Health Consultation

FORMER CHEVRON REFINERY
(SOIL VAPOR INTRUSION IN HOOVEN, OHIO)

HOOVEN, HAMILTON COUNTY, OHIO

EPA FACILITY ID: OHD004254132

NOVEMBER 27, 2006

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

You May Contact ATSDR Toll Free at
1-800-CDC-INFO
or
Visit our Home Page at: http://www.atsdr.cdc.gov

HEALTH CONSULTATION

FORMER CHEVRON REFINERY
(SOIL VAPOR INTRUSION IN HOOVEN, OHIO)

HOOVEN, HAMILTON COUNTY, OHIO

EPA FACILITY ID: OHD004254132

Prepared By:

Ohio Department of Health
Health Assessment Section
Under Cooperative Agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

PURPOSE AND HEALTH ISSUES

In May of 2004, in response to the concerns voiced by the Hamilton County Health Commissioner and area residents, the Health Assessment Section (HAS) at the Ohio Department of Health produced a Health Consultation for the Chevron Cincinnati Facility in Hooven, Ohio. Since that Health Consultation was published, Chevron has investigated the concentrations of petroleum hydrocarbons in soil gas under the village of Hooven, in sub-slab and near-slab samples adjacent to residences, and from the nested subsurface vapor wells. The results of this sampling were reported in the *Subsurface Investigation Field Activities Report and Human Health Risk Assessment, Chevron Cincinnati Facility, Hooven, Ohio,* released in October, 2005. The Hamilton County General Health District asked HAS to update the 2004 Health Consultation with the new data from this report.

On October 27, 2003, on the basis of public concerns voiced by area residents, the Hamilton County Health Commissioner submitted a letter to the director of the Ohio Department of Health formally requesting that HAS review the available environmental data and determine if residents of Hooven were being exposed to environmental contaminants from the former Chevron refinery site just east of the village. In May 2004, HAS released the *Health Consultation, Vapor Intrusion Issues in Hooven, Ohio, Former Chevron Refinery (a/k/a Gulf Oil Corporation US).* The 2004 consultation had the following conclusions:

- Contamination from the Chevron facility currently posed an *Indeterminate Public Health Hazard*, as there was not enough data to evaluate whether residents in Hooven were currently being exposed to vapors volatilizing from the underlying groundwater contamination.
- The levels of benzene and naphthalene that were found in the soil gas under the village in the past were within a range that was generally considered unacceptable by ODH and United State Environmental Protection Agency (US EPA).
- It is unknown what the contaminant levels in the indoor air were in the past or for how long residents may have been breathing contaminated air.
- There are no data that indicate the contaminant plume in the groundwater under the Chevron Refinery Site and the surrounding area has ever impacted the public drinking water supply used by Hooven residents and residents of adjacent village of Cleves.

Subsequent to the first Health Consultation, in a letter dated January 7, 2004, U.S. EPA Region V asked Chevron to re-investigate the vapor intrusion pathway due to concerns regarding the results of their previous investigations and updates in US EPA's toxicity data for benzene and ethylbenzene. As stated in US EPA's letter to Chevron, "The risk assessment conducted by Chevron on Hooven basement exposure scenario indicated a total cancer risk of 8.0×10^{-5} and a total non-cancer Hazard of 2.0 (primarily due to naphthalene data from 1999)" and "Based on the current toxicity data on benzene and ethylbenzene, it is estimated that the cumulative cancer risk and the Health Index for

Hooven basements and the southwest quadrant exceed the targeted value of 10^{-5} (incremental individual lifetime cancer risk) and a Hazard Quotient (HQ) of 1 for non-cancer risk."

In response to this letter, Chevron investigated the soil gas vapors in the vicinity of Hooven from March to May 2005 and results were reported in the *Subsurface Investigation Field Activities Report and Human Health Risk Assessment, Chevron Cincinnati Facility, Hooven, Ohio, October 2005*. The Hamilton County General Health District requested HAS to update the Health Consultation and assess public health concerns in light of the new data made available in this report.

Residents of the village of Hooven obtain their water from the Cleves public drinking water supply which has not been impacted by contamination from the Chevron site (Ohio Environmental Protection Agency [Ohio EPA], pers. Com., 2004). The primary exposure pathway of concern was determined to be the potential for residents to be exposed to vapors that may be degassing off of a gasoline plume floating on the top of the groundwater underlying the village. HAS was asked to determine whether vapors from this aerially extensive leaded gasoline and diesel plume could possibly be migrating into the homes in Hooven and adversely impacting the health of the residents of the village.

BACKGROUND

Site History

Gulf Oil Corporation built and operated the former fuel and asphalt petroleum refinery just east of the village of Hooven, Ohio from 1931 to 1985. Chevron (Chevron Texaco Products Company) purchased the refinery in 1985 and operated it until 1986. The major products produced at the refinery included gasoline, jet fuels, diesel, home-heating oils (i.e., kerosene and propane), and sulfur. The refinery operations were built on 250 acres of the Great Miami River floodplain, although the entire facility occupies approximately 600 acres. The refinery is bordered to the north, east, and south by the Great Miami River and to the west by State Route 128. The refinery facility included plant process areas, storage tanks, and other operations (Figure 1). It is located near the junction of State Route 128 and U.S. Route 50 (Figure 2), approximately twenty miles west of Cincinnati and about three miles north of the Ohio River in Hamilton County, Ohio.

There are three additional areas associated with the site: the "Land Farm", the Southwest Quadrant, and the "Islands" (Figure 2). The five-acre Land Farm is located in a wooded area on top of a ridge west of and overlooking the site. The area was the disposal site for some of the refinery's process waste sludges. The Southwest Quadrant, located on the floodplain of the river, just south of the village of Hooven, was investigated due to potential vapor intrusion concerns and is currently being developed into a commercial shopping area. The "Islands" (Islands No. 1 and 2) are in the Great Miami River southeast of the main facility and north of US Route 50. In 1995, a soil vapor extraction (SVE) system began operations on the islands to address hydrocarbon contamination resulting from a series of pipeline spills on Islands No. 1 and 2. The system was switched to bioventing with limited operation of the SVE in 2000.

The main portion of the Chevron site is at an elevation of about 500 feet above msl (mean sea level). The Southwest Quadrant is on the same floodplain at an elevation of about 505-515 feet above msl. The nearby village of Hooven is west of the former refinery and north of the Southwest Quadrant. It is at an elevation of about 525-545 feet msl, 30 to 40 feet above the level the former refinery site on the Great Miami River floodplain. The Land Farm area is located northwest of the main facility on top of a nearby bedrock ridge at approximately 680-750 feet above msl.

The village of Cleves is located on the east side of the Great Miami River and is about half a mile southeast of the Chevron facility (Figure 2). The production wells for the Cleves water supply were originally located on the east bank of the Great Miami River (Ohio EPA, 2001; USGS, 1996). The land near the facility is primarily a mixture of residential and commercial properties.

In 1985, an oil sheen was discovered on the Greater Miami River, just south of the refinery. Investigations determined that the source of the sheen was seeping petroleum hydrocarbons from contaminated groundwater from under the refinery. With Ohio EPA's approval, Gulf initiated a voluntary corrective action, which was characterized as "hydraulic containment measures". The "hydraulic containment measures" consisted of pumping the groundwater in a way that would keep the petroleum hydrocarbon plume on-site and then capture and treat the contaminated groundwater. Fourteen groundwater extraction wells were installed and the pumped groundwater was treated to remove organic contaminants. When groundwater levels were low, the production wells were pumped to create cones of depression, which allowed the petroleum hydrocarbons to form thick layers on top of the groundwater that were skimmed from the recovery wells and removed. The recovered petroleum hydrocarbons were then sold as fuel.

On May 13, 1993, Chevron entered into an Administrative Order on Consent with the US EPA Region 5 office to perform a Resource Conservation and Recovery Act (RCRA) Facility Inspection (RFI) to identify the nature and extent of the contamination at the facility. A Corrective Measures Study (CMS) was performed to evaluate the long-term corrective measures necessary to protect human health and the environment. The hydraulic containment corrective action initiated by Gulf in 1985 was incorporated into the consent order signed in 1993 (Ecology and Environments, 2000a). Phase I of the RFI investigated the extent of possible off-site contamination by examining groundwater at the sites' boundaries. Phase II addressed the groundwater and surface contamination on-site and also included a facility-wide risk assessment. The RFI was completed and approved by US EPA in 2000.

The investigations revealed a large, 263-acre plume of liquid phase hydrocarbons (mostly gasoline) floating on the groundwater beneath the facility and extending west beneath the eastern portion of the Village of Hooven (E & E, 2000b) (Figure 3). Chevron first estimated that eight million gallons of "light non-aqueous phased liquids" (LNAPL) made up the plume. Chevron's Current Condition Report estimates 5 million gallons of gasoline product floating on the water table. As of June 2004, Chevron has estimated that 3.5 millions gallons of LNAPL still remain in subsurface soils and groundwater (US EPA, 2005a). The LNAPL consists primarily of 80% leaded gasoline and 20% diesel fuel (ChevronTexaco, 2003). The plume underlies the eastern portion of the village of Hooven, including several small businesses and residential homes. The homes in Hooven have been built using a variety of designs: some have basements; some dirt floor crawl spaces; and some a combination of both basements and crawl spaces.

Geology and Hydrogeology

The Chevron site lies in a valley that was cut into limestone and shale bedrock by the ancestral Great Miami River. This bedrock is a poor source of groundwater due to the low permeability of the shale. The bedrock valleys in this part of Ohio were filled with outwash sand and gravel from the glaciers. These highly permeable materials are good sources of groundwater supplies. This outwash material has filled the valley at the site to a depth of 70 to 120 feet (Durrell, 1961; Ohio Department of Natural Resources, well logs). Large-diameter production wells at the Chevron facility were drilled into the highly permeable sand and gravel deposits to depths of 80-90 feet and produced up to 2,000 gallons of water per minute (Walker, 1986; ODNR well logs).

Almost the entire population of the lower Great Miami River region of Southwest Ohio is dependent on groundwater for their drinking water supply (Miami Conservancy District, 2004). Their drinking water supply is obtained from wells in the buried valley sand and gravel aquifer, which the US EPA, in 1988, designated as the Miami Valley Sole Source Aquifer (SSA) system. The village of Hooven and the Chevron facility are located on top of this aquifer.

DISCUSSION

Cleves and Hooven Drinking Water Supply

No residents of Hooven are known to be currently using private wells for drinking water. Residents in the Village of Hooven obtain their drinking water from Village of Cleves public drinking water supply. The production wells for the Cleves water supply were originally located about ½ mile south-southeast of the former Chevron Refinery, on the east bank of the Great Miami River (Figure 2). After discovery of the contaminated groundwater under the Chevron refinery site, concerns were expressed that contamination from the site might reach the Cleves well field. Monitoring wells were placed at the perimeter of the old Cleves well field in the early 1990's. Production wells and monitoring wells were regularly sampled for gasoline-related Volatile Organic Compounds (VOCs) throughout the latter half of the decade. There were detects of low levels of site-related chemicals in some of the outermost monitoring wells in 1994, 1997, and 1998 (Ohio EPA, personal communication, 2004). However, no site-related contaminants were detected in the Cleves public water supply wells during this time period (Ohio EPA, Division of Ground and Drinking Water staff, pers. comm., March, 2004). In 2000, an agreement was reached between the Village of Cleves and Chevron to relocate the water supply wells to a rural portion of Whitewater Township west of the village. This location is separated from the Chevron groundwater contaminant plume by a 200-foot high, north-south trending bedrock ridge (Figure 2). The new Cleves well field is not located in the same groundwater basin as the old well field and is not at risk of becoming contaminated by the gasoline plume under the Chevron Refinery Site and the village of Hooven. The new Cleves water supply well field became operational in January, 2001.

Historical Groundwater Contamination in Hooven

Since 1996, VOCs have been consistently detected in groundwater monitoring wells in the Hooven area at levels above the U.S. EPA Maximum Contaminant Levels established for drinking water. Additionally, the semi-volatile organic compound, naphthalene, has been detected in several monitoring wells. As stated previously, residents in the Village of Hooven obtain their drinking water from Village of Cleves public drinking water supply. *No one is currently at risk of exposure to site-related contaminants via the drinking water route since no one is using the groundwater under Hooven as a drinking water supply*.

Groundwater flow direction

Currently groundwater flow is controlled by Chevron's pumping of their extraction wells, causing groundwater to flow from the facility boundary and from the Great Miami River to the extraction wells in the southern portion of the Chevron site. Natural groundwater flow direction, without the pumping of Chevron's extraction wells**,** is thought to parallel surface water flow in the Great Miami River, which in the vicinity of Chevron and Hooven, is to the south and southwest (ChevronTexaco, 2003). As would be expected, groundwater flow direction is influenced by Chevron's pump and treat systems to an even a greater extent when the water levels are low. Groundwater flow direction, when the extraction wells are pumping, is radially toward these wells, with the flow direction at the Chevron facility toward the southwest; at the Southwest Quadrant towards the northeast, and at the village of Hooven toward the east-southeast, towards the Chevron site (Figure 2).

Water Table

The depth to the top of groundwater, or the water table, ranges from 15 to 30 feet below the ground surface in the vicinity of the Chevron Refinery site and the Southwest Quadrant. The village of Hooven, which sits atop a sand and gravel terrace at an elevation 30 to 40 feet above the level of Great Miami River flood plain and the Chevron site, has a depth to the groundwater table that ranges from 50 to 60 feet below the ground surface (QST Environmental, 1998).

Evaluations of this buried valley aquifer system indicate that the groundwater in these porous and permeable sand and gravel deposits is highly vulnerable to contamination from the ground surface (ODNR, Division of Water, 1989). The permeable sand and gravel soils in the area readily facilitate the seepage of chemical contaminants into the groundwater.

Water table fluctuations at the Chevron site reflect changes in groundwater levels due to seasonal recharge from precipitation, operation of groundwater production wells, and river level fluctuations. The river and the underlying groundwater aquifer are in direct hydraulic contact with one another, with groundwater seasonally discharging to the river and at other times, the river water infiltrating into the groundwater. River level fluctuations create the most pronounced and widespread fluctuations in the water table across the site (ChevronTexaco, 2003). Seasonal variations in water table elevation typically range between 2 and 5 feet, but have been up to18 ft as the river stage rises and falls throughout the year (US EPA, 2005A). River flooding has caused changes that have lasted from a week to a month in duration with a difference in elevation between the river and the aquifer ranging from 2 to 9 feet. Flood events have been known to occur at any time of the year but occur most often during the spring (ChevronTexaco, 2003).

When the water table is down, the layer of free product gasoline floating on the water table (LNAPL) has its greatest thickness. When the water table is high, this layer of gasoline largely disappears. "The influence of water table fluctuation on the LNAPL can result in repeated trapping and exposing of LNAPL to soil gas. Drought conditions may lower the water table and expose previously-trapped LNAPL product, greatly increasing the amount of the LNAPL partitioning as a vapor to soil gas. These and other conditions may confound field data and need to be addressed in order to provide practitioners with guidance as to under what conditions sampling should occur in order to provide a conservative, "worst-case" sampling event"(US EPA, 2005b).

Smear Zone and LNAPL Description

When petroleum hydrocarbons are released below the ground surface, they become intermixed between the soil grains and the groundwater, and are held in the soil by capillary forces. This light non-aqueous phase liquid (LNAPL) continues to release dissolved contaminants to surrounding groundwater for an extended period of time. As the water table changes vertically over time, the LNAPL also rises and falls, creating a contaminant “smear zone” that is difficult to treat (US EPA, 2005a). The smear zone under the Chevron facility is where gasoline and diesel fuel from the refinery’s plume are adhering to the tiny spaces between the sand and gravel deposits. The highest elevation of the smear zone typically coincides with highest point the water table has risen. At the Chevron site the smear zone is up to 20 ft thick in some places (ChevronTexaco, 2003). The smear zone is estimated to cover an area of approximately 250 acres (ChevronTexaco, 2003). The approximate dimensions of the significant smear zone are 5,600 ft by 1,370 ft, with an average thickness of about 13 ft.

In the floodplain, the LNAPL "smear zone" extends from 12 to 30 feet bgs, and is present in intermixed gravely silts, fine sands, silty gravels, and small cobbles. At the time of the year when the groundwater is low (typically late summer-early winter), most of the smear zone is present above the water table. The free-phase LNAPL layer typically ranges from 0.1 to 0.5 feet thick, but the LNAPL thickness during drought conditions in November 1999 was observed range from 0.1 to over 0.9 feet thick (ChevronTexaco, 2003). Approximately half of the groundwater plume has a layer of free-phase LNAPL with a thickness of greater than 0.5 feet (US EPA,2005). When the groundwater table is high (typically in the spring), most of the LNAPL smear zone is submerged and, in some cases, no free product layer is present. When the groundwater is above an elevation of 465 feet msl under the village of Hooven, the smear zone is thought to be below the water table (Civil & Environmental Consultants, Inc., CEC, 2001).

Prior HAS Involvement with the Hooven Site & Public Health Actions To Date

In late 2003, the Hamilton County General Health District and concerned residents asked the Health Assessment Section (HAS) at the Ohio Department of Health to evaluate available environmental data and determine if the former Chevron refinery site poses a public health threat to the people who live in the Village of Hooven, Hamilton County, Ohio. ODH staff attended a Community Advisory Panel (CAP) meeting on October 1, 2003, to gain first hand knowledge of the health concerns expressed by the residents. Residents were concerned about possible exposure to vapors from the fuel plume beneath the village and about past exposures to pollutants released by the refinery when it was in operation. HAS explained to the residents that it was necessary to document a completed exposure pathway to contaminants at levels that could cause adverse health effects in order to determine if any of their health concerns could be related to underlying groundwater contamination. HAS also informed residents that it is unlikely that past exposures could be documented due to the lack of environmental data collected when the refinery was in operation. In light of the concerns of the citizens of the Village of Hooven and the Hamilton County Health Commissioner, the Health Assessment Section reviewed the available environmental data to determine if residents of Hooven were being exposed to environmental contaminants from the Chevron facility. On May 6, 2004 the HAS released a Public Health Consultation on the Vapor Intrusion Issues in Hooven, Ohio, Former Chevron Refinery.

The 2004 Public Health Consultation had the following Recommendations:

1. The Health Assessment Section recommended Chevron collect new soil vapor data in the Village of Hooven from 5 to 10 feet below the ground surface to obtain an up-to-date picture of the soil vapor conditions in Hooven

2. Using the newly collected soil vapor data, Chevron should complete a new human health risk assessment based upon the steps outlined in the U.S. EPA vapor intrusion guidance manual (US EPA, 2002. *Draft Guidance for the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils*).

3. If the new risk assessment determines that residents could be exposed to contaminants from the groundwater plume at levels of concern, HAS will recommend that Chevron collect indoor air samples from those residences most likely to be impacted.

Between March and May 2005, Chevron sampled 7 nested deep vapor wells (5 within the plume "footprint" and 2 outside the plume "footprint"), sub-slab vapor probes in 43 residences (21 inside plume and 22 outside plume), 50 near slab vapor probes at 5 and 10 foot depth, 18 groundwater wells, and 3 locations for ambient air samples (Figure 3).

Potential Exposure Pathways

For the public to be exposed to elevated levels of contaminants from the Chevron facility, they must first come into physical contact with the contaminated soil, sediment, groundwater, or air. The likely exposure route for the Hooven residents is from breathing site-related chemicals in ambient and/or indoor air. The residential indoor air may have been contaminated from the vapors coming off the Chevron hydrocarbon plume. A **completed exposure pathway** consist of five main parts that must be present for a chemical exposure to occur. These include:

- **A source of chemicals**;
- **Environmental transport**, which is a way for the chemical to move away from its source (soil, air, groundwater, surface water);
- **A point of exposure**, which is a place where people come into physical contact with the chemical (on-site, off-site);
- **A route of exposure**, which is how people come into physical contact with the chemical (drinking, eating, touching); and
- **People who could be exposed**, which are people likely to come into physical contact with site-related chemicals.

Physical contact with a chemical contaminant, in and by itself, does not necessarily result in adverse health effects. A chemical's ability to affect a resident's health is also controlled by a number of factors including:

- How much of the chemical a person is exposed to (the dose).
- How long a person is exposed to the chemical (the duration).
- How often a person is exposed to the chemical (the frequency).
- The toxicity of the chemical of concern (how a chemical affects the body).

Other factors affecting a chemical's likelihood of causing adverse health effects upon contact include the resident's:

1. Past exposure
2. Smoking, drinking alcohol, or taking certain medications
3. Current health status, sensitivity to certain substances
4. Age
5. Family medical history

Vapor Intrusion Pathway

The 2004 HAS Public Health Consultation determined that the primary public health concern presented by the former Chevron refinery site in Hooven was the possibility that volatile chemicals associated with the underlying groundwater contamination plume (primarily gasoline) may be vaporizing off of the plume and moving as gases up through the overlying thickness of soils and into basements and crawl spaces of homes in Hooven. In these confined indoor air environments, residents could be exposed to these chemicals through inhalation of these gases in the air within the home. This potential exposure pathway is termed the *Vapor Intrusion Pathway* (see Appendix A, *Vapor Intrusion; Answers to Frequently Asked Health Questions,* Fact Sheet).

Gasoline is a mixture of refined hydrocarbon compounds, 150 simple to complex organic chemical compounds associated with crude oil. The "lighter" compounds in gasoline include a number of volatile organic compounds (VOCs); chemicals that are normally liquids that can readily vaporize into a gas when exposed to air. These include chemicals like benzene, toluene, ethylbenzene, xylenes (so-called BTEX compounds) plus heptane, hexane, naphthalene, and trimethylbenzenes. Upon being released as a gas to soils, these chemicals can migrate through the enclosing soils from areas of high pressure at depth below the ground surface to areas of low pressure on top of the ground surface. Vapor-phase hydrocarbons will tend to follow the path of the least resistance, seeking out soils that are porous and permeable, allowing for the easy movement of the gases up through the soils to the surface. Upon reaching the surface, these gases discharge to the atmosphere, mixing with the air which effectively dilutes the concentrations of these chemicals and leading to their breakdown from complex to simpler compounds due to exposure to oxygen and sunlight.

However, if these gases migrate into homes and businesses, they undergo less mixing and dilution. Concentrations may remain high enough to pose a health threat to residents and workers if these trapped gases are inhaled in by these individuals. This is particularly true in the winter months when homes are typically closed up tight, trapping the air inside and allowing for little or no free exchange with the outside air. If indoor air concentrations are high enough and/or if people are exposed to these chemicals for a long enough period of time, these vapor-phase hydrocarbons can pose a health threat to residents. Benzene is a known human cancer-causing chemical through the inhalation route in occupational settings where workers were exposed to the chemical at high concentrations (parts per million range) in the indoor air for a number of years (ATSDR, 1997). These exposures have been associated with the development of excess incidence of leukemia and other blood disorders in these workers (ATSDR, 2000). The other compounds pose primarily non-cancer health threats, usually targeting the central nervous system. Exposure to high concentrations in the air (several 10's of parts per million range) can result in dizziness, fatigue, sleepiness, headaches, and nausea (ATSDR, 1993). Prolonged exposures to these same high levels can lead to liver and kidney damage and anemia as well. It is unlikely, however, that vapor levels associated with the gasoline plume beneath the village will be high enough to result in these acute adverse health effects.

Results of Chevron Subsurface Field Investigation and Human Risk Assessment

Following up on the recommendations of the HAS 2004 Public Health Consultation, Chevron carried out an extensive subsurface gas investigation of the soils underlying the village of Hooven in March, April, and May, 2005. This investigation included sampling seven "nested" vapor wells (five within the plume "footprint" and two outside of the plume "footprint", all in the village); the installation and sampling of subslab vapor probes at 43 residences (21 inside the plume and 22 outside of the plume); the installation of 50 near-slab vapor probes at 5 and 10 ft intervals below the ground surface; sampling of 18 groundwater wells, and collection and analysis of three ambient air samples in the vicinity of the village (Trihydro, 2005). The intent of this study was to determine if volatile hydrocarbons associated with the underlying groundwater contamination plume were degassing off of the plume, making their way as vapors up through the soils under the village, and accumulating in soils in, around, and under residential areas in Hooven at levels that might pose a threat to the health of village residents.

"Nested" vapor wells sample the soil gases at specific levels below the ground surface. The Chevron wells sampled soil gas at 10 foot intervals from ground surface to depths down to 60 feet. Based primarily on the results of sampling of the seven "nested" vapor wells, Chevron determined that the vapor-phase hydrocarbons coming off of the contaminated groundwater under the site were being biologically degraded by micro-organisms in the soils under the village before they could reach the surface and impact Hooven residents. The "site model" developed by Chevron from this investigation (Trihydro, 2005, Figure ES-1) suggested that hydrocarbon vapors coming off of the underground plume became degraded a short distance above the plume such that soils at depths of 20-30 ft below the ground surface under the village contained little or no petroleum vapors (Figure 4). The inverse relationship between oxygen and carbon dioxide levels at depth (decreasing oxygen and increasing carbon dioxide) was used as evidence of this biological activity (Trihydro, 2005, Figure 9).

A variety of volatile chemicals, including some site-related hydrocarbons, were detected at low levels in the sub-slab and near-slab soil gas samples collected by Chevron from the upper 10 ft of soil underlying residential properties in Hooven. These chemicals, however, were described as not being the result of vapor migration coming up from the underlying gasoline plume, but the result of activities at or near the surface of the residential properties. These surface and near-surface sources included spills from home heating oil tanks; spills resulting from the storage of solvents, paints, and other chemicals in and around residences; leaks from cars; application of waste oil to unpaved roads in the village in the past; and chemical reactions between water-treatment chemicals (chlorine) and organic matter in the septic systems currently used by most village residents. Evidence with regard to the source(s) of these chemicals included the presence of chemical compounds (chlorinated compounds and a gasoline additive) in residential soil gas samples that were absent from the underlying groundwater contaminant plume.

Based on these sampling results, Chevron concluded that the vapor intrusion pathway from the underlying groundwater plume to the residences in Hooven was incomplete and that vapors from the plume do not migrate to the indoor air of residences in Hooven. Chevron determined in their Human Risk Assessment Report that, as the vapor intrusion pathway was incomplete, vapors from the contaminant plume do not present any measurable health risk to residents of Hooven (Trihydro, 2005).

HAS Comments and Questions regarding the Chevron Subsurface Field Investigation and Human Risk Assessment Report (2005) Results and Conclusions

The Hamilton County General Health District asked the Health Assessment Section to review and evaluate the results and conclusions made in the Chevron *Subsurface Field Investigation and Human Risk Assessment Report* (Trihydro, October, 2005) with regard to public health concerns in the village of Hooven. After reviewing the report, plus previous site-related reports generated by Chevron addressing contamination issues at the site, the Health Assessment Section has a number of questions and concerns with regard to the conclusions made in the report, based on the results of this investigation. These comments, questions, and concerns are listed below.

1) Chevron generated a Human Risk Assessment with regard to volatile organic compounds (VOCs) in the vapor intrusion pathway on the basis of only one round of soil vapor, near-slab, and sub-slab sampling.

HAS Comment: Our understanding of the process, from conversations with colleagues at US EPA and Ohio EPA plus past experience with other US EPA hazardous waste sites, is that US EPA risk assessment protocol, at least for VOCs in groundwater and in ambient air and indoor air pathways, requires a minimum of four quarters of environmental sampling data due to well-documented seasonal variations in VOC levels during the course of the calendar year. Soil gas levels for VOCs surely also will reflect these seasonal fluctuations in concentrations as they are often directly linked to groundwater contamination and serve as a source for indoor air contamination. The April, 2005 sampling carried out by Chevron does not approximate a "Worse Case Scenario" based on their own technical documents (see discussion below).

2) Based on Chevron's own studies (Civil & Environmental Consultants, 2001; Trihydro, 2005), the 2005 soil gas field investigation was not carried out under a "Worse Case Scenario".

HAS Comment: The CEC document (2001) indicated that soil vapor production off of the subsurface gasoline plume under Hooven seasonally is reduced or absent under high water table conditions which are typical of the Great Miami River watershed during the spring months, including March, April, and May. The Subsurface Field Investigation was carried our during these months in the spring of 2005. The CEC document (2001) states that the optimal time for vapor production off of the plume is during low water table events when the hydrocarbon "smear zone" bracketing the fluctuating water table is exposed above the water table. This allows for the vaporization of attached volatile compounds and migration of these chemicals as vapors up through the overlying soils towards the ground surface.

In addition, the Trihydro document (2005) indicates that a "significant rainfall event" (2.5 inches of rain over a two-day period at the end of March, 2005, resulting in stream flows of up to 21,000 ft^3/sec in the Great Miami River) occurred in the area during the initial stages of the subsurface sampling of soils under the village. The additional effects of this event on vapor levels in soils under the village due to the influx of rainwater into the underlying soils were not discussed or accounted for. There is evidence that some gasoline components may become trapped beneath the infiltrating recharge, such as from rainwater, greatly reducing their ability to volatilize into soil gas *(Weaver and Wilson, 2000; US EPA, 2005b).* By any account, the Spring of 2005 was not the optimal time for vapor production in the soils under the village and this particular sampling round does not represent a worse-case scenario.

The "Worse-Case Scenario" would more likely be captured by carrying out soil gas investigations in the area in the late summer to early winter, typical "drought" months in southwestern Ohio when the water table in the buried valley aquifer underlying the village and the site would likely be at its lowest (stream flows in the Great Miami River at levels less than 750 ft^3/sec and depths to the water table in Ohio Observation well H-1 of -24 ft below the ground surface compared to only -21 ft below ground surface in April, 2005). According to the CEC document (2001), vapor production would be at a maximum under these conditions, most likely during the months of August or September.

3) Chevron's "Site Model" (Trihydro, 2005, Figure ES-1) seems to be based on selected nested Vapor Well results (primarily those for VW-93 and VW-128 at the east edge of the village) and does not seem to be as well supported by the results obtained from the other nested vapor wells sampled from across the village, further to the west (VW-96, VW-99, VW-127, VW-129, and VW-130).

HAS Comment: Chevron'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 steadily upward-increasing levels of non-site related VOCs in soil gas in the upper 5-15 feet of soil immediately under village residences (Figure 4). These latter shallow soil gas compounds are described as consisting of chemicals not associated with the gasoline plume under the village (i.e. MTBE, chloroform, and other chlorinated solvents) and resulting from non site-related activities taking place on these residential properties. These observations match up well with the sampling results from vapor wells VW-93 and VW-128. However, these trends are less evident in the other nested vapor wells sampled across the village in 2005.

Sampling of Vapor wells VW-127, 129, and 130 detected trace levels of site-related hydrocarbons throughout the entire thickness of soils under the village. VW-96 has site-related hydrocarbons at 55 ft below the ground surface (bgs), 45 ft bgs, 40 ft bgs, 30 ft bgs, and in the upper 5 ft of soil (Table 1).

VW-127 has trace detection of the supposedly non site-related solvent perchloroethylene (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 this chemical 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 impact on soil vapor levels of some chemical compounds detected in the upper 10-15 ft of soil under homes in Hooven (see results for VW-128), the results presented are not fully conclusive as to the origins of these detected VOCs. Can Chevron distinguish between BTEX compounds coming from the underlying groundwater plume and BTEX compounds resulting from residential surface activities in Hooven?

In the Trihydro document (2005), both chloroform and PCE are described as not being site-related compounds. However, a previous site document (Ecology & Environment, 2000) lists both chloroform and PCE (as tetrachloroethylene) as Chemicals of Potential Concern at the Chevron-Hooven site.

4) It has been well-documented that soil gases often selectively seek out and follow preferred pathways (high permeability zones under the ground) that will more readily facilitate their migration through soils to the ground surface. In the Subsurface Field Investigation Report and elsewhere, there does not seem to be any discussion by Chevron or its consultants about the presence or absence of preferred pathways for soil vapor migration under the village of Hooven. There is also no mention of the potential for horizontal migration of the vapor plume in site pathway discussions.

HAS Comment: Review of the Subsurface Field Investigation Report (2005) indicated, via a series of geologic cross-sections (Figures 4-6) that the stratigraphy of the soils under the village of Hooven is anything but homogeneous. Whereas cross-section A-A' west to east across the northern edge of the village (Figure 4) shows a surface layer of silty clay and sand of variable thickness (3-10 ft) across much of the village, cross-section B-B' west to east across central and southern portions of the village (Figure 5) indicates numerous breaks in this silty surface layer, with 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' 2005, (Figure 6), traversing the east edge of the village along 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 (see Figure 5 of this document). Elsewhere in this area, a less permeable silty sand and gravel layer separates the plume from the ground surface (MW-126, VW-128, and MW-128). Soil gas sampling of VW-96 and VW-99 in 1997 and 1998 showed the presence of significant amounts of site-related vapor-phase hydrocarbons extending all of the way from the water table to the ground surface (Tables 2 and 3).

The Site Model implies that all vapor migration in soils under the village would be in a vertical direction such that elevated vapor-phase hydrocarbon concentrations would only be expected to occur directly above the area underlain by the LNAPL layer on top of the groundwater and possibly the dissolved-phase portion of the contaminant plume. West to east cross-sections A-A' and B-B' indicates that less permeable, poorly-sorted sands, gravels, 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 these soils under this part of the village. These cross-sections also suggest that vapors coming off of the plume might be more readily transported to the surface by migrating first horizontally to more permeable gravels and sands just to the west of the plume and then moving vertically up all of the way to the surface in this more homogeneous, more permeable sand and gravel unit (in vicinity of MW-101S).

5) 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. Other explanations can be given that would just as adequately explain the apparent changes in vapor-phase hydrocarbon concentrations and the inverse relationship between oxygen and carbon dioxide (CO_2) in soil gas with depth. However, none of these alternative explanations are identified or discussed in the report.

HAS Comment: Chevron's own documents (Civil & Environmental Engineering, 2001) indicate that induced "fresh air flow" diminishes below the upper 20 ft of soil under the village even when the horizontal Soil Vapor Extraction system (SVE) installed under the east edge of the village was in operation. Oxygen levels may drop off with depth even faster if the flow of air into the subsurface soils was not being induced by the operation of the SVE system. In the vicinity of the “smear zone” bracketing the water table groundwater plume, 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 with increasing depth from the ground surface could simply be the result of the depth to the contaminant plume and geochemical conditions associated with the plume just as easily as reflecting any kind of increased biological activity by bacteria degrading the hydrocarbon plume in the soils immediately above the water table.

A comparison of hydrocarbon vapor concentrations collected in 1997, 1998, and 2005 from the same nested vapor wells along the edge of the free product plume boundary under the east edge of the village is instructive. VW-93 at the east edge of the village did not have any significant vapor-phase hydrocarbon detections in the shallow vadose zone (upper 35 ft of soil) under the village of Hooven, in either 1997 or 2005. Active, on-going biodegradation of the vapor-phase portion of the plume at depth just above the water table surface seems to be a reasonable explanation for what has historically been observed in this well.

However, VW-96, just north of VW-93 (Figure 3), had significant detections of site-related hydrocarbons (1,000’s of parts per billion of ethylbenzene, toluene, and xylenes) at depths as shallow as 20 ft below the ground surface in 1997 (QST Environmental, 1998, Appendix D) (Table 2). These sample events (August and September, 1997), strongly suggest that site-related vapor-phase hydrocarbons penetrated the entire soil column under the village of Hooven in 1997, leading to the development of a completed exposure pathway linking residents in the village with vapor-phase contaminants from the underlying groundwater plume in 1997. Additional soil sampling of vapor wells VW-93, VW-96, and VW-99 carried out by Chevron in August of 1998 also had detections of site-related hydrocarbon compounds throughout the entire thickness of soil under the village and above the gasoline plume (Table 3). If natural biodegradation of vapor-phase hydrocarbons coming off the groundwater plume is a significant process breaking down these hydrocarbon vapors in the soils under the village, why was it not working in the vicinity of vapor well in August and September of 1997 and all three of these wells in August of 1998?

In contrast, vapor-phase BTEX hydrocarbons in VW-96 in the 2005 sampling of this well series are largely absent from the upper 50 ft of soil above the gasoline plume and under the village (Table 2). High levels of hydrocarbons detected just above the plume (at depths of from 55 to 40 ft bgs) in both VW-93 and VW-96 (plus VW-99 as well) in 1997 are also significantly reduced or absent in 2005. How does biodegradation explain the contrast in hydrocarbon levels in these wells between 1997 and 2005? HAS thinks this question can better be answered by looking at the potential impacts on the hydrocarbon vapors under the village resulting from the horizontal Soil Vapor Extraction system (SVE) installed under the east edge of the village in 1999.

6) The 2005 Field Investigation and Risk Assessment Report does not discuss in any detail the likely impacts that operation of the Soil Vapor Extraction system may have had on the distribution of vapor-phase hydrocarbons under the eastern edge of the village. Five out of the seven nested vapor wells sampled as part of the 2005 field investigation are located within the direct area of influence of this system (Figure 3). It is highly unlikely that five years of operation of this system has had no effect on the hydrocarbon plume underlying this part of the village. Chevron officials have reported to HAS (pers. comm., 2004) that the SVE system installed under the village in 1999 has removed approximately 425,500 pounds. of petroleum hydrocarbons as vapors from the soils beneath the village.

HAS Comment: HAS believes that both questions posed above can more readily be answered by looking at the likely impacts of the operation of the horizontal Soil Vapor Extraction system under the village on these hydrocarbon vapors, starting in 2000 and continuing up to the present. Five out the seven nested vapor wells sampled as part of the 2005 investigation are located within 100 ft of the horizontal piping that makes up the business end of the SVE system installed under the east edge of the village in 1999.

The SVE system was installed by Chevron under the east edge of the village in 1999 as the result of vapor-intrusion concerns generated by the 1997 vapor well results. When it was operating between 2000 and 2003, the system was initially very effective in reducing the amount of vapor-phase hydrocarbons in the soils immediately above the groundwater gasoline plume. The system was rarely in operation in 2003 and 2004 due to abnormally wet weather and high water tables at the site during this time period, with wet weather even in late summer and early fall when conditions are traditionally dry in southwest Ohio. As indicated above, the water table has to be low and the hydrocarbon “smear zone” exposed above the level of the groundwater for vapors to be released upward into the overlying soils. The SVE system works most effectively when vapor production is a maximum during these low water table conditions (Civil and Environmental Engineering, 2001). The levels of hydrocarbons in the soils above the plume likely remained low in 2003 and 2004 as wet weather and high water table conditions are not condusive to vaporization of hydrocarbons off of the plume. The SVE system has been operated on an intermittent basis in 2005 and 2006 as weather conditions resumed a more typical seasonal pattern.

The differences in the concentrations of vapor-phase hydrocarbons in nested vapor wells along the east edge of the village of Hooven between 1997 and 2005 (Table 2) are best explained by the operation and general effectiveness of the horizontal SVE system, reducing hydrocarbon levels at the water table and in the soils under the village during the years of its operations between 2000 and 2005.

7) 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 1999. The 2005

sampling results for these wells may reflect the effectiveness of the SVE system in removing vapor-phase hydrocarbons from the soils above the groundwater plume in the vicinity of the SVE system. Conditions represented by these particular vapor wells may not be representative of conditions as they exist under the rest of the village, at sites not under the influence of the SVE system.

HAS Comment: Due to their locations within 100 ft of the distal ends of the pipes that make up the horizontal SVE system underlying the eastern edge of Hooven (Figure 3), HAS has concerns that the line of sampled nested vapor wells (VW-128, VW-127, VW-93, VW-96, and VW-99) all have been impacted by past operations of the SVE system, removing vapor-phase hydrocarbons from the intervening thickness of soils overlying the gasoline plume and underlying the village. It is believed that the evident pattern observed in the 2005 vapor well results (= the absence of site-related hydrocarbons above the plume and at depth below the residences) is due largely to the operation of the SVE system and not strictly the result of active biodegradation of these chemicals by naturally-occurring aerobic bacteria in the intervening soils.

There are no nested soil vapor data for areas of the village further away from the SVE system yet still within the occupied portions of Hooven overlying the distal edge of the free product plume or the less well-defined "dissolved plume". These areas, beyond the direct area of influence of the SVE system, but still overlying portions of the underground gasoline plume, might show a significantly different picture of vapor migration under the village compared to the 2005 field investigation results.

Potential sites for additional nested vapor wells to fill this potential gap would be in the vicinity of MW-122, MW-125, MW-126, and MW-101 west of the current line of vapor wells and northeast of VW-99; and between it and Route 128 (near MW-121).

CHILDREN'S HEALTH CONSIDERATIONS

HAS and ATSDR understand that children are often at a greater risk of developing illness due to exposure to hazardous chemicals because of their smaller stature and developing body systems. Children are likely to breathe more air and consume more food and water per body weight than are adults. Children are also likely to have more opportunity to come into contact with environmental pollutants due to being closer to the ground surface and taking part in activities on the ground such as, crawling, sitting, and lying down on the ground. To be protective of the health of children, HAS has reviewed all data for this report as if children were the primary population being exposed. HAS will also make recommendations that will provide for the highest level of protection for children in the Hooven area.

CONCLUSIONS

After reviewing the results of the 2005 Chevron sampling of soil gas under the village of Hooven, the Health Assessment Section continues to consider the intrusion of chemical vapors into area homes from groundwater contamination beneath the village as an *Indeterminate Public Health Hazard* to the residents of Hooven. Additional data are needed to determine if the vapor intrusion pathway linking village residents to the underlying groundwater contaminant plume is currently a completed pathway or not.

The spring 2005 Chevron subsurface soil gas data suggests that site-related chemicals under the village do not reach the ground surface so that residents are not currently being exposed to these chemicals at levels that would likely result in adverse health effects. However, Chevron's conclusion was based on data that do not reflect seasonal fluctuations in contaminant levels under the village and do not constitute a "worse-case scenario". Review and evaluation of the *Subsurface Field Investigation and Human Risk Assessment Report* has led to HAS having significant questions and concerns regarding the conclusions made by Chevron with regard to the public health threat posed to residents by the site based on these specific sampling results.

Data gaps and concerns center around: 1) the lack of soil gas data capturing a "worse case scenario" when vapor-phase hydrocarbon concentrations coming off of the groundwater plume would be at a maximum; 2) a lack of critical discussions about the potential for preferred pathways in area soils to transport these vapor-phase chemicals from the water table to the ground surface and to the residents; 3) what we consider to be only weak support for Chevron's contention that natural biodegradation of the hydrocarbons in soils under the village is the most significant process preventing chemical vapors degassing from the water table from reaching the residents in the overlying village; and 4) no discussions with regard to the potential impacts of the operation of the horizontal Soil Vapor Extraction system under the village on the levels of vapor-phase hydrocarbons in soils under the village.

Review of historical soil gas data collected prior to the installation of the SVE system under the village indicates the presence of a completed exposure pathway where site-related chemical compounds of concern migrated up through the soils under the village to the ground surface in vicinity of Vapor Well series VW-96 in August and September of 1997 and in vapor wells VW-93, VW-96, and VW-99 in August 1998. Five of the seven nested vapor wells sampled by Chevron in 2005 are within the area of influence of the SVE system.

RECOMMENDATIONS

To address these questions and concerns and to fill identified data gaps, the HAS recommends the following actions be taken. Elements of this public health consultation have been provided to U.S. EPA as public comment, and responses have been included in the USEPA RCRA *Final Decision and Response to Comments-Selection of Remedial Alternative for Groundwater* document (August, 2006).

1. Additional rounds of soil gas sampling in the area are recommended in order to capture season fluctuations in the vapor-phase hydrocarbons generated by the groundwater plume under the village, especially at times when the water-table is low and vapor production more likely to be at a maximum.

   This recommendation has been incorporated into the current Administrative Order of Consent with Chevron. Details of the future sampling requirements will be described in the Workplan, which is in process of being developed.

2. A number of these soil gas sampling events needs to represent a "worse case scenario" (late summer and fall months) when the LNAPL production and vapor generation likely would be maximized.

   This recommendation has been incorporated into the current Administrative Order of Consent with Chevron. Details of the future sampling requirements will be described in the Workplan, which is in process of being developed.

3. Chevron should revise its conceptual site model to take into account the geologic heterogeneity of the subsurface soils under the village and include an evaluation of soil gas migration along preferential pathways.

4. Additional evaluation of the effectiveness of the Soil Vapor Extraction system under the village with regard to reducing vapor levels in soils under the village, particularly in conjunction with additional studies of the significance of natural biodegradation of vapor-phase hydrocarbons as a mitigating process at the site.

5. The installation and sampling of additional nested vapor wells in areas of the village that are not under the direct influence of the SVE system, but still close to the footprint of the underlying groundwater contaminant plume.

PUBLIC HEALTH ACTION PLAN

The Health Assessment Section at the Ohio Department of Health will continue to review any additional data regarding environmental contamination associated with the site to evaluate whether contamination from the Chevron site could pose a health hazard to residents of the village of Hooven at the present or in the future.

PREPARERS OF THE REPORT

Peter J. Ferron, Environmental Specialist
Robert C. Frey, Principal Investigator/Geologist

REFERENCES

AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY (ATSDR). 1993. Case Studies in Environmental Medicine: Gasoline Toxicity. US Department of Health and Human Services, US Public Health Service 20 p.

ATSDR. 1997. Toxicological Profile for Benzene (update). US Department of Health and Human Services, Public Health Service. 423 p. + Appendices.

ATSDR. 2000. Case Studies in Environmental Medicine: Benzene Toxicity. US Department of Health and Human Services, Public Health Service. 28 p.

CHEVRON TEXACO. 2003. Conceptual Groundwater Remedy Report, ChevronTexaco Cincinnati Facility. July, 2003. 97 p. + Appendices.

CIVIL AND ENVIRONMENTAL CONSULTANTS, INC. (CEC) 2001. Horizontal Soil Vapor Extraction System Operation, Maintenance, Monitoring Schedule. Chevron Environmental Management Company. November 30, 2001.

DURRELL, R.H. 1961. Pleistocene Geology of the Cincinnati Area. In Geological Society of America Guidebook for Field Trips, 1961, Cincinnati, Ohio Meeting. 350 p.

ECOLOGY AND ENVIRONMENT, INC. 2000a. Chevron Cincinnati Facility Phase II RFI Facility-wide Human Health and Ecological Risk Assessment. April 2000.

ECOLOGY AND ENVIRONMENT, INC. 2000b. Human Health Risk Assessment of Potential Exposure to Volatile Compounds. Hooven, Ohio. May 2000.

HEALTH ASSESSMENT SECTION (HAS). 2004. Health Consultation, Vapor Intrusion Issues in Hooven, Ohio, Former Chevron Refinery (aka. Gulf Oil Corporation US), Hooven, Hamilton County, Ohio. 17p.

MIAMI CONSERVANCY DISTRICT. 2004. 2004 Water Quality Assessment in the Lower Great Miami River Watershed. 2004.

OHIO DEPT. OF NATURAL RESOURCES (ODNR). 1989. Groundwater Pollution Potential of Hamilton County. ODNR Division of Water Report No.7. [University of Cincinnati Groundwater Research Center].

OHIO Environmental Protection Agency (EPA). 2001. Sanitary Survey of the Village of Cleves, Hamilton County, Public Water System, PWS ID #3100512, (for the year 2000).

OHIO EPA. 2003. Drinking Water Source Assessment for the Village of Cleves PWS ID #3100512, March, 2003.

QST ENVIRONMENTAL. 1998. A Summary of the Hooven Area Environmental Investigations, Chevron Products Company, February, 1998. 6 p + tables and figures.

SCHMIDT, C.E., PhD., Personal Communication, Letter to John Tiffany, Chevron Products Co., Dr. C.E. Schmidt, Environmental Consultant, Bed Bank, CA. February 25, 1998.

TRIHYDRO CORPORATION. 2005. Subsurface Investigation Field Activities Report and Human Health Risk Assessment Chevron Cincinnati Facility, Hooven, OH. October 2005. 73 p. + Tables and Figures.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (US EPA). 2002. Letter from Christopher Black to John Tiffany of Chevron. February 2002 Comments on the Human Health Risk Assessment for Offsite Volatiles Exposure at the Southwest Quadrant; and the Draft Report of Vapor Flux Investigation Southwest Quadrant for the Chevron Facility, Hooven, Ohio. February 27, 2002.

US EPA. 2004 Letter from Christopher Black to John Tiffany of Chevron. January 2004.

US EPA. 2005a. Cost and Performance Report for LNAPL Characterization and Remediation. Partition Interwell Tracer Testing (PITT) and Rapid Optical Screening Tool (ROST) Characterization and Evaluation of the Feasibility of Surfactant Enhanced Aquifer Remediation (SEAR) at the Chevron Cincinnati Facility, Hooven, OH. February 2005.

US EPA, 2005b. Review of Recent Research on Vapor Intrusion, US EPA, September 2005, EPA/600/R-05/106.

US EPA, RCRA Final Decision and Response to Comments- Selection of Remedial Alternative for Groundwater; The Chevron Facility near Hooven, Ohio, August, 2006; OHD 004 254 132.

UNITED STATES GEOLOGICAL SURVEY (USGS). 1996. Hooven Quadrangle 7.5 Minute Series (Topographic). [Map].

WALKER, A.C. 1986. Groundwater Resources of Hamilton County. ODNR Division of Water. [Map].

WEAVER AND WILSON. 2000. Diving Plumes, L.U.S.T.Line, New England Interstate Water Pollution Control Commission, 36(12-15).

CERTIFICATION

This Former Chevron Refinery (Vapor Intrusion Issues in Hooven, Ohio) Health Consultation was prepared by the Ohio Department of Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was begun. Editorial review was completed by the Cooperative Agreement Partner.

Technical Project Officer, CAT, CAPEB, DHAC, ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health consultation and concurs with the findings.

Team Lead, Cooperative Agreement Team, CAPEB, DHAC, ATSDR

TABLE 1.
VAPOR-PHASE HYDROCARBON DISTRIBUTION IN "NESTED" VAPOR WELLS, CHEVRON-REFINERY SITE, HOOVEN, OHIO.
MARCH – MAY 2005
Parts Per Billion Volume

Vapor Well VW-127 (Hooven & Alley)

Depth	Benzene	Toluene	Ethylbenzene	Xylene	Hexane	Trimethylbenzene	PCE
5							
10					5.7		
15	3.4	9	1.6	3.2	11		
20		2.4		1.8	6.8		
30	11	16	4.1	8.8	77		
40							18
50		5.3		6			21
60							

Vapor Well VW-128 (Hooven School)

Depth	Benzene	Toluene	Ethylbenzene	Xylene	Hexane	Trimethylbenzene	PCE
5	11	15	4.4	4.4	7.1	2	
10	7.2	10	3.9	3	4	1.6	
15	7.8	9.6	3	2.1	10	2.6	
20	1.9	1.6			2.3		
30							
40							
50							
60							

Vapor Well VW-129 (Hooven & Jefferson)

Depth	Benzene	Toluene	Ethylbenzene	Xylene	Hexane	Trimethylbenzene	PCE
5	1.6	4.2	2.1	5.1	4.5	1.6	
10	12	2.9	1.8	14	6.2	13	
15		1.6					
20	1.3	2.4	1.4	2.5			
30	1.3	4.8	2.3	3.2	2.6	1.6	
40	1.6	3.4	1.4	1.8	4		
50		3.2		7.1			
60							

TABLE 1. (Continued)
VAPOR-PHASE HYDROCARBON DISTRIBUTION IN "NESTED" VAPOR WELLS, CHEVRON-REFINERY SITE, HOOVEN, OHIO.
MARCH – MAY 2005
Parts Per Billion Volume

Vapor Well VW-130 (Hooven & Madison)							
Depth	**Benzene**	**Toluene**	**Ethylbenzene**	**Xylene**	**Hexane**	**Trimethylbenzene**	**PCE**
5					14		
10	1.3	0.27	3		37		
15		1.9	1.8		2		2.1
20					5.1		
30	3.1	15	1.8	2.5			65
40					1.4		
50		1.6					
60							
Vapor Well VW-93 (Chidlaw & Brotherhood)							
Depth	**Benzene**	**Toluene**	**Ethylbenzene**	**Xylene**	**Hexane**	**Trimethylbenzene**	**PCE**
5							
10							
15							
20							
30							
35							
40							
45							
50							
55	1300	2.1			4.3		
60					910		
Vapor Well VW-96 (Ohio & Hooven)							
Depth	**Benzene**	**Toluene**	**Ethylbenzene**	**Xylene**	**Hexane**	**Trimethylbenzene**	**PCE**
5		2.4	1.4	3		1.2	
10							
15							
20							
30						1.6	0.88
35							68
40					1.4	3.7	0.15
45						4.5	2.7
55	1300		46		6800	45	
60							

TABLE 1. (Continued) VAPOR-PHASE HYDROCARBON DISTRIBUTION IN "NESTED" VAPOR WELLS, CHEVRON-REFINERY SITE, HOOVEN, OHIO. MARCH – MAY 2005 Parts Per Billion Volume							
Vapor Well VW-99 (Ohio & Alley)							
Depth	**Benzene**	**Toluene**	**Ethylbenzene**	**Xylene**	**Hexane**	**Trimethylbenzene**	**PCE**
5							
10							
15							
20							0.88
30	12	6.9	1.2	4.4	16	1	4.6
40							
50					770		
55					51000		
60							

TABLE 2.
COMPARISONS OF VAPOR-PHASE HYDROCARBON DISTRIBUTION IN VAPOR WELL VW-96, SAMPLED IN SEPTEMBER 1997 AND APRIL 2005.
Parts Per Billion Volume

APRIL 2005 (Trihydro, 2005)					
Depth	**Benzene**	**Toluene**	**Ethylbenzene**	**Xylene**	**Total VOCs as Hydrocarbons**
5					
10					
15					
20					
30					
40					
50					
55	1300		46		
60					
SEPTEMBER 1997(QST Environmental, 1998)[1]					
Depth	**Benzene**	**Toluene**	**Ethylbenzene**	**Xylene**	**Total VOCs as Gasoline**
10		170	390	1,200	320,000
15		78	210	710	330,000
20		6,800	8,300	32,000	9,600,000
25		140	390	600	210,000
30		54	48	320	78,000
35		3,200	690	670	8,600,000
40	14,000	8,900	2,800	5,800	40,000,000
45	18,000	8,900	5,800	20,000	49,000,000
50	81,000	43,000	19,000	55,000	120,000,000
55	248,000	73,000	39,000	106,000	180,000,000
60	341,000	81,000	41,000	81,000	200,000,000

[1]QST Environmental. 1998. *A Summary of the Hooven Area Environmental Investigation.* 5 p. & Appendices. Table C-8 (Appendix D), Soil Boring MW-96S (9/97), also, C-6 (8/97).

TABLE 3. DOWNHOLE VAPOR FLUX SAMPLE RESULTS IN THE HOOVEN AREA AUGUST 1998 (Parts Per Billion Volume)							
DF-1 (Downhole Vapor Flux Well 1 near Monitoring Well MW-99S)							
Depth	**Benzene**	**Toluene**	**Ethylbenzene**	**Xylene**	**Acetone**	**Methylene Chloride**	**Total Petroleum Hydrocarbons**
5	26	69	20	33	35	1,400	10,000
10	47	120	39	66	29		26,000
20	13	25	7.1	12	10	1.2	7,100
40	2,000	61	60	860	5,100	530	5,800,000
60	34,000	2,700	25,000	48,000			50,000,000
DF-2 (Downhole Vapor Flux Well 2 near Monitoring Well MW-96S)							
Depth	**Benzene**	**Toluene**	**Ethylbenzene**	**Xylene**	**Acetone**	**Methylene Chloride**	**Total Petroleum Hydrocarbons**
5	40	22	78	150	51		66,000
10	69	151	110	230	51		46,000
20	170	151	110	220	720	68	130,000
40	660		46	78			8,700,000
60	44,000	3,200	15,000	45,000			38,000,000
DF-3 (Downhole Vapor Flux Well 3 near Monitoring Well MW-93S)							
Depth	**Benzene**	**Toluene**	**Ethylbenzene**	**Xylene**	**Acetone**	**Methylene Chloride**	**Total Petroleum Hydrocarbons**
5	250	560	200	400	67		160,000
10	8.8	9	12	45	20	0.87	5,400
20	38	27	5.5	5.3	25		22,000
40	17	18	12	32	42		17,000
60	1,200	50	44	160			6,200,000

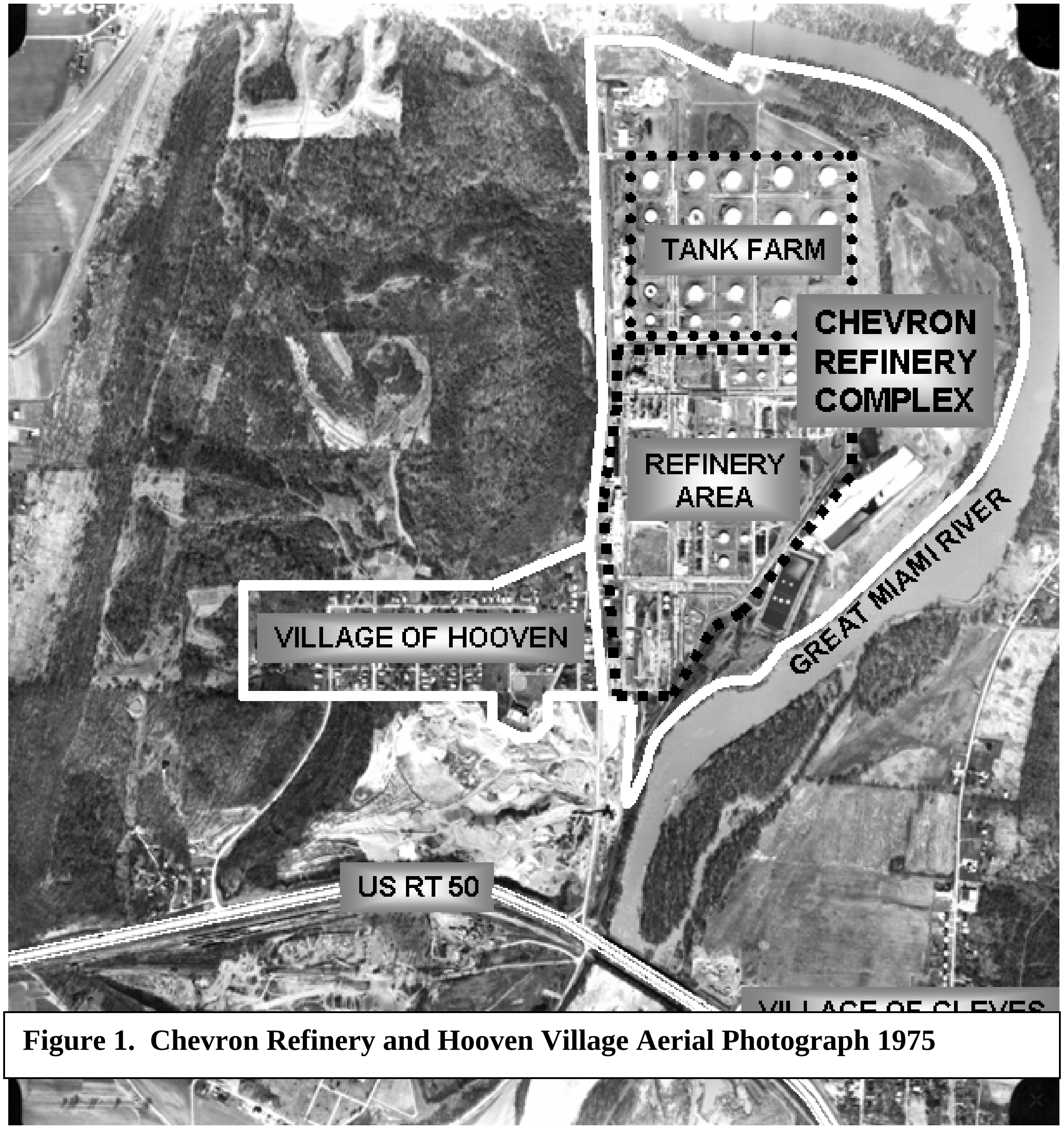


Figure 1. Chevron Refinery and Hooven Village Aerial Photograph 1975

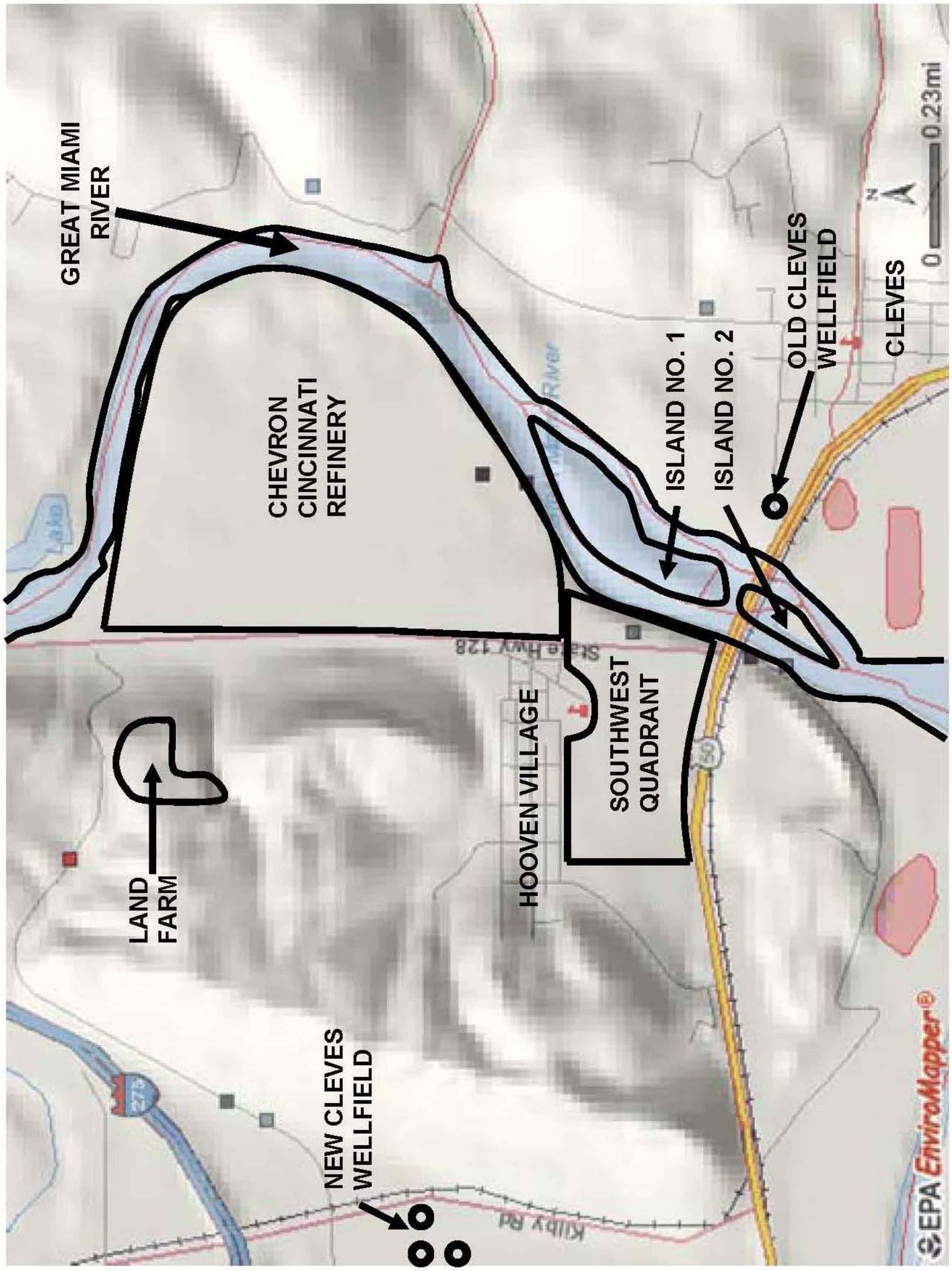


Figure 2. Site Location Map

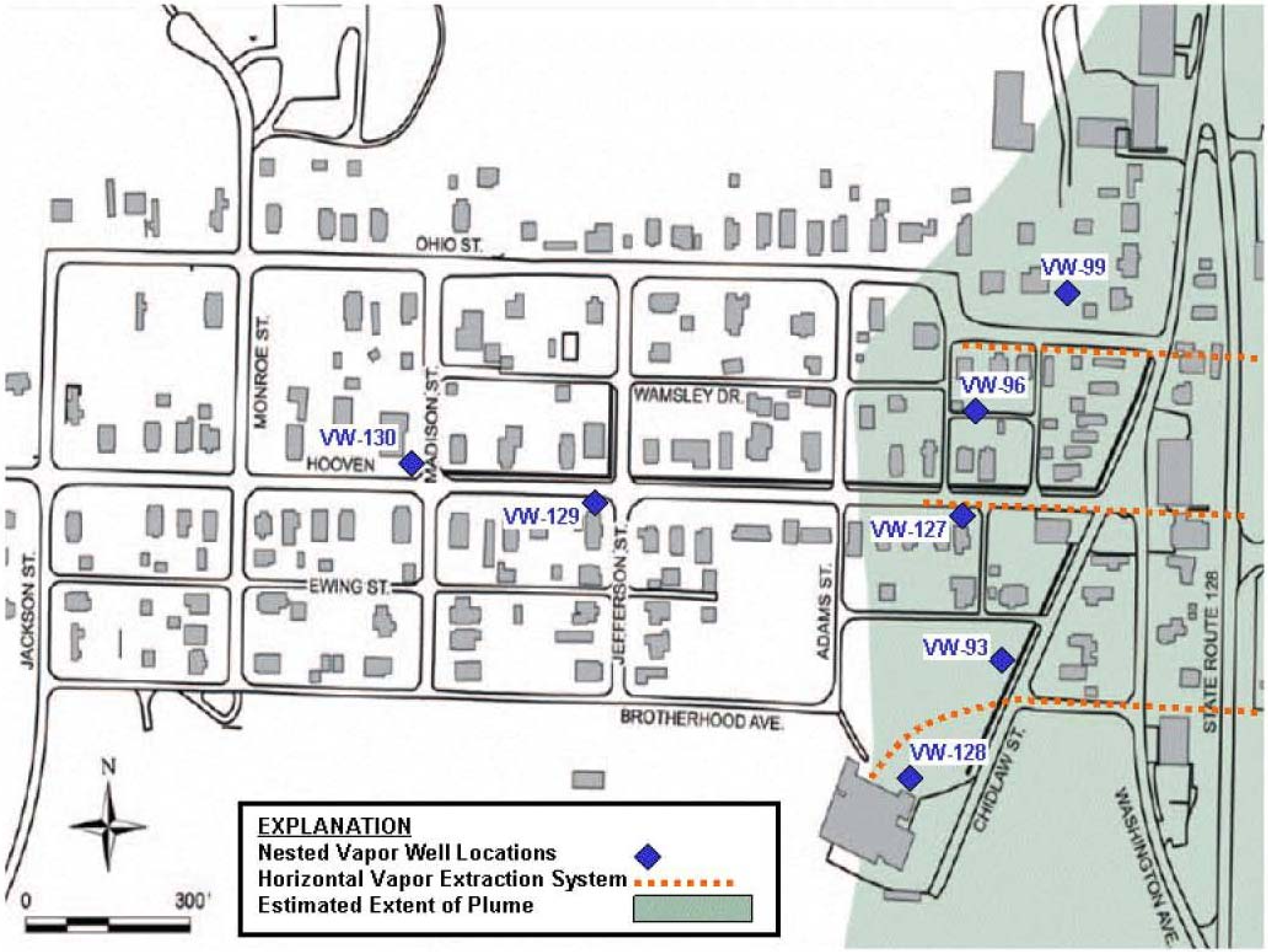


Figure 3. The Estimated Extent of the LNAPL Plume Under Hooven Village

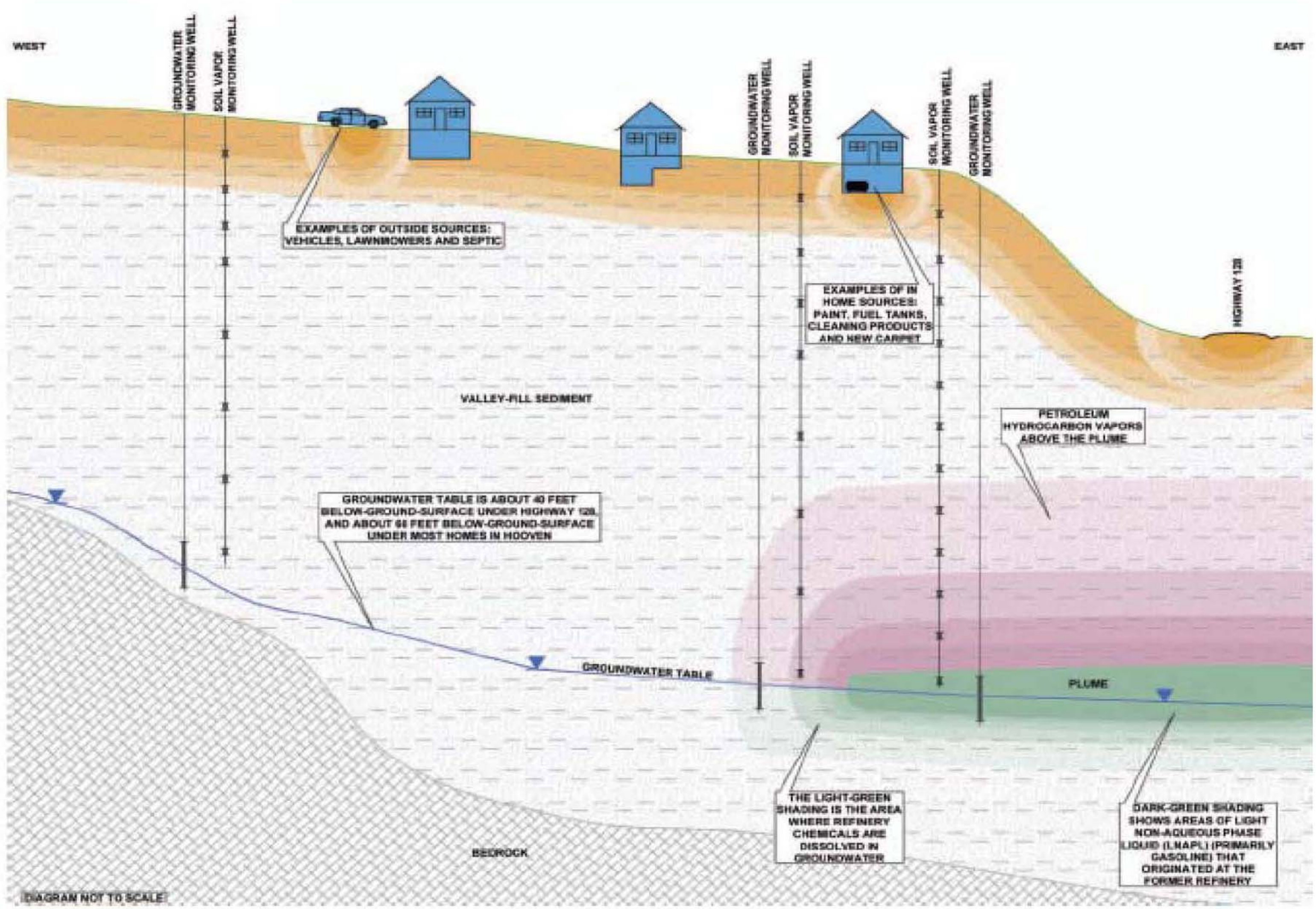


Figure 4. Chevron's Conceptual Site Model of Hooven Subsurface, East–West Cross Section

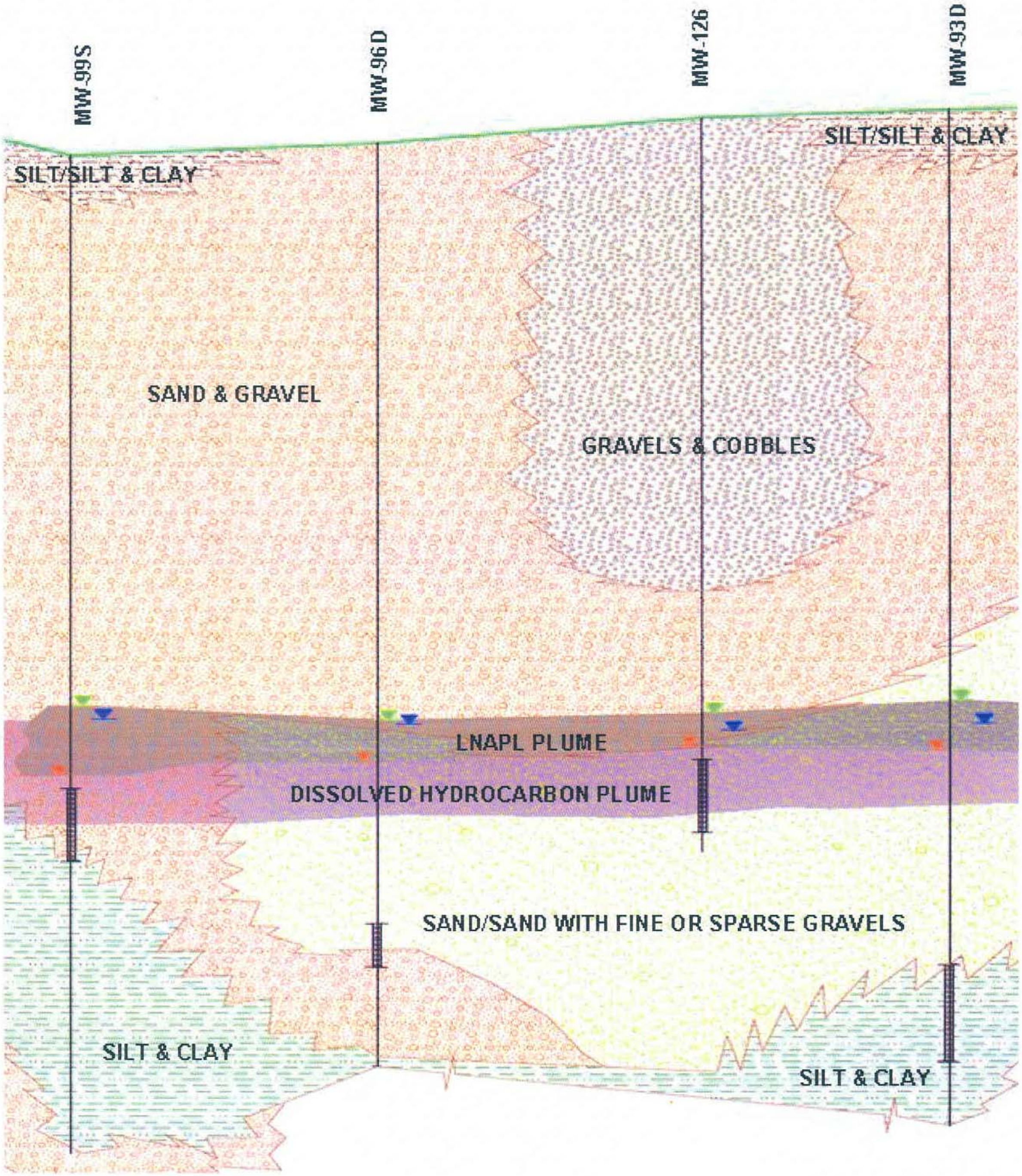


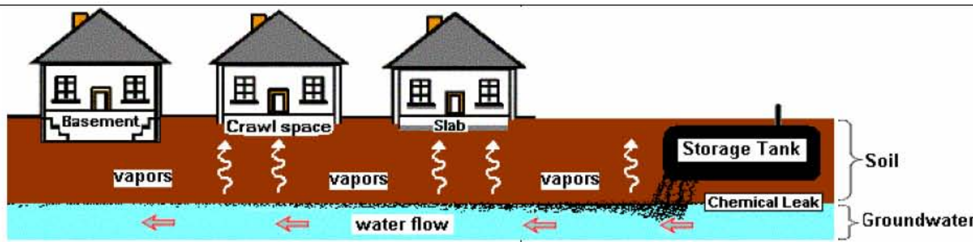
Figure 5. Generalized Geologic Cross Section Through MW-99S, MW-96D, MW-126, and MW-93D

Bureau of Environmental Health
Health Assessment Section

"To protect and improve the health of all Ohioans"

Vapor Intrusion

Answers to Frequently Asked Health Questions



What is vapor intrusion?

Vapor intrusion refers to the vapors produced by a chemical spill/leak that make their way into indoor air. When chemicals are spilled on the ground or leak from an underground storage tank, they will seep into the soils and will sometimes make their way into the groundwater (underground drinking water). There are a group of chemicals called volatile organic compounds (VOCs) that easily produce vapors. These vapors can travel through soils, especially if the soils are sandy and loose or have a lot of cracks (fissures). These vapors can then enter a home through cracks in the foundation or into a basement with a dirt floor or concrete slab.

VOCs and vapors:

VOCs can be found in petroleum products such as gasoline or diesel fuels, in solvents used for industrial cleaning and are also used in dry cleaning. If there is a large spill or leak resulting in soil or groundwater contamination, vapor intrusion may be possible and should be considered a potential public health concern that may require further investigation.

Although large spills or leaks are a public health concern, other sources of VOCs are found in everyday household products and are a more common source of poor indoor air quality. Common products such as paint, paint strippers and thinners, hobby supplies (glues), solvents, stored fuels (gasoline or home heating fuel), aerosol sprays, new carpeting or furniture, cigarette smoke, moth balls, air fresheners and dry-cleaned clothing all contain VOCs.




Can you get sick from vapor intrusion?

You can get sick from breathing harmful chemical vapors. But getting sick will depend on:
How much you were exposed to (dose).
How long you were exposed (duration).
How often you were exposed (frequency).
How toxic the spill/leak chemicals are.
General Health, age, lifestyle: Young children, the elderly and people with chronic (on-going) health problems are more at risk to chemical exposures.

VOC vapors at high levels can cause a strong petroleum or solvent odor and some persons may experience eye and respiratory irritation, headache and/or nausea (upset stomach). These symptoms are usually temporary and go away when the person is moved to fresh air.

Lower levels of vapors may go unnoticed and a person may feel no health effects. A few individual VOCs are known carcinogens (cause cancer). Health officials are concerned with low-level chemical exposures that happen over many years and may raise a person's lifetime risk for developing cancer.

How is vapor intrusion investigated?

In most cases, collecting soil gas or groundwater samples near the spill site is done first to see if there is on-site contamination. If soil vapors or groundwater contamination are detected at a spill site, environmental protection and public health officials may then ask that soil vapor samples be taken from areas outside the immediate spill site and near any potential affected business or home. The Ohio Department of Health (ODH) does not usually recommend indoor air sampling for vapor intrusion before the on-site contamination is determined.

(continued on next page)

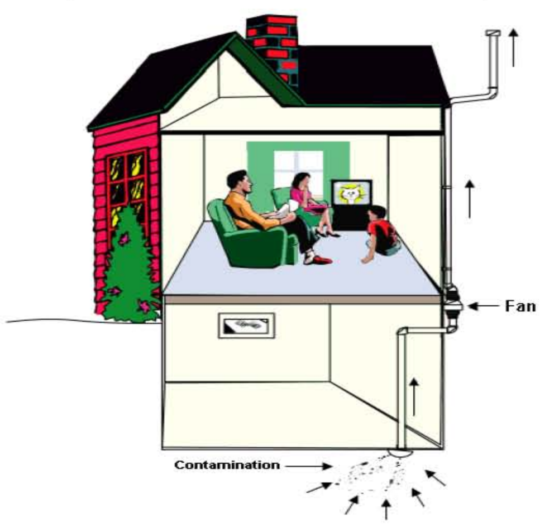
How is vapor intrusion investigated? (continued)

Because a variety of VOC sources are present in most homes, testing will not necessarily confirm VOCs in the indoor air are from VOC contamination in soils at nearby spill site. But if additional sampling is recommended, samples may be taken from beneath the home's foundation (called sub-slab samples), to see if vapors have reached the home. Sub-slab samples are more reliable than indoor air samples and are not as affected by other indoor chemical sources. If there was a need for additional sampling on a private property, homeowners would be contacted by the cleanup contractor or others working on the cleanup site and their cooperation and consent would be requested before any testing/sampling would be done.

What happens if a vapor intrusion problem is found?

If vapor intrusion is having an effect on the air in your home, the most common solution is to install a *radon mitigation system*. A radon mitigation system will prevent gases in the soil from entering the home. A low amount of suction is applied below the foundation and the vapors are vented to the outside. The system uses minimal electricity and should not noticeably affect heating and cooling efficiency. This mitigation system also prevents radon from entering the home, an added health benefit. Usually, the party responsible for cleaning up the contamination is also responsible for paying for the installation of this system. Once the contamination is cleaned up, the system should no longer be needed. In homes with on going radon problems, ODH suggests these systems remain in place permanently.

Radon Mitigation System



What can you do to improve your indoor air quality?

As stated before, the most likely source of VOCs in indoor air comes from the common items that are found in most homes. The following helpful hints will help improve air quality inside your home:

- Do not buy more chemicals than you need and know what products contain VOCs.
- If you have a garage or an out building such as a shed, place the properly stored VOC-containing chemicals outside and away from your family living areas.
- Immediately clean and ventilate any VOC spill area.
- If you smoke, go outside and/or open the windows to ventilate the second-hand, VOC-containing smoke outdoors.
- Make sure all your major appliances and fireplace(s) are in good condition and not leaking harmful VOC vapors. Fix all appliance and fireplace leaks promptly, as well as other leaks that cause moisture problems that encourage mold growth.
- Most VOCs are a fire hazard. Make sure these chemicals are stored in appropriate containers and in a well-ventilated location and away from an open pilot light (flame) of a gas water heater or furnace.
- Fresh air will help prevent both build up of chemical vapors in the air and mold growth. Occasionally open the windows and doors and ventilate.
- Test your home for radon and install a radon detector.

References:

Wisconsin Department of Health and Family Services, Environmental Health Resources, Vapor Intrusion, electronic, 2004.

New York State Department of Health, Center for Environmental Health, April 2003.

Ohio Department of Health, Bureau of Environmental Health, Indoor Environment Program, 2004.

For more information contact:

Ohio Department of Health
Bureau of Environmental Health
Health Assessment Section
246 N. High Street
Columbus, Ohio 43215
Phone: (614) 466-1390
Fax: (614) 466-4556

Created September 2004