UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5

RCRA FINAL DECISION AND RESPONSE TO COMMENTS SELECTION OF REMEDIAL ALTERNATIVE FOR GROUNDWATER

FOR

THE CHEVRON FACILITY
near HOOVEN, OHIO

AUGUST, 2006

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Introduction

The United States Environmental Protection Agency (U.S. EPA) presents this Resource Conservation and Recovery Act (RCRA) Final Decision and Response to Comments for Groundwater and Contaminated Soils at the Chevron facility near Hooven, Ohio. The previously released Statement of Basis for Groundwater outlined remedial alternatives possible at the facility, as well as U.S. EPA's proposed remedy. The public was notified about the public comment period on the Statement of Basis for Groundwater in the local newspapers and on the local radio station. The Statement of Basis for Groundwater (Attachment 1) was made available to the public for review and comment from April 12, 2006 to May 30, 2006. A Public Hearing was held on May 9, 2006 at the Whitewater Senior Center and Township Hall to explain the proposed remedy for groundwater and receive public comment and questions on the proposed remedy. An extension of the comment period was granted from May 30, 2006 to June 14, 2006 in response to concerned citizens requesting additional time. The comments were received by mail, fax, e-mail and in addition many of the comments on the proposed remedy came from the public hearing. U.S. EPA recorded the public hearing comments in a Transcript of Proceedings and is herein responding to the comments in writing. After considering all the comments, U.S. EPA is adding additional detail to the proposed remedy in response to the public concerns. The Final Decision presented in this document supports, but also presents additional detail and clarification, for the proposed remedy.

Selected Remedy

The remedy will consist of the following remedial components:

- Periodic source removal of Light Non-Aqueous Phase Liquids (LNAPL) from the subsurface through a high grade pumping scheme which is anticipated to take from 6 to 12 years;

- Monitor containment of Light Non-Aqueous Phase Liquids (LNAPL) and dissolved contaminant plume. Gradually shut down hydraulic control wells and restore natural gradients;

- Contingencies: if performance measures are not met, the pumps will be turned back on, and other alternative technologies will be analyzed and chosen to remediate the plume (for example SVE, IAS, SEAR);

- Engineered controls to stabilize the bank of the Great Miami River at both the Refinery and Gulf Park, and continued monitoring of the Great Miami River and river bank for releases;

- Monitored Natural Attenuation (MNA) of dissolved contaminant plume and LNAPL plume with associated sampling and 5 year review of the progress of the natural attenuation with the performance measure of complete aquifer restoration to below current Safe Drinking Water Act Maximum Contaminant Level (MCL) in 30 years. The 30 year time frame will begin after completion of the high grade pumping for source control which is 6 to 12 years, bringing the total timeframe to 36 to 42 years;

- Institutional controls to include prohibitions on potable groundwater use and basement construction on the refinery site;

- Point of compliance (POC) and other performance monitoring;

- Continued source removal of volatile petroleum constituent from the LNAPL smear zone beneath the town of Hooven through soil vapor extraction (SVE) during periods of high grade pumping, and whenever the groundwater level falls below the trigger levels;

- Continued monitoring of soil vapor wells in Hooven; and

- Financial Assurance for implementation of the remedy

The remedy will be designed to be protective of human health and the environment. The long-term corrective action objective is to restore groundwater to its maximum beneficial uses. U.S. EPA's goal for the 36 to 42 year time frame is to achieve the current drinking water MCLs throughout the area of contaminated groundwater. Benzene is the most widespread contaminant, and it exceeds the MCL by the greatest factor; thus it is the primary contaminant that will be used to track the cleanup of the plume. The goal for this timeframe is based on the projected attenuation pattern for benzene which involves biodegradation. Other organic contaminants, such as ethylbenzene, and 1,2-dichlorobenzene will also follow an attenuation pattern involving biodegradation. The dissolved ethylbenzene concentrations are expected to meet the current MCL in 90% of the wells at the site within 25 to 30 years after the completion of the high-grade pumping for source control. In other words, the concentration of ethylbenzene is expected to meet the MCL a little sooner than benzene. The concentration of 1,2-dichlorobenzene is expected to meet the MCL a little later than benzene. Inorganic contaminants, such as lead and arsenic, will probably follow a different attenuation pattern because they do not biodegrade. Further improvement is expected to occur very slowly. Nevertheless, at the end of the 36 to 42 year time period, the concentrations of the inorganic constituents are expected to be below the current levels, and the current levels are close to the MCLs.

After the 36 to 42 year time frame, the groundwater will still have taste and odor problems, and will still have unacceptable concentrations of other non-volatile chemicals, i.e metals. These conditions will exist for a long time. Thus, the use of the groundwater will remain restricted and natural attenuation will continue until the groundwater quality is fully restored.

Because achieving this long-term objective will take many years, a series of interim corrective action objectives, as listed below, have been developed for the Chevron groundwater plume. These interim objectives have been designed to ensure that human health and the environment are protected until the long-term corrective action objective is achieved.

The following interim remedial objectives have been identified:

- 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 riverbank to prevent erosion

These interim remedial objectives are interrelated and are to be achieved through the various components of the remedy.

A key component of the remedy is the containment and stabilization of the LNAPL and dissolved contaminant plumes. The LNAPL and dissolved contaminant plumes are currently contained by the ongoing interim measure consisting of the operation of a recovery well system that hydraulically controls the plumes. However, studies have indicated that the LNAPL plume may be stable under natural gradients. Consequently, operation of the site-wide recovery system may not be necessary to contain the LNAPL plume. In addition, the benzene and related petroleum compounds that emanate from the LNAPL source are generally biodegradable in groundwater. On-site monitoring has suggested that natural attenuation stabilizes the dissolved plume emanating from the LNAPL plume. Consequently, hydraulic control may not be necessary to contain the dissolved plume.

During the early phases of the remedy, hydraulic control of the plume will be gradually eased and the migration of the plumes monitored carefully to verify that the LNAPL and dissolved plumes are stable under natural groundwater gradients. The remedy includes an extensive ongoing program of monitoring both the LNAPL and dissolved plumes to verify that both plumes are stable.

For the dissolved plume, a network of monitoring wells establishes a “Containment Point of Compliance” (“POC”), beyond which the LNAPL plume or dissolved contaminants above MCLs will not be allowed to migrate. These monitoring wells are located at the approximate down-gradient boundary of the current plume, and additional wells may be added to completely monitor the down-gradient boundary (Figure 4).

Sampling of these wells will be conducted semiannually for the first five years, annually for the next five years (staggered to account for seasonality), biennially for the next ten years, and every five years thereafter. Should the performance monitoring indicate that MCLs have been exceeded at or beyond the Containment POC, operation of the extraction well system will be resumed. If necessary, Chevron will analyze and implement additional remedial measures in order to ensure containment of the dissolved plume. Alternatives evaluated and Chevron's recommended alternative will be submitted to U.S. EPA for its review and approval. Whenever new wells are installed, Chevron will develop an initial data set for the new wells by sampling quarterly for the first two years.

To ensure containment of the LNAPL plume, the ROST wells and groundwater monitoring wells outside the smear zone will be tested for the appearance of LNAPLs. These monitoring wells will be sampled semiannually for the first five years, annually for the next five years (staggered to account for seasonality), biennially for the next ten years and every five years thereafter. The contingency, if LNAPL is seen migrating, is to resume year round pumping. In addition, Chevron will analyze alternate LNAPL recovery mechanisms (including focused aggressive source removal technologies such as air sparging and solvent flushing (SEAR)) and propose a recommended alternative to U.S. EPA for its review and approval. Chevron shall implement additional remedial measures to ensure containment of the LNAPL plume.

Residual (immobile) LNAPL has been observed along the river bank. This residual has been observed to be released to the river during periods of high river flow due to bank scour and sloughing of contaminated soils along the river bank at the refinery and in Gulf Park. To eliminate such releases, the remedy may require the installation of engineered structures along contaminated portions of the bank to stabilize the bank and prevent sloughing of contaminated soil into the Great Miami River. Should this monitoring indicate that the LNAPL plume is not stable in the area adjacent to the river, special engineered barriers to LNAPL migration will be implemented along the river. The ongoing performance monitoring program will include close monitoring of the LNAPL and dissolved plumes along the Great Miami River to ensure that discharges to the river do not occur.

Since the LNAPL plume, more specifically the benzene and related volatile compounds contained in the LNAPL, are the source of contaminants in the dissolved plume, the remedy includes measures to remove as much LNAPL from the subsurface as is practical. The LNAPL recovery operations conducted to date as an interim measure have demonstrated diminishing returns. The remaining LNAPL is held in the LNAPL smear zone located above and below the water table. Most of this LNAPL is contained below the normal water table elevation and is only available for recovery during periods of low water table elevations, typically early fall to mid-winter. This scheme has been termed high grade pumping. High grade pumping involves concentrated pumping during periods of naturally occurring low water table elevation to further lower the water table in a localized area and enhance the recovery of LNAPL in that area. High grade pumping will be operated in areas where significant quantities of potentially recoverable LNAPL are known to exist starting in the southwest corner of the facility near Hooven and the Southwest Quadrant and progressing eventually to other areas more centrally located in the facility. LNAPL recovery operations during periods of normal and high water table elevations will be suspended since recovery of reasonable amounts of LNAPL is no longer possible during these periods. At the time of the 5 year review, U.S. EPA will evaluate the high grade LNAPL recovery systems' performance to make sure that the sources of the releases have been controlled so as to reduce or eliminate, to the extent practicable, further releases of hazardous waste (including hazardous constituents) that might pose threats to human health and the environment. The high grade pumping program will continue to recover LNAPL from the subsurface until this approach is no longer capable of efficiently recovering further LNAPL.

Depletion of benzene and related volatile compounds in the LNAPL is necessary to meet the long-term corrective action goal of returning groundwater to its most beneficial use and meeting MCLs. This depletion is expected to occur through a number of processes in addition to biodegradation. Benzene is removed from the LNAPL by dissolving into groundwater passing through the smear zone. Benzene also continues to volatilize from the smear zone into the air contained in the vadose zone overlying the water table. Operation of the SVE system beneath Hooven during periods of high grade pumping, and whenever the groundwater level falls below the trigger levels; is included in the remedy to further accelerate volatilization during these periods. The recovery of LNAPL through the high grade pumping program is also intended to directly remove source material. Modeling and other analysis have resulted in predictions that these mechanisms should remove sufficient benzene and related compounds from the LNAPL to achieve the long-term performance measure of attaining current MCLs in groundwater within 42 years. In order to verify that these predictions are correct, the performance monitoring component of the remedy includes periodic investigation of the LNAPL extent and composition, combined with appropriate analysis of these data, to confirm the timely achievement of the long-term performance measure. MNA parameters should be collected and analyzed on a 5 year interval to properly gauge progress of predicted attenuation of the hydrocarbons in the subsurface, Appendix 1 contains the U.S. EPA Region 5 Framework for Natural Attenuation Decisions for Groundwater which lays out a flowchart for decision making and indicator parameters to test for in the field. Should this performance monitoring indicate that MCLs will not be achieved in a timely manner, as monitored by the 5 year reviews, additional removal of LNAPL must be implemented by Chevron. Chevron will evaluate alternatives and submit its recommended alternative to U.S. EPA for its review and approval.

The remedy includes a number of institutional and engineering controls to address any potential exposures that may occur during the interim remedial period. The institutional controls shall be established in a manner to be legally enforceable against existing and future property owners, and shall include the following use restrictions:

1) Land use restrictions on the facility property which are consistent with the soil cleanup standards and anticipated future land uses;
2) Prohibitions on construction of basements or other sub-grade areas for human occupancy on the facility, it is anticipated the facility will have industrial and recreational re-use, with no residential development, day care centers or pre-schools.
3) Prohibitions on potable use of ground water on the facility; and
4) Notice to existing and future owners of off-site properties situated above the plume emanating from the Chevron facility of restrictions on well installation contained in Ohio Revised Code Chapter 3701 – 28 (individual residential drinking water wells) and Chapter 3745-09 (public drinking water system wells.)

The restrictions in 1) through 3) above will be in the form of restrictive covenants that run with the land in conformance with the Ohio Uniform Environmental Covenants Act, Ohio Revised Code Section 5301.80 to 5301.92.

The remedial activities described in this section, including the land use controls, are designed to allow for redevelopment of the refinery property during site remediation before final remedial goals have been met. The company will have to provide an assurance that adequate financial resources are available for implementation of the remedy.

The performance measures of the remedy can be viewed in terms of the receptors potentially impacted by the LNAPL and groundwater plumes. These receptors can be grouped into the following categories based on location: 1) human receptors in Hooven, 2) human receptors in the Southwest Quadrant, 3) the Great Miami River, 4) groundwater at and beyond the POC, and 5) on-site receptors. The strategy of the remedy for protecting each of these potential receptor groups is discussed below.

1.) Human Receptors in Hooven: The LNAPL and dissolved groundwater plumes lie beneath a portion of Hooven. The principal potential exposure pathway to human receptors in Hooven is inhalation of constituents volatilized from the LNAPL and migrating through soil vapor to the surface. The performance measures for Hooven are (1) to ensure that the constituents from the Chevron plume will not exceed risk based residential standards in soil vapor at the ground surface (these standards are identified in U.S. EPA Office of Solid Waste and Emergency Response (OSWER) Draft Vapor Intrusion (VI) Guidance, 2002); (2) to remove as much LNAPL and associated volatile constituents from the LNAPL plume beneath Hooven, as is practical; and (3) to stabilize the LNAPL plume beneath Hooven under natural gradient conditions.

Recent investigations have demonstrated that the vapor inhalation pathway is incomplete. Bezene is more likely to present a human health risk than any other chemical in Chevron’s plume of groundwater contamination due to its toxicity. However, investigation of contaminant concentrations in subsurface vapor have demonstrated that benzene quickly attenuates through biodegradation. To ensure that this pathway does not pose any unacceptable risks in the future, the remedy includes ongoing soil vapor monitoring beneath Hooven. The vapor monitoring wells that will be tested are nested vapor wells 93, 96, 99 and 129. These wells will be sampled at 5, and 10 feet below ground surface and at 10 foot intervals to the groundwater table. These nested vapor wells will be tested twice annually during the spring and fall or to account for the high and low water table conditions for the first two years of sampling, once per year during three to five, and then every three years thereafter. If conditions permit, the samples will be collected when the water table altitude is at or below 463.5 ft-elevation for one week or longer, and before the HSVE system is operated. In addition, the SVE system installed beneath Hooven will continue to operate during periods of low water table and when the high grade pumping is performed. The operation of the SVE system at this time will serve both to capture any volatile constituents vaporizing from the smear zone and to further deplete these constituents from the upper portion of the LNAPL smear zone beneath Hooven, thus reducing the future source of benzene vapor beneath Hooven. If vapor samples show that there is a complete pathway from groundwater to the surface in concentrations exceeding the risk-based levels, Chevron shall implement measures to prevent the vapors from intruding into homes in Hooven. Such measures may include year-round groundwater pumping, operation of SVE, and/or other engineered control(s), and installing vapor vents or other engineered controls in foundations.

The high grade pumping program during periods of low water table will similarly remove LNAPL from beneath Hooven, further reducing the source of benzene and stabilizing the LNAPL plume beneath Hooven. The monitoring wells outside the smear zone will be tested to insure no new LNAPL appearance. The monitoring wells to insure LNAPL stability will be sampled semiannually for the first five years, annually for the next five years, staggered (to account for seasonality) biennially for the next ten years, and every five years thereafter. The contingency, if LNAPL is seen migrating, is to resume year-round pumping and re-evaluate alternate LNAPL recovery techniques, which may include focused aggressive source removal (e.g. air sparging, solvent flushing etc.).

2.) Human Receptors in the Southwest Quadrant: The LNAPL and dissolved groundwater plumes also lie beneath the western portion of the Southwest Quadrant. The principal potential exposure pathways to the human receptors in the Southwest Quadrant include the extraction and use of contaminated groundwater and inhalation of benzene through vapor migration of benzene to the ground surface. The performance standards in the southwest quadrant are to protect human receptors from exposure to contaminants in groundwater and to stabilize the LNAPL and groundwater plumes in this area. The remedy includes engineering and land use controls addressing the potential human exposures in the Southwest Quadrant. These controls include the installation of vapor barriers in buildings in these areas, and drinking water well permitting and siting restrictions imposed by the Ohio Department of Health. The high grade pumping scheme is designed to remove LNAPL from beneath portions of the Southwest Quadrant and further stabilize the LNAPL plume in this area. Monitoring of the LNAPL in the Southwest Quadrant will be accomplished using Rapid Optical Scanning Technology (ROST) wells in three or four transects. These will be located outside the smear zone and monitored semiannually for the first five years, annually for the next five years, staggered (to account for seasonality) biennially for the next ten years, and every five years thereafter. If LNAPL is detected at these ROST wells then Chevron must resume year-round pumping until compliance is restored, and re-evaluate alternate LNAPL recovery techniques. The contingencies could include focused aggressive source removal (e.g. air sparging, solvent flushing etc.)

3.) Great Miami River: The performance standards for the Great Miami River are to (1) prevent any NAPL migration to the river and (2) to prevent the development of a NAPL sheen in the river. The performance standards for the Great Miami River also include (3) the prevention of any un-permitted discharge containing contaminants to the Great Miami River. While preliminary studies appear to indicate that the LNAPL plume will be stable under natural gradients in the vicinity of the river, the remedy requires engineered or hydraulic barriers to contain the LNAPL plume should performance monitoring fail to demonstrate that the LNAPL plume is stable in the area near the river. The monitoring program includes surface and groundwater monitor locations along the Great Miami River, with "early" warning components and monitoring locations at the river bank/smear zone interface. Monitoring includes, visual inspections, piezometers and monitoring wells near the river, and wells to sample pore space in river sediment. The frequency and locations of sampling are to be determined depending on river study findings. Locations known today where sampling and stabilization are needed are at the refinery and Gulf Park. Chevron is prohibited from allowing any un–permitted discharges containing contaminants to the Great Miami River. In addition, Chevron will evaluate contingency alternatives, including perimeter treatment system (e.g. sparge curtain, funnel/gate etc.), aggressive source removal (e.g. air sparging, SVE, solvent flushing (SEAR) etc.), and implement additional corrective measures if necessary to meet the performance standard of no migration of LNAPL or dissolved constituents into the Great Miami River. Chevron shall analyze alternatives and submit its recommended alternative to U.S. EPA for its review and approval.

4.) Groundwater at and Beyond the Point of Compliance (POC): The performance standard for the remedy in the downgradient area of the plume is to prevent the migration of LNAPL or dissolved constituents above appropriate regulatory levels (i.e., MCLs) beyond the POC. This POC will be established at the approximate boundaries of the current plume. Thus, the remedy is designed to prevent any further expansion of either the LNAPL or dissolved phase plumes. It is expected that expansion of the LNAPL plume will be prevented by the natural stabilization of the plume. The benzene and related petroleum compounds that emanate from the LNAPL source are generally biodegradable in groundwater. On-site monitoring has confirmed that natural attenuation stabilizes the dissolved plume emanating from the LNAPL plume. Consequently, it is expected that the migration of the dissolved plume will be controlled by MNA. Monitoring of the plume is key; therefore sampling will be conducted semiannually for the first five years, annually for the next five years, (staggered to account for seasonality) biennially for the next ten years, and every five years thereafter. This performance monitoring will confirm if MCLs for groundwater will be exceeded at the six monitoring wells near the POC and no LNAPL detections in the three or four transects of ROST wells mentioned above. However, should the LNPAL plume migrate or the dissolved constituents above MCLs appear in the POC wells, Chevron will resume year-round pumping until compliance is restored. In addition, Chevron will evaluate contingency alternatives, including perimeter treatment system (e.g. sparge curtain, funnel/gate etc.), aggressive source removal (e.g. air sparging, SVE, solvent flushing etc.), and implement additional corrective measures if necessary to meet the performance standards of allowing no migration of LNAPL or dissolved constituents above MCLs beyond the POC. Chevron will evaluate alternatives and submit its recommended alternative to U.S. EPA for its review.

5.) On-Site Receptors: The performance standards for protecting people who will be working on-site in the future are (1) to prevent exposures to vapor constituents, (2) prevent exposure to soil containing residual contamination, and to (3) prevent groundwater use. These standards are to be met, in part, by implementing engineering controls (e.g., vapor barriers) in buildings during the redevelopment of the property. In addition, institutional controls that prevent exposure to groundwater and residual contamination in soils will be implemented in an expeditious fashion. The groundwater and land use restrictions, as stated previously, will be in the form of restrictive covenants that run with the land in conformance with the Ohio Uniform Environmental Covenants Act, Ohio Revised Code Section 5301.80 to 5301.92.

Public Participation Activities

A public notice appeared in the Harrison Press and the Western Hills Press on April 12, 2006, and in the Cincinnati Enquirer (western zone) on April 13, 2006. The public notice was also broadcast on 89.7 FM WNKU, NPR Radio during the April 13 and 14, a.m. “drivetime;” April 15, 8 a.m. - 4 p.m.; April 17, p.m. “drivetime;” and April 18, noon to 10 p.m. Additionally, a fact sheet summarizing the statement of basis was sent to U.S. EPA’s mailing list and the SB, fact sheet and online comment form were posted at www.epa.gov/region5/sites/chevron. A public hearing was held on May 9, 2006 in the Whitewater Senior Center and Township Hall to receive comments from interested members of the public. The hearing was held from 6:30 to 10:30 pm, and approximately 70 people attended. First, EPA gave a presentation summarizing the Statement of Basis for Groundwater. The remainder of the evening was devoted to recording and verbally responding to comments and questions from the public. Additional correspondence was received after the hearing. The original comment period of April 12 to May 30, 2006 was extended to June 14, 2006 in response to concerned citizens requesting additional time and a one-week delay to some residents in receiving the fact sheet. The Statement of Basis and supporting Administrative Record were placed in the Public Library of Cincinnati Miami Township Branch 8,

N. Miami Rd. Cleves, OH 45002, and the U.S. EPA, Region 5 Waste, Pesticides and Toxics Division Records Center 77 West Jackson Boulevard, 7th Floor, Chicago, Illinois 60604-3590 for public review.

Public Comments and U.S. EPA's Response

Many comments and questions were received orally and recorded in a transcript of the public hearing on the Statement of Basis for Groundwater. Many of the same issues were touched on in the comments and questions received by letter, fax and e-mail and EPA has summarized the questions into 68 separate subjects and written responses to these questions and comments.

COMMENTS

1. Comment: The groundwater is contaminated, so aren't the people who live or work in Hooven drinking contaminated water?

   Response: No. The residents of Hooven have been served by the Village of Cleves' municipal water supply system since the early 1950s. This is a clean supply of water from a source that is not affected by Chevron's contamination. Currently, the water supply is from a well field in the Whitewater Valley east of the Great Miami River Valley.

2. Comment: Leaks, spills, fires, explosions, and air pollution (soot) occurred while the Gulf Oil Company was operating the refinery and land farm prior to 1985. Human exposures to chemical contaminants were probably much higher in the past, before Chevron closed the refinery and began recovering petroleum contamination from the groundwater. Why doesn't U.S. EPA require an assessment of any possible past exposures?

   Response: The May 13, 1993 Administrative Order on Consent (AOC) required Chevron to assess all potential sources of releases that could still pose an exposure risk. The legal authority for the AOC between U.S. EPA and Chevron comes from Section 3008(h) of the Resource Conservation and Recovery Act. This law gives U.S. EPA the authority to require Chevron to cleanup its past releases of petroleum contamination into the environment, but it does not authorize U.S. EPA to look into past exposures or to adjudicate claims for compensation from past personal injuries or harm. Compensation for harm resulting from historic exposures would be the arena of private litigation.

   So, U.S. EPA's objectives for this project are to determine the nature and extent of the current contamination, and assess the potential current and future exposure pathways with the goal of selecting the appropriate construction, operation and maintenance work needed for the cleanup. We don't assess whether people were exposed to contaminants in the past, because it wouldn't change the construction, operation or maintenance work needed for the current cleanup project.

3. Comment: U.S. EPA or other agency should study the linkage between residents' health problems and site-related contaminants.

   Response: Although U.S. EPA determines what health risks site contaminants might pose to nearby residents as a group, the Agency has no jurisdiction to evaluate individual health complaints or study their causes. However, the federal Agency for Toxic Substances and Disease Registry (ATSDR) and state and local health departments have some responsibility for responding to health concerns related to past exposures to hazardous chemicals. These agencies can review data on ground water, soil and air contamination and recommend to U.S. EPA actions that need to be taken to safeguard people's health. In rare instances, they can conduct health studies to determine whether individuals' health has been affected by site chemicals.

   U.S. EPA's responsibility and focus has been to develop a cleanup plan that will prevent people's exposure to site contaminants now and in the future. Because of residents' concerns, however, U.S. EPA's site team has met with ATSDR and Ohio Department of Health and shared the health-related comments expressed at the meeting and in writing. This is what the Agency has learned:

   - Ohio Department of Health is conducting a statistical analysis of the state's cancer registry (a database of cancer diagnoses and deaths) to determine if cancer rates in Hooven are higher than those outside the Hooven area.
   - With the assistance of ATSDR, Ohio Department of Health is using recently-collected soil vapor data to revise the health consultation completed in May 2004. The report will give ODH's opinion as to whether contaminants in the ground water plume under Hooven are migrating to the surface and affecting people's health. And, it may provide U.S. EPA recommendations for further study or action to prevent people's exposure. General information about health consultations is available at:

     http://www.atsdr.cdc.gov/HAC/consult.html.

   The 2004 health consultation can be reviewed at the Cleves library and at: http://www.atsdr.cdc.gov/hac/pha/FormerChevronRefinery050604-OH/FormerChevronRefineryHC050604.pdf.

   For more information about ODH's efforts, contact Robert Frey, Chief- Health Assessment Section, Ohio Department of Health, at (614) 466-1069 or rfrey@odh.ohio.gov

4. Comment: Many residents and former refinery workers have cancer and other serious health problems and believe they are related to contamination from the Chevron facility.

   Response: Many residents and former workers described cancer and other health problems at recent public meetings and in written comments. The federal laws governing the Chevron cleanup require that U.S. EPA ensure the site is properly investigated and cleaned up so that future exposures to site chemicals are prevented. The law does not authorize the Agency to study whether the site chemicals are the cause of people's health problems. However, the Agency has studied ground water contamination extensively as well as the possible ways people can come in contact with it and reached the following conclusions:

- Ground water under the Chevron property and portions of Hooven is contaminated.
- Chevron initially began pumping out contaminated ground water in 1985 and vapors from under Hooven in 1999.
- For people to suffer health effects they must be in direct contact with pollution by breathing contaminated vapors, drinking tainted water or touching the contamination.
- Residents living in Hooven and near the site are not drinking contaminated water. The village of Cleves provides water to Hooven-area residents. This source taps ground water unaffected by the contamination and the village tests the water. To U.S. EPA's knowledge, no one is using a residential well installed into the tainted ground water plume. People are therefore not coming in direct contact with contaminated water.
- Recent ground water and soil vapor studies conducted by Chevron under U.S. EPA's direction show that contaminated vapors (the air between rock and soil particles) near the ground water plume do not reach the surface. Therefore, people are not currently coming into direct contact with contaminants in vapors.

5. Comment: There must be a current pathway for residents and workers in Hooven to be exposed to the chemical contaminants from the Chevron site.

   Response: This issue was thoroughly investigated because the protection of human health is U.S. EPA's highest priority. Reports assessing the exposure and risk to the people in Hooven were submitted in the year 2000 and 2005. A human health risk assessment was submitted for the Southwest Quadrant in 2002.

   It is well documented that the public drinking water supply for the village of Hooven was never affected by the contaminated groundwater from the former Chevron refinery.

   We were also concerned that soot might have been released from the refinery into the air prior to 1986 and might have settled onto the soils in Hooven and remain there today. So the soils in the residential area were sampled and tested for hazardous chemicals. However, none of the samples had contaminant levels that pose unacceptable risks.

   We were also concerned that the contaminants in the groundwater might evaporate into the pore spaces of the soils above the plume of groundwater contamination. We were concerned that these vapors might rise up through the soil and enter into the basements and crawlspaces of residences that have dirt floors or cracked concrete. This is the potential pathway that required the most extensive investigation. The issue was investigated in four ways. First, deep wells were constructed in the soils above the plume of groundwater contamination. These wells were designed to allow sampling of the soil gas at several different levels below the ground surface. As expected, the highest concentrations of contaminants were found in the soil gas just above the groundwater table. However, the vapors do not extend all the way up to the ground surface. Instead, soil gas samples taken about half way between the groundwater table and the ground surface had only trace amounts of contamination.

Second, the soil gas samples from these wells were tested for evidence of biological decomposition. The results indicated that the bacteria in the soil break down the vapors as they rise upwards through the soil. The oxygen and carbon dixode readings from the gas samples confirm the bacteria breakdown. This explains the reason why the vapors dissipate about halfway between the groundwater table and the ground surface.

Third, shallow wells were constructed near a good number of the residences in Hooven. Soil gas samples were taken from these wells and through small holes drilled through the basement floors. Except for a few residences that have already been contacted, the-soil gas samples taken were found to have no substantial concentrations of any contaminants. The concentrations in the soil gas near the homes that are directly above Chevron's plume of groundwater contamination were about the same as the concentrations in the soil gas near the homes that are not directly above the plume.

And fourth, although the soil gas near a few of the homes was found to have vapor concentrations that might pose unacceptable risks if they can enter the homes through the basements or crawlspaces, the chemical contaminants near these homes are not the same chemical contaminants that are in Chevron's plume of groundwater contamination.

One chemical that is not present in Chevron's plume is chloroform. It is possible that chlorinated wastewater might interact with organic matter in the septic tanks and release chloroform into the soil gas through the leaching fields. In any case, since chloroform did not originate from the former Chevron refinery site, Chevron has no responsibility to investigate this matter any further.

Based on this thorough investigation, the U.S. EPA has determined that currently there are no exposure pathways from Chevron's contamination to the community residents, and that Chevron's contamination does not pose any current human health risks to the residents or workers in the community.

It is possible that some of the health problems seen in this community might be related to exposures from the past operations when the facility was active prior to 1986. However, the U.S. EPA did not evaluate the health risks due to from past exposures for the reasons described in our response to Issue # 2.

6. Comment: If some Hooven residents are still concerned about soil vapors, how can they seal their basements better? Would the basements have to be filled with concrete?

   Response: After receiving soil vapor sampling results we sent letters to owners and renters of homes that had soil gas contaminant levels that were above U.S. EPA's guidelines. No samples of indoor air were collected. The soil gas outside the homes was sampled, and the potential for contamination of indoor air was estimated. The residents were advised about the possibility that contaminated soil gas might enter their homes. We recommended that those owners consider the idea of reducing the potential for vapors to enter their homes, and we described some ways that this could be done, including sealing cracks and filling in crawl space area with a barrier material which may include flowable concrete. Our intent was to start a conversation about the sampling results and the possible improvements that could be made to the homes. U.S. EPA's pamphlet entitled "Consumer's guide to Radon Protection: How to Fix Your Home" is a helpful guide to preventing soil gas from entering a home. The pamphlet is available on-line at http://www.epa.gov/radon/images/consguid.pdf .

(Note: the pamphlet discusses radon gas, which is a naturally-occurring soil gas that has nothing to do with Chevron's contamination. However, the techniques described in the pamphlet would work to prevent any kind of vapor barrier from entering a basement or crawl space. Also note that an inexpensive radon test kit will not test for volatile organic compounds, which are the contaminants of concern in Hooven.)

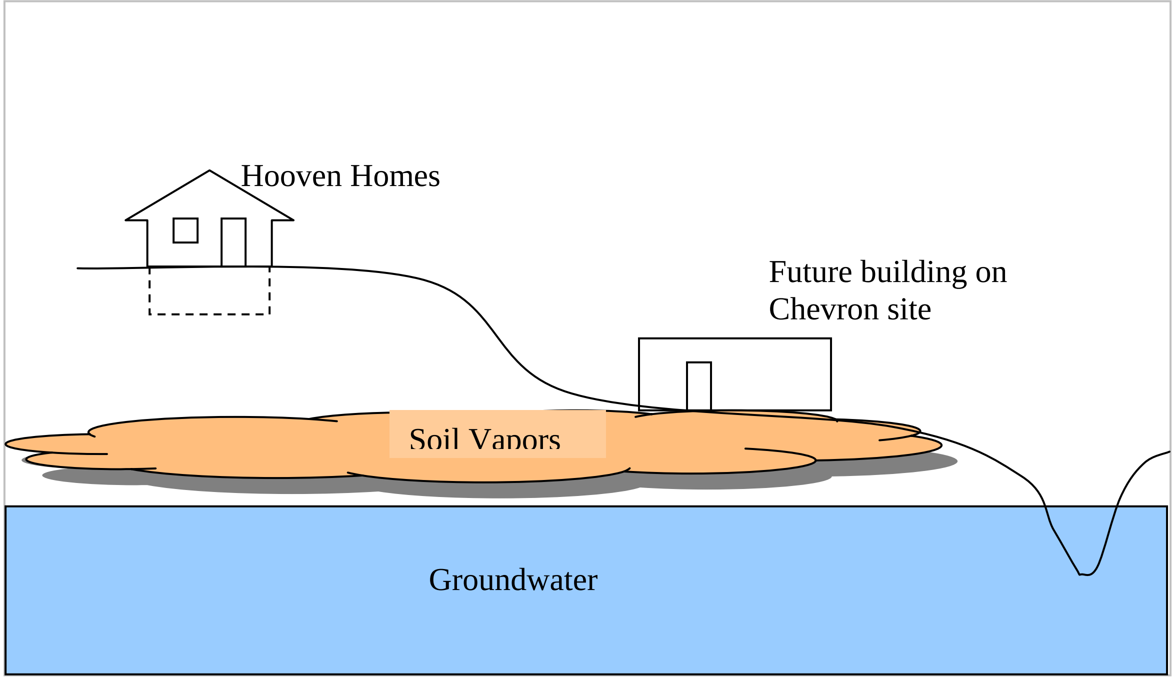
7. Comment: The remediation time frame of 30 years or longer is unacceptable because people who live or work in Hooven are currently being exposed to chemical contaminants from the Chevron site. The unacceptable exposures should be stopped immediately. U.S. EPA should get Chevron (or some government agency) to purchase the homes that have unacceptable exposure and demolish them.

   Response: Protecting the health of people in the Hooven area from the environmental contamination from the former Chevron refinery is our highest priority. If we believed that Hooven residents were currently being exposed to hazardous chemicals, then we would have required Chevron to stop those exposures immediately. Based on sampling of soil, groundwater and the vapors in the pore space of the soil, an analysis of all potential exposures pathways has been conducted. We believe that no one is being exposed to unacceptable levels of the chemical contaminants from the former Chevron refinery. It is especially important to note that all of the residents of Hooven are served by a safe public drinking water system, and that the vapors in the soils above the contaminated groundwater degrade before reaching the ground surface. Thus, the vapors from Chevron's contaminated groundwater are not intruding into the residences, and are not causing the indoor air to be unsafe.

   It is impossible to clean up the groundwater immediately. All of the cleanup alternatives would take many years to restore the groundwater to a usable condition. But as long as no one is being exposed to unsafe levels of hazardous chemicals, it would not be unreasonable to select a remedy with a long cleanup time frame.

8. Comment: New buildings to be constructed on the former refinery site will not be allowed to have basements because that might result in unacceptable human exposures to vapors rising from the contaminated groundwater. So, how can U.S. EPA say that the residential basements in Hooven are safe?

   Response: The residences in Hooven are located up the hill from the former Chevron Refinery. The ground surface at the former refinery site is generally about 20 to 55 feet lower than the ground surface where the residences are located. The ground water surface is also higher under the residences than under the former refinery site, but only a few feet higher. So, if a basement were to be constructed on the former Chevron refinery site, it might extend down into the soil vapors, and that would be unacceptable.



9. Comment: Does the rising and falling of the groundwater level make any difference in the potential for vapors to intrude into homes? Soil vapor testing should be done in the springtime when the groundwater level is highest.

   Response: When the ground water level is high in the springtime, the top of the groundwater is closer to the bottoms of the basements and crawlspaces. The contaminants are dissolved in the groundwater and are less likely to evaporate into the pores between the soil particles above the groundwater. When the groundwater level is low in the late summer/early fall, there is obviously more space between the groundwater and the basements. However, the contaminants have a tendency to accumulate in a layer on top of the groundwater (LNAPL). This makes it easier for the volatile contaminants to evaporate into the pores of the soil above the groundwater. In addition, more of the "smear zone" is exposed, which also makes it easier for the contaminants to evaporate.

   Tests of soil vapors below and next to Hooven homes, and at varying depths within the soil profile and aquifer have demonstrated that the vapors have not risen to the level of the basements. However, as a precautionary measure, U.S. EPA will require Chevron to sample the nested vapor wells twice annually for the first two years of the final remedy's sampling period, once in the spring (high water table) and once in the fall (low water table).

10. Comment: Which homes are safe to live in? Which homes are safe to visit?

    Response: With regard to Chevron's contamination, it should be clearly understood that all of the homes in Hooven are safe to live in and to visit.

    As described in our response to Comment #6, during the course of the thorough investigation into Chevron's contamination, a few homes were found to have unusual situations that are not related to Chevron's contamination. We felt an obligation to tell the owners and residents of these homes about the results of the soil vapor sampling, and they have all been notified. None of these homes are unsafe in the short-term. If the soil vapors situation around these homes persists for many years into the future, the risk to the residents would still be relatively low, due to the limited frequency of exposure to vapors that might be present in the basement.

11. Soot was deposited on the soil of residences in Hooven while the refinery was in operation. Has the soil been tested for the chemical contaminants in soot? Is it safe to eat the vegetables that the residents grow in their home gardens? Is it safe for children to play in the yards? Is it safe for children to come in direct contact with dirt and mud?

    Response: Soil testing has been conducted in portions of Hooven, in proximity to residences, in association with Hooven Sewer Line Risk Assessment from July 2004. The soil testing was over various locations in Hooven and analyzed for metals, Volatile Organic Compounds (VOCs) and Semivolatile Organic Compounds (SVOCs). Samples taken near the surface (at 0.5 foot to 3 foot) and at depth (7 to 10 feet below the surface) revealed no detections of VOCs or SVOCs in those samples. Metals analysis, taken at those same depths revealed results within acceptable EPA risk limits, with only arsenic exceeding those limits. The level of arsenic found in Hooven is typical of the arsenic that occurs naturally in the soils in this part of Ohio. Analysis was conducted for the risk associated with touching (dermal) exposure and breathing (inhalation) exposure from the soil samples taken in the Hooven Sewer Line Risk Assessment. The risk from exposure to soils and vapors to construction workers – who have more contact with soils than the residents - is minimal. The risk to residents would be much less.

12. Comment: We don’t trust Chevron. Is U.S. EPA basing its proposed remedy for the Chevron site in Hooven entirely on data collected by Chevron? Are U.S. EPA representatives on-site whenever samples are taken? How often do U.S. EPA representatives visit the site? Has U.S. EPA ever analyzed any samples from the Chevron project in U.S. EPA’s own laboratory? If so, have the results been compared with the sample analysis results from Chevron’s laboratory?

    Response: U.S EPA representatives have visited the former Chevron facility many times since the consent agreement was signed in 1993, and are quite familiar with the site. The consent agreement required Chevron to submit many workplans and reports, and U.S. EPA representatives have read and reviewed all of these workplans and reports. Chevron was required to submit sampling plans and quality assurance project plans to U.S. EPA prior to initiating the sampling. U.S. EPA project team carefully reviewed the proposed sampling locations, as well as the procedures for taking the samples and making sure that they are properly delivered to the laboratory. The U.S. EPA project team also reviews the laboratory test methods and operating procedures to make sure that the laboratory can get reliable results. U.S. EPA representatives have also observed some of Chevron’s sampling events to verify that the approved workplans were being followed. Prior to the May 9 public hearing, the U.S. EPA had collected split samples with Chevron on site on at least three occasions in various media and sent them to our own laboratory for analysis. Splitting samples means that a sample is taken and divided into two parts.

Each of the two parts is sent to a different laboratory. We then compared the results from our laboratory with the results from Chevron's laboratory and found them to be about the same.

While unsettling to some, U.S. EPA representatives do not observe all of the sampling events at all of the cleanup projects that we oversee. Most environmental laws are based on the concept that the "polluter pays." Thus the responsible company must conduct and pay for the investigation and cleanup. The appropriate level of U.S. EPA oversight and direction depends on the circumstances in each different situation. The U.S. EPA can bring both civil and criminal charges against any individual or company if found to have falsified any sampling results. It is also important to note that Chevron has found extensive contamination in the groundwater and in the soils at the former refinery site while following the U.S. EPA-approved sampling plans.

In response to the comments that we received on this issue, U.S. EPA and Ohio EPA representatives collected split samples during the week of June 26, 2006. U.S. EPA split soil vapor samples with Chevron, and Ohio EPA split groundwater samples from the former land farm area. In addition, U.S. EPA took split samples of soils from a portion of the former refinery site where the soil removal had recently been conducted.

The groundwater and soil sampling were regularly scheduled events, but the soil gas sampling was not. U.S. EPA asked Chevron to schedule a sampling event for the soil gas wells located in Hooven public rights-of-way, and Chevron agreed. The final laboratory reports from the two laboratories have not yet been received, but the preliminary results from the U.S. EPA laboratory confirm the existence of a layer of clean soil gas about half way between the groundwater and the ground surface. We plan to issue another newsletter later this year to explain the final laboratory reports.

13. Comment: Is U.S. EPA willing take samples from Chevron's soil vapor wells and then give those samples to a local community group for analysis at a laboratory that it selects?

    Response: We addressed the issue by splitting samples with Chevron as described above. If we had given samples to a community group, and if its laboratory results were substantially different from those reported by Chevron's laboratory, then U.S. EPA would have had to take additional split samples to determine which of the two laboratories produced the incorrect results. So, we went ahead and analyzed split samples in our own laboratory. The laboratory results will be explained in a fact sheet to be issued later this year.

14. Comment: Does the excavation phase of local construction projects, such as installing new sewers, allow the soil vapors above the plume of groundwater contamination to be released to the air?

    Response: No. Typical excavation projects are generally not deep enough to be affected by the vapors from Chevron's groundwater contamination. A specific study of any health risks associated with the sewer construction has already been conducted. Samples of soils and vapor well samples were collected in 2004, and a report entitled *Hooven Sewer Line Risk Assessment* was prepared. The analysis concluded that the risk of construction workers breathing Volatile Organic Compounds (VOCs) while working in a trench was very low. Of course, any persons who may be nearby during construction would have even lower risks of exposure to VOCs, because they would be farther away from the trench.

15. Comment: Why did Chevron mention vapor sampling results from New York in Chevron's report on the vapor intrusion issue in Hooven?

    Response: This question refers to the study conducted by the New York State Department of Health (NYSDOH). Between 1997 and 2003, the NYSDOH undertook a study of the occurrence of volatile organic chemicals (VOCs) in the indoor air of homes that heat with fuel oil. The purpose of the study was to characterize the indoor air environment of fuel oil heated homes not affected by a fuel spill to compare with homes that have been affected by fuel oil spills. The study included basement, living space and outdoor samples from 104 homes, tested during both heating and non-heating seasons. The intent of referencing this study in the Hooven investigation was to provide some information on the background levels of volatile organic chemicals in indoor air of the homes heated with fuel oil. This information was provided as supporting evidence and did not influence in any way the conclusion that there is no exposure pathway from vapors coming from contaminated groundwater.

16. Comment: If the people who live or work in Hooven aren't being exposed to chemical contaminants from the Chevron site, then why is U.S. EPA proposing any cleanup at all?

    Response: The U.S. EPA is tasked with protecting human health and the environment, including the groundwater. Accordingly, our long-term goal is to restore the groundwater so that it can be used. Also, while studies have shown that there is currently no exposure pathway to the people of Hooven, the plume of contamination needs to be monitored closely to make sure that an exposure pathway does not develop in the future. The cleanup remedy calls for periodic monitoring of the soil gas and groundwater to assess the status of the cleanup and ensure human health is not adversely affected. It also calls for monitoring to make sure that the plume of contamination will not migrate beyond its current boundaries.

17. Comment: Is the school safe? Is the school yard safe for children to play?

    Response: Yes, the school is safe and the schoolyard is safe for children to play. A site risk assessment was conducted for the school by Chevron and its consultants at the request of the elementary school principal. U.S. EPA reviewed this risk assessment. Risk analysis showed that the school indoor air environment is safe for the kids, teachers, and the caretaker. Since the soil gas is considerably diluted in the outdoor air when compared to indoor air, the school yard is safe and the concentrations will be even lower than in the indoor air.

18. Comment: Is the Great Miami River safe for swimming and other recreational uses?

Response: Yes. Sampling of the surface water of the Great Miami River in the summer of 2005 has shown sample results that meet the Ohio EPA surface water quality standards.

19. Comment: Is it safe for children to come in direct contact with surface water and sediments while playing in the creek north of the former refinery site?

    Response: The creek north of the refinery is upgradient of the regional groundwater flow in the area. Therefore, the contamination from the refinery does not flow towards the creek or the area to the north of the refinery. Data collected in the north end of the refinery since the Order was in place shows the plume within the refinery boundary. This data leads to the conclusion that the groundwater contamination from the refinery has not impacted that area.

20. Comment: Have the deer, birds, fish and other wildlife been tested for contamination?

    Response: An ecological risk assessment was conducted for the Chevron Site in November, 2000 and it was reviewed and approved by U.S. EPA. The risk assessment considered birds (American robin, marsh wren, and red winged blackbird), fish, and other wildlife including fox squirrel, eastern cottontail, woodchuck, and raccoon. The risk assessment found little risk to wildlife, except in the area of the Solid Waste Management Units (SWMUs), and this is one of the reasons that these SWMUs are being excavated as part of the 2004 soils remedy. A specific report was requested for analysis of the deer population during the August 2003 public hearing on the soils remedy. In response to the comments, U.S. EPA asked Chevron to study this issue. Chevron submitted the report *Cincinnati Facility Deer Ingestion Pathway: Risk Analysis* in January 2005. The report studied the risk of eating venison from deer harvested near the Chevron site by hunters. The deer are assumed to eat the vegetation on the Chevron facility as a large portion of their diet. The report concludes that no unacceptable risks to human health are associated with consumption of the deer.

21. Comment: Is the corn being grown on local farms safe?

    Response: U.S. EPA is not aware of any threat to corn crops in the area.

22. Comment: Is the water in Cleves safe to drink? Has U.S. EPA determined whether the plume of contaminated groundwater from the former refinery extends under Cleves? Why did Chevron contribute money to the relocation of the Cleves water supply wells to Kilby Road?

    Response: Currently, the water in Cleves is supplied by the Cleves Waterworks. Its supply wells are located in the Whitewater Valley west of the Chevron facility. The previous water supply wells for Cleves were located east of the Great Miami River and north of route 50. A plume of contamination was present in an adjacent area on an island in the Great Miami River, due to pipeline leaks. There were a series of monitoring wells between the island plume and the Cleves water supply wells. These early warning monitoring wells were sampled every two weeks from 1995 to May, 2001 and no impact from the plume was ever seen in these wells. U.S. EPA was not involved in any transactions between Cleves and Chevron regarding relocation of the water supply wells.

23. Comment: In July of 2005, seepage was observed in Gulf Park. Is that seepage related to the groundwater contamination originating from the former refinery site?

    Response: On July 13, 2005 small releases called “spotting” were observed near Gulf Park. Monitoring of this site began immediately, including surface water sampling. While the surface water results indicated all results were within Ohio EPA surface water quality standards, the oil spots were seen near some contaminated soil on the shore. Chevron’s pipelines run from the refinery through the islands and Gulf Park to a terminal on the Ohio River. The source of this contamination was a Chevron pipeline leak in Gulf Park. This contamination is separate from the main plume at the refinery. These releases were initially observed sporadically and subsequent visual monitoring of the river has shown no continuation of these releases.

24. Comment: Some commenters expressed a preference for Alternatives 3, 4, or 5 because those alternatives seem more active and would clean up the environment quicker. Similarly, others commented that the remediation time frame should be no longer than 15 years.

    Response: It is technologically impossible to clean up the groundwater immediately. All of the cleanup alternatives would take many years to restore the groundwater to a usable condition. Alternatives 3, 4, and 5 call for equipment to operate for 12, 10, and 8 years respectively, and monitored natural attenuation would begin after that time. As long as no one is being exposed to unsafe levels of hazardous chemicals, it would not be unreasonable to select a remedy with a long cleanup time frame.

25. Comment: Some commenters said that Hooven is a low income area, and suggested that U.S. EPA would select a remedy with a shorter cleanup time frame if the former refinery site had been located in a more affluent area.

    Response: The U.S. EPA policy states “a preference for expeditious stabilization of the releases, followed by timely completion of corrective action and full restoration of contaminated media; however, a number of factors may influence the time frame within which the cleanup standards can be attained, including: the extent and nature of the contamination from the facility; risks to human health and the environment before and during the remedy implementation; practical capabilities of the remediation technologies; the availability of treatment and disposal options; and the desirability of utilizing emerging technologies.” The income level of the community is not a factor in selecting the appropriate remediation time frame.

26. Comment: How did U.S. EPA consider cost-effectiveness when it proposed Alternative 2? Shouldn’t the health care costs resulting from unacceptable exposures to contaminants have been factored into the analysis of costs?

    Response: We considered five alternative remedies in our April 9, 2006, Statement of Basis for Groundwater. Cost was not the only factor in our decision to propose Alternative 2 as the remedy for the Chevron site. Four alternatives met our most important requirements. Our guidelines call them our four “threshold criteria:” to provide adequate protection of human health or the environment, to provide adequate control of the source of the contamination, and to meet applicable standards. One alternative (no further action) did not meet our threshold requirements, so it was eliminated from further consideration. We then used five additional criteria to compared the four alternatives that did pass. Our guidelines call them our five "balancing criteria:" (1) Long-term reliability; (2) Reduction of toxicity, mobility or volume of wastes; (3) Short-term effectiveness; (4) Implementability; and (5) Cost. The cost considered is based on the total estimated cost of construction and maintenance of the remedy over its lifetime.

We want to make it clear that that protecting your health and the health of others in the Hooven area is our highest priority. If we believed that Hooven residents were currently being exposed to hazardous chemicals, then we would have required Chevron to stop those exposures immediately. Based on sampling of soil, groundwater and the vapors in the pore space of the soil, an analysis of all potential exposures pathways has been conducted. We believe that no one is being exposed to unacceptable levels of the chemical contaminants from the former Chevron refinery. It is especially important to note that all of the residents of Hooven are served by a safe public drinking water system, and that the vapors in the soils above the contaminated groundwater dissipate before reaching the ground surface. Thus, the vapors from Chevron's contaminated groundwater are not intruding into the residences, and are not causing the indoor air to be unsafe.

27. Comment: What's the purpose of the 5-year review?

    Response: The purpose of the five year review in the cleanup plan is to assess the progress of the remedy component. For example, if the groundwater monitoring results indicate that contamination is not naturally degrading at the rate anticipated, then other possible remedies need to be considered. In addition, if contamination is detected in the "point of compliance" monitoring wells at the edge of the plume, then the pumps should be turned back on, and other remedy choices would need to be assessed.

28. Comment: Will the high grade pumping cause soil erosion below ground? In Florida, the pumping of groundwater sometimes causes sinkholes to develop.

    Response: The geology of Florida region and the Hooven area are very different. The Hooven Area is a glacially carved valley filled in with glacial outwash material, primarily sands and gravel. The Florida region has bedrock made of limestone. Limestone can dissolve in groundwater easily, forming caverns within the rock. When the roof of the cavern reaches the surface and collapses a sink hole is formed. The sands and gravel deposits in the Hooven area do not form sinkholes when water is pumped out of them.

29. Comment: Where does Chevron send the petroleum products that they recover from the groundwater? Where do they send the contaminated soil that they excavate?

    Response: The petroleum pumped out of the ground comes in two types; groundwater that contains a very small amount of dissolved constituents, and more concentrated petroleum known as Light Non-Aqueous Phase Liquid or (LNAPL).

The dissolved phase petroleum is treated on site in a treatment plant on the Chevron site with a constructed treatment wetland as the final treatment. The LNAPL recovered is sold as to cement kiln for use as a low grade fuel. The soils that are excavated are sent to several different places depending on whether they are classified as hazardous wastes or solid wastes according to the regulations. The hazardous soils are sent to a hazardous waste landfill in Roachdale, Indiana. The non-hazardous soils are sent to the Stony Hollow facility in Dayton, Ohio and previously the Cherokee Run landfill located in Bellefontaine, Ohio.

30. Comment: Why do trucks park near a little gate on the left side of Cilley Road as they make their way up the hill from Route 128? Are they dumping contaminated soil somewhere in that area?

    Response: During the week of June 24, representatives of the U.S. EPA and Ohio EPA visited the land farm and looked for any evidence of dumping. (Trucks transporting contaminated soils from the former refinery site are not supposed to take that route or dump anything there.) If any dumping had occurred within the past few months, the vegetation would have been disturbed. We found that the vegetation mature at about five feet high and had not been disturbed.

31. Comment: There’s no air monitoring at the Chevron site.

    Response: The site has 3 air monitoring stations that were installed as part of the soils cleanup. The station area located upwind, downwind, and between Hooven and the soil excavations. Monitoring for particulates are accordance with the National Ambient Air Quality Standards (NAAQS), and operates seven days a week and uses a 24 averaging time sample. Air toxic samples Volatile Organic Compounds (VOCs) are taken week days when excavation is taking place, an upwind and downwind sample. Air sampling for metals are taken twice a week using a high volume sampler.

32. Comment: After the groundwater cleanup is completed, what can the groundwater be used for?

    Response: The contaminated groundwater cannot be used in the near future, but U.S. EPA’s long-term goal is to restore the groundwater so that it can be used as drinking water.

33. Comment: It might be difficult to sell my property right now, due to the concern about unacceptable health risks. I might get less money for my property than for a comparable property located elsewhere, away from the Chevron site. Will anyone reimburse me for my loss?

    Response: If anyone involved in property transactions (owner, realtor, banker, mortgage broker, underwriter, prospective buyer) wants to know the current situation in regards to human health risk in Hooven please have them contact the U.S. EPA project manager, Christopher Black, at (312) 886-1451. If you prefer, you can contact him by e-mail at black.christopher@epa.gov. The U.S. EPA cannot reimburse homeowners for property devaluation.

34. Comment: Which map shows the locations of the wells that Chevron has abandoned?

    Response: The monitoring network for contaminated groundwater is summarized in the *Semi Annual Groundwater Monitoring Report.* The report shows the current monitoring well locations, a review of the past *Semi Annual Groundwater Monitoring Reports* would reveal any particular well that is no longer in use or abandoned. U.S EPA is not currently aware of a single map that shows all abandoned wells. Certain monitoring wells have been abandoned due to age, condition problems, or redundancy and have been abandoned with U.S. EPA approval.

35. Comment: In the past, vapors must have been present in the air above ground in the creek area because bad odors occurred frequently and a fire broke out in 1980.

    Response: The creek referred to, I assume, is the creek that flows towards the Great Miami River north of the facility. This area is upgradient of groundwater flow as explained in question # 19. U.S. EPA does not anticipate any impact from the contamination on site to this creek north of the facility, be it groundwater or vapor impact.

36. Comment: Thirty or forty years ago, the groundwater contaminant plumes at the former refinery property, Gulf Park, Cleves Commercial Park might have been connected to form one big plume.

    Response: The plume that originates on the Chevron property and is present under Hooven and the southwest quadrant is separate from the plumes at Gulf Park and on the island in the Great Miami River. The plumes at Gulf Park and on the island in the Great Miami River are from Chevron’s pipeline releases. The plume that originates on the Chevron property is from primarily from releases from the storage of refined product at the site. The current borders of these plumes have been defined and they have been differentiated as distinct plumes.

37. What happened to the asbestos pipe insulation when the refinery was demolished? It appears that no effort was made to prevent human exposures to asbestos dust during the demolition.

    Response: The demolition of the refinery was conducted by Chevron and they are subject to the Clean Air Act - National Emissions Standards for Hazardous Air Pollutants (NESHAP) standards. The Asbestos NESHAP requires facility owners and/or operators involved in demolition and renovation activities to control emissions of particulate asbestos to the outside air. Chevron is responsible to remain in compliance with these regulations during the demolition activities.

38. Comment: People who worked at the refinery have said that there were leaky valves and piping associated with Pump Well #3 and Pump Well #7.

    Response: In the Spring of 2004 pump wells # 4 and #5 were undergoing maintenance due to failing components in the well. At times, the refurbishing of wells involves using an acidic solution to clean out calcification or iron rich buildup. When this process takes place, personnel involved wear personal protective equipment, such as tyvec suits, to keep the acidic solution off of them. These wells at the north end of the Chevron facility are currently in use mainly to provide clean water to the granulated active carbon unit, which is a part of the water treatment plant on site.

39. Comment: In the past, cattle and vegetables were raised on land leased from Gulf Oil Company. Was that food safe to eat?

    Response: U.S. EPA can only assume where the land was that was leased to Gulf Oil. We assume it was the ridge top area, west of Rte. 128. U.S. EPA's May 1993 Adminstrative Order on Consent, included among other tasks, identifying the Solid Waste Management Areas (SWMUs), the Areas of Concern (AOCs) and identifying the nature and extent of the groundwater plume. In this process studies were done on the facility and off site properties. U.S. EPA is not aware of impacts on any lands used for agricultural purposes. The location of the leased lands mentioned in the question and when these lands were used for agriculture is not identified; therefore comparing these locations and time of use to the environmental data available could not be conducted in response to your comment.

40. Comment: How many cleanup projects does Chevron have in Region 5? How many cleanup projects does U.S. EPA oversee in Region 5?

    Response: Chevron is also cleaning up a former Texaco refinery in Lockport Illinois under the RCRA corrective action program. The U.S. EPA is currently overseeing about 178 RCRA corrective action projects in Region 5 (Illinois, Indiana, Michigan, Minnesota, Ohio and Wisconsin). Some are still investigating the contamination and other sites have already been cleaned up. This list includes a variety of industrial facilities, such as steel mills, oil refineries, chemical plants, metal finishers, smelters, and automobile factories. Chevron's Lockport, Illinois project is one of at least 221 additional RCRA cleanup projects that the six state agencies within Region 5 are overseeing.

41. Comment: There should have been more public involvement from 1993 to 2003.

    The 1993 legal agreement between Chevron and U.S. EPA required Chevron to do public outreach. Chevron established the Chevron Community Advisory Panel (CAP) and held its first meeting in 1995. Nearly 100 public meetings of the CAP have been held. Over the years, Chevron has given the residents the opportunity to sit on the panel, and all meetings have been open to the public. U.S. EPA has fulfilled its guidelines for public involvement, including holding public comment periods on its proposed cleanup plans (Statements of Basis) and holding public hearings and meetings. In the past few years, it has also mailed fact sheets to residents of the area. Chevron has also issued its own fact sheets.

42. Comment: Why did some people experience a delay in receiving U.S. EPA's Fact Sheet?

    Response: A U.S. EPA representative made an error in addressing a box of newsletters for shipment, causing a delay of about one week. We apologize for this error. Please note that we extended the comment period by about two weeks from

May 30 to June 14.

43. Comment: Some commenters think another public meeting should be held so that we can get a better understanding of the situation.

Response: We have already mailed fact sheets summarizing the cleanup proposal to area residents and made the Statement of Basis available on our web page, the Cleves library and other places near Hooven. We also held a public hearing with a presentation, followed by questions and answers and an opportunity to comment. At this point, the best way for residents to get to get a clearer understanding of our proposed remedy is to contact U.S. EPA's project manager, Christopher Black, at (312) 886-1451 and ask him questions directly. If you prefer, you can contact him by e-mail at black.christopher@epa.gov. At this point, another public meeting wouldn't be as effective as a one-on-one conversation.

44. Comment: Nothing has been accomplished since 1985.

Response: A lot has been accomplished. Here are some of the highlights:

- Potential human health exposure pathways have been thoroughly investigated, and the U.S. EPA has determined that no one is currently being exposed to unacceptable levels of contamination from the Chevron facility
- 3½ million gallons of petroleum products have been pumped from the groundwater and managed safely
- The plume of contaminated groundwater is not expanding beyond the area where it already exists
- Following a public comment period and a public hearing, the final remedy was selected in 2004 for sludges and contaminated soils
- Since the remedy for sludges and contaminated soils was selected in 2004, 337,661 tons of hazardous waste have been removed from the former refinery site and placed in secure landfills
- A land use plan for the former refinery site has been developed with significant input from community leaders
- Nearly 100 public meetings of the Community Advisory Panel have been held

Ohio Department of Health Comments and U.S. EPA Responses

45.Comment : The accumulation of free-product and vapor-phase hydrocarbons under the village led to vapor-phase hydrocarbons making their way up from the water table to the soils immediately under residential portions of the village in 1997 (see results for VW 96 collected in 1997). This vertical migration of vapor phase hydrocarbons necessitated the installation by Chevron of the horizontal SVE system under the east edge of the village in 1999. The system's operation in 2000-2002 (and subsequent intermittent operations in 2005-2006) appears to have been somewhat successful in removing some of the vapor-phase hydrocarbons from the soils under the village and interrupting the flow of these vapors from the plume at depth to the shallow subsurface soils under the village. Contrary to Chevron's claims, we believe the operation of the SVE system has led to the apparent "gaps" in vapor phase hydrocarbons in soils under the village evident in nested vapor wells adjacent to the SVE system, not natural biodegradation by aerobic microbes.

> Response: There has been multiple sampling of soil vapors in Hooven. Different methods were employed to measure soil vapors. Vapor monitoring wells, and vapor flux measurements-both downhole and surface. Vapor monitoring wells measure the soil gas concentrations in a permanent well and the downhole vapor flux measurements are taken in a soil boring and measure the flux, or change in soil gas flow. Vapor Well (VW) VW-93 and VW-96 were installed in July and August 1997, and VW-99 was installed in November 1997. Initial sampling of VW-93 (in August '97) and VW-96 (in September '97) was conducted using only Tedlar bags and using the TO-3 method of analysis. Subsequent sampling of these vapor monitoring wells on 12/97, was conducted using summa canisters and the TO-3 method of analysis. The initial August and September 1997 did not use summa canisters and the samples also yielded results with high detection limits, leaving uncertainty as to the actual results. The December 1997 sampling shows primarily non-detect results for benzene at 15 and 35 feet below the surface. U.S. EPA review of the data from 2005 showed similar results from the pre-SVE sampling which showed vapor results near the plume and at the surface with non detect or trace amounts in between. This data leads us to conclude the SVE, while removing a lot of the mass of the plume in the vapor phase, is not the cause of the "gap" seen in soil vapor data in 2005.

46. Comment: We continue to have concerns with regard to the potential for vapor-phase hydrocarbons from the underlying plume to migrate through soils under the village of Hooven in areas above the free-product and dissolved phase portions of the plume but outside of the cone of influence of the current SVE system. Additional nested vapor wells need to be installed in these areas to determine if the plume under the village indeed poses a threat to these portions of the village outside the area of influence of the SVE system.

> Response: As stated in the response to question 45, the data leads us to conclude the SVE, while removing a lot of the mass of the plume in the vapor phase, is not the cause of the "gap" seen in soil vapor data. In terms of the vertical influence SVE in Hooven is targeted toward the smear zone (50-60 ft bgs) rather than the shallow depth (20-30 ft) at which the gap is found. From a map view the radius of influence of the three SVE wells covers most of the plume footprint under Hooven. The Interim Measures and Implementation Report and the Operation and Maintenance Plan for the Hooven SVE system details the radius of influence and testing for the SVE wells installed under Hooven. The recently installed nested wells such as MW-126 and MW-127 over the dissolved plume and MW-129 and MW-130 beyond the plume supports that conclusion.

47. Comment: We feel the potential for vapor intrusion in the commercial area currently being built in the Southwest Quadrant Area needs additional investigation as well. These properties are on the floodplain of the Great Miami River immediately downgradient of the pooled accumulations of hydrocarbons and appear to be much more vulnerable to vapor intrusion than the village which is sitting atop an additional 20+ feet of soil.

Response: U.S. EPA is aware of the risk in the Southwest Quadrant. The LNAPL and dissolved groundwater plumes also lie beneath the western portion of the Southwest Quadrant. The principal potential exposure pathways to the human receptors in the Southwest Quadrant include the extraction and use of contaminated groundwater and inhalation of benzene through vapor migration of benzene to the ground surface. The performance standards in the southwest quadrant are to protect human receptors from exposure to contaminants in groundwater and to stabilize the LNAPL and groundwater plumes in this area. The proposed remedy includes engineering and land use controls addressing the potential human exposures in the Southwest Quadrant. These controls include the installation of vapor barriers in buildings in these areas, and a statutory prohibition on groundwater use on the installation of wells where known contaminants will be conducted to a well. The high grade pumping scheme is designed to remove LNAPL from beneath the Southwest Quadrant and further stabilize the LNAPL plume in this area. Monitoring of the LNAPL in the Southwest Quadrant will be accomplished using Rapid Optical Scanning Technology (ROST) wells in three or four transects. These will be located outside the smear zone and monitored semiannually for first five years, annually for next five years, staggered (to account for seasonality) biennially for next ten years, every five years thereafter. If LNAPL is detected at these ROST wells then Chevron must resume year-round pumping until compliance is restored, and re-evaluate alternate LNAPL recovery techniques subject to U.S. EPA's review and approval. The contingencies could include focused aggressive source removal (e.g. air sparging, solvent flushing etc.)

48. Comment: How you can exceed the non-cancer hazard index for benzene in this area (HI = 2) yet still be within the "acceptable level" regarding long-term cancer risks?

Response: EPA considers this unacceptable level and accordingly institutional and engineering controls have been recommended for the Southwest Quadrant area as explained above in comment # 47.

49. Comment: Are engineering and land use controls in SW Quadrant currently in force? Development is already well along in the area. From Statement of Basis for Groundwater, 2006.

Response: Yes, Engineering barriers have been offered to property owners on the Southwest Quadrant by Chevron. The selected remedy includes engineering barriers in the Southwest Quadrant. Also, as the Statement of Basis explains, groundwater use is restricted, by Ohio EPA regulations.

50. Comment: The Health Assessment Section has concerns as to whether the remedial technologies that are part of Alternative 2 will have any more impact on reducing the volume of the free-product in the groundwater under the site than the previous 20 years of pumping and treating have had. Given the current set of alternatives, we think a combination of the targeted high-rate pumping proposed in Alternative 2, coupled with Alternative 5 (using a surfactant to help facilitate removal of hydrocarbons from the smear zone and release them for capture by the pump & treat system), would likely be a more effective approach to take to try and reduce the volume of hydrocarbons still remaining in the aquifer under the village than the limited high-grade pumping approach proposed in Alternative 2.

Response: There are significant differences in the pump rate between the high grade pumping proposed and the previous well pump rate of the pump wells on site. The high grade pump rate pump is at approximately 3,500 gal/min vs. the previous rate of 1,200 gal./min. This increased pumping rate at the wells near Hooven, as tests have shown, would help reduce the plume from under Hooven. Alternative 5 would still have the same problems as laid out in the Statement of Basis. The technology, as shown in bench top studies, may increase dissolved concentrations of contaminants thereby spreading the plumes in groundwater and requiring additional containment measures. The ability to put in a dense grid of SEAR in Hooven would not be possible, given the grid density proposed in the Groundwater Statement of Basis.

51. Comment: We would also like a more detailed description from Chevron with regard to future operation of the SVE system under the village as, in our opinion, this system, more than any remediation carried out by Chevron at this site to date, seems to have been the most effective at reducing the public threat to the residents of Hooven from the underlying contaminant plume.

Response: U.S. EPA recognizes the Hooven SVE system as an effective means to reduce the contamination source under Hooven. Continued operation of the soil vapor extraction system is a component of the proposed remedy as described in ground water statement of basis. The Final Decision and Response to Comments adds more detail to clarify the conditions under which Chevron should operate the Hooven soil vapor extraction system in the future.

52. Comment : How is it that Chevron-Texaco was allowed to submit a Human Risk Assessment re: Volatile organic compounds (VOCs) in the Vapor Intrusion pathway -- based on only one single sampling event?

Our understanding of the process from conversations with peers at Ohio EPA and past experience with other US EPA Haz-mat sites is that US EPA risk assessment protocols, at least for VOCs in groundwater and ambient and/or indoor air pathways, require a minimum of four quarters of environmental sampling data due to well-documented seasonal fluctuations in VOC levels throughout the year. Soil gas levels for VOCs surely also will reflect these seasonal fluctuations in concentrations as they are directly linked to groundwater plumes or vapors coming off of contaminated soils. The April, 2005 sampling carried out by Chevron-Texaco does not even approximate a “Worse Case Scenario” based on their own documents.

HAS recommends carrying out additional rounds of soil vapor sampling under the village of Hooven to more completely capture potential seasonal variations in soil gas under the village

Response: Vapor intrusion assessment is an evolving science. Following the issuance of draft vapor intrusion guidance by OSWER in Dec 2003, U.S. EPA Region 5 revisited the vapor intrusion issue in Hooven and requested Chevron to revise the risk assessment submitted in May 2000. The vapor intrusion guidance requires the facility to conduct a pathway analysis through multi tiered screening process. After it is made certain that the pathway is complete, risk assessment is required to assess the risk associated with the complete inhalation exposure pathway. It should be noted that the deep nested wells, near surface and subsurface vapor probes in the sampled locations in Hooven are permanent probes that provide the option of re-sampling when required.

The deep nested well sampling from 5 locations from the March 2005 sampling event supported the main idea that the petroleum hydrocarbon concentrations decline rapidly in the deep vadose zone which is 30 to 55 ft. below ground surface. Soil gas VOC concentrations at this depth from all the three nested vapor probes over the plume and dissolved plume did not exceed the site specific screening criteria. Further, the identification of similar compounds at trace levels near the surface (5 to 10 ft bgs) inside and outside the plume suggested the possibility of contribution of VOCs from surface activities.

The March 2005 sampling event is not the only event which provides the evidence that active degradation is extensive at the deep vadose zone. Two sample events conducted in September 2005 (at low water table/ worst case scenario) and June 2006 (samples collected and analyzed by EPA) also confirmed the active degradation of petroleum hydrocarbons in the deep vadose zone and a “clean zone” free of plume related VOCs between 20 and 30 ft bgs. Please note that EPA is keeping track of this incomplete pathway and requires Chevron to conduct semi annual sampling for the first 2 years. Efforts will be taken to conduct the sampling event during seasons likely to present a worst case scenario.

53. Comment: Based on Chevron-Texaco’s own studies (Horizontal SVE System O & M and Monitoring Schedule; CEC, November, 2001), the 2005 soil gas field investigation was not carried out under a “Worse Case Scenario”.

This document indicated that soil vapor production is limited under high water table conditions which are typical of the Great Miami River watershed during the spring months – including April, 2005 when the field investigation was carried out. Chevron-Texaco has stated in it’s documents (CEC, 2001) that the optimal time for vapor production was during low water table events when the hydrocarbon “smear zone” bracketing the fluctuating water table is exposed above the water table, allowing for vaporization of attached volatiles and migration of these chemicals as vapors up through the overlying soils towards the ground surface.

In addition, Chevron-Texaco’s 2005 document indicates that a “significant rainfall event” (2.5 “ rain in a two-day period at the end of March with stream flow up to 21,000 ft^3/sec in the GMR) occurred in the area during the initial stages of the subsurface gas sampling under the village. The additional effect of this event on vapor levels in soils under the site due to the influx of surface waters into the underlying soils is largely unknown.

On both counts, this was not the optimal time for vapor production in soils under the site and this sampling time period certainly does not represent anything close to a worst case scenario.

The “Worst Case Scenario” would more likely be captured by carrying out soil gas investigations in the late summer and early fall, typical “drought” months in SW Ohio when the water table in the buried valley aquifer underlying the floodplain of the GMR is likely to be at its lowest (stream flows of <750 ft^3/sec in the GMR and depths to water table in Ohio Observation well H-1 of -24 ft bgs compared to -21 ft bgs in April 05). According to Chevron-Texaco, vapor production should be at a maximum under these conditions at this time.

HAS recommends that at least one of the additional soil gas sampling events captures this “Worse Case Scenario” – i.e. sampling in late summer or early fall.

Response: Following the March 2005 sampling event, two other events have already taken place - one in September 2005 and the other in June 2006 to account for worst case scenario and seasonal variation. In all these events, VW-96 continues to show high vapor concentration near the source area. The concentration of BTEX rapidly declines with the upward migration. A “clean zone” free of VOCs is identified between 20 and 35 feet in all these sampling events confirming an incomplete pathway for inhalation exposure for the residents of Hooven.

54. Comment: Chevron-Texaco’s “Site Model” (October, 2005 Report, Figure ES-1) seems to be based on selected nested Vapor Well results (primarily those for VW 128 and VW 93) and does not seem to be as well supported by the results obtained from other nested Vapor Wells across the village (VW 127, VW 129, VW 130, VW 96, and VW 99).

Chevron-Texaco’s Site Model predicts detections of site-related hydrocarbons within 10 feet of the water table over the plume, followed by a VOC-free zone 20-30 ft below the ground surface, with higher levels of a different suite of VOCs in the upper 10-15 ft of soil under the village. These latter shallow subsurface soil gas compounds are described as consisting of chemicals not associated with the gasoline plume under the village (i.e. Chloroform, MTBE, chlorinated solvents) and resulting from non site-related activities taking place on these residential properties.

VW 127, 129, and 130 detected trace levels of site-related hydrocarbons throughout the entire vadose section of the soils under the village. VW 96 has site-related hydrocarbons at 55 ft bgs, 45 ft bgs, 40 ft bgs, 30 ft bgs, and in the upper 5 ft of soil.

VW 127 has trace detections of supposedly non site-related PCE at depths of 40 and 50 ft bgs; VW 130 has PCE at depths of 15 and 30 ft bgs; VW 96 has PCE at depths of 30-45 ft bgs; and VW 99 has PCE at depths of 20-30 ft bgs. What is the source of this PCE? How did it get where it is? Why isn’t it detected in soils above and below the soil intervals where it was found?

While it is likely that surface activities in residential properties have had some effect on soil vapor levels of some compounds in the upper 10-15 ft of soil in the area (see VW 128), the results presented are not fully conclusive as to the origins of these detected VOCs. Can US EPA or Chevron-Texaco distinguish between BTEX from the site and BTEX in soils resulting from surface activities by Hooven residents?

To my knowledge, MTBE was never used as a gasoline additive in Ohio (might have been used in adjacent portions of northern Kentucky: Louisville and Covington area). [USGS data in Carter et. Al. 2006. Journal of AWWA. 98:4:91-104]

Note: A previous site document (Chevron Cincinnati Facility Phase II Facility Wide Human Health and Ecologic Risk Assessment, E&E, April, 2000, p.2-11 and 2-16) lists both Chloroform and Tetrachloroethene (PCE) as Chemicals of Concern at the Chevron-Texaco site.

HAS would like some answers to or clarification of some of these questions re:

distribution of VOCs in soil horizons under the village.

Response: In its earlier comment, HAS pointed out that VW-96 is the worst affected well with respect to high concentration of BTEX near the source area. The presence of gap even in the worst affected well presents the evidence for incomplete pathway under current conditions. This is further confirmed by the subsequent sampling which occurred in September 2005. In response to the request from the residents of Hooven, EPA conducted an independent sample analysis in June 2006. Both the sampling events in well VW-96 showed a gap free of BTEX between 20 and 30 ft bgs.

The chemical concentrations measured under homes and in other shallow (<10ft) samples were all very low, generally less than 100 micrograms per cubic meter (ug/m3). The volume of shallow soil gas beneath a residential property (approximately 50 ft by 150 ft by 10 ft with a 25% air-filled porosity) is about 531 m^3. Therefore, the total mass of a chemical needed to create concentrations of 100 ug/m3 is only 53,100 ug, which is the same as 53 milligrams, or 0.053 grams. This is less than a single drop for most compounds. This amount is readily released from various sources at the surface, such as oiled roads, leaking vehicles, septic systems, and chemical storage areas in garages or other outbuildings.

Another way for chemicals like those detected in shallow Hooven soils to find their way under homes is for them to flow out of the homes themselves. This is not unique to Hooven or to Ohio or to the country as a whole. Nearly all humans who live in homes with heating or air conditioning and use consumer products like cleaners, air fresheners, beauty products, paint, glue, new carpet and more, have small amounts of these chemicals in their homes. In April 2006, United States Geological Survey (USGS) submitted a report which can be found at http://water.usgs.gov/nawqa/vocs/national_assessment/. The assessment of groundwater included analyses of about 3500 water samples collected during 1985-2001 from various types of wells, representing almost 100 different aquifer studies. According to this report, VOCs were detected at trace amounts in 90 of 98 aquifer studies. Of the 42 VOCs detected in ground water samples the most detected at high frequency are chloroform, PCE, MTBE, TCE and toluene (Refer chapter 3, Fig .8, page 12 of the above referenced document). This report highlights that the detected VOCs were associated with natural or a mix of natural and anthropogenic factors that would affect their source, transport and fate in ground water. Table 4 in this chapter shows the positive association of chemicals such as PCE, TCE and chloroform with septic systems and urban lands apart from contribution through RCRA facilities.

Methyl Tertiary Butyl Ether (MTBE) is found at the surface and not a depth in the plume. Chevron had not manufactured MTBE at the refinery and the nearby Kentucky portion of the Cincinnati area had reformulated gasoline containing MTBE. Tetracholroethene (PCE) is not detected in the groundwater samples in Hooven taken in the spring of 2005.

Note: The reference to the Chevron Cincinnati Facility Phase II Facility Wide Human Health and Ecologic Risk Assessment, E&E, April, 2000, p.2-11 and 2-16 only lists chloroform and PCE as part of the phase II analyte list not contaminants of concern.

55. Comment: In the Subsurface Field Investigation Report and elsewhere there doesn’t seem to be any discussion about the presence or absence of preferred

pathways for soil vapor migration under the village of Hooven. There are also no discussions of the potential for horizontal migration of the vapor plume in the discussions of the site.

Review of the Subsurface Field Investigation Report (2005) indicated, via a series of site geologic cross-sections that the stratigraphy of the soils under the village of Hooven is anything but homogeneous. Whereas cross-section A-A' west-east across the northern end of the village (Figure 4) shows a layer of silty clay and sand of variable thickness (3-10 ft) across much of the village; cross-section B-B' west-east across the central and southern portions of the village (Figure 5), indicates numerous breaks in this silty surficial layer, with the more permeable sand and gravel beds extending right up to the ground surface (around MW-129 and between MW-101S and MW-126).

Cross-section C-C' (Figure 6), traversing the east edge of the village in a north-south line, shows homogeneous, highly permeable sand and gravel extending all the way from the LNAPL at the water table to the shallow subsurface soils under the village in the vicinity of VW-96 and VW-99. Interestingly, soil gas sampling of VW-96 in 1997 showed the presence of significant amount of site-related vapor phase hydrocarbons extending all the way from the water table to the surface.

Conversely, vapor well VW 128, when sampled in 2005, lacked detectable levels of vapor phase hydrocarbons at depths below 20 ft. According to the cross-section, this location is not underlain by the hydrocarbon LNAPL plume, so lacks a source for the hydrocarbon vapors in the deeper subsurface.

The site model implies that all vapor migration in soils under the village would be in a vertical direction such that elevated vapor phase hydrocarbons would only be expected to occur directly above the area underlain by the LNAPL and possibly the dissolved phase contaminant plume. West-east Cross-sections A-A' and B-B indicates that less permeable gravels, sands, silts, and clays overly the plume along the eastern edge of the village, possibly limiting the ability of the hydrocarbons vaporizing off of the plume to move upward through the soils under this part of the village. These cross-sections also suggest that vapors coming off of the plume might be more readily transported towards the surface by migrating first to more permeable gravels and sands just to the west of the plume and then moving vertically up all the way to the surface in this more homogeneous permeable sand and gravel unit (in vicinity of MW-101S).

HAS recommends a more thorough review of the stratigraphy of the vadose zone soils under the site with the idea that there might be some defined preferred soil gas pathways under the village of Hooven due to the geology of these soils. This certainly appears to have been the case with VW 96. The potential for horizontal migration of vapor phase hydrocarbons should also be more fully investigated. These analyses might be useful in determining the siting of additional nested vapor wells under the village.

Response: Thank you for your comment, U.S. EPA has reviewed the geologic cross sections and is aware of some heterogeneity in the deposits under Hooven. The geology was taken into account when looking at the vapor results. For clarification, VW-128 is over the dissolved phase plume, and the surface layer described above as "silty clay" is described in the report as silt or silt and clay with fine sand.

56. Comment: The case presented for active biological degradation of the vapor phase site-related hydrocarbons in the soil intervals immediately above the hydrocarbon smear zone associated with the gasoline plume seems weak.

Chevron-Texaco's own documents (CEC, November, 2001) indicate that induced "fresh air flow" diminishes below the upper 20 ft of soil even when the SVE system installed under the east edge of village was in operation. Oxygen levels may drop off even faster if air flow into the soils is not being induced by SVE system operation. In the vicinity of the "smear zone" bracketing the water table, vapor flow is described as "oxygen-deficient" due to methane-rich vapors generated in the smear zone and vaporizing directly off of the plume. This suggests that the decrease in oxygen levels and the increase in CO_2 levels with increasing depth from the ground surface could be simply the result of the depth to the contaminant plume and the chemistry of the vapors coming off of the plume just as easily as reflecting any kind of increased biological activity by bacteria degrading the hydrocarbon vapor plume in the soils immediately above the water table.

A comparison of hydrocarbon vapor concentrations collected in 1997 and 2005 from the same Vapor Wells along the edge of the free product plume boundary under the east edge of the village is instructive. VW 93 has never had any significant vapor phase hydrocarbons in the vadose zone (= upper 35 ft of soil) under the village of Hooven. It didn't have any significant detects in 1997 and had none in 2005.

In contrast, VW 96, just north of VW 93, had significant levels of site-related hydrocarbons (1,000s of ppb of toluene, ethylbenzene, and xylenes) at depths as shallow as 20 ft below the ground surface in 1997. These sample events (August & September, 1997) strongly suggest that site-related vapor phase hydrocarbons penetrated the entire soil column under the village in 1997, leading to the development of a completed exposure pathway linking residents in the village with the contaminants in underlying gasoline plume in 1997. It does not appear that natural biodegradation of the vapor phase plume was all that effective in reducing vapor phase contaminant concentrations in VW 96 in 1997.

However, the BTEX hydrocarbons in VW 96 in the 2005 sampling of this well are absent from the upper 50 ft of soil above the gasoline plume and under the village. High levels of hydrocarbons detected just above the plume (55-40 ft bgs) in both VW 93 and VW 96 (plus VW 99 as well) in 1997 are significantly reduced or totally gone in 2005. The difference appears to be the result of the installation and operation of the horizontal Soil Vapor Extraction system under the east edge of the village starting in 2000 and continuing into 2003. All of these sampled nested vapor wells are proximal to the distal ends of the SVE piping. It appears that the SVE system was installed by Chevron under the east edge of the village in 2000 as the result of vapor intrusion concerns generated by these 1997 vapor well results. When it was operating on a regular basis between 2000 and 2003, it appears the system was very effective in reducing the amount of vapor phase hydrocarbons in the vadose zone soils immediately above the plume. The system was rarely in operation in 2003 and 2004 due to abnormally wet weather and high water tables in the vicinity of the site, even into late summer and early fall months which typically are dry in SW Ohio, normally resulting in low water table levels. Evidently, the SVE system has been operated on an intermittent basis in 2005 and 2006 as weather conditions resumed a more typical seasonal pattern.

The case for significant biodegradation of vapor phase contaminations within 10-20 ft of the gasoline plume does not seem to us to be that strong. A remedial plan for soil gas that relies just on natural biodegradation of vapor phase contaminants does not seem adequate re: public health concerns of the village residents.

The 1997 soil gas sampling under the village provides some evidence that village residents may have been exposed to site-related compounds from the vapor phase of the plume via a completed pathway prior to the installation of the current SVE system under the east edge of the village in 2000. Subsequent sampling suggests that this SVE system was effective in significantly reducing vapor phase contaminants in soil gas above the plume when it was operating between 2000 and 2003.

How does the operation of the current SVE system fit into the Remedial plan for the site or does it? Will there be a remedial plan for the soil vapor pathway or are the Company and US EPA simply writing off this pathway as being incomplete and therefore, of no public health importance?

Response: : Comparison of concentrations between 60 ft and 40 ft bgs in the deep nested well VW-96 and VW- 99 over the plume at various sampling events show a significant reduction in the BTEX concentration as the vapor migrates upwards. Sampling events such as December 1998, February 1999 and June 1999 occurred before the installation of SVE system and each one of them show a significant reduction in concentration at a depth of 40 ft bgs. Reduction in BTEX concentration in association with a classic profile of decreasing oxygen and increasing carbon dioxide at the deep vadose zone is indicative of biodegradation. U.S. EPA is also aware that biodegradation at the deep vadose zone solely is not responsible for source reduction and does not dispute that Hooven residents may have been exposed to site-related compounds from the vapor phase of the plume via a completed pathway prior to the installation of the current SVE system. HAS is correct in pointing out that since the installation of SVE, the source concentration is dramatically reduced. To U.S. EPA, public health at Hooven is of utmost importance. Although the latest sampling events since the installation of SVE system confirmed the incomplete vapor intrusion pathway, U.S. EPA proposes to continue the operation of SVE system as an effective means to reduce the contamination source under Hooven. Please refer to the Ground water Statement of Basis and the listed conditions for operation of SVE in the Groundwater remedy final decision document.

57. Comment: The results of the 2005 soil gas sampling of nested Vapor Wells, especially VW-128, VW-127, VW-93, VW-96, and VW-99 along the eastern edge of the village of Hooven, may not be representative of vapor intrusion conditions away from the SVE system installed in the immediate vicinity of these wells in 2000. The 2005 sampling results for these wells may reflect the effectiveness of this SVE system in reducing hydrocarbon vapor levels above the gasoline plume and may not be representative of conditions underlying the rest of the village.

Due to their location proximal to the distal ends of the SVE system underlying the eastern edge of Hooven, HAS has concerns that line of sampled nested Vapor Wells VW 128, 127, 93, 96, and 99 all have been impacted by past operations of the SVE system, reducing vapor levels in the intervening soil intervals above the gasoline plume.

There is no data for areas further away from the SVE system yet still within occupied portions of Hooven overlying the “dissolved plume” or the free-product plume. These areas, beyond the direct area of influence of the SVE system, might show a significantly different picture of vapor migration under the village.

Potential sites for additional nested Vapor Wells to fill in this potential gap would be in the vicinity of MW-122, MW-125, and MW-101 west of the current line of Vapor Wells and northeast of VW-99, between it and Rt. 128 (maybe near MW-121).

HAS will be recommending the installation of additional nested Vapor Wells in the areas detailed above.

Response: Same answer as # 46

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58. Comment: Section II (p. 2), Section V (pgs 14-15), Section VI (Table 1), and Section VII (pgs 19-20, 22) refer to a final cleanup goal of achieving maximum contaminant levels (MCLs) throughout the plume within 30 years. Our interpretation of 30-years being the functional definition for “achieving the site specific remediation objectives within a timeframe that is reasonable compared to other remedial alternatives” is a reasonable starting point for defining the time to completion. However, 30-years as an absolute goal is not documented in published regulations, and does not appear to be based on technical or health based rationale. The actual time to final cleanup should be tied to the site specific circumstances and the level of risk presented by residual contamination. Based on decades of site data, remediation results, and groundwater modeling, reaching the MCL for benzene within 30 years of completion of the active remediation phase (e.g. after completion of the high-grade period) is expected to be achievable. The high-grade period is expected to last between 6 and 12 years.

Response: If there was a need to use the groundwater under Hooven and the former Chevron refinery site as a source of drinking water in the foreseeable future, then it would be reasonable to select a remedy with a cleanup timeframe that’s short enough to meet the need. However, since there is an ample amount of uncontaminated groundwater readily available nearby, there is no particular urgency to use the groundwater under Hooven or the former Chevron refinery as a drinking water source in the foreseeable future. Thus, we must determine whether the length of the cleanup time frame is reasonable by comparing the proposed alternative (#2) with the other alternatives that are available (#3, 4 and 5). We also need to make sure that the proposed remedy will be implemented expeditiously as can be reasonably expected.

We’ve compared the alternatives, and Alternative 2 is still the best overall. Controlling the source of the groundwater contamination is the most effective way to ensure that monitored natural attenuation will be as successful as can be expected. Chevron has removed the leaky tanks, pipes and ponds that were the original sources of the groundwater contamination. Chevron has also taken steps to make sure that sludges and contaminated soils are not an ongoing source of groundwater contamination. In many other U.S. EPA cleanup projects, we only need source control measures similar to these to assure a timely cleanup using monitored natural attenuation.

However, the situation here is complicated by the fact that the petroleum products that originally leaked out of the tanks and pipes have formed an LNAPL layer and a smear zone, which are now serving as the current sources of the contamination. Considering these complications, the overall time frame for cleaning up the Chevron groundwater contamination will be longer than the remediation time frame for many of the other projects that the U.S. EPA is handling. Considering the fact that there are no ongoing unacceptable human health exposures nor any urgent need to use the groundwater in Hooven as a source of drinking water, as well as these complications, the overall time frame of 36 to 42 years is reasonable in this situation.

Benzene is the most widespread contaminant, and it exceeds the MCL by the greatest factor; thus it is the primary contaminant that will be used to track the cleanup of the plume. The goal for this timeframe is based on the projected attenuation pattern for benzene which involves biodegredation. Other organic contaminants, such as ethylbenzene, and 1,2-dichlorobenzene will also follow an attenuation pattern involving biodegredation. The dissolved ethylbenzene concentrations are expected to meet the current MCL in 90% of the wells at the site within 25 to 30 years after the completion of the high-grade pumping for source control. In other words, the concentration of ethylbenzene is expected to meet the MCL a little sooner than benzene. The concentration of 1,2-dichlorobenzene is expected to meet the MCL a little later than benzene. Inorganic contaminants, such as lead and arsenic, will probably follow a different attenuation pattern because they do not biodegrade. Further improvement is expected to occur very slowly. Nevertheless, at the end of the 36 to 42-year time period, the concentrations of the inorganic constituents are expected to be below the current levels, and the current levels are just above the MCLs.

After the 36-to 42-year time frame, the groundwater will still have taste and odor problems, and will still have unacceptable concentrations of other non-volatile chemicals. These conditions will exist for a long time. Thus, the use of the groundwater will remain restricted and natural attenuation will continue until the groundwater quality is fully restored.

59. Comment: Section III (pgs 4 and 6) indicates that the hydrocarbon smear zone is located at a depth between 10 to 30 feet below ground surface (bgs). The smear zone observed beneath the facility, Hooven, and the commercial properties located to the southwest of the facility (Southwest Quadrant) is variable depending on surface elevation, depth to water and the thickness of the smear zone, and is generally deeper than 10 to 30 feet bgs. For example the depth to the top of the smear zone beneath Hooven is approximately 30-60 feet bgs and depth to the bottom of the smear zone is approximately 50-75 feet bgs.

Response: EPA notes your comment, depending on where you are on and off the site, the distance to the smear zone varies. EPA did not mean to apply only one set distance from ground surface to smear zone.

60. Comment: Section IV (A) (p. 9) indicates that “the human health screening values used were the U.S. EPA Region 9 Preliminary Remediation Goals (PRGs).” The

Region 9 PRGs were not used for screening soil vapor sample results collected in Hooven during investigation activities completed in 2005. The soil vapor screening levels for the Subsurface Investigation and Field Services Report and Human Health Risk Assessment, Chevron Cincinnati Facility, Hooven, Ohio (Trihydro 2005) were obtained from the U.S. EPA Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils, published in 2002.

Response: EPA agrees with this comment.

61.Comment: Section IV (B)(1) (pgs 9-10) describes the contaminants of potential concern (COPCs) to groundwater, and differentiates them by three areas: Facility property, Hooven, and Southwest Quadrant. The final list of COPCs should be based on a review of historical trends and current knowledge regarding individual constituent chemical and physical characteristics. The COPCs for the Facility property, Hooven, and the Southwest Quadrant should be a single list that reflects contaminants associated with the LNAPL; both those that can dissolve from the LNAPL and those that can result from chemical reactions/weathering of the LNAPL (i.e. daughter products, metals, inorganics). Two of the COPCs (isopropylbenzene and total xylenes) have not been reported above remedial standards in groundwater samples collected since 1998, and three other COPCs have only a single detection (acetone, toluene, pyrene) above remedial standards since 1998. These should be removed from the list of COPCs.

Response: U.S. EPA has determined that these COPCs should remain on the list. The COPC for Hooven are listed in the Human Health Risk Assessment for Hooven, 2000. COPCs for the refinery property are listed in the Human Health and Ecological Risk Assessment of 2000. The COPCs for the Southwest quadrant are listed in the Southwest Quadrant Risk Assessment 2002.

62.Comment: Section IV (B)(2) (p.10) refers to “groundwater vapor” and identifies Vapor COPCs. This section would be more accurately titled “Soil Vapor COPCs”, as soil gas samples and flux chamber samples were used to evaluate the potential for inhalation of volatiles in indoor and outdoor air pathways. The discussion could be further clarified by explaining that constituents of potential concern in soil vapor can derive from multiple sources at the surface and in the subsurface, and the long-term monitoring program is to monitor the potential contribution of COPCs to soil vapor from the LNAPL and dissolved phase plumes associated with the Chevron facility. The term “soil vapor” should be used, rather than “groundwater vapor”.

Response: Duly noted

63.Comment: The vapor migration pathway from LNAPL or dissolved plume to indoor air in the residents of Hooven was determined to be incomplete (see p. 12 of the Statement of Basis), so there are no COPCs for vapor intrusion in Hooven. Therefore, the COPC list should be removed. Chevron will work with U.S. EPA to develop an analyte list that will be monitored during the final remedy to confirm the pathway for vapor migration into residences remains incomplete.

Response: Contaminants of Potential Concern remain the same whether the pathway is complete or incomplete. The pathway remains while the potential still exists.

64.Comment: Section IV (C)(1b) Future Construction/Remediation Worker (p. 11) indicates the RME is 0.032. The hazard index (HI) for the reasonable maximum exposure (RME) should be 0.32.

Response: U.S. EPA agrees the RME should be 0.32.

65.Comment: Section IV (C)(2a) Future Industrial/Commercial Worker (p. 11) indicates the RME is 0.035, and that the hazard indices discussed are for inhalation of vapors in a basement. The HI for the RME should be 0.35. The hazard indices discussed in this section are for outdoor inhalation of vapors. Section IV (C)(2a)(i) discusses the basement scenario hazard indices.

Response: EPA agrees with the comment.

66.Comment: Section IV (C)(4a) Future Adolescent Recreator (p. 11) states that "a subgroup of SVOCs, the polynuclear aromatic hydrocarbons (PAHs), was the major source of carcinogenic risk in the Recreational Reuse Area." PAHs were a driver for soil exposure but not for inhalation.

Response: EPA agrees with the comment.

67.Comment: Section VII Scope of Proposed Remedy – Alternative 2 (p. 21) indicates that Chevron shall sample any new wells installed along the point of compliance (POC) boundary quarterly for two-years. These wells are not expected to contain any dissolved phase constituents. In keeping with the sample size for valid statistical analyses recommended by the U.S. EPA in the Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities (February 1989, U.S. EPA, Office of Solid Waste, Waste Management Division), of four independent sampling events, Chevron proposes that any new wells installed along the POC boundary will be sampled semiannually during the first two years following installation, and that the sampling frequency would then revert to that followed for the rest of the wells being monitored.

Response: U.S. EPA is concerned about dissolved phase plume migration and that any initial migration be found by groundwater well monitoring. As, per the Statement of Basis, when the pumping wells are phased out, quarterly sampling is necessary to assess the dissolved phase plume boundary.

Ohio Environmental Protection Agency (OEPA) Comment and U.S. EPA's Response

68. Comment: One of the stated performance standards for the proposed remedy's impact to the Great Miami River directs Chevron Corporation to ensure

> "the prevention of any discharge of dissolved constituents to the river above appropriate Ohio EPA surface water standards."

An additional stipulation within this section states:

> "If OEPA surface water standards are exceeded or sheens appear on the Great Miami River, then the contingency is to resume year-round groundwater pumping until compliance with the standard is restored."

Furthermore, a final stipulation citing Ohio EPA surface water standards within this section states:

> "In addition, Chevron will evaluate contingency alternatives, including perimeter treatment system (e.g., sparge curtain, funnel/gate, etc.), aggresive source

> removal (e.g., air sparging, SVE, solvent flushing (SEAR) etc.), and implement additional corrective measures if necessary to meet the performance standard of allowing no migration of LNAPL or dissolved constituents into the river above OEPA surface water standards.”

Chapter 6111 within the Ohio Revised Code (ORC) is the authority utilized by our agency’s Division of Surface Water to regulate all discharges to waters of The State of Ohio. The following prohibition is noted:

> *6111.04. Acts of pollution prohibited; exceptions.*
>
> *(A) Both of the following apply except as otherwise provided in division (A) or (F) of this section:*
>
> *(1) No person shall cause pollution or place or cause to be placed any sewage, sludge, sludge materials, industrial waste, or other wastes in a location where they cause pollution of any waters of the state.*
>
> *(2) Such an action prohibited under division (A)(1) of this section is hereby declared to be a public nuisance.*
>
> *Divisions (A)(1) and (2) of this section do not apply if the person causing pollution or placing or causing to be placed wastes in a location in which they cause pollution of any waters of the state holds a valid, unexpired permit, or renewal of a permit, governing the causing or placement as provided in sections 6111.01 to 6111.08 of the Revised Code or if the person's application for renewal of such a permit is pending.*

Therefore, in accordance with applicable Ohio Law, U.S. EPA should revise the Statement of Basis to prohibit Chevron Corporation from conducting any un-permitted discharges containing contaminants to waters of the state.

Response: We agree with the OEPA interpretation of their surface water regulation to prohibit un-permitted discharges containing contaminants to the Great Miami River.

Future Actions

U.S. EPA and Chevron are negotiating an Administrative Order on Consent to implement the selected remedy. Oversight by U.S. EPA will be conducted to insure adherence to the modifications to the remedy based on the public’s comments. In the event that Chevron would decide not to implement the selected remedy, U.S. EPA may use its enforcement authorities to order Chevron to implement the selected remedy.

Declaration

Based upon the Administrative Record compiled for this corrective action, U.S. EPA has determined that the selected remedy is appropriate and is protective of human health and the environment.

____

Margaret Guerriero Date
Director, Waste, Pesticides and Toxics Division
U.S. EPA, Region 5

ATTACHMENT I

STATEMENT OF BASIS
FOR
SELECTION OF REMEDIAL ALTERNATIVE
FOR GOUNDWATER
AT

CHEVRON
Near HOOVEN, OHIO

APRIL, 2006

OHD 004 254 132

STATEMENT OF BASIS
for Groundwater

Chevron Cincinnati Facility
Hooven, Ohio
EPA ID No. OHD 004 254 132

April 2006

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Statement of Basis for Groundwater
Chevron Cincinnati Facility
Hooven, Ohio

I. INTRODUCTION

This Statement of Basis (SB) explains the proposed remedy for contaminated groundwater at the former Chevron Refinery Facility (Chevron facility) in Hooven, Ohio. This is the final proposed remedy for the site under the current Administrative Order on Consent (AOC) from 1993. This proposed remedy addresses groundwater contamination's impact on soil vapor, surface water, river bank soil, and current and future groundwater use. In addition, the SB includes summaries of corrective measure alternatives, pertaining to contaminated groundwater, prepared by Chevron and evaluated by the United States Environmental Protection Agency (U.S. EPA). U.S. EPA will select a final remedy for contaminated groundwater at the Chevron facility only after the public comment period has ended and the information provided by the public has been reviewed and public comments considered. This SB to address groundwater contamination is being issued separately from the soils remedy to expedite implementation of the soils remedy. The Final Decision for Sludges and Contaminated Soils was issued by U.S. EPA in January 2004. A Performance Agreement to implement the Sludges and Contaminated Soils between U.S. EPA and Chevron was signed in March 2004 and is currently being implemented by Chevron with U.S. EPA oversight.

This SB is being issued by U.S. EPA as part of its public participation responsibilities under the Resource Conservation and Recovery Act (RCRA). The document summarizes information that can be found in greater detail in the final RCRA Facility Investigation (RFI), Corrective Measure Study (CMS) for Groundwater, Conceptual Groundwater Remedy Report, and other pertinent documents contained in the Administrative Record. U.S. EPA encourages the public to review these documents in order to gain a more comprehensive understanding of the Chevron facility and the RCRA activities that have been conducted.

U.S. EPA may modify the proposed remedy or select another remedy based on new information or public comments. Therefore, the public is encouraged to review and comment on the SB. The public is involved in the remedy selection process by reviewing the SB, submitting written comments, and attending the public hearing scheduled for May 9, 2006, at the Whitewater Senior Center and Township Hall, 6125 Dry Fork Road, Whitewater Township, Ohio. The meeting is also an opportunity to hear a summary of the proposed groundwater remedy and to provide verbal comment on the SB.

II. PROPOSED REMEDY

U.S. EPA is proposing the following remedy to address groundwater contamination from Chevron facility:

The Proposed Remedy will consist of the following remedial components:

- Periodic source removal of Light Non-Aqueous Phase Liquids (LNAPL) from the subsurface through a high grade pumping scheme;
- Monitor containment of Light Non-Aqueous Phase Liquids (LNAPL) and dissolved contaminant plume. Gradually shut down hydraulic control wells and restore natural gradients;
- Contingencies: if performance measures are not met, the pumps will be turned back on, and other alternative technologies will be analyzed and chosen to remediate the plume (for example SVE, IAS, SEAR);
- Engineered controls to stabilize the bank of the Great Miami River at both the Refinery and Gulf Park, and continued monitoring of the Great Miami River bank for releases;
- Monitored Natural Attenuation (MNA) of dissolved contaminant plume and LNAPL plume with associated sampling and 5 year review of the progress of the natural attenuation with the performance measure of complete aquifer restoration to below Safe Drinking Water Act Maximum Contaminant Levels (MCLs) in 30 years;
- Institutional controls to include prohibitions on potable groundwater use and basement construction on the refinery site;
- Point of compliance (POC) and other performance monitoring;
- Continued source removal of volatile petroleum constituent from the LNAPL smear zone beneath the town of Hooven through soil vapor extraction (SVE) during periods of high grade pumping;
- Continued monitoring of soil vapor wells in Hooven.
- Financial Assurance for implementation of the remedy

A more detail discussion of the proposed remedy is in Section VII - Scope of Proposed Remedy.

III. FACILITY BACKGROUND

The Chevron facility is located in Whitewater Township, Hamilton County, Ohio, just east of the town of Hooven, and west of the Great Miami River. Land use surrounding the Chevron facility is residential, commercial, and wooded to the west. The site occupies approximately 600 acres bordered on the north, east, and south by the Great Miami River. Commercial retail property is developed along State Route 128, southwest of the Chevron facility (Figure 1). The Chevron facility also includes a Land Treatment Unit (or Landfarm) located on a ridge northwest of the main portion of the refinery area. Two islands (Number 1 and Number 2) in the Great Miami River are also considered part of the Chevron facility because underground pipelines pass beneath the islands. The pipeline also runs below portions of Gulf Park (where contamination has been detected), and leads to a former loading dock for Chevron's refinery products on the Ohio River.

The manufacturing and refinery portion of the Chevron facility was operated from 1931 until 1986. Gulf Oil Corporation operated the facility from 1931 until 1985. Chevron acquired Gulf Oil Corporation in 1985 and assumed operation until May 1986, when refinery operations were terminated. The refinery produced gasoline, jet fuels, diesel, home-heating fuels, asphalt, and sulfur. Refinery sludges and solids, many of which are classified as hazardous wastes, were also generated during manufacturing operations. A majority of the refinery structures have been demolished. The remaining facility structures include an office building, a security building, a maintenance shed, and various structures associated with ongoing interim measures and remediation activities.

On January 21, 1985, a hydrocarbon sheen was observed seeping into the Great Miami River near the southern boundary of the Chevron facility. The seep indicated a hydrocarbon plume in groundwater beneath the facility. Petroleum hydrocarbon recovery systems were installed by Chevron, and a larger network of recovery and extraction wells have been installed and operated since 1985. Currently, the Chevron facility pumps and treats four to five million gallons of groundwater on a seasonal basis. Analysis of the hydrocarbon waste in groundwater indicated it was primarily refined leaded gasoline and a smaller part diesel fuel.

Chevron has been pumping large amounts of groundwater for over 20 years, and has recovered significant amounts of petroleum hydrocarbons. The term Light Non Aqueous Phase Liquid (LNAPL) is used to describe the pure petroleum hydrocarbons in liquid form that are not dissolved in water. At the facility, the LNAPL includes primarily refined gasoline and a lesser amount of diesel fuel. The quantity that originally leaked form the facility is estimated to have been 5 million gallons in total. About 2.5 million gallons were recovered within the first three years after pumping was initiated, and about one million gallons were recovered over the next 18 years. The Chevron facility has recovered between 10,000 to 200,000 gallons of LNAPL per year since 1988. Over the years, pumping and treating has gradually become less and less efficient in recovering LNAPL. The amount of LNAPL that is still remaining underground today is adhering to the soil particles at a depth of 10 feet below ground surface (bgs) to approximately 30 feet bgs. This is known as the smear zone.

On May 13, 1993, Chevron entered into an Administrative Order on Consent (Consent Order) with U.S. EPA that required Chevron to conduct the necessary investigations (i.e., RFI) to fully identify the nature and extent of contamination at the facility, to evaluate the long-term corrective measures (i.e., CMS) necessary to protect human health and the environment, to conduct interim measures which involved closure of many of the higher priority Solid Waste Management Units (SWMUs) and Areas of Concerns (AOCs) at the facility, and to continue groundwater pump and treat with recovery of petroleum hydrocarbons from the groundwater. Separate CMSs were subsequently performed for soils and sludges and for groundwater, resulting in two reports entitled *Chevron Cincinnati Facility Soils and Sludges Corrective Measures Study* (URS 2001a) and *Chevron Cincinnati Facility Groundwater Corrective Measures Study* (URS 2001b). A remedy was proposed for the soils and sludges by U.S. EPA in a *Statement of Basis for Sludges and Contaminated Soils* that was issued in June 2003. The final remedy for sludges and contaminated soils was subsequently selected by U.S. EPA in January 2004. The remedy selected for soils and sludges was excavation and removal with domestic off-site disposal. This remedy was put into a Performance Agreement on March 4, 2004 between Chevron and U.S. EPA and is currently being implemented by Chevron using the approved June 2004 Work Plan to perform the soils cleanup. The remedy for groundwater contamination is now being proposed in this SB.

Since completion of the RFI and CMS, there have been continued efforts to further define the nature and extent of the LNAPL and dissolved plume. Additional investigations have been conducted for this purpose. Chevron submitted a *Conceptual Groundwater Remedy Report* (Chevron, 2003) to U.S. EPA that provided further analysis and optimization of the remedial option recommended in the groundwater CMS. This document was reviewed extensively by U.S. EPA, which resulted in several remaining questions on the groundwater remedy. These remaining questions have been the main focus of several studies at the facility, beginning in late 2004 up to the present.

Most recently, there have been a series of long-term, high grade LNAPL recovery tests and a shutdown test at the facility to assess the feasibility of the proposed corrective measures contained in the groundwater CMS. The implementation of these tests was outlined in two work plans submitted to U.S. EPA by Chevron: the *Work Plan for Long-Term High-Grade LNAPL Recovery Test, Additional Assessment Activities to Support Groundwater Remedy* (Chevron 2005a), and the *Work Plan for Extended Non-Pumping Aquifer Evaluation, Additional Assessment Activities to Support Groundwater Remedy* (Chevron 2005b). The goal of the long-term high grade pumping test was to determine if LNAPL recovery, under concentrated pumping during occasional periods of naturally occurring low water table (referred to as high grade pumping), was a viable option for LNAPL removal. The long-term high grade LNAPL recovery test was performed during the seasonal low groundwater table. The shutdown test was performed to verify the effects of shutting down the production wells at the outer edges of the plume and to evaluate the stability of the plume under natural hydraulic gradients.

A. Site Hydrogeology

The Chevron facility lies in a glacial valley cut into Ordovician-age shale and partially filled with glacial outwash gravel and fluvial deposits of the Great Miami River. The steep-walled valley is approximately one-half mile wide and 100 feet deep. The bedrock shale is consolidated and has a low hydraulic conductivity, but is locally fractured and jointed and interbedded with thin layers of limestone. Overbank silt and sand deposits derived from floods of the Great Miami River generally overlie coarser-grained sand and gravel derived from glacial outwash.

The hydrogeology of the Great Miami River buried valley aquifer is characterized by high hydraulic conductivity, textural heterogeneity, and rapid water level changes driven by river stage. Investigations at the site confirm that discontinuous surficial flood plain deposits and fill cover most of the refinery site and are up to 15 feet thick. Below this are highly conductive sands and gravels up to 100 feet thick, which form the productive part of the aquifer. High transmissivity and significant textural heterogeneity characterize these aquifer materials. This aquifer has been designated a sole-source aquifer by the U.S. EPA, and is the principal source of drinking water for the area and commonly yields more than 1,000 gallons per minute.

Groundwater and the river are both controlled by the bedrock structure of the system. Groundwater and the Great Miami River are in direct hydraulic communication, and groundwater flows in the same direction as the river (i.e., south/southwest) in the site vicinity. The water table is affected mainly by the river stage, which is typically high during the spring and declines over the summer into the fall. However, the river stage can change abruptly in response to storms. Groundwater flow is from north to south, generally parallel to the river when pumping is not taking place. Groundwater velocities are typically in the range of two to four feet/day.

The depth to the water table beneath the former refinery portion of the facility ranges from approximately 15 to 40 feet below ground surface (bgs). The elevation of the water table varies seasonally, generally reaching its seasonally lowest elevation in autumn and its seasonally highest elevation in spring. The aquifer beneath the facility has a maximum saturated thickness of approximately 65 to 80 feet.

B. Groundwater Contamination

Both LNAPL and dissolved-phase contamination occur at the Chevron facility. The two types of contamination are closely related, with LNAPL being the primary source of the dissolved-phase groundwater contamination. Both the LNAPL and dissolved phase plumes have been extensively studied.

While the refinery was in operation, refined petroleum products were released to the surface and subsurface. The petroleum products moved downward through the soil, leaving residual hydrocarbons in the subsurface. Where enough product was released, a layer of petroleum product or LNAPL accumulated in the water table zone. These petroleum products did not readily migrate deeper into the aquifer because they tend to float on the water table. However, as the product layer thickens, LNAPL also tends to spread laterally on the water table. Thus, as the result of the releases at the facility, the LNAPL plume spread, ultimately resulting in an approximately 250-acre footprint of LNAPL and dissolved-phase contamination on the groundwater. The LNAPL plume covers much of the facility and has spread under the southern portion of Hooven and into the commercial area to the southwest of the facility referred to as the Southwest Quadrant.

As LNAPL accumulates, thicker layers of LNAPL form and depress the water table. This layer of LNAPL at the water table tends to move up and down with the water table. As the water table moves up and down, LNAPL is retained as residual LNAPL in subsurface materials by capillary forces, creating a smear zone around the water table. Water table fluctuations over the years and the history of LNAPL release and movement resulted in a relatively thick hydrocarbon smear zone in the central areas of the plume, but there is only a thin smear zone in the lateral and distal portions of the plume in areas along the Great Miami River and in areas such as Hooven and the Southwest Quadrant. The LNAPL smear zone extends from a depth of 10 feet bgs to a maximum depth of approximately 30 feet bgs in the central area of the plume.

Although estimates are available for the amount of LNAPL released, the time and amount of the LNAPL releases on site are uncertain. The petroleum product releases that caused the LNAPL plume may have occurred at any time during the facility's 55-year operational history (1931 - 1986). Although details of the releases are unknown, LNAPL chemistry data, product history, and production runs suggest that much of the LNAPL was released in the 1950s and 1960s. Sampling of the LNAPL plume indicates that the LNAPL is a mixture of approximately 80 percent leaded gasoline and 20 percent diesel fuel. The LNAPL can be divided into two types based on physical properties: a low viscosity, low density LNAPL and a higher viscosity, higher density LNAPL. The latter LNAPL type is limited to a small area in the eastern portion of the site.

The dissolved groundwater contamination observed at the Chevron facility consists primarily of constituents derived from the petroleum products released at the site, although some contamination may have been derived from the sludges formerly disposed on site. These sludges are now being removed as part of the contaminated soil and sludges remedy. The sludges are wastes from the refinery process and generally contain metals, semi-volatile organic compounds (SVOCs), and volatile organic compounds (VOCs). The dissolved petroleum constituents observed on site include benzene, ethylbenzene, and naphthalene. Benzene is the most widespread contaminant, with concentrations as high as 5,000 micrograms per liter (µg/l) in groundwater beneath the facility. The Maximum Contaminant Level (MCL) for benzene under the Safe Drinking Water Act is 5 micrograms per liter (µg/l). Groundwater monitoring indicates that the distribution of dissolved benzene is primarily limited to the shallow portions of the saturated zone of the aquifer, within and beneath the LNAPL smear zone. However, benzene is observed in deep groundwater in the vicinity of the groundwater production wells used to control plume migration. In these areas, the pumping has increased vertical gradients, drawing some dissolved-phase hydrocarbons deeper into the aquifer. Dissolved benzene generally is not detected outside the area containing residual LNAPL because of the inward gradient maintained by the groundwater production wells. The source of the dissolved benzene currently observed in groundwater is primarily the LNAPL in the subsurface, which contains benzene and related petroleum constituents. These constituents dissolve out of the LNAPL and into the groundwater as it flows through the LNAPL smear zone.

C. Interim Remedial Measures

In early 1985, in a response to a LNAPL sheen emanating from the river bank adjacent to the then Gulf Oil refinery, focused groundwater and initial LNAPL recovery was initiated by Chevron to contain and recover the LNAPL, as well as the dissolved-phased plumes. This extraction well system has expanded over the years at the site to include 16 high-volume groundwater production wells. These wells are installed at various locations throughout the property. The number of wells in use has varied depending on containment and LNAPL recovery needs. These production wells have been operated to create an inward hydraulic gradient that captures LNAPL and prevents further lateral expansion of the LNAPL plume. The inward hydraulic gradient also inhibits the migration of dissolved hydrocarbons from the site.

Approximately 3.5 million gallons of LNAPL have been recovered to date. The exact amount of hydrocarbon remaining in the aquifer is uncertain and difficult to determine. However, based on the historical recovery curves, more than half of the hydrocarbon has already been removed. Seventy-three percent of the cumulative LNAPL recovery occurred during the first three years of pumping at just two to three recovery wells, with the remaining 27 percent coming in the last 17 years from these, and several additional wells.

The LNAPL recovery rate has diminished over time, indicating that the recoverable fraction remaining is relatively small and that the inherent mobility of the LNAPL plume has been greatly reduced. Recovery rates over the last few years are only a fraction of the initial recovery rates and are strongly linked to seasonal low water tables or periodic drought conditions that expose the lower portion of the smear zone. These conditions allow LNAPL to drain to recovery locations under increased gradient created by pumping large volumes of groundwater. As a result, in recent years LNAPL recovery operations have been carried out mainly during the fall low water-table season. During these times, partially penetrating wells (partially penetrating into the zone of LNAPL contamination) are brought on line; these wells create cones of groundwater depression that capture floating LNAPL. In these cones of depression, LNAPL is recovered by skimming it from recovery wells located within or adjacent to the production wells. The recovered LNAPL is pumped through metered lines for storage in above-ground tanks prior to off-site shipment.

At other times, the water levels raise enough to trap and immobilize most of the LNAPL in soil pores. The LNAPL becomes less mobile and the plume becomes more stable during these periods. Regardless, the productions wells are pumped year round at sufficient rates to ensure hydraulic containment of both the dissolved and LNAPL plumes. Typical high water table groundwater pumping rates are approximately 2.5 million gallons per day (mgd), while low water table groundwater pumping rates are up to 5 mgd. The effectiveness of the hydraulic containment system to control hydraulic gradients is evaluated by gauging an extensive network of monitoring wells (more than 115 wells) and two river measuring points six times per year for water level and LNAPL thickness.

Natural processes within LNAPL plumes tend to limit their spread. These natural processes include the retention of residual LNAPL in soils and the dissipation of the pressure within the LNAPL plume as the plume thins due to spreading. If LNAPL releases are stopped, the spread of the resulting LNAPL normally stabilizes over time. The recovery of LNAPL further enhances the stabilization of LNAPL. Due to the large amounts of LNAPL that have already been recovered to date, the LNAPL plume may be approaching stability under natural hydraulic gradients. A Shutdown test conducted from November 2005 to February 2006 demonstrated plume stability in that period of time, and no measurable expansion of the LNAPL or dissolved plume occurred.

In addition to the groundwater extraction program designed to recover and contain LNAPL and dissolved plumes, horizontal soil vapor extraction (HSVE) was implemented beneath the community of Hooven in 1999 to ensure that unacceptable vapor exposure was not occurring. The HSVE system also serves as an additional measure for petroleum hydrocarbon removal. Like the LNAPL recovery program, the HSVE system has experienced strongly diminishing returns as the available vapor has been removed. Currently, only seasonal vapor recovery is possible when the water table is low and the smear zone beneath Hooven is exposed.

D. Land Use

A conceptual future land use plan for the former Chevron facility (Figure 2) has been developed with input from citizens and through Chevron’s Community Advisory Panel. Future land reuse option for the site is a mixed use scenario that includes potential industrial/commercial, open space, and recreational uses. Due to the fact that the facility is located in the Great Miami River floodplain, residential and institutional reuses are not viable; however portions are being considered for recreational development. The area being considered for industrial/commercial reuse is located inside the 100-year flood protection berm.

IV. SUMMARY OF CONTAMINATION RISKS

A. Risk Assessment History and Review

A conceptual land use plan was prepared to guide risk assessment, remediation, and potential redevelopment of the facility. The current land use plan is a mixed-use scenario, including potential industrial/commercial, open space, and recreational uses (Figure 2). Assessment of risk at the site was addressed in the *Chevron Cincinnati Facility Phase II Facility-Wide Human Health and Ecological Risk Assessment* (E&E 2000a). Additional assessment of risk to human health in the town of Hooven and in the Southwest Quadrant was addressed in the *Human Health Risk Assessment of Potential Exposure to Volatile Compounds, Hooven, Ohio, Revision 2* (E&E 2000b), *Human Health Assessment for Potential Offsite Volatiles Exposure at the Southwest Quadrant* (E&E 2002), and most recently *Subsurface Investigation and Field Activities Report and Human Health Risk Assessment, Chevron Cincinnati Facility*, *Hooven , Ohio* (Trihydro, 2005). The sample results from the RFI and off-site vapor investigations were used as input parameters in the risk assessments. The results were screened using risk values that relate to the proposed reuse of the area (i.e., industrial, recreational). The human health screening values used were the U.S. EPA Region 9 Preliminary Remediation Goals (PRGs). The results relating to ecological areas were screened using the U.S. EPA Region 5 Ecological Data Quality Levels (EDQLs). Using these screening methods, contaminants of potential concern (COPCs) were identified. These COPCs were used in the conceptual site model (CSM) that summarized the relationship between the sources and the receptors.

Using the CSM, contaminated media were identified as surface soils, subsurface soils, sediment, groundwater, and surface water. The pathways of exposure for human health are dermal (skin) contact, inhalation of vapors, inhalation of soil particles, and ingestion. The receptors for human health pathways are future industrial workers, future recreational users, construction workers, remediation workers, and residents of Hooven. The ecological receptors are terrestrial, wetland, and aquatic plants and animals.

The risks associated with the sources of contamination in surface soils, subsurface soils, and sediment were addressed and summarized in the *Statement of Basis for Sludges and Contaminated Soils* (U.S. EPA 2003); therefore, these risks are not addressed in this SB. On March 4, 2004 U.S. EPA signed a remedy for the sludges and contaminated soils, and Chevron is performing the cleanup of the selected soils remedy.

B. Contaminants of Potential Concern (COPCs)

1. Groundwater COPCs
    a. Facility property: The COPCs for human health in groundwater from refinery operations at the Chevron facility are benzene, ethylbenzene, 1,4-dichlorobenzene, acetophenone, bis(2-ethylhexyl)phthalate, naphthalene, pyrene, dissolved lead, and total arsenic.

   - b. Hooven: The COPCs for human health in groundwater at Hooven are benzene, ethylbenzene, naphthalene, 1,2,4 trimethyl benzene, 1,3,5 trimethyl benzene,n-propyl benzene, isopropyl benzene, n-Hexane, acetone, toluene and xylene.
   - c. Southwest Quadrant: The COPCs for human health in groundwater in the Southwest Quadrant are benzene, ethylbenzene, naphthalene, 1,2,4 trimethyl benzene, 1,3,5 trimethyl benzene,n-propyl benzene, isopropyl benzene, n-Hexane, acetone, toluene and xylene.

2. Vapor COPCs
   - a. Facility property: COPCs for human health in groundwater vapor at the Chevron facility are acetone, benzene, chlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, naphthalene, and trichloroethene.
   - b. Hooven: The COPCs for human health in groundwater at Hooven are benzene, ethylbenzene, naphthalene, 1,2,4 trimethyl benzene, 1,3,5 trimethyl benzene,n-propyl benzene, isopropyl benzene, n-Hexane, acetone, toluene and xylene.

   - c. Southwest Quadrant: COPCs for human health in the groundwater vapor in the town of Hooven are acetone, benzene, chlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, 1,1-dichloroethylene, ethlybenzene, methylene chloride, naphthalene, toluene, 1,1,2-trichloroethane, m- and p-xylene, and o-xylene.

C. Human Health Risk Characterization

The human health risk characterization makes a quantitative estimate of risks at the Chevron facility. The characterization uses the COPCs, the CSM, an assessment of the toxicity, and an assessment of the exposure to calculate the risks. Calculations for risk characterization used two different methods, the reasonable maximum exposure (RME), and the central tendency (CT) method.

The noncarcinogenic risk characterization looks at all noncarcinogenic COPCs and arrives at a hazard index (HI) for these contaminants. U.S. EPA specifies that an HI equal to, or less than one, is considered acceptable, and an HI greater than one indicates an unacceptable risk to human health. The noncarcinogenic risk exceeded the HI of one for the commercial/industrial receptor in basement indoor air. This risk is addressed in this proposed remedy with institutional controls through prohibition of basement construction on the facility.

1. Noncarncinogenic Risks in Recreational Reuse Area
   - a. Future Adolescent Recreator Calculations indicate negligible noncarcinogenic inhalation hazards for outdoor inhalation of vapors based upon the RME and CT assumptions. The HI for RME (0.029) and CT (0.014) methods were well below one. 1,3-dichlorobenzene was the primary contributor to the hazard values.

   b. Future Construction/Remediation Worker Calculations indicate negligible noncarcinogenic inhalation hazards for outdoor inhalation of vapors based upon the RME assumption. The HI for the RME (0.032) method was well below one.

2. Noncarcinogenic Risks in Industrial Reuse Area
   a. Future Industrial/Commercial Worker Calculations indicate negligible noncarcinogenic inhalation hazards for inhalation of vapors in a basement based upon the RME and CT assumptions. The HI for RME (0.035) and CT (0.19) methods were well below one. 1,3-Dichlorobenzene was the primary contributor to the hazard value.
      i. *Basement Scenario* (Working in basements) Calculations indicate unacceptable noncarcinogenic inhalation hazards for inhalation of indoor vapors based upon the RME assumption. The HI for the RME (1.4) method was slightly above one. Toluene and ethylbenzene were the primary contributors to the hazard values.
   b. Future Construction.Remediation Worker Calculations indicate negligible noncarcinogenic inhalation hazards for inhalation of outdoor vapors based upon the RME assumption. The HI for the RME (0.32) method was well below one.

3. Noncarcinogenic Risks in the Southwest Quadrant
   a. Commercial Worker
      i. *Basement Scenario* Calculations indicate unacceptable or significant noncarcinogenic inhalation hazards for indoor chemicals in a basement, based upon the RME assumptions. The HI for basement vapor inhalation (2.0) exposure using the RME methods was greater than one. Benzene was the primary contributor to the hazard value.

The risk characterization then looks at all carcinogenic COPCs and arrives at an estimated carcinogenic risk. USEPA's range of acceptable risk is 1×10^{-4} to 1×10^{-6}. This risk is equivalent to one additional person in 10,000 to one additional person in 1,000,000 contracting cancer from a lifetime exposure to these contaminants.

4. Carcinogenic Risks in Recreational Reuse Area
   a. Future Adolescent Recreator Calculations indicate negligible carcinogenic risk for a future adolescent due to inhalation of outdoor vapors. The total carcinogenic risk for the vapor inhalation exposure pathway was calculated to be 1.8×10^{-7} using the RME method and 6.9×10^{-8} using the CT method. This risk falls below the U.S. EPA acceptable risk range. A subgroup of SVOCs, the polynuclear aromatic hydrocarbons (PAHs), was the major source of carcinogenic risk in the Recreational Reuse Area.
   b. Future Construction/Remediation Worker Calculations indicate negligible carcinogenic risk for a future construction/remediation worker due to inhalation of outdoor vapors. The total carcinogenic risk for the vapor inhalation exposure pathway was calculated to be 1.7×10^{-7} using the RME method. This risk falls below the U.S. EPA acceptable risk range.

5. Carcinogenic Risks in Industrial Reuse Area
    a. Future Industrial/Commercial Worker Calculations indicate negligible carcinogenic risk for a future industrial/commercial worker due to inhalation of outdoor vapors. The total carcinogenic risk was calculated to be 1.5 x 10^{-5} using the RME method and 2.0 x 10^{-6} using the CT method. The calculated risks fall within the U.S. EPA acceptable risk range.
        i. *Basement Scenario* Calculations indicate significant carcinogenic risk for a future industrial/commercial worker due to inhalation of vapors in a basement. The total carcinogenic risk was calculated to be 1.7 x 10^{-2} using the RME method. This risk is greater than the U.S. EPA acceptable risk range. The only contributor to this risk was benzene. This value was derived following the assumption that a commercial/industrial worker inhales the vapor in the basement for 8 hours day, 5 days a week for 25 years.
    b. Future Construction/Remediation Worker Calculations indicate negligible carcinogenic risk for a inhalation of outdoor vapors. The total carcinogenic risk was calculated to be 4.1 x 10^{-6} using the RME method. This risk is within the U.S. EPA acceptable risk range.

6. Carcinogenic Risks for the Southwest Quadrant
    a. Commercial Worker
        i. *Basement Scenario* Calculations indicate negligible carcinogenic risk for basement vapor inhalation exposures. The total carcinogenic risk across all exposure pathways was calculated to be 5.1 x 10^{-5} for the RME method. This risk is within the U.S. EPA acceptable risk range. Benzene is the only contributor to this risk.

Risk to Subpopulations in Hooven

The assessment of risk to human health in May 2000, indicated a noncarcinogenic inhalation hazard of 3.0 as well as a carcinogenic inhalation risk of 8.0 x 10^{-5} for indoor chemicals for the basement scenario in the town of Hooven. These values were derived following the assumption that a resident lives in the basement for 24 hours a day, 350 days a year for 30 years. A follow-up study was completed in June 2005 to update the human health risk assessment and to reevaluate the crack ratio assumptions used in the subsurface vapor intrusion model in the risk assessment report with the revised toxicity data currently available for some of the COPCs under study. The analytical data from the recent study on the vertically nested wells showed that petroleum hydrocarbon COPCs detected in vapor samples immediately above the LNAPL and dissolved plume attenuate within a short distance above the groundwater table. The attenuation is attributed to active biodegradation confirmed through oxygen and carbon dioxide profiles in the plume area. Further, the soil gas concentrations of constituents identified in the LNAPL/dissolved plume are below the generic screening levels at depths shallower than 30 ft. below ground surface in all the nested wells inside the plume. As a result of these observations and in accordance with U.S. EPA's Office of Solid Waste and Emergency Response (OSWER) draft vapor intrusion guidance, the vapor migration pathway from LNAPL or dissolved plume to indoor air in the residents of Hooven is considered incomplete. Thus under current conditions, carcinogenic risk and/or non-carcinogenic hazard from groundwater contamination is assumed to be insignificant to Hooven residents as well as the school children and faculty as a result of this incomplete pathway.

D. Ecological Risks

The ecological risk characterization looks at receptors classified into terrestrial, wetlands, and Great Miami River components. The ecological risk characterization associated with the terrestrial and wetland receptors was addressed in the *Statement of Basis for Sludges and Contaminated Soils* (U.S. EPA 2003).

1. Aquatic Life Risk Analysis
   The Great Miami River, which is adjacent to the facility on the north, east, and south, was investigated. Surface water samples were taken to determine whether petroleum contamination has been released to the river. No site-related petroleum contamination was detected in surface water. Riverbank soil samples were also collected to evaluate potential ecological receptors of riverbank contamination. Residual PAH contamination from a release of hydrocarbon seepage to the river that was discovered on January 21, 1985, affects a small area of the riverbank along the southern extent of the refinery property. Riverbank and surface water samples indicate that the impacts of this contamination on aquatic life are expected to be minimal.

   On May 16, 2005, oil releases the size of quarters were noticed in the Great Miami River near Monitoring Well 85 along the western shore. A boom was placed in the river in the area of the release, and initial erosion control measures were put in place. Investigations revealed the impacted soil along the bank was eroding into the river and releasing petroleum hydrocarbons. A similar situation arose on July 13, 2005 in Gulf Park on the eastern bank of the Great Miami River where localized small releases of hydrocarbons were observed. Surface water, river sediment and groundwater were sampled near these releases and initial results show no exceedances of Ohio EPA regulatory standards. Anticipated shoreline erosion controls in areas along the Great Miami River are expected to prevent contaminated soil from eroding into the river, these controls are detailed in the Scope of the Proposed Remedy (Section VII).

   Groundwater pumping has occurred since 1985 to prevent discharges to the river. Currently, preliminary modeling regarding potential flow to the river under natural gradients is being developed. Groundwater monitoring wells are being installed and sampled adjacent to the river to further develop the preliminary models and determine the extent of contamination and the surface water groundwater interaction near the Great Miami River.

V. SUMMARY OF ALTERNATIVES

The corrective measure alternatives analyzed to clean up contaminated groundwater at and from the Chevron facility are presented below.

$ **Alternative 1**: No-Action

$ **Alternative 2:** High Grade Pumping, Containment of plume, MNA, Institutional Controls, Stabilization of Riverbank, Hooven SVE, and Vapor Well Monitoring.

$ **Alternative 3**: Sitewide Soil Vapor Extraction (SVE), Containment of plume, MNA, Institutional Controls, Stabilization of Riverbank, Hooven SVE, and Vapor Well Monitoring.

$ **Alternative 4**: Sitewide SVE and In-Situ Air Sparging (IAS), Containment of plume, MNA, Institutional Controls, Stabilization of Riverbank, Hooven SVE, and Vapor Well Monitoring.

$ **Alternative 5**: Sitewide Surfactant Enhanced Aquifer Remediation (SEAR), Containment of plume, MNA, Institutional Controls, Stabilization of Riverbank, Hooven SVE, and Vapor Well Monitoring.

Alternative 1: No-Action

The no-action alternative provides a baseline for comparing the benefits and costs of other alternatives. This alternative assumes that no additional actions will occur at the facility to remediate groundwater beyond what has already been completed.

Alternative 2: High Grade Pumping, Containment, MNA, and Institutional Controls

This alternative includes source removal (recovery of LNAPL); containment of the dissolved phase and LNAPL plumes to prevent further migration of contamination; and natural attenuation of both LNAPL and dissolved contaminants to ultimately achieve concentration levels of dissolved contaminants in the ground water at or below Federal drinking water standards (Safe Drinking Water Act Maximum Contaminant Levels (MCLs) in 30 years. Alternative 2, as well as Alternatives 3, 4 and 5 also require implementation of institutional (non-engineering) controls (e.g., deed restrictions, equitable servitude) to restrict certain land and ground water uses on the facility. These institutional controls will prevent exposure to the LNAPL and groundwater plumes throughout the on-site and off-site areas. See the more detailed discussion of the land and water uses to be restricted in Section VII: Scope of the Proposed Remedy—Alternative 2. Recovery of LNAPL will be achieved through a high grade pumping scheme in the area of high concentration (Figure 3) designed to remove LNAPL during periods of low water table elevations. Containment will be achieved through LNAPL plume stabilization supplemented with hydraulic control if necessary. MNA will reduce the concentrations of dissolved contaminants in down gradient areas of the plume. In addition to controlling down gradient dissolved contaminants, MNA will be relied on, in part, to further deplete benzene and other petroleum constituents from the LNAPL. The Hooven Soil Vapor Extraction (HSVE) system will continue to be used to control vapors volatilizing from the LNAPL and further deplete volatile constituents in the LNAPL plume beneath the town of Hooven. In addition, sampling of vapor monitoring wells will be conducted in Hooven. This alternative also includes stabilization of the bank at the refinery and Gulf Park along the Great Miami River, where releases were previously observed. The company would have to provide an assurance that adequate financial resources are available for implementation of the remedy. Analyses of mass loss on specific contaminants at the site conducted by Chevron suggest that MCLs can be reached within 30 years.

Alternative 2 serves as the basis for the remaining three alternatives. These additional alternatives differ from the Alternative 2 only in the additional technologies employed to enhance the removal of LNAPL.

Alternative 3: Sitewide SVE, Containment, MNA, and Institutional Controls

This alternative would feature a sitewide SVE system in addition to the corrective measures described in Alternative 2. The SVE system would be implemented via a network of mostly parallel, horizontal wells underlying the entire site. These wells would be drilled from existing north-south site roads and would be spaced approximately 300 feet apart. The system would be composed of approximately 17 horizontal wells on site and three or four additional wells off site, south of Hooven. The SVE system would be used to remove volatile contaminants, including benzene, from the unsaturated zone. The system should increase the natural depletion of volatile constituents from the upper portions of the LNAPL smear zone and thus reduce the time to achieve the cleanup of the entire plume to MCLs. The system would be operated as long as it continued to be effective in removing volatile constituents in the subsurface, which is estimated to be a period of five to ten years. This is not the overall time frame, i.e., the time estimated to reach MCLs.

Alternative 4: Sitewide SVE & IAS, Containment, MNA, and Institutional Controls

This alternative would feature an IAS system in addition to the corrective measures described in Alternative 3. The IAS system would involve the injection of air below the LNAPL smear zone via a network of vertical wells laid out in an orthogonal grid. Like SVE, the IAS system would strip volatile components from the subsurface and facilitate biodegradation through aeration of the subsurface. The IAS wells would be installed on 50-foot centers which would result in approximately 3,500 wells for the two-acre plume area. The SVE system would operate concurrently with the IAS system and capture the volatile constituents stripped from the subsurface by the IAS system. Like the SVE system, the IAS system would be operated as long as it continued to be effective in removing volatile constituents in the subsurface, which is estimated to be a period of five to ten years. This is not the overall time frame, i.e., the time estimated to reach MCLs.

Alternative 5: Sitewide SEAR & SVE, Containment, MNA and Institutional Controls

Alternative 5 would feature SEAR in addition to the corrective measures described in Alternative 3. This alternative differs from Alternative 4 only by replacing SEAR for IAS as a means for removing LNAPL from beneath the water table. Under this alternative, SEAR would be used to flush most of the LNAPL from the saturated zone and remove the free phase, while SVE would attack the vadose zone. SEAR would be implemented during periods of low water table to take advantage of the natural vertical drainage of LNAPL under such conditions. The implementation of SEAR during periods of low water table elevation would help to minimize the volume of aquifer to be treated, and thus, the volume and cost of surfactant to be used. SEAR is different from the other technologies considered because it would be implemented in small blocks referred to as panels. A panel would be treated in a few weeks, after which time the operation would move to the next down gradient panel. This process would extend over several low water seasons, progressing down gradient until the entire site is treated. The surfactant mix would be injected through a row of injection wells spaced 10 to 15 feet apart and extracted through a parallel row of wells 50 feet from the injection row. Under these assumptions, approximately 17,000 wells would be drilled.

VI. EVALUATION OF ALTERNATIVES

A. Evaluation Criteria

This section presents the process used to evaluate the five cleanup alternatives and the results of the evaluation for contaminated groundwater. The evaluation criteria used are described in the May 1, 1996, Advance Notice of Proposed Rulemaking (ANPR) for Corrective Action at Hazardous Waste Management Facilities 61 Federal Register 19432. Although the rule was never published as a final rule, it is used by U.S. EPA as guidance for selecting corrective measures at RCRA corrective action facilities. The ANPR criteria are applied in a two-phased evaluation: Proposed remedies are screened to see if they meet the four threshold criteria. The remedies that meet the threshold criteria are then evaluated using five balancing criteria to identify the remedy that provides the best relative combination of attributes.

The threshold criteria require that all remedies: (1) be protective of human health and the environment; (2) attain media cleanup standards (concentration levels of hazardous constituents identified by U.S. EPA as protective of human health and the environment); (3) control the source(s) of releases of hazardous waste (including hazardous constituents) that pose threats to human health and the environment; and (4) comply with applicable standards for waste management. The cleanup standards for the contaminated groundwater at the Facility are Safe Drinking Water Act Maximum Contaminant Levels (MCLs). The balancing criteria are: (1) long-term reliability and effectiveness; (2) reduction of toxicity, mobility, or volume of wastes; (3) short-term effectiveness; (4) implementability; and (5) cost.

B. Selection of the Proposed Remedy

U.S. EPA conducted a review of the corrective measure alternative in Chevron's October 2001 groundwater CMS. The threshold criteria have been evaluated by U.S. EPA for all the proposed remedies. Alternative 1, the no action alternative, does not meet all of the threshold criteria and is not considered for evaluation by the balancing criteria. Alternative 1 does not protect human health and the environment, control the source, attain any cleanup standards, or propose any waste management. U.S. EPA determined alternatives 2, 3, 4, and 5 meet the threshold criteria and are evaluated relative to the balancing criteria.

1. Long-Term Reliability
   While the pumping and wastewater treatment systems involved in Alternative 2 will require some maintenance, this alternative has been shown to be reliable in short term tests and has been proven reliable in the long term. Alternatives 3 and 4 are not routinely operated at the scale envisioned at the Chevron site and can be considered less reliable in the long term than Alternative 2. Alternative 5 is developmental and has been conducted at the bench scale (laboratory test) only and is considered the least reliable in the long term of all the alternatives considered.

2. Reduction of Toxicity, Mobility or Volume of Wastes
   All of the proposed alternatives would reduce the toxicity of the residual LNAPL by depletion of benzene and related compounds or through direct removal of LNAPL from the subsurface. Recent tests have shown the mobility of LNAPL is not significant at the Chevron site, and appears to be stable. Consequently, none of the alternatives offers any significant advantages relative to reductions in mobility. With their more aggressive approach to removal of LNAPL from the subsurface, Alternatives3, 4 and 5 appear to offer advantages, as compared with alternative 2, with regard to the reduction in the volume of residual LNAPL and the time frame for achieving MCLs. Alternative 2, relying in large part on natural degradation, would generate less waste than the other alternatives. Alternative 5 with its SEAR technology would result in the greatest reductions in residual LNAPL volumes although it may increase mobility in the process.

3. Short-Term Effectiveness
   The high grade pumping scheme in Alternative 2 is only operational and effective during extended periods of low rainfall when groundwater levels expose the smear zone.

Consequently, the short-term effectiveness of this alternative is dependent on weather patterns. Alternative 2 also relies heavily on the volatilization of benzene into soil vapor and the dissolution of benzene into groundwater to deplete the benzene and related contaminants contained within the LNAPL. This reliance on natural attenuation mechanisms adversely impacts the short-term effectiveness of Alternative 2. Although somewhat more effective than Alternative 2, the short-term effectiveness of Alternative 3 is limited by the fact that SVE only addresses the contaminants in the unsaturated zone and does not address the large amounts of LNAPL held below the water table in the LNAPL smear zone. While the effectiveness of SVE in Alternative 3 would be enhanced during low water table conditions, this alternative would then be subject to the same limitations imposed on the high grade pumping by weather conditions. The addition of IAS to Alternative 4 would help to more rapidly address the LNAPL below the water table and would likely improve the short-term effectiveness of the remedy. The SEAR technology in Alternative 5 is most effective at low water tables which are present only at certain times of the year. SEAR would overall remove the most LNAPL, and consequently would likely provide the greatest short-term effectiveness.

4. Implementability
   Alternative 2 is readily implementable. The equipment necessary to implement the high grade pumping scheme in Alternative 2 is already largely in place and the treatment system has been in operation at the site. Although high grade pumping would require low water table conditions, such conditions may be sufficiently frequent so as not to adversely impact the implementability and therefore effectiveness of Alternative 2. Alternatives 3 and 4 require the installation of large networks of SVE and IAS (Alternative 4) wells. While these technologies have been used on a lesser scale at many other sites, the scale that would be involved in implementing these technologies at the Chevron site is very large and reliability of the performance is unclear. Thus, Alternative 3 and 4 may be considered less implementable than Alternative 2. The added complexity of the IAS system in Alternative 4 and the major drilling effort required makes Alternative 4 less implementable than Alternative 3. The implementation of the SEAR technology on this scale in Alternative 5 would be unprecedented and would have to be considered developmental. The extensive injection and recovery well system required for the SEAR technology combined with the complexities of this technology clearly make Alternative 5, as described, the least implementable of all the alternatives. In addition, both the IAS and SEAR technologies may increase dissolved concentrations of contaminants thereby spreading the plumes in groundwater and require additional containment measures, also making Alternatives 4 and 5 less implementable. The high grade pumping scheme in Alternative 2 has the advantage of having significant reach in the subsurface including beneath portions of Hooven. Alternative 2 is the most readily implementable remedy.

5. Costs
   The estimated costs for each Alternative in 2006 dollars are presented in Table 1 below. The total cost figures here differ from the cost figures in the 2000 Groundwater CMS

because the 2000 cost estimate included the cost of continued site wide pumping through the life of the remedy. The 2006 estimates presumes that the hydraulic control wells will gradually be shut down within a few years after the remedy is implemented.

Table 1. Present Worth of All Costs Associated with Alternatives 2 through 5

Alternative	Initial Source Removal Technology	Present Worth ($ millions)			
		Initial Source Removal		Duration (years)	Total
		Capital	O&M		
2	High Grade Pumping	$11,292,499	$14,514,433	30	$25,806,932
3	SVE	$20,690,474	$26,250,945	12	$46,941,419
4	IAS + SVE	$27,359,122	$35,417,392	10	$62,776,514
5	SEAR + SVE	$99,102,293	$18,163,889	8	$117,266,181

C. Summary

Alternative 2 appears to be the most easily implemented and most reliable in the long tem of all the remedial alternatives considered. Alternative 2 is not the most effective in the short term nor in reducing mobility, toxicity or volume of wastes. While considered less implementable and reliable, Alternative 3 provides only modest improvement in the remedial time frame over Alternative 2. Alternative 4 and particularly Alternative 5 have shown the potential for significant reduction of residual LNAPL and significant improvements in the timeframe of the remedy. The advantages of short-term effectiveness and reduction in volume of LNAPL in Alternatives 3, 4 and 5 are balanced with the disadvantages regarding their implementability and long-term reliability. The last balancing criteria U.S. EPA has to consider is costs, Alternatives 3, 4, and 5 are progressively more costly than Alternative 2. When all the balancing criteria are weighed against the four alternatives, Alternative 2 outweighs Alternative 3, 4 and 5. Consequently, Alternative 2 (*Advantage*-implementable, long-term reliability, and costs/*Disadvantag*e-short-term effectiveness; reduction in mobility, toxicity or volume of wastes) is recommended as the proposed groundwater remedy at the Chevron facility.

VII. SCOPE OF PROPOSED REMEDY - ALTERNATIVE 2

The proposed remedy, Alternative 2, has been designed to be protective of human health and the environment. The details of this proposed remedy are laid out in this section. The long-term corrective action objective is to restore groundwater to its maximum beneficial uses by achieving drinking water MCLs throughout the area of contaminated groundwater. Based on mass loss estimates for contaminants at the facility, U.S. EPA expects that MCLs will be achieved throughout the plume within 30 years. Thus the proposed remedy includes the long-term performance standard of restoring the ground water to MCLs by 2036. However, because achieving this long-term objective will take many years, a series of interim corrective action objectives have been developed for the Chevron groundwater plume. These interim objectives have been designed to ensure that human health and the environment are protected until the long-term corrective action objective is achieved.

As indicated in the Summary of Facility Risks (Section IV) the principal contaminant of concern in groundwater is benzene, although benzene, toluene, ethylbenzene, and xylene (BTEX) compounds are found in groundwater above MCLs. Benzene poses a risk to human health through ingestion via drinking water and inhalation. The discharge of BTEX compounds and other contaminants to the Great Miami River also pose potential risks to ecological receptors.

The following interim remedial objectives have been identified:

- 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 riverbank to prevent erosion

These interim remedial objectives are interrelated and are to be achieved through the various components of the proposed remedy.

A key component of the proposed remedy is the containment and stabilization of the LNAPL and dissolved contaminant plumes. The LNAPL and dissolved contaminant plumes are currently contained by the ongoing interim measure consisting of the operation of a recovery well system that hydraulically controls the plumes. However, studies have indicated that the LNAPL plume may be stable under natural gradients. Consequently, operation of the site-wide recovery system may not be necessary to contain the LNAPL plume. In addition, the benzene and related petroleum compounds that emanate from the LNAPL source are generally biodegradable in groundwater. On-site monitoring has suggested that natural attenuation stabilizes the dissolved plume emanating from the LNAPL plume. Consequently, hydraulic control may not be necessary to contain the dissolved plume.

During the early phases of the remedy, hydraulic control of the plume will be gradually eased and the migration of the plumes monitored carefully to verify that the LNAPL and dissolved plumes are stable under natural groundwater gradients. The remedy includes an extensive ongoing program of monitoring both the LNAPL and dissolved plumes to verify that both plumes are stable.

For the dissolved plume, a network of monitoring wells establishes a “Containment Point of Compliance” (“POC”), beyond which the LNAPL plume or dissolved contaminants above MCLs will not be allowed to migrate. These monitoring wells are located at the approximate down-gradient boundary of the current plume, and additional wells may be added to completely monitor the down-gradient boundary (Figure 4). Sampling of these wells will be conducted semiannually for the first five years, annually for the next five years (staggered to account for seasonality), biennially for the next ten years, and every five years thereafter. Should the performance monitoring indicate that MCLs have been exceeded at or beyond the Containment POC, operation of the extraction well system will be resumed. If necessary, Chevron will analyze and implement additional remedial measures in order to ensure containment of the dissolved plume. Alternatives evaluated and Chevron’s recommended alternative will be submitted to U.S. EPA for review. Whenever new wells are installed, Chevron will develop an initial data set for the new wells by sampling quarterly for the first two years.

To ensure containment of the LNAPL plume, the ROST wells and groundwater monitoring wells outside the smear zone will be tested for the appearance of LNAPLs (Figure 4 & 5). These monitoring wells will be sampled semiannually for the first five years, annually for the next five years (staggered to account for seasonality), biennially for the next ten years and every five years thereafter. The contingency, if LNAPL is seen migrating, is to resume year round pumping. In addition, Chevron will analyze alternate LNAPL recovery mechanisms (including focused aggressive source removal technologies such as air sparging and solvent flushing (SEAR)) and propose a recommended alternative for U.S. EPA review. Chevron shall implement additional remedial measures to ensure containment of the LNAPL plume.

The ongoing performance monitoring program will include close monitoring of the LNAPL and dissolved plumes along the Great Miami River to ensure that discharges to the river do not occur. Should this monitoring indicate that the LNAPL plume is not stable in the area adjacent to the river, special engineered barriers to LNAPL migration will be implemented along the river. Residual (immobile) LNAPL has been observed along the river bank. This residual has been observed to be released to the river during periods of high river flow due to bank scour and sloughing of contaminated soils along the river bank at the refinery and in Gulf Park. To eliminate such releases, the proposed remedy may require the installation of engineered structures along contaminated portions of the bank to stabilize the bank and prevent sloughing of contaminated soil into the Great Miami River.

Since the LNAPL plume, more specifically the benzene and related volatile compounds contained in the LNAPL, are the source of contaminants in the dissolved plume, the proposed remedy includes measures to remove as much LNAPL from the subsurface as is practical. The LNAPL recovery operations conducted to date as an interim measure have demonstrated diminishing returns. The remaining LNAPL is held in the LNAPL smear zone located above and below the water table. Most of this LNAPL is contained below the normal water table elevation and is only available for recovery during periods of low water table elevations, typically early fall to mid-winter. The proposed remedy includes a scheme of pumping during periods of naturally occurring low water table to further lower the water table in order to exploit this LNAPL behavior. This scheme has been termed high grade pumping. High grade pumping involves concentrated pumping during periods of naturally occurring low water table elevation to further lower the water table in a localized area and enhance the recovery of LNAPL in that area. High grade pumping will be operated in areas where significant quantities of potentially recoverable LNAPL are known to exist starting in the northwest corner of the facility near Hooven and the Southwest Quadrant and progressing eventually to other areas more centrally located in the facility. LNAPL recovery operations during periods of normal and high water table elevations will be suspended since recovery of reasonable amounts of LNAPL is no longer possible during these periods. At the time of the 5 year review, we will evaluate the high grade LNAPL recovery systems' performance to make sure we have controlled the sources of releases so as to reduce or eliminate, to the extent practicable, further releases of hazardous waste (including hazardous constituents) that might pose threats to human health and the environment. The high grade pumping program will continue to recover LNAPL from the subsurface until this approach is no longer capable of efficiently recovering further LNAPL.

Depletion of benzene and related volatile compounds in the LNAPL is necessary to meet the long-term corrective action goal of returning groundwater to its most beneficial use and meeting MCLs. This depletion is expected to occur through a number of processes in addition to biodegradation. Benzene is removed from the LNAPL by dissolving into groundwater passing through the smear zone. Benzene also continues to volatilize from the shallow portion of the smear zone into the air contained in the vadose zone overlying the water table. Operation of the SVE system beneath Hooven during periods of high grade pumping is included in the remedy to further accelerate volatilization during these periods. The recovery of LNAPL through the high grade pumping program is also intended to directly remove source material. Modeling and other analysis have resulted in predictions that these mechanisms should remove sufficient benzene and related compounds from the LNAPL to achieve the long-term performance measure of attaining MCLs in groundwater within 30 years. In order to verify that these predictions are correct, the performance monitoring component of the remedy includes periodic investigation of the LNAPL extent and composition, combined with appropriate analysis of these data, to confirm the timely achievement of the long-term performance measure. MNA parameters should be collected and analyzed on a 5 year interval to properly gauge progress of predicted attenuation of the hydrocarbons in the subsurface, Appendix 1 contains the *U.S. EPA Region 5 Framework for Natural Attenuation Decisions for Groundwater* which lays out a flowchart for decision making and indicator parameters to test for in the field. Should this performance monitoring indicate that MCLs will not be achieved in a timely manner, i.e., within thirty years, additional removal of LNAPL must be implemented by Chevron. Chevron will evaluate alternatives and submit its recommended alternative to U.S. EPA for its review.

The remedy includes a number of institutional and engineering controls to address any potential exposures that may occur during the interim remedial period. The institutional controls shall be established in a manner to be legally enforceable against existing and future property owners, and shall include the following use restrictions:

1) Land use restrictions on the facility property which are consistent with the soil cleanup standards and anticipated future land uses;
2) Prohibitions on construction of basements or other sub-grade areas for human occupancy on the facility;
3) Prohibitions on potable use of ground water on the facility; and
4) Notice to existing and future owners of off-site properties situated above the plume emanating from the Chevron facility of prohibitions on well installation contained in Ohio Revised Code Sections 3745-09-04.

The restrictions in 1) through 3) above will be in the form of restrictive covenants that run with the land in conformance with the Ohio Universal Environmental Covenants Act, Ohio Revised Code Section 5301.80 to 5301.92.

The remedial activities described in this section, including the land use controls, are designed to allow for redevelopment of the refinery property during site remediation before final remedial goals have been met.

The company will have to provide an assurance that adequate financial resources are available for implementation of the remedy. The performance measures of the proposed remedy can be viewed in terms of the receptors potentially impacted by the LNAPL and groundwater plumes. These receptors can be grouped into the following categories based on location: 1) human receptors in Hooven, 2) human receptors in the Southwest Quadrant, 3) the Great Miami River, 4) groundwater at and beyond the POC, and 5) on-site receptors. The strategy of the proposed remedy for protecting each of these potential receptor groups is discussed below.

<u>Human Receptors in Hooven</u>: The LNAPL and dissolved groundwater plumes lie beneath a portion of Hooven. The principal potential exposure pathway to human receptors in Hooven is inhalation of constituents volatilized from the LNAPL and migrating through soil vapor to the surface. The performance measures for Hooven are (1) to ensure that no constituents from the Chevron plume exceed risk based residential standards in soil vapor at the ground surface (these standards are identified in U.S. EPA Office of Solid Waste and Emergency Response (OSWER) Draft Vapor Intrusion (VI) Guidance, 2002); (2) to remove as much LNAPL and associated volatile constituents from the LNAPL plume beneath Hooven, as is practical; and (3) to stabilize the LNAPL plume beneath Hooven under natural gradient conditions.

Recent investigations have demonstrated that the vapor inhalation pathway is incomplete. Investigation of contaminant concentrations in subsurface vapor have demonstrated that benzene quickly attenuates through biodegradation. To ensure that this pathway does not pose any unexpected risks in the future, the proposed remedy includes ongoing soil vapor monitoring beneath Hooven. The vapor monitoring wells that will be tested are nested vapor wells 93, 96, 99 and 129. These wells will be sampled at 5, and 10 feet below ground surface and at 10 foot intervals to the groundwater table. These nested vapor wells will be tested once per year for the first five years, then every three years thereafter. If conditions permit, the samples will be collected when the water table altitude is at or below 463.5 ft-elevation for one week or longer, and before the HSVE system is operated. In addition, the SVE system installed beneath Hooven will continue to operate during periods of low water table when the high grade pumping is performed. The operation of the SVE system at this time will serve both to capture any volatile constituents vaporizing from the smear zone and to further deplete these constituents from the upper portion of the LNAPL smear zone beneath Hooven, thus reducing the future source of benzene vapor beneath Hooven. If vapor samples show that there is a complete pathway from groundwater to the surface in concentrations exceeding the risk-based levels, Chevron shall implement measures to prevent the vapors from intruding into homes in Hooven. Such measures may include year-round groundwater pumping, operation of SVE, and/or other engineered control(s), and installing vapor vents or other engineered controls in foundations.

The high grade pumping program during periods of low water table will similarly remove LNAPL from beneath Hooven, further reducing the source of benzene and stabilizing the LNAPL plume beneath Hooven. The monitoring wells outside the smear zone will be tested to insure no new LNAPL appearance. The monitoring wells to insure LNAPL stability will be sampled semiannually for the first five years, annually for the next five years, staggered (to account for seasonality) biennially for the next ten years, and every five years thereafter. The contingency, if LNAPL is seen migrating, is to resume year-round pumping and re-evaluate alternate NAPL recovery techniques, which may include focused aggressive source removal (e.g. air sparging, solvent flushing etc.).

Human Receptors in the Southwest Quadrant: The LNAPL and dissolved groundwater plumes also lie beneath the western portion of the Southwest Quadrant. The principal potential exposure pathways to the human receptors in the Southwest Quadrant include the extraction and use of contaminated groundwater and inhalation of benzene through vapor migration of benzene to the ground surface. The performance standards in the southwest quadrant are to protect human receptors from exposure to contaminants in groundwater and to stabilize the LNAPL and groundwater plumes in this area. The proposed remedy includes engineering and land use controls addressing the potential human exposures in the Southwest Quadrant. These controls include the installation of vapor barriers in buildings in these areas, and a statutory prohibition on groundwater use on the installation of wells where known contaminants will be conducted to a well. The high grade pumping scheme is designed to remove LNAPL from beneath the Southwest Quadrant and further stabilize the LNAPL plume in this area. Monitoring of the LNAPL in the Southwest Quadrant will be accomplished using Rapid Optical Scanning Technology (ROST) wells in three or four transects. These will be located outside the smear zone and monitored semiannually for first five years, annually for next five years, staggered (to account for seasonality) biennially for next ten years, every five years thereafter. If LNAPL is detected at these ROST wells then Chevron must resume year-round pumping until compliance is restored, and re-evaluate alternate LNAPL recovery techniques. The contingencies could include focused aggressive source removal (e.g. air sparging, solvent flushing etc.)

Great Miami River: The performance standards for the Great Miami River are to (1) prevent any NAPL migration to the river and (2) to prevent the development of a NAPL sheen in the river. The performance standards for the Great Miami River also include (3) the prevention of any discharge of dissolved constituents to the river above appropriate Ohio EPA surface water standards. While preliminary studies appear to indicate that the LNAPL plume will be stable under natural gradients in the vicinity of the river, the proposed remedy requires engineered or hydraulic barriers to contain the LNAPL plume should performance monitoring fail to demonstrate that the LNAPL plume is stable in the area near the river. The monitoring program includes surface and groundwater monitor locations along the Great Miami River, with "early" warning components and monitoring locations at the river bank/smear zone interface. Monitoring includes piezometers and monitoring wells near the river and wells to sample pore space in river sediment. The frequency and locations of sampling are to be determined depending on river study findings. Locations known today where sampling and stabilization are needed are at the refinery and Gulf Park. If OEPA surface water standards are exceeded or sheens appear on the Great Miami River, then the contingency is to resume year-round groundwater pumping until compliance with the standard is restored. In addition, Chevron will evaluate contingency alternatives, including perimeter treatment system (e.g. sparge curtain, funnel/gate etc.), aggressive source removal (e.g. air sparging, SVE, solvent flushing (SEAR) etc.), and implement additional corrective measures if necessary to meet the performance standard of allowing no migration of LNAPL or dissolved constituents into the river above OEPA surface water standards. Chevron shall analyze alternatives and submit its recommended alternative to U.S. EPA for its review.

Groundwater at and Beyond the Point of Compliance (POC): The performance standard for the proposed remedy in the downgradient area of the plume is to prevent the migration of LNAPL or dissolved constituents above appropriate regulatory levels (i.e., MCLs) beyond the POC. This POC will be established at the approximate boundaries of the current plume. Thus, the proposed remedy is designed to prevent any further expansion of either the LNAPL or dissolved phase plumes. It is expected that expansion of the LNAPL plume will be prevented by the natural stabilization of the plume. The benzene and related petroleum compounds that emanate from the LNAPL source are generally biodegradable in groundwater. On-site monitoring has confirmed that natural attenuation stabilizes the dissolved plume emanating from the LNAPL plume. Consequently, it is expected that the migration of the dissolved plume will be controlled by MNA. Monitoring of the plume is key; therefore sampling will be conducted semiannually for the first five years, annually for the next five years, (staggered to account for seasonality) biennially for the next ten years, and every five years thereafter. This performance monitoring will confirm if MCLs for groundwater will be exceeded at six monitoring wells near the POC and no LNAPL detections in the three or four transects of ROST wells mentioned above. However, should either plume prove not to be stable, Chevron will resume year-round pumping until compliance is restored. In addition, Chevron will evaluate contingency alternatives, including perimeter treatment system (e.g. sparge curtain, funnel/gate etc.), aggressive source removal (e.g. air sparging, SVE, solvent flushing etc.), and implement additional corrective measures if necessary to meet the performance standards of allowing no migration of LNAPL or dissolved constituents above MCLs beyond the POC. Chevron will evaluate alternatives and submit its recommended alternative to U.S. EPA for its review.

On-Site Receptors: The performance standards for protecting people who will be working on-site in the future are (1) to prevent exposures to vapor constituents, (2) prevent exposure to soil containing residual contamination, and to (3) prevent groundwater use. These standards are to be met, in part, by implementing engineering controls (e.g., vapor barriers) in buildings during the redevelopment of the property. In addition, institutional controls that prevent exposure to groundwater and residual contamination in soils will be implemented in an expeditious fashion. See the discussion of appropriate land and groundwater use restrictions to be implemented in Section VII. Scope of Proposed Remedy - Alternative 2.

VIII. PUBLIC PARTICIPATION

U.S. EPA solicits input from the community on the corrective measures proposed for clean up of contaminated groundwater. The public is also invited to provide comment on corrective measure alternatives not addressed in this SB. U.S. EPA has set a public comment period from April 12, 2006 through May 30, 2006, to encourage public participation in the selection process. The comment period will include a public hearing where U.S. EPA will present the investigation results and the proposed remedy, answer pertinent questions, and accept oral and written comments. In addition, written comments will be accepted by U.S. EPA up to the close of the comment period.

The public hearing is scheduled for May 9th, 2006, at the Whitewater Senior Center and Township Hall, 6125 Dry Fork Road, Whitewater Township, Ohio.

The Administrative Record for the Chevron Facility is available at the following locations:

Public Library of Cincinnati
Miami Township Branch
8 N. Miami Rd.
Cleves, OH 45002

U.S. EPA, Region 5
Waste, Pesticides and Toxics Division Records Center
77 West Jackson Boulevard, 7th Floor
Chicago, Illinois 60604-3590
(312) 886-0902
Hours: Mon-Fri, 8:00 a.m. - 4:00 p.m.

General information about the site is available on U.S. EPA's Web page:
epa.gov/region5/sites/chevron

After consideration of the comments received, U.S. EPA will select the remedy and document the selection in the Final Decision and Response to Comments. In addition, public comments will be summarized and U.S. EPA's response provided. The Final Decision and Response to Comments will be drafted at the conclusion of the public comment period and incorporated into the Administrative Record.

To send written comments or request technical information on the Chevron facility, please contact:

Mr. Christopher Black
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U.S. EPA, Region 5
77 West Jackson Boulevard
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To request information on the public comment period process, please contact:

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U.S. EPA, Region 5
77 West Jackson Boulevard
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Chicago, Illinois 60604-3590
(312) 353-6646
E-mail: bill.briana@epa.gov

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FIGURES

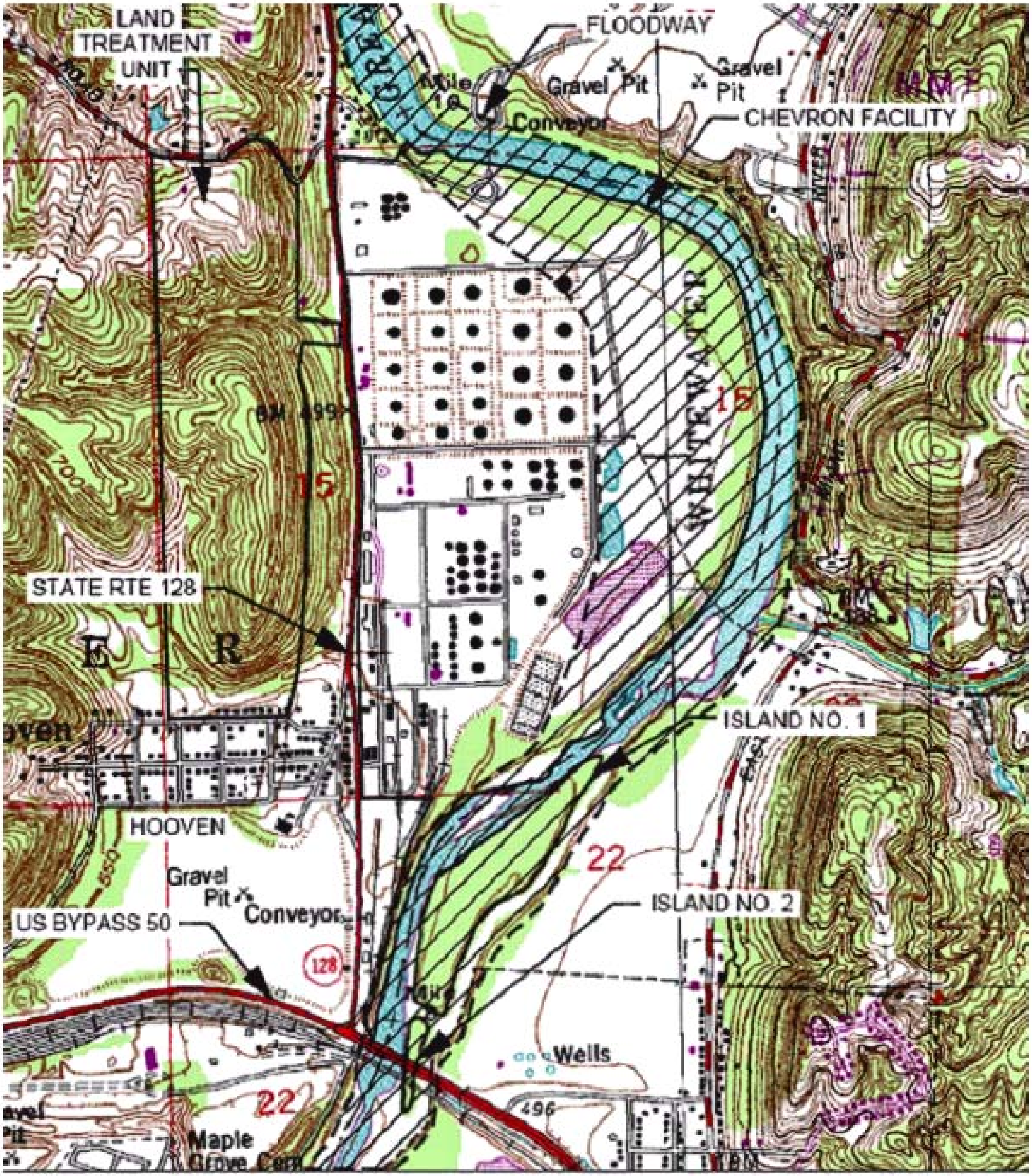


Figure 1. Site Location and Former Facility Layout Map Chevron Cincinnati Facility Site, Hooven, Ohio

Figure 2.
Future Land Use Figure:
Mixed Use Scenario

Chevron Cincinnati
Facility Site,
Hooven, Ohio

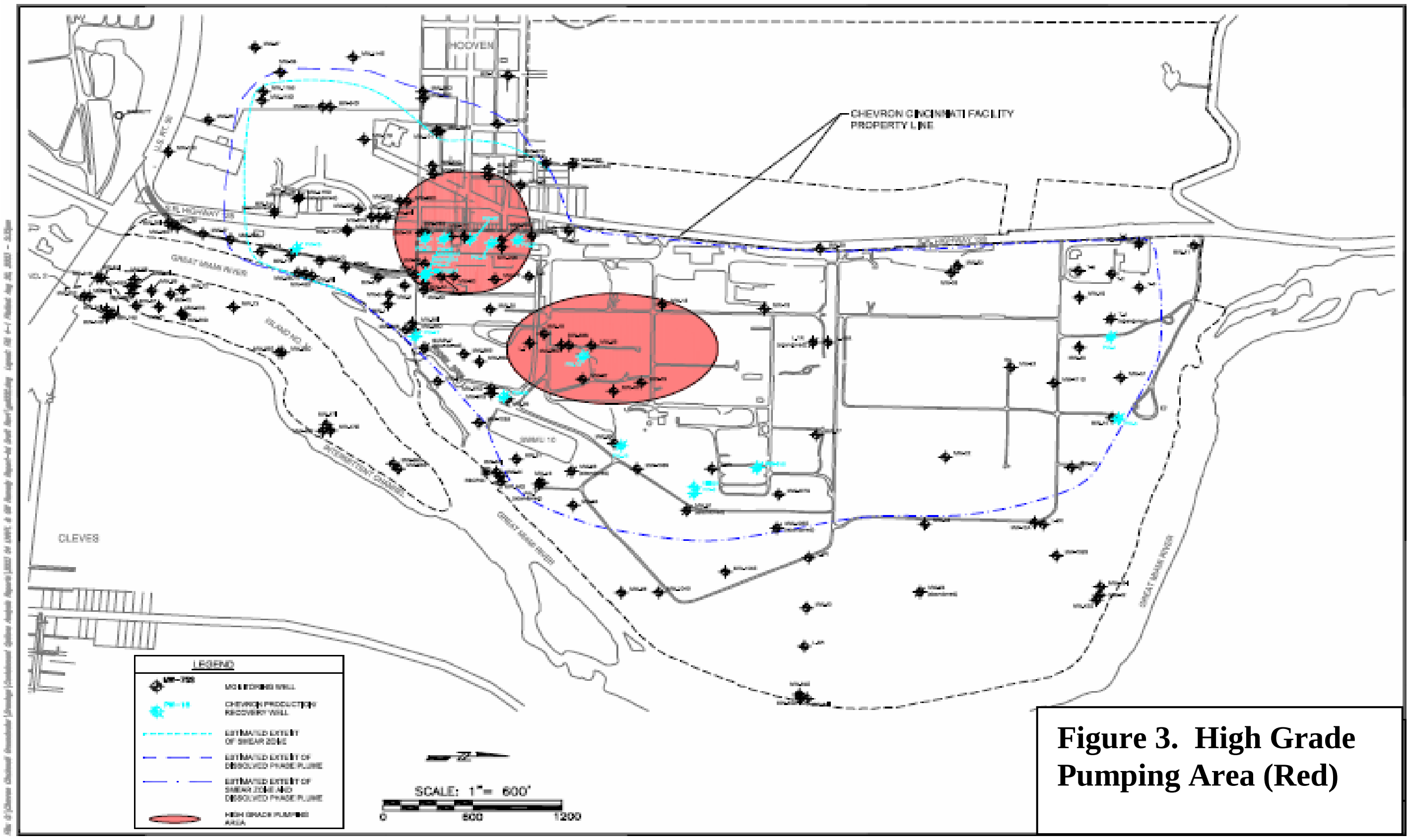


Figure 3. High Grade Pumping Area (Red)

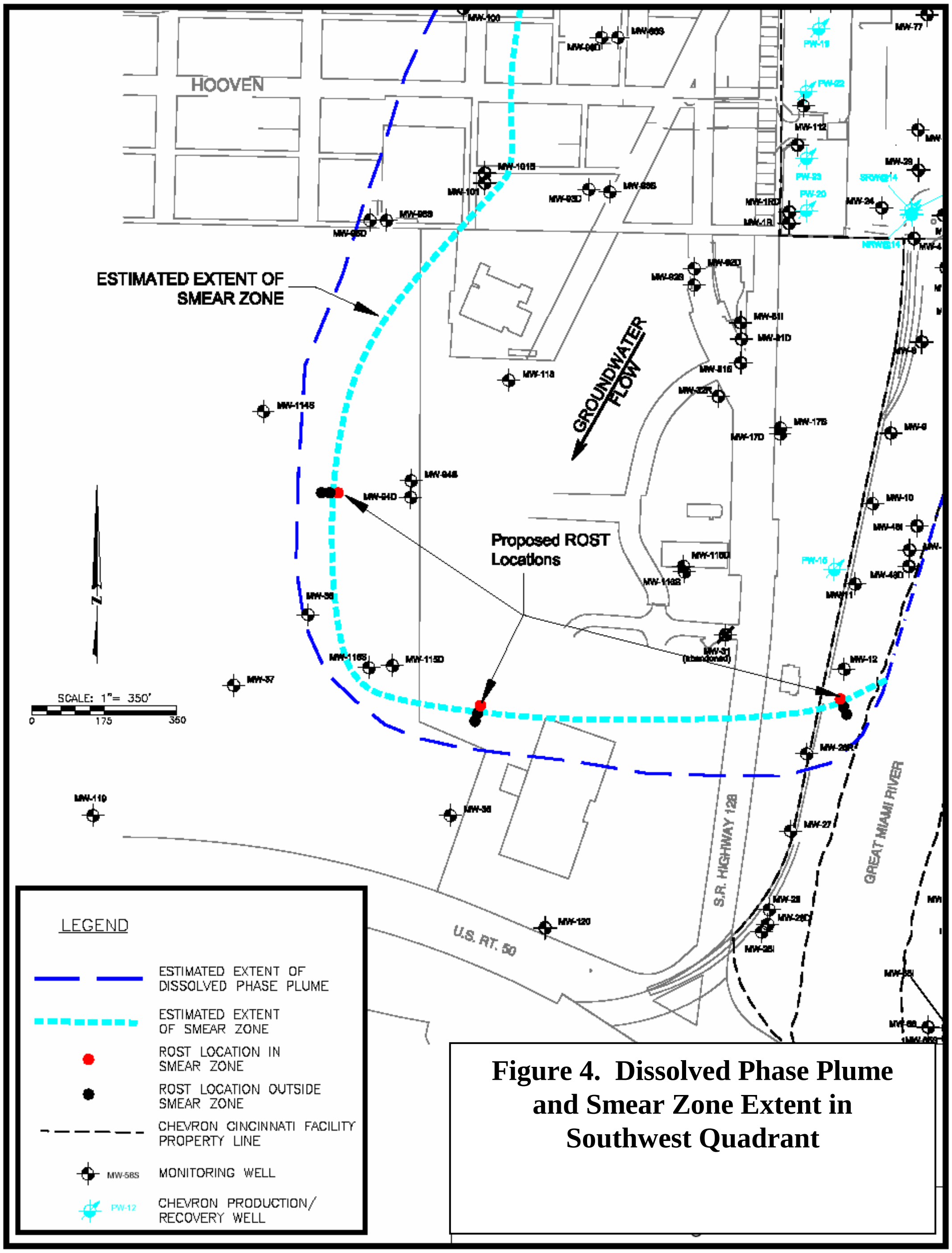
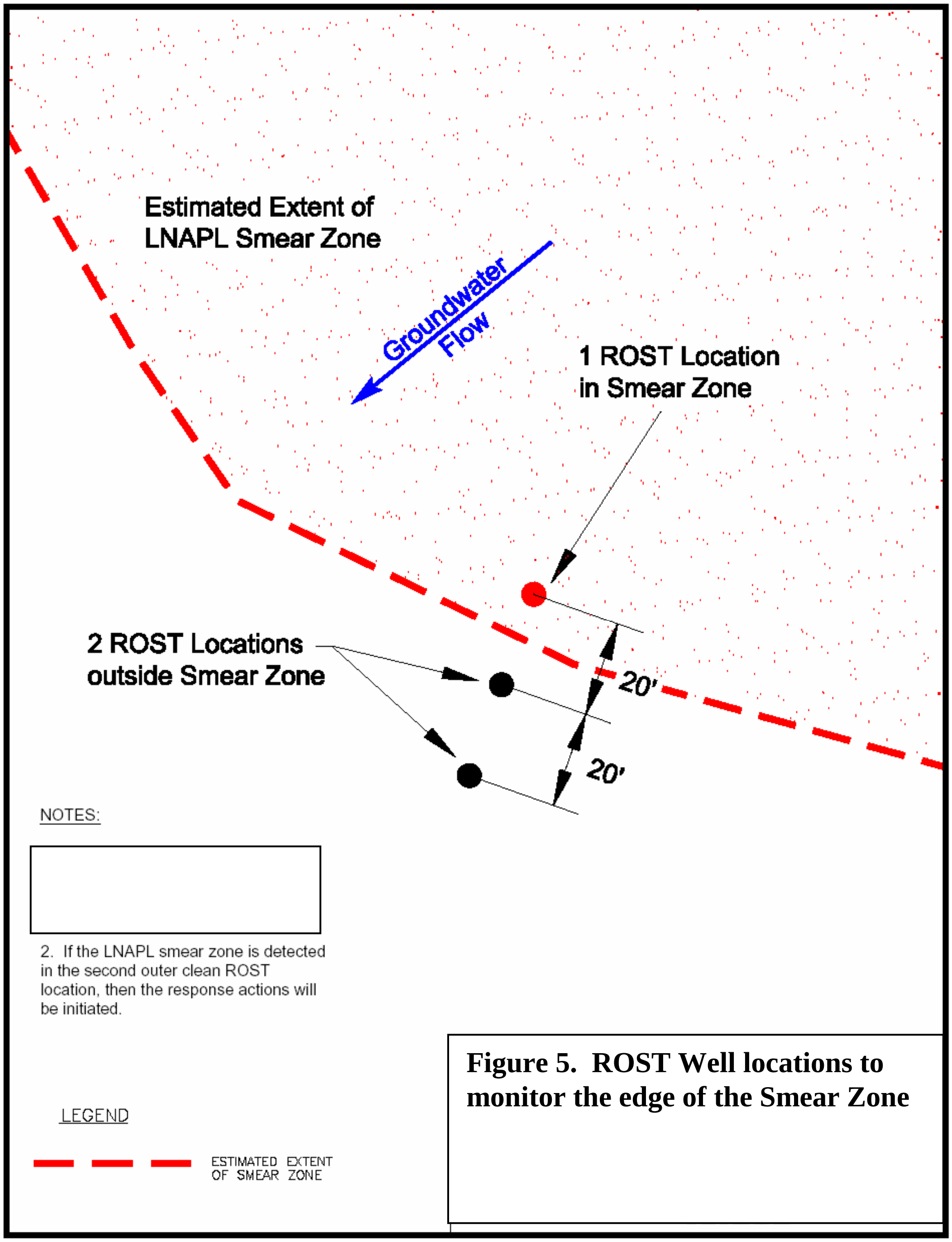


Figure 4. Dissolved Phase Plume and Smear Zone Extent in Southwest Quadrant



NOTES:

2. If the LNAPL smear zone is detected in the second outer clean ROST location, then the response actions will be initiated.

Figure 5. ROST Well locations to monitor the edge of the Smear Zone

APPENDIX 1
Region 5 Framework for Monitored Natural Attenuation Decisions for Groundwater
September, 2000

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5

DATE: September 27, 2000

SUBJECT: Transmittal of Monitored Natural Attenuation Framework

FROM: William E. Muno, Director
Superfund Division

TO: Superfund Staff

Attached is the document "Region 5 Framework for Monitored Natural Attenuation Decisions for Ground Water" which I have approved for release in the Region 5 Superfund Program. The Framework provides technical direction in the Region 5 Superfund Program based on the final OSWER Directive on the *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*. The document is a framework to be used to ensure that the proper data is collected when making monitored natural attenuation remedy decisions. It includes a discussion of the process of making natural attenuation decisions and a brief explanation of the use of the natural attenuation data in the evaluation process.

In order to maximize the sound science represented by the Framework while minimizing decision delays, the Framework is to be implemented in a phased approach with a transition period for full implementation by October 1, 2001.

- For those sites without an approved workplan and where Monitored Natural Attenuation (MNA) is proposed for consideration, the data requirements of the Framework shall be fully implemented now.
- For those sites already considering MNA as a remedial alternative or remedy modification with an approved workplan for data collection, the recommendations of this Framework should be considered. The site's project manager should consult with a Region 5 Superfund geologist to determine what modifications to the existing data collection efforts are required to adequately evaluate MNA consistent with the Framework.
- For those sites where MNA has been selected and/or those sites which are in the process of implementing MNA, the ground-water sampling requirements contained in the Framework should be fulfilled by the MNA monitoring program. In addition, a comprehensive contingency remedy including implementation criteria as discussed in the OSWER Directive should be developed for these sites.

The Framework document includes the Framework text; one figure (a flowchart of the decision-making process); three tables (a table summarizing the various natural attenuation processes, a table listing required indicator parameters and sampling frequencies, and a table summarizing the data uses of each parameter); and a glossary of technical terms.

The Framework was developed by a workgroup composed of the hydrogeological support staff

(Luanne Vanderpool, Doug Yeskis, Gary Cygan) and five RPMs (Brad Bradley, Karen Cibulskis, Ross Del Rosario, Dion Novak and Terese Van Donsel). If you have any questions on the document, please contact the workgroup co-chairs (Luanne Vanderpool at 3-9296 or Doug Yeskis at 6-0408) or any other member of the workgroup.

REGION 5 FRAMEWORK
FOR
MONITORED NATURAL ATTENUATION DECISIONS
FOR GROUND WATER

Introduction - Monitored Natural Attenuation (MNA) is an increasingly utilized remedial option for contaminated ground water. This Framework outlines the types of data that will be used to evaluate MNA. Typically MNA is selected as a remedy in combination with one or more other actions (e.g. source control); or selected as a remedy modification to replace another action. This Framework is not meant to serve as a replacement for proper technical review from a qualified hydrogeologist, but is instead meant to educate Remedial Project Managers (RPMs) on the MNA evaluation process and to provide general direction on the type and amount of information needed for decision-making. The major decisions and actions required to evaluate and implement monitored natural attenuation are summarized in the flowchart in Figure 1. When possible, the specific boxes in Figure 1 are cited in the text of this Framework.

This Framework summarizes the current state-of-the-science and the U.S. EPA policy on the use of monitored natural attenuation in the Superfund program. As additional research, site investigations and remedial actions are completed, this paper should be revised to include new information and concerns. This Framework is applicable to the majority of Superfund sites; however, unusual, site-specific circumstances may require approaches other than those specified in this document. In these instances, the appropriate Regional hydrologists/geologists/technical specialists should be consulted. A reference list for the citations in this Framework, a list of other sources of information, and a glossary for italicized terms is attached.

What is Monitored Natural Attenuation? -Monitored Natural Attenuation is a remedy alternative that relies on natural attenuation processes to achieve site-specific remedial objectives within an acceptable timeframe. Natural attenuation is defined as “naturally occurring processes in the environment that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater”. These processes are briefly described in Table 1.

Current U.S. EPA policy concerning the use of MNA for the remediation of ground water is provided in the OSWER Directive, **Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action and Underground Storage Tank Sites** (U.S. EPA, 1999a). When relying on natural attenuation processes for site remediation, the U.S. EPA prefers those processes that are *destructive* (U.S. EPA, 1999a, page 3). Biodegradation (which may be aerobic or anaerobic) is the most important destructive process, although radioactive decay and abiotic degradation of some compounds does occur. The other attenuation processes are *nondestructive*. While natural attenuation of organic compounds (U.S. EPA, 1998, Appendix B) generally means breakdown (biodegradation) by microorganisms, natural attenuation of metals (Waters et al, 1998) often means immobilization or transformation by the soil matrix, geochemical changes and/or dispersion.

When the U.S. EPA implements natural attenuation as a remedy at a Superfund site, the Agency uses a monitored natural attenuation approach. The selection of a MNA remedy assumes that natural attenuation can be documented to be occurring at a site as discussed in this Framework.

The MNA remedy involves establishing a long-term monitoring program (Figure 1, Box 11b) with criteria for evaluating the monitoring data to determine if contaminant levels are decreasing as expected (Figure 1, Box 11a). The use of MNA also has the expectation that it will be used "in conjunction with other active remediation measures (e.g., source control)" (U.S. EPA, 1999a, page 17) and that a contingency remedy (Figure 1, Box 8a) will be developed, which can be implemented if MNA fails to perform as anticipated or required (U.S. EPA, 1999a, page 24). This Framework does not address the issues of source control (Figure 1, Box 1c) or contingency remedies (Figure 1, Box 8a) that are part of the MNA decision.

What Information is Needed? - A detailed site characterization is required to evaluate the possible implementation of MNA as a remedial alternative. The characterization should include collecting data to define (vertically and horizontally over time) the nature and distribution of the contaminants of concern and contaminant sources, as well as the potential impacts on receptors as listed below (U.S. EPA, 1998, page 34)(Figure 1, Box 1b):

- data on the location, nature, and extent of contaminant sources
- data on the location, nature, extent, and concentrations of dissolved contamination
- chemical properties of the contaminants and the subsurface materials which the contaminants migrate through
- contaminant phase distribution and partitioning (such as presence of *NAPL*, gaseous phases, dissolved phases)
- rates of biological and non-biological transformation
- ground-water geochemical data (major anions and cations, organic carbon, pH, etc.)
- geologic information on the type and distribution of subsurface materials (transmissive vs. non-transmissive materials, thicknesses and horizontal extent)
- aquifer hydraulics and characteristics, including *hydraulic conductivity* and *hydraulic gradients*, particularly preferred flow pathways
- location of areas of recharge and discharge and rates
- potential contaminant migration pathways to points of exposure to human or ecological receptors
- flux of water through areas of recharge and discharge
- toxicity versus carcinogenicity (risk, concentration limits, etc.)
- an understanding of how all of these factors are likely to vary with time

A conceptual site model should be developed to integrate site characterization data and guide both investigative and remedial actions. The conceptual model provides the basis for assessing all potential remedial technologies including MNA at the site. A site-specific conceptual model is a three-dimensional representation of the ground-water flow and *solute* transport system. This model conveys what is known or suspected about contamination sources, release mechanisms, and the transport and fate of those contaminants and includes the site's geochemical and biochemical conditions. The conceptual model should indicate ORP (*oxidation-reduction potential)* conditions at the site and identify any zonation of ORP conditions along contaminant flowpaths since many degradation and transformation processes are controlled by ORP conditions. The conceptual model should also indicate whether conditions exist to support the biological activity necessary for biodegradation and biotransformation processes. "Conceptual site model" is not synonymous with "computer model" or "simulation model"; however, a computer/simulation model may be helpful for understanding and visualizing current site conditions or for predictive simulations of potential future conditions. The conceptual site model should be constantly evaluated during the site characterization process against all possible remedial alternatives. As the model is evaluated, additional site characterization data may be necessary to complete the MNA evaluation.

All potential exposure pathways to contaminants should be identified during site characterization. If currents threats to human health or the environment are identified (Figure 1, Box 4b), remedial measures should be evaluated, selected and implemented prior to further consideration of MNA (Figure 1, Box 1c). MNA should not be considered as a possible remedial method until current, unacceptable exposure pathways have been eliminated. To ensure protectiveness, site risks should be thoroughly evaluated and all pathways of exposure should be considered (including commonly overlooked pathways such as volatilization into basements, migration into sewer systems, etc.) as well as the extent of all chemical contamination. When considering MNA, the evaluation of the extent of contamination may be broader than the original delineation of contaminants of concern in order to include less obvious compounds as described in detail in the OSWER Directive (U.S. EPA, 1999a, page 5) and to quantify degradation by-products (i.e., daughter products) of the contaminants of concern (which may be more toxic and/or mobile than the parent compounds).

MNA should be considered an unlikely remedy to be considered for compounds that have a high degree of persistence and toxicity.

Should I consider MNA for my site? - Once site characterization data has been collected and a conceptual model is developed, the next step is to evaluate the potential effectiveness of MNA as a remedial alternative. It must be recognized that demonstrating MNA may not be easy and that MNA is not always an effective remedial alternative. The National Research Council (2000) cautions:

> Although natural attenuation has been well documented as a method for treating the fuel components benzene, toluene, ethyl benzene, xylene (BTEX); currently it is not well established as a treatment for most other common classes of groundwater contaminants. Under limited circumstances, it can be applied at sites contaminated with other types of compounds, such as chlorinated solvents and metals, but its successful use will depend on attenuation rates, site conditions, and the level of scientific understanding of processes that affect the contaminant. In some cases, natural attenuation will be effective only at sites with special environmental conditions conducive to attenuation of the contaminants in question. In other cases, the use of natural attenuation is problematic because scientific understanding is too limited to predict with sufficient confidence whether this strategy will protect public health and the environment.

Analyzing the data generated by site monitoring is the next step in evaluating MNA. Although the evaluation process is the same for all sites, the level of effort needed to carry it out varies substantially with the complexity of the site and the likelihood that the contaminant is controlled by a natural attenuation process. While natural attenuation may be a feasible alternative in many cases, it must be understood that a higher level of data gathering and analysis is required to demonstrate MNA when the contaminant is likely to be persistent, is likely to be mobile, the controlling attenuation mechanisms are uncertain, and/or the hydrogeology is complex.

The demonstration of MNA should follow a three-tiered approach. In this approach, successively more detailed information is collected as required to establish a net loss of contaminants and the processes responsible for this loss. All data (including hydraulic conductivity data and water- level measurements) used for this evaluation should be collected, handled and analyzed consistent with the U.S. EPA requirements for quality assurance/quality control. These three categories of supporting site-specific information are commonly referred to (U.S. EPA, 1999a, page 15) as "lines of evidence" (Figure 1, Boxes 5b and 6c).

1. **Primary Category of Information**
   Historical ground-water and/or soil-chemistry data that demonstrate a clear and meaningful trend of decreasing contaminant mass and/or concentration. Data should include analytical results for the contaminants of concern and their degradation by-products from nine or more rounds of samples collected under non-pumping conditions over a period of three to five years. There should be at least two years of quarterly sampling to evaluate seasonal effects on the contaminant concentrations. This data should be collected from appropriately located sampling points, including within the plume source area, within the center of the plume and at the leading edges of the plume. In addition, samples should be collected from points located vertically (above and below) and horizontally (upgradient and downgradient) outside the area of ground-water contamination. The most recent analytical data on ground water should be no more than two years old at the time of the evaluation. Demonstrating that a trend of decreasing contaminant concentration is clear and meaningful should be based on statistical tests which indicate a high degree of confidence in the apparent trend line. Additional rounds of samples may be required to demonstrate this trend.

2. **Secondary Category of Information**
   Hydrogeologic and geochemical data that can be used to demonstrate indirectly the type(s) of natural attenuation processes and the rate at which such processes will reduce contaminant concentrations. This data should be collected from appropriate locations that are distributed both vertically and horizontally throughout the plume. Sample locations should consider heterogeneties in geologic structures and in the spatial distribution of contaminants. Ground-water flow paths and rates should be fully and accurately defined, as this is one of the most important factors in evaluating the applicability of natural attenuation. The locations should be sampled under non-pumping conditions and should include, at a minimum:

   a. Contaminants of concern and their potential degradation by-products as determined from literature searches (Fetter, 1993, Chapelle, 1993, U.S. EPA, 1998).
   b. Routine Indicator Parameters, including pH, dissolved oxygen, ORP (a.k.a.: Redox, Eh or *Oxidation/Reduction Potential*), temperature, and specific electrical conductance (a.k.a.: SEC) (see Table 2 and Table 3 for details).
   c. Indicator Parameters which can be used to support MNA decisions, such as: alkalinity, chloride, nitrite, nitrate, dissolved methane, iron (II) and iron (III), chloride, sulfate, sulfide, total organic carbon, etc. (see Table 2 and Table 3 for details).
   d. Vertical and horizontal characterization of the distribution of *hydraulic conductivity*

and its effect on contaminant concentrations. Most of the field methods used to determine hydraulic conductivity represent horizontal hydraulic conductivity. For sites where vertical components of ground-water flow and/or contaminant transport are present, the vertical hydraulic-conductivity component should also be determined. Hydraulic conductivity estimates should be based on:

- Single and multiple-well aquifer tests (at least 25% of wells single-well tested and one or more multiple-well aquifer tests).
- Single-well aquifer tests (at least 50% of wells tested, or all wells if fewer than 10 wells present). Note: These may under-estimate hydraulic conductivity if large-scale heterogeneties are present.
- Other field characterization methods (e.g., flowmeters, tracer tests) may be appropriate under certain site conditions, which can be evaluated by the appropriate Regional hydrologists/geologists/technical specialists. Tracer tests can be especially helpful in determining contaminant transport properties, especially since these are performed at the field scale.

Note: Laboratory permeability tests should be performed on low permeability soils (clays, silty clays, marls, etc.) only.

e. Water levels should be measured to determine ground-water-flow directions. These water levels should be taken from possible receptors, including surface-water bodies and pumping wells.

f. Seasonal variations and trends should be evaluated by obtaining data from different times of the year to determine if changes in contaminant concentrations, indicator parameters or *water types* are caused by natural attenuation or may be attributed to seasonal variability. To determine seasonal variations, the effects of different, potential influences on water quality (such as recharge events, pumping effects, etc.) need to be evaluated and documented. In most cases, this will require quarterly water-quality samples, with more frequent water-level measuring events during the period of evaluation of the applicability of natural attenuation. These water-level measuring events usually are monthly, but continuous monitoring (e.g. use of data loggers) of water levels is needed to assess high frequency events, such as pumping or tidal cycles.

The information (a. thru f.) listed above should be incorporated in a detailed site-specific conceptual model that describes the contaminant migration pathways and the natural-attenuation processes involved, as well as estimates of travel times of contaminants from sources to receptors. The conceptual model should also include degradation by-products, degradation rates and potential future receptors. Consideration should be given to all applicable processes that may affect the contaminant concentrations as listed in Table 2, when determining the list of field and indicator parameters to be analyzed at a site.

3. Supplemental Category of Information

Data from field or *microcosm* studies which directly demonstrate the occurrence of a particular natural attenuation process at the site. In microcosm studies ground-water and aquifer materials are collected and studied in the laboratory in small containers (microcosms) The disappearance of the contaminant, along with the disappearance of terminal electron acceptors or the appearance of appropriate reduction products, is measured over time to demonstrate the ability of native microorganisms to degrade given compounds. Like any bench-scale testing done as part of treatability studies, care should be taken to ensure the transferability of the results from the laboratory to field conditions. Microcosm studies can also be used to estimate biodegradation rates; however, field-derived values are preferred due to uncertainty about the representiveness of the microcosm results for actual field conditions. Microcosm studies are time-consuming and expensive; they should only be undertaken at sites where there is considerable uncertainty concerning the biodegradation potential of the contaminants.

How is the MNA Decision Made? - The primary category of information uses historical contaminant data to determine if the contaminant plume is shrinking, stable, or expanding (Figure 1, Box 6b). This first category of information can be used to show that a contaminant plume is being attenuated; it does not necessarily show that contaminant mass is being destroyed nor does it provide the information necessary to evaluate the applicable attenuation process(es). For sites which have sufficient historical monitoring data, the primary category of information may be adequate to demonstrate remediation by MNA. In the absence of historical evidence for reductions in contaminant concentrations (i.e. the plume is expanding), the argument for natural attenuation probably cannot be made. If the primary category of information is inconclusive or inadequate, it is necessary to obtain the secondary category of information (Figure 1, Box 6c). Even when the secondary category of information is available, field monitoring and contaminant data collection should continue in order to ultimately substantiate the primary category of information. For sites with insufficient historical monitoring data, the collection and evaluation of geochemical data (secondary category of information) should be used to expedite the demonstration of remediation by MNA rather than waiting to develop a longer historical record. When data from the secondary category of information are inadequate or inconclusive, data from the supplemental category of information may be used to help support information from the primary and secondary categories. The supplemental category of information, by itself, is not sufficient to support a MNA decision.

Although not a category of information, solute fate and transport simulation models may be valuable when evaluating natural attenuation when properly chosen and implemented. Such models can be used to evaluate the relative importance of natural attenuation mechanisms, to predict the migration and attenuation of the dissolved contaminant plume through time, to predict cleanup timeframes, or to provide an estimate of time required to reach a receptor well. The use of solute fate and transport modeling in the natural attenuation evaluation is described by Wiedemeier, et al., 1999.

Even when the primary category of information is conclusive, further effort should still be made to develop the secondary category of information. The challenge in evaluating MNA is not only demonstrating that natural attenuation is occurring. This can be a relatively easy task. Rather, the appropriate evaluation of MNA as a remedial alternative requires making the determination that the natural attenuation processes are taking place at a rate that is protective of human health and the environment (Figure 1, Box 7b), that there is a reasonable expectation that these processes will continue at acceptable rates for an acceptable period of time (Figure 1, Box 8b), and that the MNA remedy is capable of achieving the site specific remediation objectives within a timeframe that is reasonable compared to other remedial alternatives (Figure 1, Box 9b).

Tables: Table 1. Summary of Major Processes Affecting Contaminant Concentrations
Table 2. Required Indicator Parameters and Sampling Frequency
Table 3. Uses of Indicator Parameters

Figure 1. Monitored Natural Attenuation Flow Chart for Decision-Making

References

Additional Sources of Information

Glossary of Terms

Table 1
Summary of Major Processes Affecting Contaminant Concentrations

(Italicized words are defined in glossary)

Processes	Relevance	Description	Dependencies	Effect
Destructive				
Abiotic Degradation	Organic	A variety of chemical transformation mechanisms (e.g., hydrolysis, *redox* reactions, elimination reactions, etc.) that degrade contaminants without microbial facilitation, commonly significant for *halogenated compounds*.[1]	Dependent on contaminant properties and ground-water geochemistry.	Can result in partial or complete degradation of contaminants. Rates typically much slower than for biodegradation. May result in more toxic by-products than parent compound.
Biodegradation	Organic & Inorganic	Microbially mediated *oxidation-reduction* reactions that degrade contaminants. Oxygen consumption, *denitrification*, sulfate reduction, iron reduction, methanogenesis and *reductive dehalogenation* are among the more common processes.	Dependent on ground-water geochemistry, microbial population and contaminant properties. Biodegradation can occur under aerobic and/or anaerobic conditions, however, the kinetics of aerobic reactions are generally more rapid.	May ultimately result in complete degradation of contaminants. Typically the most important process acting to reduce contaminant mass. May result in more toxic by-products than parent compound. May mobilize certain inorganics such as As, Mn and Fe.

Table 1
Summary of Major Processes Affecting Contaminant Concentrations

(Italicized words are defined in glossary)

Processes	Relevance	Description	Dependencies	Effect
Radioactive Decay	Inorganic	A process by which the nucleus of a radioactive atom undergoes spontaneous decay into one or more nuclei with a different number of protons. The process continues until a stable nucleus (nuclei) is/are produced. Usually assumed to be controlled by first order kinetics. Relevant only to radiogenic elements.	No dependencies on environmental parameters. Decay will occur until a stable nucleus (nuclei) is produced. For example, radioactive decay rates exhibit no relationship to temperature, pressure or concentrations, or any other characteristic of the local environment.	Decay can result in partial or complete *transmutation* of the radionuclide(s) of concern. However, the production of *daughter nuclides* may represent an enhanced hazard that could outweigh the benefit due to loss of the parent nuclide. Special consideration should be given to the time frames required for sufficient decay.
Nondestructive				
Advection [2]	Organic & Inorganic	Movement of solute by bulk (flowing) ground-water movement. This first order control on flow is described by *Darcy's Law*.	Dependent on physical aquifer properties, mainly *hydraulic conductivity*, effective *porosity*, and *hydraulic gradient*. Independent of contaminant properties.	Most important control on the movement of contaminants in the subsurface.

Table 1
Summary of Major Processes Affecting Contaminant Concentrations
(Italicized words are defined in glossary)

Processes	Relevance	Description	Dependencies	Effect
Dispersion [2,3]	Organic & Inorganic	Mechanical fluid mixing due to ground-water movement and aquifer (pore space) heterogeneities.	Dependent on aquifer properties and scale of observation. Independent of contaminant properties.	Causes longitudinal, transverse, and vertical spreading of the plume. Reduces *solute* concentration.
Diffusion	Organic & Inorganic	Spreading and dilution of contaminant in response to a concentration gradient. Usually operates on a scale extending from a few centimeters to, at most, a few hundreds of centimeters.	Dependent on contaminant properties and concentration gradients. Described by *Fick's Laws*.	Diffusion of contaminant from areas of high concentration to areas of low concentration. Generally unimportant relative to dispersion at most ground-water flow velocities. May become important in low permeability formations or at very low hydraulic gradients.

Table 1
Summary of Major Processes Affecting Contaminant Concentrations

(Italicized words are defined in glossary)

Processes	**Relevance**	**Description**	**Dependencies**	**Effect**
Sorption	Organic & Inorganic	Reaction between aquifer materials and *solute* whereby compounds become attached to formation materials (e.g., organic carbon or clay minerals) as commonly described by the partition coefficient.	Dependant on aquifer material properties (e.g., organic carbon and clay mineral content, sulfide content, electrical conductance, *bulk density*, specific surface area, and porosity) and contaminant properties (e.g., water *solubility values*, *hydrophobicity*, *octanol-water partitioning coefficient*, *charge balance* considerations).	Tends to reduce apparent *solute transport velocity* and removes *solutes* from the ground water via sorption to the formation material.
Biotransformation[4]	Inorganics & Organics	Microbially mediated *oxidation-reduction* reactions that transform contaminants, making them less soluble or more soluble in water. Alternatively, sulfide or iron (II) produced by biological activity may precipitate metals.	Dependent on ground-water geochemistry, microbial population and contaminant properties. Biotransformation can occur under aerobic and/or anaerobic conditions.	Does not result in the complete destruction of contaminants. The reactions may be reversible.

Table 1
Summary of Major Processes Affecting Contaminant Concentrations

(Italicized words are defined in glossary)

Processes	**Relevance**	**Description**	**Dependencies**	**Effect**
Oxidation-Reduction (Redox) [4]	Organic & Inorganic	A reaction couple producing a change in *valence* state (e.g., H_2S, HSO_4^-, SO_4^{2-}). For every oxidation reaction, there exists an accompanying reduction. Only inert gases, halogens, alkali metals and earths are relatively immune to redox. Although seldom reaching equilibrium, redox rates of reaction are usually kinetically slow. Organic examples may be: $\frac{1}{2} CH_2O + H^+ = \frac{1}{2} CH_3OH$	Function of aqueous pH, DO, TOC, and microbial character(s). Accurate measurements of redox potentials are difficult to make in the field mostly due to slow kinetics. If the Fe^{2+}/Fe^{3+} couple predominates, the accuracy of field measurements increases.	Produces an oxidized contaminant with accompanying change in solubility characteristics, along with a chemically reduced couple, or visa versa. Redox reactions may exert major influence on ground-water quality because of the large number of possible redox reactions and the frequency of redox changes. A common example of redox behavior is the reduction of Mn(IV) in minerals to the more soluble and toxic Mn^{+2}.
Partitioning from *NAPL*	Organic	Partitioning from *NAPL* into ground water. *NAPL* plumes, whether mobile or residual, tend to act as a continuing source of ground-water contamination.	Dependent on aquifer materials and contaminant properties, as well as ground-water flux through or past *NAPL* plume.	Dissolution of contaminants from *NAPL* represents the primary source of dissolved contamination in ground water.

Table 1
Summary of Major Processes Affecting Contaminant Concentrations

(Italicized words are defined in glossary)

Processes	Relevance	Description	Dependencies	Effect
Volatilization	Organic [5]	Release of dissolved contaminants from the ground-water into the vapor phase (soil gas).	Dependent on the chemical's vapor pressure, *Henry's Law* constant, and, to a lesser extent, temperature.	Removes contaminants from ground water and transfers them to soil gas or the atmosphere.
Precipitation	Inorganic	Occurs when contaminant concentration exceeds its maximum solubility at equilibrium resulting in a transfer from the aqueous phase to the solid phase.	Dependent on contaminant properties, especially solubility product constants, and ground-water geochemistry.	Can result in transformation of soluble contaminant into solid phase product thereby reducing aqueous contaminant concentration in ground water.

[1] Because industrial organic compounds that contain chlorine have only recently been introduced to the environment in large quantities (since the late 1940's), the indigenous microorganisms are not fully adapted to them, and their degradation is generally slow compared to degradation of naturally occurring compounds.

[2] Recharge processes are responsible for driving advection and mechanical dispersion.

[3] In most situation the effects of dispersion are difficult to isolate from the effects of diffusion. The effects of dispersion and diffusion are combined in the term hydrodynamic dispersion (Freeze and Cherry, 1979).

[4] Included as "non-destructive" since process is reversible in nature.

[5] To be accurate, some inorganic compounds with high vapor pressures also volatilize such as mercury or methyl-mercuric chloride (e.g., CH_3HgCl).

Table 2
Required Field and Laboratory Indicator Parameters

Process [1]	Required Parameter [2]	Frequency
Abiotic Degradation	Chloride, Specific Electrical Conductance, Oxidation-Reduction Potential, Dissolved Oxygen, pH, Temperature, Turbidity	every sampling round
Biodegradation or Biotransformation	Alkalinity, Calcium, Carbon Dioxide, Chloride, Specific Electrical Conductance, Iron (II), Magnesium, Methane, Nitrate, Nitrite, Oxidation-Reduction Potential, Dissolved Oxygen, pH, Potassium, Sodium, Sulfate, Sulfide, Temperature, Turbidity, Dissolved Organic Carbon	every sampling round
	Arsenic, Manganese, Iron (III), Total Organic Carbon	first sampling round [3,4]
	Dissolved Hydrogen	only if other data is inconclusive [5]
Radioactive Decay	Alkalinity, Specific Electrical Conductance, Oxidation-Reduction Potential, Dissolved Oxygen, pH, Temperature, Turbidity, Total Dissolved Solids, Dissolved Organic Carbon, Total Suspended Solids	every sampling round
	Cation Exchange Capacity, Clay Content, Total Organic Carbon, Sulfide	first sampling round [3,4]
	Partitioning Coefficient	site-specific conditions determine necessity [6]
Advection	Specific Electrical Conductance, Oxidation-Reduction Potential, Dissolved Oxygen, pH, Temperature, Turbidity [7]	every sampling round
Dispersion	Specific Electrical Conductance, Oxidation-Reduction Potential, Dissolved Oxygen, pH, Temperature, Turbidity [7]	every sampling round
Diffusion	Specific Electrical Conductance, Oxidation-Reduction Potential, Dissolved Oxygen, pH, Temperature, Turbidity [7]	every sampling round
Sorption	Alkalinity, Specific Electrical Conductance, Oxidation-Reduction Potential, Dissolved Oxygen, pH, Sulfides, Sulfates, Temperature, Turbidity, Dissolved Organic Carbon	every sampling round
	Cation Exchange Capacity, Clay Content, Grain Size, Total Organic Carbon	first sampling round [3,4]
	Partitioning Coefficient	site-specific conditions determine necessity [6]
Oxidation-Reduction	Specific Electrical Conductance, Oxidation-Reduction Potential, Dissolved Oxygen, pH, Temperature, Turbidity, Sulfide, Iron (II)	every sampling round
	Partitioning Coefficient	site-specific conditions determine necessity [6]

Table 2
Required Field and Laboratory Indicator Parameters

Process [1]	Required Parameter [2]	Frequency
Partitioning from NAPL	Specific Electrical Conductance, Oxidation-Reduction Potential, Dissolved Oxygen, pH, Temperature, Turbidity, Iron (II)	every sampling round
	Clay Content, Grain Size, Total Organic Carbon	first sampling round [3,4]
Volatilization	Specific Electrical Conductance, Oxidation-Reduction Potential, Dissolved Oxygen, pH, Temperature, Turbidity, Iron (II)	every sampling round
	Grain Size	first sampling round [3,4]
Precipitation	Specific Electrical Conductance, Oxidation-Reduction Potential, Dissolved Oxygen, pH, Temperature, Turbidity, Iron (II)	every sampling round
	Cation Exchange Capacity, Clay Content, Grain Size, Total Organic Carbon	first sampling round [3,4]
	Partitioning Coefficient	site-specific conditions determine necessity [6]

[1] All applicable processes should be considered and discussed, with supporting information, prior to a decision of the required parameters to be analyzed.

[2] A summary of the data uses of the required parameters are provided in Table 3.

[3] A single round of samples will be needed for this parameter, unless later investigation/site characterization activities indicate that the ground-water contamination plume(s) have varying *oxidation/reduction potentials* and/or dissolved oxygen levels (variations of more than instrument error, which is commonly 5% to 10%).

[4] A single round of samples will be needed for this parameter. However, if the plume(s) is found in other area(s) than first investigated, or in additional aquifers, or found in different types of aquifer materials than first sampled, then additional samples should be collected and analyzed from these locations.

[5] Dissolved Hydrogen may be necessary if the other data is inconclusive or contradictory. Until such time that the Dissolved Hydrogen procedure is more routine and easily implemented in the field, it should only be analyzed when necessary.

[6] USEPA, 1998 (for organics) and USEPA, 1999b (for inorganics) provide information on the necessity of determining site-specific partition coefficients.

[7] These parameters are analyzed for stabilization parameter during ground-water sampling.

Table 3
Data Uses of Indicator Parameters

Parameter	Data Use	References
GROUND WATER		
Alkalinity (CO_2, HCO_3^-, CO_3^{-2})	Used for *charge balance* during major ion analysis	b, c
	Changes in alkalinity can result from biological activity in ground water through production of carbon dioxide (CO_2).	a, h
	A measure of the *buffering capacity* of ground water to pH changes.	a, b, d
Arsenic (As^{+3}, As^{+5})	To determine if anaerobic microbiological activity is dissolving arsenic from aquifer matrix material. May require determination of the *speciation* of arsenic.	a
Calcium (Ca^{+2})	Used for *charge balance* during major ion analysis	b, c
Carbon Dioxide (CO_2)	Can act as an electron acceptor for anaerobic microorganisms.	a
	By-product of some degradation pathways.	a
Chloride (Cl^-)	Used for *charge balance* during major ion analysis.	b, c
	Chloride can be from other sources such as road salt, general waste, etc.	b
	Dechlorination processes (see *reductive dehalogenation)* from chlorinated compounds may result in increases in chloride.	a, h
	Can be used as a conservative tracer to determine ground-water flow rates.	a
Iron (II) (Fe^{+2})	May indicate an anaerobic degradation process that transforms vinyl chloride, or BTEX compounds.	a, d, h
Hydrogen, Dissolved (H_2)	Dissolved hydrogen is an electron donor. May indicate the potential for reductive dechlorination to occur. Dissolved hydrogen concentrations indicate ambient redox conditions.	a, h

Table 3
Data Uses of Indicator Parameters

Parameter	Data Use	References
Magnesium (Mg^{+2})	Used for *charge balance* during major ion analysis.	b, c
Manganese (Mn^{+2}, Mn^{+3}, Mn^{+4})	To determine if anaerobic biological activity is dissolving manganese from aquifer matrix material. May require determination of *speciation*.	a, d, h
Methane (CH_4)	Methane is a by-product of methanogenesis. Associated with conditions that promote reductive dechlorination.	a, h
Nitrate (NO_3^-)	Nitrate may act as a medium for growth of microorganisms for anaerobic degradation, if oxygen is depleted. Nitrate inhibits reductive dechlorination.	a, h
Nitrites (NO_2^-)	Is an intermediate during the denitrification processes. Product of ammonia oxidation by aerobic microorganisms. Toxic by-product of denitrification of nitrate.	d
Oxidation-Reduction Potential (ORP or sometimes Eh)	Used as stabilization parameter during ground-water sampling.	f
	Used for determining the presence of oxygen in ground water (Oxidation state).	b, h
	Frequently, the electrode potentials measured in the field must be corrected to standard conditions.	a
Oxygen, Dissolved (O_2)	Used as stabilization parameter during ground-water sampling and aids in determining the redox regime.	f
	Used for determining the concentration of oxygen in ground water.	a, h
Partition Coefficient (also known as a Distribution Coefficient or K_d) [1]	Used for determining the relative mobility of contaminant. Direct measure of the partitioning of a contaminant between the formation materials and ground water.	g

Table 3
Data Uses of Indicator Parameters

Parameter	Data Use	References
pH	Used for *charge balance* during major ion analysis. Used as stabilization parameter during ground-water sampling. Chemical and biological reactions are pH dependent.	b, c f h
Potassium (K^+)	Used for *charge balance* during major ion analysis.	b, c
Specific Electrical Conductance (SEC) (also commonly referred to as Conductivity or Specific Conductance)	Used for *charge balance* during major ion analysis. Used as an estimate of Total Dissolved Solids Used as a stabilization parameter during ground-water sampling. Directly related to ion concentration in solution and therefore may indicate total number of ions.	b, c c f a
Sodium (Na^+)	Used for *charge balance* during major ion analysis.	b, c
Sulfate (SO_4^{-2})	Used for *charge balance* during major ion analysis. Sulfate may act as an electron acceptor for anaerobic degradation.	b, c a, h
Sulfide (S^{-2})	Sulfide may be produced by sulfate reduction by sulfate-reducing bacteria, primarily in the form of hydrogen sulfide (H_2S). Tests are typically for H_2S. The presence of sulfide is a good indication that sulfate reduction is on-going.	d, h

Table 3
Data Uses of Indicator Parameters

Parameter	Data Use	References
Temperature	Used to support the evaluation of *charge balance* during major ion analysis. Used as stabilization parameter during ground-water sampling. Chemical and biological reactions are temperature dependent. Affects the solubility of dissolved gases.	b, c f a, h a
Total Dissolved Solids (TDS)	Used with Total Suspended Solids to determine fraction of particulates that are able to pass a specified filter size. The particulates can be mobile in ground water and may provide a mechanism for facilitated transport for compounds that otherwise would not be mobile.	
Total Inorganic Carbon (CO_2, HCO_3^-, CO_3^{-2}) [2]	Used for *charge balance* during major ion analysis Changes in alkalinity can result from biological activity in ground water through production of carbon dioxide (CO_2). A measure of the *buffering capacity* of ground water to pH changes.	b, c a, h a, b, d
Total Organic Carbon (TOC)	Used to classify plume and to determine if reductive dechlorination is possible in the absence of anthropogenic carbon.	a
Total Suspended Solids (TSS)	Used with Total Dissolved Solids. TSS is the total fraction of particulates.	
Turbidity	Used as stabilization parameter during ground-water sampling. Represents fine particles suspended in water, which can be correlated to TDS and TSS.	f

Table 3
Data Uses of Indicator Parameters

Parameter	Data Use	References
FORMATION MATERIALS		
Biologically Available Iron (III) (Fe^{+3})	Iron (III) may serve as the terminal electron acceptor for the destruction of fuel hydrocarbons and vinyl chloride.	a
Cation Exchange Capacity (CEC)	Measure of the capacity of formation materials to sorb metals. Composed of sorption sites on both clay and organic matter.	d, g
Grain Size	Size of grains controls some sorption and precipitation properties.	h, i
Clay Content	Clay provides sorptive sites for metals, organics and radio-nuclides. Different clay mineralogical types may also affect sorption. May be completed via x-ray analysis for mineralogy determination, via sieve analysis, or via natural-gamma geophysical logs for relative differences in clay content. Also, sorption is pH dependent.	d, g, i
Total Organic Carbon (TOC)	The rate of migration of various contaminants in ground water is dependent upon the amount of TOC in the aquifer matrix.	a, d
	May also preferentially sorb some metals, organics and radio-nuclides.	d, g, h
	TOC may reduce Chromium (VI) to Chromium (III), making it less mobile and less toxic.	j

For information on analytical procedures/methods/references, see Table 2.1 in U.S. EPA, 1998 and/or the Standard Methods for the Examination of Water and Wastewater, 18th edition, 1992.

[1] Methods for determining partition coefficients are presented in USEPA, 1999b, with the general recommendation that in-situ tests be performed.

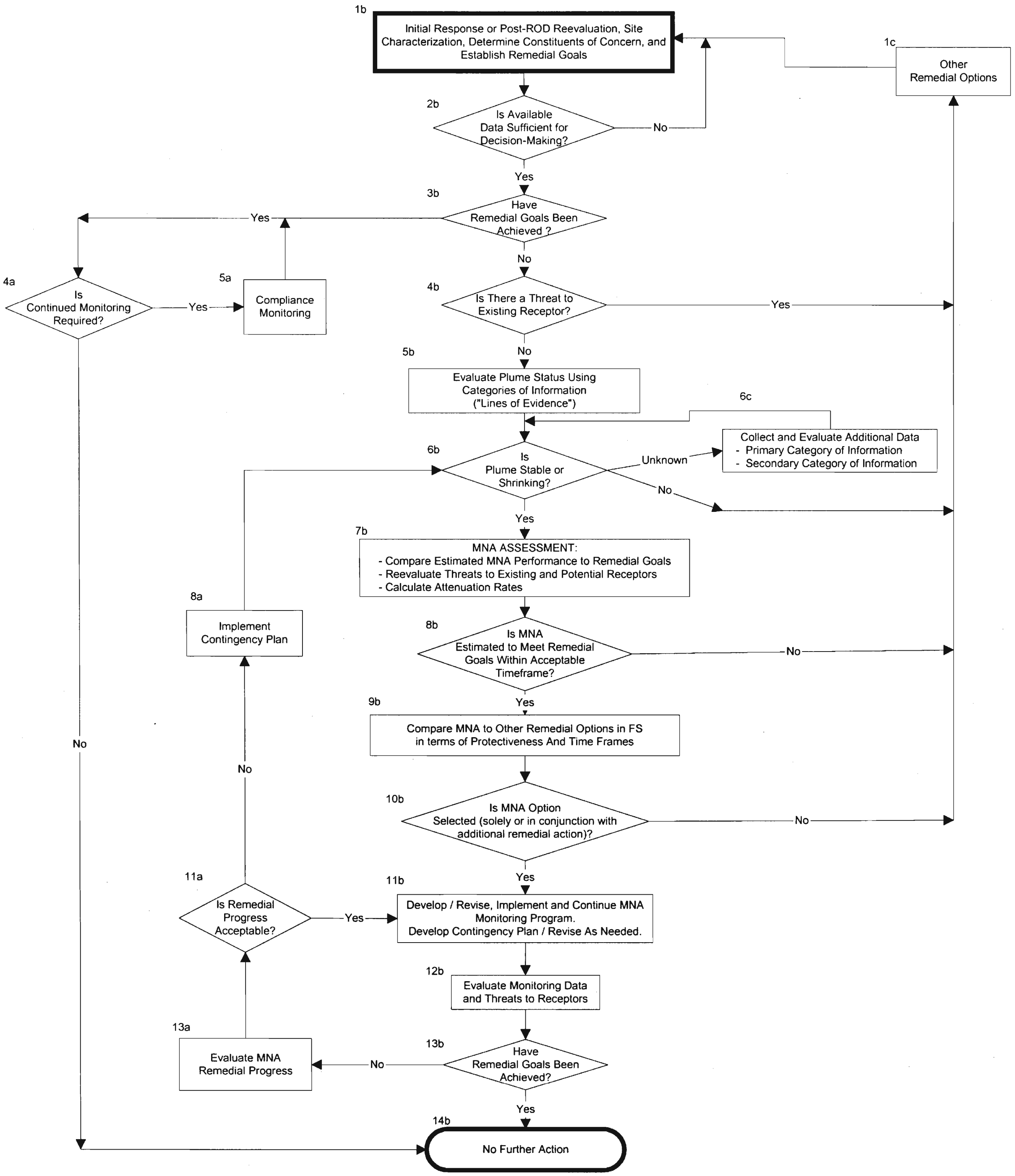
[2] Total Inorganic Carbon can be determined by calculation or by modification of TOC method.

References:

a) United States Environmental Protection Agency, 1998
b) Hem, 1985
c) Hounslow, 1995
d) Deutsch, 1997
e) Wiedemeier, Rifai, Newell and Wilson, 1999
f) Puls and Barcelona, 1996
g) United States Environmental Protection Agency, 1999b
h) Azadpour-Keeley, Russell and Sewell, 1999
i) Piwoni and Keeley, 1990
j) Palmer and Puls, 1994

FIGURE 1

Monitored Natural Attenuation Flowchart for Decision-Making



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Glossary of Terms

Abiotic	A process occurring without the involvement of microorganisms.
Buffering Capacity	The ability of either water or a water-rock (aquifer) system to resist pH change when mixed with a more acid or alkaline water or rock. This concept is particularly useful in understanding what reactions may influence the pH of natural waters.
Bulk Density	Total mass of aquifer solids and enclosed fluid(s), per unit volume.
Charge Balance	Refers to the need for electrical neutrality in flowing ground water. In essence, the total charge of the positive ions (cations) per unit volume generally must equal the total charge of the negative ions (anions), per unit volume. The charge difference between anions and cations can be used to determine the relative accuracy of the alkalinity, chloride, and sulfate analytical results, and generally should be within 5% of each other. If the charge is out of balance by more than 5%, the analysis may be inaccurate and should be re-examined. The charges may not be balanced if other constituents are present (including significant quantities of organics) or the water is very acid (with significant H^+ ions). The more common cations and anions are calcium, magnesium, potassium, sodium, carbonate, chloride and sulfate.
Darcy's Law	The principle relationship controlling ground-water movement, $Q = KA\ (dh/dl)$ where Q is the quantity of water per unit time, A is the cross-sectional area perpendicular to flow, K is *hydraulic conductivity* and (dh/dl) is the *hydraulic gradient*. Units are volume/time.
Daughter Nuclides	The nuclides formed from a parent nucleus, for example ^{238}U producing ^{234}Th, through radioactive decay. These nuclides usually have half-lives many orders of magnitude shorter than the parent nucleid e.g., ^{238}U or ^{232}Th.
Denitrification	Process whereby compounds containing nitrogen and oxygen act as an electron acceptor allowing biodegradation of the electron donor, e.g. a hydrocarbon contaminant.
Destructive Processes	A process that either chemically transforms a compound into another, or *transmutes* an atom (as in the radiogenic process). These reactions usually proceed in one direction only (irreversible). See *nondestructive* process.

Electrical Surface Charge	Electrical charges associated with unbalanced ions in crystal structure and/or ions attached to a surface through sorption which produce a net positive or negative charge per unit surface area. These localized areas may form adsorption sites for dissolved compounds in groundwater. Particularly relevant in fine-grained materials such as clays.
Electron Acceptors	Something for microorganisms to "breathe". In order for complete oxidation of an organic compound to occur, these compounds must be available to accept the electrons generated from the food source. The most common, in the preferred order are: oxygen (O_2), nitrate (NO_3^-), manganese IV (Mn^{4+}), ferric iron (Fe^{3+}), sulfate (SO_4^{-2}), CO_2, organic carbon, and chlorinated solvents. The coupled process of oxidation of organic compounds with the reduction of electron acceptors is termed respiration. Electron acceptors are reduced during the reaction.
Electron Donors	The "food" for oxidizing microorganisms e.g., simple molecules like sugars, organic acids, fulvic and humic acids, and petroleum-derived hydrocarbons. Need to be present for biodegradation to proceed. Electron donors are oxidized during the reaction.
Fick's Laws	Relationships governing the mass of a diffusing substance per unit time. The rate of contaminant transport through diffusion is proportional to the contaminant's concentration gradient or the change in concentration with distance.
Halogenated Compounds	Organic compounds containing any member of the non-metallic group VIIA in the periodic chart (F, Cl, Br, I, or At). Compounds containing chlorine are most common, for example TCE (trichloroethylene), TCA (1,1,1-trichloroethane) and vinyl chloride.
Henry's Law	A linear relationship describing the dissolved concentration in solution in water versus the partial pressure of the constituent in a vapor (air) above the fluid at equilibrium. At equilibrium the dissolved concentration and the partial pressure are related through Henry's constant.
Hydraulic Conductivity	The coefficient in Darcy's Law which equates the hydraulic gradient to the rate of ground-water flow. It describes the water transmission (flow) properties of geologic materials. Values are usually high for sand and gravel and low for clay and most rocks. Units are length/time and typically range from 10^{-11} cm/s to 10^{2} cm/s for unfractured rock and gravel, respectively.

Hydraulic Gradient	A quantity, $(\Delta h_L / L)$, describing the difference in water head measurements (elevations) (Δh_L), divided by the distance between the wells being measured (L). A measure of the driving force for ground-water flow. Units are dimensionless length/length. See hydraulic conductivity.
Hydrophobic	Tendency of covalently bonded, non-polar compounds to avoid dissolution in the polar solvent, water. See *hydrophilic*.
Hydrophilic	Tendency of a compound to favor dissolution in water rather than being sorbed onto sediments or organic layers, for example. See *hydrophobic***.**
Microcosm	A laboratory experiment set up to resemble as closely as possible the conditions of the natural environment under consideration.
NAPL	Non-Aqueous Phase Liquid, or an immiscible liquid in water. NAPL's tend to be formed by hydrophobic chlorinated organic compounds and may have densities either greater than or less than that of ground water, causing the NAPL to sink or float.
Nondestructive Processes	Processes that maintain a state of chemical or physical equilibrium and are capable of reversing themselves given the appropriate conditions. See *destructive* processes.
Octanol-Water Partitioning Coefficient	The unit-less ratio of the equilibrium concentration of a constituent in an organic solvent (octanol) versus that in pure water. Used as a measure of the hydrophobic tendencies (insoluble in water) of a compound.
Oxidation-Reduction Potential	The loss or gain of electrons among reactive elements or compounds, also termed '*Redox*', ORP or Eh. The loss of electrons by the electron donor is called oxidation while the gain of electrons is termed reduction. Oxidation must be accompanied by reduction since the electron exchange between the *electron acceptor* and *donor* must balance. The same is true for the inverse case, reduction processes. See electron donors/acceptors, valence.
Porosity	The ratio of openings (voids) to the total volume of a soil or rock, expressed as percentage or decimal fraction.
Redox	See Oxidation-Reduction Potential
Reductive dehalogenation	Process whereby a halogen (I, Br, Cl, F) atom is replaced with a hydrogen atom; e.g. PCE → TCE → DCE → vinyl chloride → ethane. This progression results in a successively lower number of

	halogens (chlorine, in the above case, and termed "dechlorination") attached to the compound structure.
Solubility Value	Maximum constituent concentration in solution at a given temperature and pressure at equilibrium. Common units are mass per volume, mass/unit weight, and weight/unit weight.
Solute	The dissolved inorganic or organic constituent.
Solute Transport Velocity	Average velocity of a given dissolved chemical constituent in ground water. In ground water, solute transport velocities range from the average ground-water velocity to a small fraction of the ground-water velocity.
Speciation	The chemical species corresponding to a particular oxidation state of an element. For instance, ferrous iron, Fe^{2+} versus ferric iron, Fe^{3+}. May be important in understanding the chemical conditions of ground water with respect to ORP and pH conditions. Especially important to distinguish toxicity potential when considering Cr^{3+}versus Cr^{6+}.
Transmutation	Indicates a spontaneous change in the number of neutrons and/or protons in a nucleus due to radioactive decay, resulting in the transformation to a different element such as ^{238}U (uranium) transmuting to ^{234}Th (thorium).
Valence	Electrical charge an atom would acquire if it would form ions in aqueous solution. Controls the chemical character of an ion, for example, Cr^{3+} , with a valence of +3, while that of Cr^{6+} is +6. Also known as the oxidation number.
Water Type	A convenient method of describing the variation in chemical composition between natural waters. Different styles of plots and diagrams are available to present variations in composition (e.g. Piper Diagram, Stiff Pattern, or a Trilinear Diagram). These plots are used to distinguish between different waters in the same aquifer based on their chemical characteristics, which reflect their sources and interactions between the ground water, the rock in the aquifer and geochemical/biochemical reactions taking place in ground water.

ATTACHMENT II

ADMINISTRATIVE RECORD INDEX
CHEVRON/TEXACO
HOOVEN, OHIO
OHD 004 254 132

ADMINISTRATIVE RECORD INDEX
CHEVRON/TEXACO
HOOVEN, OHIO
OHD 004 254 132

	Date:	To:	From:	Format:	Subject:
1	July 17, 2006	Bri Bill, US EPA	Robert C. Frey, ODH	Letter	ODH comments to the EPA preferred Plan for the Contaminated Groundwater at Chevron Cincinnati facility
2	June 27, 2006	Bri Bill	Steve Chabot, Member of Congress	Letter	Letter recognizing Alysha Johnson's Letter concerning Chevron's Clean-up and handing matters over to US. EPA -attachment: Alysha Johnson's Letter
3	June 27, 2006	Benny Muncy	Bharat Mathur	Letter	Control reply concerning Chevron clean-up
4	June 27, 2006	Virginia Pappin	Bharat Mathur	Letter	Control reply concerning Chevron clean-up
5	June 27, 2006	Mr. & Mrs. John Wheeler	Bharat Mathur	Letter	Control reply concerning Chevron clean-up
6	June 26, 2006	Bri Bill	Steve Chabot, Member of Congress	Letter	Letter recognizing Kelly Greer's Email concerning Chevron's Clean-up and handing matters over to US. EPA -attachment: Kelly Greer's Email
7	June 19, 2006	Bri Bill	Steve Chabot, Member of Congress	Letter	Letter recognizing Elaine Reeves' letter concerning Chevron's Clean-up and handing matters over to US. EPA -attachment: Elaine Reeves' Letter
8	June 19, 2006	Bri Bill	Steve Chabot, Member of Congress	Letter	Letter recognizing Rodney Wheeler, Jr. & Rodney Wheeler, Sr.'s Letter concerning Chevron's Clean-up and handing matters over to US. EPA -attachment: Rodney Wheeler, Jr. & Rodney Wheeler, Sr.'s Letter
9	June 19, 2006	Bri Bill	Steve Chabot, Member of Congress	Letter	Letter recognizing the Detmer Family Letters concerning Chevron's Clean-up and handing matters over to US. EPA -attachment: Detmer Family Letters
10	June 16, 2006	Bri Bill	Steve Chabot, Member of Congress	Letter	Letter recognizing Melissa J. Breeding's Letter concerning Chevron's Clean-up and handing matters over to US. EPA -attachment: Melissa J. Breeding's Letter
11	June 16, 2006	Bri Bill	Steve Chabot, Member of	Letter	Letter recognizing Theodore Moses' Letter concerning Chevron's Clean-up and handing

			Congress		matters over to US. EPA -attachment: Theodore Moses' Letter
12	June 16, 2006	Bri Bill	Steve Chabot, Member of Congress	Letter	Letter recognizing Britni Smith's Email concerning Chevron's Clean-up and handing matters over to US. EPA -attachment: Britni Smith's Email
13	June 16, 2006	Bri Bill	Steve Chabot, Member of Congress	Letter	Letter recognizing Crissy A. Moses' Letter concerning Chevron's Clean-up and handing matters over to US. EPA -attachment: Crissy A. Moses' Letter
14	June 16, 2006	Bri Bill	Steve Chabot, Member of Congress	Letter	Letter recognizing Donna M. Moses' Letter concerning Chevron's Clean-up and handing matters over to US. EPA -attachment: Donna M. Moses' Letter
15	June 16, 2006	Bri Bill	Steve Chabot, Member of Congress	Letter	Letter recognizing Vince Pappin's Letter concerning Chevron's Clean-up and handing matters over to US. EPA -attachment: Vince Pappin's Letter
16	June 14, 2006	Chevron and US EPA	Deidre Lewis	Letter	Concerns regarding Chevron's proposed cleanup/final remedy
17	June 14, 2006	Christopher Black, US EPA	Alysha Johnson	Email	Comments to Statement of Basis for Groundwater
18	June 14, 2006	Bri Bill, US EPA	Marsha Kay Klosterman	Email	Hooven Chevron Clean-up
19	June 14, 2006	Christopher Black, US EPA	Bri Bill, US EPA	Email	FWD: Hooven Chevron Clean-up
20	June 14, 2006	Christopher Black, US EPA	Deidre Lewis	Email	Hooven Chevron Clean-up/Final Remedy
21	June 13, 2006	Christopher Black, US EPA	Whitewater Township Residents	Letter	Petition concerning Chevron cleanup/final remedy method
22	June 13, 2006	Christopher Black, US EPA	Kelly Greer	Email	Hooven Chevron Clean-up/Final Remedy
23	June 13, 2006	Christopher Black, US EPA	Britni Smith	Email	Hooven Chevron Clean-up/Final Remedy
24	June 13,	Christopher	William Balsley	Email	Hooven Chevron Clean-up/Final Remedy

	2006	Black, US EPA	Jr.		
25	June 5, 2006	Steven L. Johnson, US EPA	Steve Chabot, Member of Congress	Letter	Letter recognizing Virginia Pappin's letter concerning Chevron's Clean-up and handing matters over to US. EPA - attachments: Virginia Pappin's, Benny Muncy, and Mabel & John J. Wheelers letters
26	May 30, 2006	Christopher Black, US EPA	Randy W. Jewett, Chevron	Letter	RE: U.S. EPA Statement of Basis for Groundwater, Chevron Cincinnati Facility, Hooven, Ohio, U.S.
27	May 30, 2006	Bri Bill, US EPA	JK Services	Fax	Questions/Comments on Chevron
28	May 25, 2006	Christopher Black, US EPA	John Breeding & Melissa M. Breeding	Letter	IN RE: Chevron Contamination Hooven/Cleves Refinery
29	May 25, 2006	Christopher Black, US EPA	Melissa J. Breeding	Letter	IN RE: Chevron Contamination Hooven/Cleves Refinery
30	May 24, 2006	Christopher Black, US EPA	Larry Detmer	Letter	IN RE: Chevron Contamination Hooven/Cleves Refinery
31	May 24, 2006	Christopher Black, US EPA	Olivia Detmer	Letter	IN RE: Chevron Contamination Hooven/Cleves Refinery
32	May 24, 2006	Christopher Black, US EPA	Amy Detmer	Letter	IN RE: Chevron Contamination Hooven/Cleves Refinery
33	May 22, 2006	Christopher Black, US EPA	Rodney Wheeler Sr. & Rodney Wheeler Jr.	Letter	IN RE: Chevron Contamination Hooven/Cleves Refinery
34	May 22, 2006	Christopher Black, US EPA	Theodore E. Moses Jr.	Letter	IN RE: Chevron Contamination Hooven/Cleves Refinery
35	May 22, 2006	Christopher Black, US EPA	Vince Pappin	Letter	IN RE: Chevron Contamination US EPA Proposed Consent Agreement Hooven/ Cleves Refinery
36	May 22, 2006	Christopher Black, US EPA	Virginia Pappin	Letter	IN RE: Chevron Contamination US EPA Proposed Consent Agreement Hooven/ Cleves Refinery

37	May 22, 2006	Christopher Black, US EPA	Mabel & John Wheeler	Letter	IN RE: Chevron Contamination Hooven/Cleves Refinery
38	May 22, 2006	Christopher Black, US EPA	Donna M. Moses	Letter	IN RE: Chevron Contamination Hooven/Cleves Refinery
39	May 19, 2006	Bri Bill, US EPA	Jeff G. Hines, OEPA	Letter	RE: Chevron Statement of Basis
40	May 19, 2006	Christopher Black, US EPA	Crissy A. Moses	Letter	IN RE: Chevron Contamination Hooven/Cleves Refinery
41	May 15, 2006	Christopher Black, US EPA	Benny Muncy	Letter	IN RE: Chevron Contamination Hooven/Cleves Refinery
42	May 9, 2006	Chevron	USEPA		Proposed Plan for Contaminated Groundwater – Transcript of Proceeding
43	March 16, 2006	Christopher Black, USEPA	Rittle Keith, Tri-Hydro	Email	RE: Chevron GW Mtg. Date – email submitting cost estimates of the alternative remedies (With Attachments – no hard copy)
44	February 16, 2006	Christopher Black, USEPA	Paul Michalski, Tri-Hydro	Email	Progress Update, Extended Non-Pumping Aquifer Evaluation (With Attachments)
45	January 25, 2006		Chevron Environmental Management Company		Plug and Abandonment Notification, Groundwater Production Wells PROD_8, PROD_9, PROD_16, PROD_17, PROD_18
46	January 25, 2006	Christopher Black, USEPA	Paul Michalski, Tri-Hydro	Email	Review of Preliminary Non-Pumping Aquifer Evaluation Results (With Attachments)
47	January 20, 2006	Christopher Black, USEPA	Rittle Keith, Tri-Hydro	Email	Shut-Down Test Data (With Attachments –NEED HARD COPY)
48	January 16, 2006	Christopher Black, USEPA	Rittle Keith, Tri-Hydro	Email	Extended Non-Pumping Aquifer Evaluation (With Attachments)
49	2006		U.S Department of Interior & USGS		Volatile Organic Compounds in the Nation’s Ground Water and Drinking-Water Supply Wells (National Water-Quality Assessment Program – Circular 1292)
50	December 9, 2005	Christopher Black, USEPA	Paul Michalski, Tri-Hydro	Email	Progress Update, Extended Non-Pumping Aquifer Evaluation (With Attachments)*
51	November	Christopher	Rittle Keith,	Email	Cincinnati High-Grade Pump-Test Status

	17, 2005	Black, USEPA	Tri-Hydro		
52	October 21, 2005		US EPA		Comments Regarding Subsurface Investigation Field Activities Report & Human Health Risk Assessment
53	October 18, 2005		Trihydro		Subsurface Investigation & Field Activities Report & Human Heath Risk Assessment for Chevron Cincinnati Facility, Hooven, Ohio
54	October, 2005	Bri Bill, US EPA	Bob Frey, ODH	Email	Additional HAS concerns & questions -attachment: Health Assessment Review
55	September 19, 2005	Christopher Black, USEPA	Rittle Keith, Tri-Hydro	Email	Hooven Chromatograms Analysis
56	September 14, 2005	Technical Meeting	Aqui-Ver, Inc.	Power-Point	Chevron Cincinnati Facility, Remedy Preformance Measures (from CMS/Remedy Report Update), conceptual thoughts
57	September 1, 2005		Chevron Environmental Management Company		Work Plan for Extended Non-Pumping Aquifer Evaluation, Additional Assessment Activities to Support Groundwater Remedy
58	August 23, 2005		Chevron Environmental Management Company		Work Plan for Long-Term High-Grade LNAPL Recovery Test, Additional Assessment Activities to Support Groundwater Remedy
59	August 10, 2005		Chevron Environmental Management Company		Work Plan for Additional Assessment Activities Along the East Bank of the Great Miami River
60	July 29, 2005		Chevron Environmental Management Company		Second Progress Update, Additional Assessment Activities to Support Groundwater Remedy
61	June 30, 2005		Chevron Environmental Management Company		Subsurface Investigation Field Activities and the Human Health Risk Assessment (Hard Copy Needed)
62	June 30, 2005		Chevron Cincinnati Groundwater Task Force		Update to Site Conceptual Model and Summary of Remedial Decision Basis Chevron Cincinnati Facility
63	June 15,		Chevron		Third Letter Work plan for Additional Assessment

	2005		Environmental Management Company		Activities to Support the Groundwater Remedy
64	June 3, 2005	Christopher Black, USEPA	Paul Michalski, Tri-Hydro	Email	High Grade Pump Test/48-Hour Shut Down Event Wrap Up (With Attachments)*
65	May 31, 2005	Christopher Black, USEPA	Paul Michalski, Tri-Hydro	Email	5/26/05 High Grade Pump Test/48-Hour Shut Down Event (With Attachments)*
66	May 26, 2005	Christopher Black, USEPA	Paul Michalski, Tri-Hydro	Email	5/26/05 High Grade Pump Test Update (With Attachments)
67	May 26, 2005	Paul Michalski, Tri-Hydro & Gary Beckett, Aqui-Ver, Inc.	Christopher Black, USEPA	Email	RE: Cincinnati Pump Test Update*
68	May 26, 2005	Paul Michalski, Tri-Hydro & Christopher Black, USEPA	Gary Beckett, Aqui-Ver, Inc.	Email	RE: Cincinnati Pump Test Update *
69	May 24, 2005	Christopher Black, USEPA	Paul Michalski, Tri-Hydro	Email	RE: Cincinnati Pump Test Update (With Attachments)*
70	May 20, 2005	Christopher Black, USEPA	Rittle Keith, Tri-Hydro	Email	RE: Cincinnati Groundwater Update (With Attachments)*
71	May 18, 2005	Christopher Black, USEPA	Rittle Keith, Tri-Hydro	Email	Update Regarding Great Miami River Observations (With Attachments)*
72	May 16, 2005	Christopher Black, USEPA	Rittle Keith, Tri-Hydro	Email	Chevron Cincinnati Facility Status Report *
73	May 13, 2005	Christopher Black, USEPA	Paul Michalski, Tri-Hydro	Email	Non-Pumping Aquifer Evaluation Update, Chevron Cincinnati Facility (With Attachments) *
74	May 11, 2005	Christopher Black, USEPA	Paul Michalski, Tri-Hydro	Email	5/11 Cincinnati Groundwater Remedy Meeting *

75	April 19, 2005		Chevron Environmental Management Company		Response to USEPA Comments Regarding the March 15, 2005 Letter Workplan for Additional Assessment Activities to Support the Groundwater Remedy
76	April 1, 2005		USEPA		Comments Regarding the March 15, 2005 Letter Workplan for Additional Assessment Activities to Support the Groundwater Remedy
77	March 31, 2005		Chevron Environmental Management Company		Response to USEPA Comments dated March 18, 2005, Hooven Vapor Investigation Sampling and Analysis Workplan
78	March 25, 2005		Chevron Environmental Management Company		Revisions to the Conceptual Framework for a Groundwater Remedy Performance Based Order
79	March 18, 2005		USEPA		Comments Regarding the Hooven Vapor Investigation Sampling and Analysis Workplan
80	March 15, 2005		Chevron Environmental Management Company		Second Letter Workplan for Additional Assessment Activities to Support the Groundwater Remedy
81	March 3, 2005		Try-Hydro Corporation and GeoSyntec Consultants		Hooven Vapor Investigation Sampling and Analysis Workplan
82	March 1, 2005	March 5, 2005 Technical Meeting	Aqui-Ver, Inc.	Power-Point	Groundwater Conceptual Model Updates
83	February 18, 2005		Chevron Environmental Management Company		Progress Update, Additional Assessment Activities to Support Groundwater Remedy
84	February 10, 2005		Chevron Environmental Management Company		Conceptual Framework for Groundwater Remedy Performance Based Order
85	January 10, 2005		Environmental Resources		Cincinnati Facility Deer Ingestion Pathway: Risk Analysis

			Management		
86	January 5, 2005		Chevron Environmental Management Company		December 15, 2004 Meeting Summary Regarding the Groundwater Remedy for the Chevron Cincinnati Facility
87	December 9, 2004		Chevron Environmental Management Company		Response to USEPA Comment dated July 13, 2004, Conceptual Groundwater Remedy Report Draft Version 0
88	December 8, 2004		Chevron Environmental Management Company		First Workplan for Additional Assessment to Support Groundwater Remedy Report
89	November 23, 2004	Presented at November 18, 2004 Technical Meeting	Aqui-Ver, Inc.	Power-Point	Cincinnati Groundwater Remedy Field Investigation Workplan (Data Gap Workscop)
90	October 25, 2004		Chevron Environmental Management Company		Summary and Follow-up from October 19, 2004 Meeting Regarding the Groundwater Remedy
91	October 19, 2004	Presented at October 19, 2004 Technical Meeting	Aqui-Ver, Inc.	Power-Point	The Conceptual Final Remedy
92	October 19, 2004	Presented at October 19, 2004 Technical Meeting	Aqui-Ver, Inc.	Power-Point	Groundwater Conceptual Remedy Discussion, Cincinnati EPA Meeting (Two Sets)
93	August 17, 2004		Chevron Environmental Management Company	Letter	Letter Transmitting GAC Influent/Effluent Data
94	July 16, 2004		Try-Hydro	File	Risk Assessment – Hooven Sewer Line Investigation
95	July 13, 2004		USEPA		Comments on the "Chevron Cincinnati Facility Conceptual Groundwater Remedy Report Draft –

					Revision 0
96	January 7, 2004		USEPA		Comments Regarding the Risk Assessment on Hooven and Southwest Quadrant
97	July, 2003		Chevron Cincinnati Groundwater Task Force		Conceptual Groundwater Remedy Report for the Chevron Cincinnati Facility
98	June, 2003		USEPA		Statement of Basis for Sludge's and Contaminated Soils for Chevron/Texaco Cincinnati Facility
99	November, 2002	File	USEPA		OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)
100	May, 2002		Ecology & Environment, Inc. (E&E)		Chevron Cincinnati Facility, Human Health Risk Assessment for Potential Offsite Volatiles Exposure at the Southwest Quadrant. Revision 1.
101	December, 2001		Environmental Science & Engineering, Inc.		RCRA Facility Investigation Report for the Chevron Cincinnati Facility. Revision 2.
102	October, 2001		URS		Chevron Cincinnati Facility Groundwater Corrective Measures Study
103	September, 2001		URS		Chevron Cincinnati Facility Soils and Sludge's Corrective Measures Study
104	March 30, 2001		Chevron	File	Operation and Maintenance Plan – Hooven Horizontal Soil Vapor Extraction System
105	March 30, 2001		Chevron	File	Interim Measures and Implementation Report
106	November, 2000		E & E		Chevron Cincinnati Facility, Phase II Facility Investigation Report for the Chevron Cincinnati Facility. Revision2.
107	May, 2000		E & E		Human Health Risk Assessment of Potential Exposure to Volatile Compounds Hooven, Ohio. Revision 2.
108	October 5, 1999		Civil & Environmental Consultants, Inc.		Hooven Water Use Survey: Report of Findings
109	September 20, 1999	Ken Bardo, USEPA	John Tiffany, Chevron	Letter	Responses to Approval with Modifications dated August 20, 1999
110	August, 1999	Chevron	Environmental Science & Engineering, Inc.		A Summary of the Hooven Area Environmental Investigations Performed by Chevron Products Company

111	August 20, 1999	John Tiffany, Chevron	Ken Bardo, USEPA	Letter	RE: Approval with Modifications of Remedial Action Plan of the Hooven Area Hydrocarbon Plume, Chevron U.S.A., Inc.
112	June 3, 1999	Chevron Products Company	Environmental Resources Management		Remedial Action Plan – Hooven Area Hydrocarbon Plum
113	April,1999		USEPA		Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites
114	* no date provided	Christopher Black, US EPA	Olivia Detmer	Letter	Concerns regarding Chevron's proposed cleanup /final remedy

APPENDIX 1

Region 5 Framework for Monitored Natural Attenuation Decisions for Ground Water