hamilton County. Data will be recorded on the HSVE Field Sampling Log (Figure 6-3).

6.4 PERFORMANCE METRICS AND CONTINGENCIES

Daily monitoring of system performance is tracked against programmed set points intended to keep the system operating at optimum level to incinerate recovered vapor per emissions permit requirements. Exceedence of these set points causes the system to shut down automatically until conditions can be evaluated and corrected. The system will then be reset and operations resumed by the operator.

The HSVE system will be shut down when supplemental natural gas exceeds 58,000 cubic feet per day, when high-grade pumping ceases, or when groundwater is above the trigger level.

7.0 VAPOR MONITORING

7.1 COMPONENT DESCRIPTION

Long-term monitoring of nested soil vapor wells beneath the town of Hooven will be conducted to ensure that an incomplete vapor pathway between the LNAPL plume and the ground surface beneath Hooven remains and persists. Results of each monitoring event will be evaluated in relation to specific performance metrics. If exceeded, EPA will be notified, and a set of corrective measures will be taken.

7.2 COMPONENT INSTALLATION/OPERATION

Existing soil vapor sampling infrastructure consists of a set of six (6) nested soil vapor wells strategically positioned throughout Hooven for the acquisition of soil vapor samples 1) over the LNAPL plume (VW-93, VW-96, & VW-99), 2) over the dissolved-phase plume (VW-127 & VW-128), and 3) outside both the LNAPL and dissolved-phase plumes (VW-129). Soil vapor probes are positioned at 5- and/or 10- foot intervals extending from ground surface to between 50 and 60 feet below ground surface (ft-bgs). At this time, there are no plans for additional infrastructure for long-term monitoring of nested soil vapor wells beneath the town of Hooven.

7.3 SAMPLING/MONITORING

Under the final remedy, five vapor wells will be regularly sampled. The USEPA's Final Decision identified four long-term monitoring vapor wells VW-93, 96, 99, and 129. VW-128 will also be monitored so that additional data is collected near the school, and so that one of the wells monitored over the long-term is over the dissolved-phase plume. Thus, the wells proposed for long-term monitoring are VW-93, VW-96, VW-99, VW-128, and VW-129 (Table 7-1 & Figure 7-1). Vapor wells will be sampled twice annually during Spring and Fall, or to account for high and low water table conditions, for the first two years, annually for the next three years, and then every three years thereafter. The wells will be sampled at 5 and 10 feet below ground surface and at 10 foot intervals to the groundwater table (e.g. 20, 30, 40, 50, and 60 ft-bgs) utilizing the established soil vapor sampling operating procedure (Appendix A).

For a particular year, if high grade pumping is not anticipated (i.e., the water table is unlikely to approach applicable trigger levels) then soil vapor sampling will be conducted during the predicted period of the lowest annual water table (typically between July – September). If during a particular year high grade pumping is anticipated, then soil vapor sampling will be conducted following commencement of high grade pumping and the establishment of steady-state pumping conditions and/or maximum predicted draw down, but prior to activation of the HSVE system.

Vapor samples will be submitted for laboratory analysis of the Table 7-2 volatile & semi-volatile organic compounds by Modified EPA Method TO-15, and fixed gases by Modified ASTM D-1946. In addition to other assessments, the results of the laboratory analyses will be used to construct soil vapor profiles, which visually demonstrate changes in petroleum hydrocarbon concentrations and oxygen/carbon dioxide concentrations with depth. The soil vapor profiles generated for locations over the LNAPL plume and a comparison with a vapor profile for a location outside of the LNAPL and dissolved-phase plumes (background) provide multiple lines of evidence to support or refute the incompleteness of the vapor pathway.

7.4 PERFORMANCE METRICS AND CONTINGENCIES

If the analysis of the soil vapor sampling data in Hooven indicates that 1) there is a complete pathway from the hydrocarbon vapors emanating from the LNAPL plume to the ground surface, and 2) COCs originating from the plume listed in Table 7-2 are observed in the five- or ten-foot samples at concentrations exceeding the soil gas screening standards set forth for residential indoor air (for houses with dirt basements) in the USEPA Vapor Intrusion Guidance screening criteria for a residential scenario, USEPA will be notified of the monitoring results within five (5) days of receipt of qualified data. Additional corrective measures will be evaluated to prevent vapors from migrating upward from the LNAPL plume into occupied buildings in Hooven at concentrations exceeding residential screening standards set forth in USEPA Office of Solid Waste and Emergency Response (OSWER) 2002 Draft Vapor Intrusion (VI) Guidance. A plan detailing evaluated alternatives, recommended corrective measures, and supporting documentation will be submitted to USEPA within sixty (60) days of the receipt of qualified monitoring data demonstrating the complete vapor pathway.

8.0 GULF PARK

8.1 COMPONENT DESCRIPTION

The Gulf Park site, located in Cleves, Ohio, is equipped with a bioventing system (see Figure 8-1) for in-situ treatment of petroleum hydrocarbon-impacted soil at the site. Bioventing is a form of bioremediation which uses naturally occurring microorganisms in the soil to break down petroleum constituents. Bioventing stimulates the in-situ biodegradation of petroleum hydrocarbon-impacted soil by injecting air at low flow rates to provide sufficient oxygen to sustain natural microbial activity. Airflow is injected at rates designed to maximize oxygen delivery to the subsurface while minimizing volatilization of hydrocarbon constituents, thus eliminating the necessity for air pollution control measures.

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

As a result of subsurface investigations, the original 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 (BV-1 through BV-14) designed to deliver approximately 30 to 35 cubic feet per minute (cfm) to each injection well, and a rotary blower, which was designed to operate on an 8-hour on and 16-hour off cycle. Valve controls for the air injection wells installed in the soccer field area are located in a nearby shed.

The bioventing system was expanded in August-October 2000, consisting of an additional 38 bioventing wells (BVW-1 through BVW-38) constructed of 2-inch diameter PVC casing and 0.010-inch slotted screen. A final section of piping was connected to the bioventing wells in the southwest area of the site in early 2001. The bioventing wells were completed below grade and connected to a separate valve control shed, which was constructed during the bioventing system expansion, via individual piping consisting of 3-inch diameter Schedule 40 PVC.

In October 2005, the existing positive displacement blower was replaced with a centrifugal blower with variable speed drive capable of supplying approximately 35 scfm to each of the 52 biovent lines. The new configuration allowed for all of the bioventing wells to be operated simultaneously and eliminated phased daily operation of the biovent lines.

8.2 COMPONENT INSTALLATION/OPERATION

At this time, there are no plans for additional infrastructure necessary for operation of the Gulf Park bioventing system. The existing system will be operated based on agency-approved startup/shutdown criteria established based on groundwater trigger levels in the impacted area beneath the soccer fields. Historical resiprometry testing has indicated that higher respiration rates occur in the deeper vapor probes completed in the lower portion of the smear zone. However, this portion of the smear zone is only exposed above the groundwater table during extreme drought conditions. The current groundwater elevation trigger level for startup/shutdown of the various bioventing system wells is 464 msl in monitoring well GPW-5S. This trigger level may change over time as biodegradation continues and conditions at the Gulf Park site evolve.

Once the groundwater elevation reaches the trigger level, the system will be started and the biovent lines will be opened. Due to annual precipitation cycles, the groundwater level typically is above the trigger level from December/January through May/June and below the trigger level intermittently from June/July through November/December. This window of the low water table condition is considered the seasonal operation period.

8.3 SAMPLING/MONITORING

Each of the individual bioventing wells has a valve to regulate air flow and a port that is used to temporarily install instrumentation to monitor temperature, pressure, and air flow. This data is gathered for purposes of evaluating system operating efficiencies, and is not directly related to performance metrics associated with the 2006 Order.

In addition to daily operation checks, system monitoring will be conducted on a weekly basis to evaluate the effectiveness and performance of the bioventing system and to determine if and when operational adjustments are necessary. Data collected during system performance monitoring will include:

- Date and time of measurements.
- Airflow injection rates, temperature, and pressure of each of the four bioventing well lines weekly.

- Airflow rate, temperature, and pressure between the blower and the manifold system weekly.
- Gauging fluid levels at the system trigger level well GPW-5S weekly.
- Table 2-1 constituent analytical results for the wells shown on Figure 8-1 and as listed in Table 8-1 annually.
- Soil gas pressure, total VOCs, carbon dioxide, oxygen, methane, and Lower Explosive Limit (%LEL) in selected nested vapor monitoring points. The nested vapor monitoring points (VP-1 through VP-7) are installed 25- and 50-feet from the biovent lines associated with the expanded system. Each of the nested vapor monitoring points consists of a monitoring probe installed within the shallow and a second probe installed in the deeper portions of the smear zone. Soil vapor field measurements will be acquired while the system is active and following a period of inactivity, typically during the middle of the anticipated operation time and after the system has been shutdown for the season.
- Ambient air temperature.

The annual groundwater monitoring will be conducted according to the approved, modified site QAPP, and per industry standard protocols. The samples will be collected, analyzed and reported similarly to those planned for the main site. System monitoring results will be reported to the agencies on an annual basis, within 90 days after the completion of each calendar year.

8.4 PERFORMANCE METRICS AND CONTINGENCIES

Performance metrics and contingencies associated with operation of the Gulf Park bioventing system pertain to maintaining optimum operational parameters. The long-term goal of the system operation is to achieve Region IX commercial/industrial PRGs in soil, and the groundwater cleanup criteria for the constituents listed in Table 2-1. Thus, the annual monitoring results will be compared to this standard, and progress toward meeting these goals will be evaluated and discussed.

TABLES

FIGURES

APPENDIX A

SUGGESTED OPERATING PROCEDURE FOR SOIL GAS PROBE PURGING AND SAMPLE COLLECTION

APPENDIX B

MONITORED NATURAL ATTENUATION TRACKING TREND GRAPHS