Health Consultation

DELPHI HOME AVENUE SITE
(VAPOR INTRUSION)

DAYTON, MONTGOMERY COUNTY, OHIO

EPA FACILITY ID: OHN000510205

AUGUST 19, 2008

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

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Prepared By:
Ohio Department of Health
Under Cooperative Agreement with the
The U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

SUMMARY

This public health consultation (PHC) was prepared by the Health Assessment Section (HAS) of the Ohio Department of Health (ODH) under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). This PHC evaluates the public health threat posed by residential exposure to environmental contamination associated with the Delphi VOC Plume site in Dayton, Ohio.

Chemicals from former underground storage tanks on the Delphi facility have migrated through the soil and groundwater into the adjacent residential neighborhood by a process known as vapor intrusion. HAS evaluated the potential health impacts to the community, and with the assistance of ATSDR, recommended health-based short-term and long-term screening levels for residential indoor air and sub-slab soil gas to the U.S. Environmental Protection Agency (U.S. EPA). HAS and ATSDR made recommendations with regard to public health interventions if indoor air or sub-slab soil gas levels were exceeded.

HAS concluded that the site currently poses a ***public health hazard*** based on environmental sampling of the Delphi VOC Plume site and the detection of site-related chemicals in some of the residences. Seven residential locations out of about 30 properties sampled exceeded the indoor air long-term screening levels for one or more of the chemicals of concern. The U.S. EPA and Delphi have taken actions that will prevent vapors from entering homes in the near future; installing vapor abatement systems (VAS) that reroute gases to the outside of the home and reduce or eliminate the gases under and in the home. Subsequent sampling of indoor air following installation and operation of the VAS systems has confirmed that vapor-phase chemicals inside and under the homes no longer pose a health threat to these residences. In addition, Delphi has installed and is operating a large-scale soil vapor extraction (SVE) system on its property to address the on-site source of contamination. The SVE system, fully operational since July 2007, is already having an impact in reducing soil gas levels of the chemicals of concern in the residential area, as indicated by recent evaluation of soil gas levels on-site and off-site.

BACKGROUND AND STATEMENT OF ISSUES

Site Location and Description

The Delphi Home Avenue facility, located at 2701 Home Avenue in Dayton, Montgomery County, Ohio, is an industrial auto parts complex located in an urban residential area about one mile west of downtown Dayton. The facility, formerly owned by General Motors Corp., makes engine mounts and brake products. The eastern edge of the facility is adjacent to residential areas, including but not limited to South Ardmore Avenue, Bish Avenue and Cowart Avenue. Underground storage tanks containing perchloroethylene (PCE), trichloroethylene (TCE), 1,1,1-trichloroethane (1,1,1-TCA), and chloroform were once located in the eastern edge of the complex adjacent to this neighborhood. The soils and groundwater beneath the facility are contaminated with volatile organic compounds (VOCs) that historically leaked from the former underground storage tanks.

PCE, 1,1,1-TCA, TCE, and chloroform were detected in groundwater and soil gas on-site and in soil gas off-site under residential properties. Delphi installed a Soil Vapor Extraction (SVE) system on-site in 2006 to clean up contaminated soils at the site. Delphi installed probes in 2005 and 2006 along South Ardmore, Bish and Cowart Avenues and sampled soil gas for VOCs. Delphi laboratory results indicated PCE concentrations as high as 180,000 parts per billion (ppb) by volume, 1,1,1-TCA as high as 179,000 ppb, TCE concentrations as high as 7,700 ppb, and chloroform concentrations as high as 11,000 ppb in the off-site soil gas.

On March 5, 2007, the Ohio EPA requested assistance from U.S. EPA Region 5 to investigate the potential for vapor intrusion from historic spills from underground storage tanks containing TCE, PCE and chloroform originating from the Delphi facility on Home Avenue in Dayton to migrate under and into nearby residences.

Delphi, through the environmental consultant Haley and Aldrich, and without U.S. EPA oversight, collected sub-slab air samples in twelve homes located east of the Delphi facility during April and May of 2007. Sub-slab samples showed PCE concentrations up to 3,600 ppb, 1,1,1-TCA levels up to 1,100 ppb, TCE levels up to 1,300 ppb, and chloroform levels up to 4,700 ppb.

U.S. EPA requested recommendations from the Health Assessment Section (HAS) at the Ohio Department of Health (ODH) for health-based screening values, which were provided in a letter to U.S. EPA in June 2007 (Appendix A.).

Demographics

The area within one mile of the site is primarily African-American (96%), with children age 6 and younger and adults age 65 and older comprising about 12% and 16% of the total population, respectively (see Figure 1).

Area Geology and Hydrogeology

The Delphi-Home Avenue facility consists of 55-acres in west Dayton, paralleling West Third Street to the north and US Rt. 35 to the south (Figure 1). The western half of the facility is located on the east side of a bedrock hill at an elevation of 840 ft above Mean Sea Level (MSL) with the land sloping down to an elevation of roughly 760 ft MSL on the west side of South Ardmore Avenue, roughly ½ mile to the east (Figure 2). The Delphi property is located, geologically, on the western edge of a buried bedrock valley that underlies the flood plain of the Great Miami River. The underlying bedrock valley is filled with up to 200 ft of water-saturated sand, gravel, and clay that make up the Miami Valley Aquifer system; the source of drinking water for much of the Dayton area. All Delphi-area residents get their drinking water from the City of Dayton municipal water supply whose source is the groundwater pumped from the Miami Valley Aquifer at the Miami North well field, five miles to the northeast and upstream from the Delphi-Home Avenue site (City of Dayton, pers. comm., 2007). Groundwater contamination at the

Delphi-Home Avenue site has no impact on the quality of the water being pumped at the Miami North well field and used for drinking water by West Dayton residents.

In the vicinity of the Delphi-Home Avenue site, the valley-fill sand and gravel deposits thin to the west, pinching out up against the bedrock hill underlying the west end of the Delphi property. On the east side of the property, adjacent to S. Ardmore Avenue, the site is underlain by about 50-60 ft of mostly porous and permeable loose sand, gravel, and clay-rich soils (Figure 3). These consist of: 1) a surficial clay layer up to 10 ft thick; followed by 2) up to 10 ft of sand and gravel; 3) another clay layer 0 to 4 ft thick; and, 4) a water-bearing sand and gravel layer 30+ ft thick (ODNR well logs, 2008). Under the eastern half of the site, the groundwater surface is about 35-40 ft below the ground surface (Haley & Aldrich, 2007). Groundwater flow under the Delphi property appears to be to the east-southeast toward the Great Miami River. Most residences in the area are single-family homes with basements or crawl spaces that are cut into the shallow sand and gravel layer, 10-15 ft below the ground surface.

Discovery of Site-Related Contamination

Delphi initiated environmental sampling at the Home Avenue plant starting in 2003 with the installation of a limited number of groundwater monitoring wells. The focus of additional investigations in 2005 and 2006 centered on several former underground storage tank (UST) areas at the eastern edge of the Delphi property (Figure 2). The USTs were used to store solvents and other chemicals used in manufacturing processes at the plant. The USTs were dug-up and removed in 1989, but the enclosing soils – contaminated by spills and leaks from the tanks, evidently were left in-place at the site. Two primary contaminant “hot spots” were identified (Figure 2):

<u>Area A</u>: at the southeast corner of the Delphi property in the vicinity of S. Ardmore Avenue; included 10 USTs, each capable of storing from 1,000 to 12,000 gallons of solvents, including perchloroethylene (PCE), 1,1,1-trichloroethane (1,1,1-TCA), trichloroethylene (TCE), and waste oil and gasoline; and,

<u>Area B</u>: at the north side of the eastern edge of the property, near the south end of Bish Avenue; one UST that stored up to 6,000 gallons of chloroform.

Delphi Corporation Investigations

In 2005, Delphi installed a large number of temporary probes both on-site and off-site to sample soils and groundwater. This led to additional site-wide sampling in 2006, including 107 soil borings (222 soil samples collected from depths from the surface to 30 ft); sampling of 13 on-site and off-site groundwater monitoring wells; installation and sampling of 35 permanent on-site and off-site soil vapor sampling points; and the sampling of an additional 30 temporary off-site soil vapor sample sites.

<u>On-site Soil Sampling Results:</u>

As indicated above, in 2005 Delphi collected soil samples from 65 borings on the east half of the Delphi plant property, collecting 170 soil samples for lab analysis. Soil samples were collected down to depths as much as 30 ft below the ground surface. Discrete soil samples were collected from each boring at depths of: 1) 0-2 ft bgs; 2) 8-10 ft bgs; and 3) depths greater than 15 ft bgs.

On-site, the solvent PCE was detected in soils at levels ranging from 5 to 170,000 parts PCE per billion parts of soil (ppb). The highest levels of PCE typically were found in soils in the vicinity of UST Area A at depths of 15 ft or more. The solvent chloroform was detected in soils at concentrations from 1.6 to 130,000 ppb with the highest levels detected in the uppermost 0-2 ft of soil in the vicinity of former UST Area B.

Soils contaminated with high levels of a variety of volatile organic compounds, including the solvents PCE, TCE, 1,1,1-TCA, and chloroform, are closely associated with former UST Areas A and B at the east end of the Delphi plant property. These contaminated soils are likely the primary sources of the groundwater and soil gas contamination detected under the Delphi property and under adjacent residential areas along S. Ardmore and Bish Avenues, immediately east and north of the plant property.

<u>Groundwater Contamination under the Delphi Site:</u>
Groundwater was detected in two distinct layers below the Delphi site: 1) shallow "perched" groundwater in the upper shallow sand and gravel layer 10-15 ft bgs; and 2) a deeper, primary water table in the sand and gravel unit below the second clay layer, at a depth of 35-40 ft below the site (Figure 3). Site-related contaminants of concern (COCs) were detected in both aquifers although concentrations of contaminants were significantly higher in the shallow "perched" groundwater than in the deeper "primary" aquifer.

Elevated concentrations of PCE (up to 8,000 ppb) and 1,1,1-TCA (up to 1,300 ppb) were detected in the shallow "perched" groundwater sampled in the vicinity of UST Area A on the Delphi property in 2004. Similarly, elevated levels of chloroform (up to 3,300 ppb) were detected in "perched" groundwater under UST Area B on-site in 2004. "Perched" groundwater sampled from borings along the north edge of the Delphi property had only single-digit part per billion, trace-levels of site-related contaminants. One of three soil-boring sites along the eastern fence-line of the site (just west of S. Avondale) sampled for groundwater in 2005 had elevated levels of PCE (660 ppb); 1,1,1-TCA (440 ppb); and TCE (490 ppb).

Groundwater samples collected from the deeper, "primary" sand and gravel aquifer under the Delphi site in 2003 and 2004 had only double-digit part per billion levels of site-related COCs, including 1,1,1-TCA (up to 28 ppb) and TCE (up to 29 ppb). Samples of groundwater from several locations off-site in the surrounding residential neighborhood collected in 2006 had only trace levels (fraction of a part per billion) at most locations with somewhat higher levels of chloroform (up to 12 ppb) and TCE (up to 20 ppb) detected at depths of 40+ ft under residential areas east of S. Avondale. These detections in the groundwater pose no exposure threat to area residents as they are buried at a depth of 40+ ft below the ground surface and are separated from the surface by two separate low-permeability clay layers. Also, nobody is using the groundwater for drinking water.

Soil Vapor Sampling:

Based on the discovery of contaminated soils and groundwater under the Delphi site in the vicinity of UST areas “A” and “B”, plus the presence of porous and permeable soils under the site and extending under adjacent residential areas along S. Avondale, Bish, and Cowart Avenues, Delphi installed a system of 35 permanent soil gas probe sites both on-site under the plant and off-site in adjacent residential areas in 2006 (Figure 4). Most of these gas probes were set up to sample soil gas at depths of from 6.5 to 10 ft below the ground surface (bgs). An additional 30 temporary soil gas probes were also installed in off-site areas surrounding the plant property in 2006. These probes also were set to sample soil gas at depths from 6.5 to 7 ft bgs. The relative make-up of the chemicals detected in the soil vapor samples collected on-site closely match the known constituents of the USTs in on-site Areas A and B, further linking the soil vapor levels on and off-site with the contaminated soils on-site.

On-Site Soil Vapor Results:

Concentrations of the solvent 1,1,1-TCA collected from permanent on-site soil gas probes in former UST Area A ranged up to 54,000 ppb. Levels of PCE in soil gas on-site in and around UST Area A ranged up to 56,000 ppb. Levels of the solvent TCE were detected as high as 7,700 ppb in Area A.

Chloroform was detected at concentrations as high as 5,800 ppb in the vicinity of UST Area B on the north edge of Delphi property line. PCE levels in on-site soil gas in the vicinity of UST Area B ranged up to 41 ppb; TCE was detected at levels as high as 620 ppb; and 1,1,1-TCA was detected in Area B at levels as high as 17,000 ppb.

Off-site Soil Vapor Results:

In 2006, Delphi collected soil vapor samples from 11 permanent off-site soil gas probe sites and an additional 38 temporary soil gas probes sample points. Permanent probe samples from off-site areas adjacent to on-site UST Area A (south end of South Avondale Ave.) had detections of PCE as high as 10,000 ppb and 1,1,1-TCA up to 11,000 ppb. Temporary soil gas probes in the same area had PCE at levels as high as 180,000 ppb; 1,1,1-TCA up to 179,000 ppb; TCE as high as 3,800 ppb; and chloroform at levels up to 1,900 ppb.

Permanent off-site soil gas probe sites in residential areas in the vicinity of south end of Bish Avenue, across the fence-line from former UST Area B, had PCE levels as high as 1,800 ppb; 1,1,1-TCA up to 58 ppb; TCE up to 250 ppb; and chloroform as high as 890 ppb. Off-site temporary gas probe sites in the same area sampled in 2006 had PCE up to 32,000 ppb; 1,1,1-TCA as high as 260 ppb; TCE as high as 1,600 ppb; and chloroform up to 6,500 ppb.

The detections of significant amounts of site-related vapor-phase PCE, 1,1,1-TCA, TCE, and chloroform in soil gas underlying off-site residential areas immediately adjacent to the Delphi plant property line in 2006 led to concerns on the part of Delphi and Ohio EPA with regard to a completed vapor intrusion pathway allowing these chemicals to migrate via the soil gas route to off-site residences. These results led to the request for US EPA's Emergency Response Branch to evaluate the off-site contaminant risks to residents in the area in 2007 and the development, installation, and operation of the on-site Soil Vapor Extraction system to try and capture on-site vapor-phase chemicals before they migrated off-site to adjacent residences in 2006.

U.S. EPA Soil Gas/Indoor Air Investigation and Meetings

HAS was initially advised of the issues at the site via Ohio EPA Southwest District Office (SWDO) staff and the U.S. EPA Emergency Response Branch On-Scene Coordinator at a technical meeting held at the SWDO in Dayton, Ohio on March 23, 2007.

On May 31, 2007, U.S. EPA, the HAS, Ohio EPA, Public Health of Dayton and Montgomery County, and Delphi participated in a public meeting to discuss the vapor intrusion investigation with the area residents. HAS staff discussed the chemicals of concern and answered health-related questions from the audience. U.S. EPA and their contractor Weston Solutions, Inc. also recruited residents at the meeting to allow U.S. EPA access to their property to sample sub-slabs and indoor air in their homes.

From April 2007 through July, 2007, Delphi and U.S. EPA collected sub-slab and indoor air samples at 15 residences (U.S. EPA 2007).

On October 3, 2007, HAS staff participated in one-on-one meetings with residents who had their homes (sub-slabs & indoor air) sampled by U.S. EPA for VOCs associated with the Delphi Home Avenue site. Representatives from U.S. EPA, Delphi, Public Health - Dayton and Montgomery County, and HAS met with 10 residents living adjacent to the plant. U.S. EPA discussed the site history; nature of the vapor intrusion pathway; presented residents with their results; proposed plans for further action regarding their homes, and then answered questions. Future actions included either installation of sub-slab vapor abatement systems, quarterly monitoring or no further action. Systems were offered to five residences and quarterly monitoring to the other five residences. On October 16, 2007, U.S. EPA had signed access agreements with all 10 sets of residents for installation of mitigation systems or the quarterly monitoring.

On November 14, 2007, HAS staff, along with US EPA and representatives of Delphi, met with community residents and local government officials at the Westwood Recreation Center in Dayton to provide residents with an update on results of the on-going U.S. EPA-Delphi Time-Critical Removal Action addressing vapor intrusion issues in the neighborhood. Roughly 50-60 people were in attendance, including 15-20 residents plus numerous government officials, a number of community activists, and a class from the University of Dayton.

The U.S. EPA On-scene Coordinator presented an update on the ongoing vapor intrusion investigation, including the results of the recent U.S. EPA sampling of sub-slabs and indoor air in 8 area residences and the recently signed Administrative Order of Consent between U.S. EPA and Delphi to investigate vapor intrusion concerns in the area. This work was divided into Phase I work to install vapor mitigation systems in five sampled homes and pursue quarterly monitoring in another five houses, and Phase II work to expand the sampling of area homes for chlorinated solvents north and west of the known area of contamination. HAS staff talked about the chemicals of concern and their toxicity. This was followed by an animated Question & Answer session with the public.

Questions and concerns voiced by the audience focused on the source(s) of the contamination at the plant property and what was being done to clean this up; releases of contaminants to the air from the Soil Vapor Extraction system being used to clean up contaminated soils at the site; health impacts on long-term residents living near the plant; and the need for a community health study to determine the extent of these impacts. An extended discussion followed: including the rationale for such a health study, who would do it, how it would be funded, its design, and what would be the intended outcome from the study. HAS described some of the problems with such a study, including:

- Lack of information on past exposures to the community;
- Rapid metabolism of these chlorinated solvents and their typically quick elimination from the body;
- Lack of knowledge about health impacts from long-term exposure to low parts-per-billion levels of these solvents detected in the off-site environment;
- The lack of unique health symptoms linked to such exposures.

HAS passed on the community’s request for a health study to ATSDR in Atlanta. ATSDR’s Division of Health Studies will present its position on whether or not such a study is appropriate or feasible for this community during a public meeting planned for August 20, 2008. HAS also requested the Chronic Disease and Behavioral Epidemiology Section at ODH to conduct a community cancer incidence assessment of the impacted area. ODH plans to complete a cancer incidence report and have the results presented at the same public meeting in August 2008.

Delphi Off-site Investigation & Mitigation

Delphi installed individual home vapor abatement systems in five residences in December 2007. Follow-up sampling was conducted to confirm that the systems were operating effectively. Quarterly monitoring was conducted for five other residences that had sub-slab levels for PCE, TCE, or chloroform that exceeded sub-slab screening levels but had indoor air results that were below ODH-recommended indoor air screening levels.

The Phase 2 vapor investigation included targeting 28 additional residences north and south of the Delphi facility for sampling. Twelve properties were sampled in March 2008, eight homes were uninhabitable, and eight property owners did not respond despite best efforts by Delphi. Of the 12 homes sampled, two additional locations were identified for vapor mitigation, and one additional location was identified for quarterly monitoring.

As of July 2008, of the 32 locations which were sampled by Delphi and/or U.S. EPA, a total of seven were selected for vapor abatement systems, 14 did not require any further action, and six were identified for further investigation via quarterly monitoring. Sixteen additional targeted locations were not able to be tested due to a lack of access, either due to an inability to contact the owner or due to the properties being without utilities and uninhabitable.

Delphi On-site Remediation

Delphi, in April 2006, in order to address the source of the vapor-phase solvents detected in the community, installed and operated a large-scale soil vapor extraction (SVE) system on its property. Following approval by Ohio EPA for expanded operation, the system has been operated 24/7 since July 2007. The SVE system removes the chemical vapors from the ground through four extraction wells. These extraction wells are spaced around the area where the chemicals of concern were historically contained in underground storage tanks. The extraction wells are positioned to prevent chemical vapors from moving off Delphi's property. Since it began operation, the SVE system has removed over 1,890 lbs of contaminants (Delphi pers. comm. 2008). Operation of the on-site SVE system has already resulted in observable reductions in soil vapor concentrations in the neighborhood (Delphi pers. comm. 2008). The Ohio EPA oversees the operation of the SVE system and tracks performance by reviewing monthly performance reports. Operation of the SVE system over the next several years should reduce on-site and off-site soil vapor levels, eventually eliminating the vapor intrusion threat to off-site residents.

DISCUSSION

Potential Exposure Pathways

For the public to be exposed to elevated levels of chemical contaminants in and around the Delphi site, they must first come into contact with the contaminated groundwater, soils, soil gas, or air. To come into contact with chemical contaminants in the environment there must be a completed exposure pathway. A completed exposure pathway consists of five main parts, which must be present for a chemical exposure to occur.

A **completed exposure pathway** consists of five main parts:

1. **A source of contamination**;
2. **Environmental transport**, which is a way for the chemical to move away from its source (soil, soil gas, air, groundwater, surface water);
3. **A point of exposure**, which is a place where people come into physical contact with the chemical (on-site, off-site);

4. **A route of exposure**, which is how people come into physical contact with the chemical (breathing, drinking, eating, touching); and
5. **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 (dose).
- How long a person is exposed to the chemical (duration).
- How often a person is exposed to the chemical (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

> Volatile organic compounds (VOCs) are chemicals that can vaporize (readily change from a liquid to a gas) from contaminated groundwater or soil and migrate as a gas to the indoor environment of nearby buildings (see Vapor Intrusion Fact Sheet).

Factors that favor the transport of these chemicals at the Delphi site include elevated levels of the VOCs PCE, TCE, and chloroform detected in onsite soils and groundwater and onsite and offsite soil gas. Also, the geology in the vicinity of the site, including the presence of porous and permeable soils at shallow depths just below the ground surface at the site and under the adjacent neighborhood, allows for ready migration of onsite soil gases offsite into residential portions of Bish and South Ardmore Avenues.

The U.S.EPA and Delphi detected VOCs in sub-slab soil gas and the indoor air in sampled residences, indicating a completed exposure pathway.

Chemicals of Concern

The primary contaminants of concern at the Delphi site are perchloroethylene (PCE), 1,1,1-trichloroethane (1,1,1-TCA), trichloroethylene (TCE), and chloroform.

Exposure Evaluation

HAS recommended health-based guidance values to be used to evaluate the results of sampling of sub-slab soil gas and indoor air in residential and commercial properties in the vicinity of the Delphi Home Avenue site in a letter to U.S. EPA dated June 4, 2007.

Short-term action levels were derived from ATSDR's Minimal Risk Levels (MRLs) for inhalation exposures to airborne contaminants. MRLs are an estimate of the daily human exposure to a substance that is not expected to cause adverse health effects during a specified period of exposure. MRLs are based on non-cancer health effects. The short-term action level was applied by HAS to denote a level that would trigger immediate action to be taken to reduce exposure levels in homes affected by vapor intrusion.

Long-term screening levels were derived from the target concentrations listed in the U.S. EPA OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils [Subsurface Vapor Intrusion Guidance] (2002). The values presented for these specific compounds are based on a theoretical cancer risk of 1 in 10,000 (10^{-4}) and assume exposure for 24 hours per day for 350 days per year over a period of 30 years, or a non-cancer hazard index of greater than one.

Phase 1

Delphi and U.S. EPA collected sub-slab soil gas samples at 15 residential properties from April 2007 through July 2007 as a part of the Phase 1 Indoor Air Sampling and Mitigation Work Plan (U.S. EPA 2007). Twenty residential units in all were tested, since some of the properties had more than one residence. The sub-slab soil gas data is presented in Table 1. Nine properties, consisting of 11 residential units, had VOC levels detected underneath the slab that exceeded the recommended sub-slab screening levels.

The indoor air sample results for Phase 1 are shown in Table 2. Five properties exceeded the 0.4 ppb long-term screening level for TCE. In addition to the presence of TCE in the indoor air, one unit also had a level of chloroform that exceeded the 2.2 ppb long-term screening level for chloroform, and one unit also had a level of PCE that exceeded the 12 ppb long-term screening level for PCE.

Phase 2

Twenty-eight additional properties were included in the Phase 2 Indoor Air Sampling and Mitigation Work Plan. Sampling for Phase 2 began in March 2008. As of May 2008, 12 additional homes were tested. The sub-slab soil gas data for Phase 2 is presented in Table 3. The indoor air sample results for Phase 2 are shown in Table 4. Two additional homes were identified as having TCE indoor air levels that were above screening levels. However, 16 out of the 28 homes targeted in Phase 2 were not able to be sampled due to a lack of response from the owner (8 homes) or the properties were lacking utilities and considered to be uninhabitable (8 homes).

Seven properties in the immediate neighborhood of the Delphi facility in Dayton, Ohio, had VOC levels in the indoor air above recommended long-term screening levels.

Overall, 32 out of 46 residences in the area have been sampled as of July 15, 2008. Of those 32 locations that have been sampled, seven locations were recommended for vapor abatement system installation. A total of seven vapor abatement systems have been installed to date by Delphi (U.S. EPA Site Profile July 15, 2008 Update). Follow-up sampling has demonstrated that indoor air levels of contaminants of concern in those homes were no longer exceeding health-based long-term risk levels.

Health Evaluation

<u>Perchloroethylene (PCE)</u>

Discussion

Perchloroethylene, (also known as tetrachloroethylene, PCE, or PERC) is a nonflammable liquid at room temperature and was widely used for dry cleaning of fabrics and for metal degreasing. Other major uses of PCE were as a solvent in some consumer products and as a building block to make other chemicals. It evaporates easily into the air and has a sharp, sweet-smelling odor. At levels in excess of 1 part PCE per million parts of air (1 ppm or 1,000 ppb), the odor of PCE can be detected by most people (ATSDR 1997a). Much of the PCE that gets into surface water and soil evaporates into the air. In the air, it is broken down by sunlight into other chemicals or brought back to the soil and water by rain. Because PCE can travel through soils quite easily, it can make its way into underground water, where it may remain for a long time. Under oxygen-poor environmental conditions and with time, bacteria will break down some of the PCE that is in groundwater, leading to the formation of dichloroethylene and vinyl chloride (Vogel & McCarty 1985).

There are three ways that people are typically exposed to PCE; 1) from occupational sources, 2) from consumer products, and 3) from environmental sources. PCE in the environment is found most frequently in the air and less often in drinking water. It does not appear to bioaccumulate in fish or other animals that live in water (see Fact Sheet for PCE).

Acute Effects

PCE was used safely in the past as a general surgical anesthetic agent at concentrations high enough to cause a loss of consciousness. Single exposures in air at high concentrations (greater than 100,000 ppb in air) can cause dizziness, headache, sleepiness, confusion, nausea, difficulty in speaking and walking, unconsciousness, and death. Skin irritation may result from repeated or prolonged exposure to this chemical. High exposures have occurred in work or hobby environments where there have been accidental exposures to concentrated PCE. High exposures have also occurred from intentional chemical abuse to get “high.” Animal studies, with exposures to high concentrations of PCE, have concluded that such exposures may cause liver and kidney damage and cancers. The relevance of these animal studies to humans, however, is unclear (ATSDR 1997a).

ATSDR established 200 ppb PCE in air as a Minimal Risk Level (MRL), based on protection from neurological effects associated with acute (short-term) exposure to PCE (ATSDR 1997a). HAS used this value as a short-term action level for PCE in indoor air in residential structures.

The levels of PCE detected in the indoor air of the basements near the Delphi site in Dayton, Ohio are in the low ppb range (0.09 to 19 ppb) and are not expected to cause any short-term health effects.

Chronic Effects (Noncancer)
Animal studies have reported effects on the liver, kidney, and CNS from chronic inhalation exposure to PCE. ATSDR has calculated a chronic-duration inhalation minimal risk level (MRL) of 40 ppb for PCE based on neurological effects in humans (ATSDR 1997a).

Cancer Risk
The U.S. Environmental Protection Agency (U.S. EPA), the National Toxicology Program (NTP), and the International Agency for Research on Cancer (IARC) classify carcinogens based on the strength of the scientific evidence linking a substance with cancer outcomes under the reported conditions of testing. PCE's classification as a human carcinogen is under review by the U.S. EPA. Although exposure to PCE has not been directly shown to cause cancer in humans, the NTP has determined that PCE is *"reasonably anticipated to be a human carcinogen"* (NTP 2005). IARC has classified PCE as a Group 2A carcinogen (IARC, 1995); *probably carcinogenic to humans* (limited human evidence, sufficient evidence in animals).

PCE tends to be retained in the body for a longer period of time than TCE, having the ability to accumulate to a limited extent in fatty tissues (NIOSH, 1976; 1978). Several studies of workers at dry-cleaning businesses have suggested associations between the development of elevated occurrence of urinary tract, kidney, and cervical cancers and chronic exposures to high levels (thousands of parts per billion range) of PCE and other dry-cleaning chemicals in the air at their places of work (Katz and Jowett, 1981; Brown and Kaplan, 1987). These studies were confounded by the presence of carbon tetrachloride, TCE, and several petroleum-based solvents, in addition to PCE, in these indoor air environments.

The Woburn, Massachusetts study (Lagako et al., 1984), the New Jersey study (Fagliano et al., 1990), and ATSDR studies of PCE and TCE contaminated water supplies at the Camp Lejuene Marine base (ATSDR, 2003) have associated exposure to these chemicals via the drinking water route with increased levels of leukemia in specific populations within these communities.

HAS recommended a long-term screening level of 12 ppb for PCE in indoor air, based on a calculated 10^{-4} cancer risk. Only one of the homes tested near the Delphi site exceeded this level and it received a sub-slab vapor abatement system.

Trichloroethylene (TCE)

Discussion

The primary use of trichloroethylene has been the degreasing of metal parts and its use has been associated with the automotive and metal-fabricating industries from the 1950's through the 1970's. It is an excellent solvent for removing greases, oils, fats, waxes, and tars. As a solvent it was used alone or blended with other solvents, such as PCE. These solvents were also added to adhesives, lubricants, paints, varnishes, paint strippers, pesticides, and cold metal cleaners. When in surface soils, TCE will form a gas faster than many other volatile organic compounds. It has been shown that the majority of the TCE put on soils close to the surface will vaporize into the air. When TCE is released into the air, it reacts relatively quickly with sunlight and other chemicals with about half of it breaking down in about a week. TCE's ability to stick to soil is largely dependent on the organic carbon content of the soil; soils with a higher organic carbon content tend to more effectively adsorb the TCE. TCE is known to be only slightly soluble in water, but there is ample evidence that dissolved TCE remains in groundwater for a long time. Studies show that TCE in water will vaporize rapidly upon contact with the air. In a sand and gravel aquifer, TCE in the groundwater would rapidly vaporize into the air spaces between soil grains. Studies indicate that it would then disperse by two primary routes; first, diffusion through the soil air spaces and then be re-adsorbed by groundwater or infiltrating rainwater, or second, it would migrate to the surface and be released to the atmosphere. The primary means of degradation of trichloroethylene in groundwater is by bacteria, but a breakdown product by this means is vinyl chloride, a known human carcinogen that potentially can be more of a health concern than TCE (Vogel and McCarty, 1985).

Acute Effects

Studies of workers in industries that used TCE on a regular basis indicated that breathing large amounts (greater than 100,000 ppb in air) of TCE can cause impaired heart function, unconsciousness, and death. Breathing high levels of TCE for long periods can cause nerve, kidney, and liver damage. Breathing lesser amounts of TCE may cause headaches, lung irritation, dizziness, poor coordination, and difficulty concentrating. OSHA has set an occupational limit of 100,000 ppb for TCE for an 8-hour workday, 40-hour workweek. ATSDR has established a 2,000 ppb acute MRL for TCE, based on protection from neurological effects associated with acute (short-term) exposure to TCE (ATSDR 1997b).

Chronic Effects (Noncancer)

ATSDR does not have a chronic-duration inhalation minimal risk level for TCE; however, ATSDR has established a 100 ppb MRL based on protection from neurological effects to intermediate exposure (15-365 days) to TCE (ATSDR 1997b). The intermediate ATSDR value of 100 ppb has been used by HAS as a "short term action level" that would trigger immediate action to reduce exposure levels in homes affected by vapor intrusion.

The levels of TCE detected in the indoor air of the basements near the Delphi site in Dayton, Ohio are in the low single-digit ppb range (up to 4.2 ppb TCE) and do not pose a short-term health threat to the residents.

Cancer Risk

TCE was most recently classified by the U.S. EPA as a B2 carcinogen – a probable human cancer-causing agent. However, the cancer classification of TCE has been withdrawn and is currently under review by U.S. EPA. The National Toxicology Program has determined that TCE is *"reasonably anticipated to be a human carcinogen"* (NTP 2005). IARC has classified TCE as a Group 2A carcinogen; *"probably carcinogenic to humans"* (IARC 1995).

Occupational exposure to TCE, based on the analysis of seven studies of workers, was associated with excess incidences of liver cancer, kidney cancer, non-Hodgkin's lymphoma, prostate cancer and multiple myeloma, with the strongest evidence for the first three cancers (NTP 2005). Agreement between animal and human studies supports the conclusion that TCE is a potential kidney carcinogen. High doses are needed to induce liver toxicity and cancer in animals; however differences in the mode of action of the major metabolites in humans suggest that humans would be less susceptible to liver cancer (National Academy of Sciences [NAS] 2006).

The health effects from drinking and/or inhaling low levels of TCE over long periods of time remain poorly-documented and controversial (ATSDR 1997b). A study of residents in Woburn, Massachusetts associated excessive cases of acute lymphocytic leukemia in children with their mothers' exposure to elevated levels of TCE (183 – 267 ppb) in a public drinking water well over a course of 5 to 10 years (Lagako et al. 1984). The impacted well also contained low levels (<50 ppb) of PCE, 1,2-DCE, and chloroform. Statistically significant excess leukemia cases in females were associated with residents exposed to TCE and other chemicals in their drinking water supply in New Jersey (Fagliano et al. 1990). A health study conducted by ATSDR of birth defects and childhood leukemia in children born to parents stationed at Camp Lejeune Marine base between 1975 and 1988 linked an increased incidence of these adverse health effects to the parents' exposure to high levels of TCE (up to 1,400 ppb), PCE (up to 407 ppb), and 1,2-DCE (up to 215 ppb) in the base public drinking water supply (ATSDR 2003). Further investigations of the Camp Lejuene exposures are being carried out by ATSDR. The drinking water supply used by Dayton residents living adjacent to the Delphi site has not been impacted by the contamination linked to the Delphi site and is safe to use.

Consecutive surveys of self-reported health effects from over 4,000 residents at 15 sites in five states exposed to TCE through their drinking water supplies (of levels of 3 to 24,000 ppb) for varying periods of time (7-20 years) failed to link these exposures with the development of excess cancer cases. Non-cancer health effects tentatively linked to these exposures included an increased incidence of strokes, increased incidence of diabetes, some increased incidence in liver and kidney disease, and urinary tract disorders (ATSDR 1999).

HAS recommended a long-term screening level of 0.4 ppb for TCE in indoor air, based on a theoretical cancer risk of 1 in 10,000 (10^{-4}). Seven of the properties near the Delphi site in Dayton, Ohio exceeded the 0.4 ppb long-term screening level for TCE and received in house sub-slab vapor mitigation systems.

1,1,1-Trichloroethane (1,1,1-TCA)

Discussion
1,1,1- Trichloroethane (1,1,1-TCA), also known as methyl chloroform, is a colorless liquid with a sweet, sharp odor. It was often used as a solvent to dissolve other substances, such as glues and paints. In industry, it was widely used to remove oil or grease from manufactured parts and was developed initially as a safer solvent to replace other more toxic chlorinated and flammable solvents. Currently 1,1,1-trichloroethane is almost entirely used as a precursor for the chemical production of hydrofluorocarbons. No 1,1,1-trichloroethane was to be produced and sold for domestic use in the United States after January 1, 2002, because of its potential effects on the ozone layer.

Outdoor air levels of 1,1,1-trichloroethane in urban areas have been reported to be in the range of 0.1–1 ppb, while the concentrations in rural areas have been reported to be less than 0.1 ppb. 1,1,1- Trichloroethane tends to evaporate from soil surfaces to the atmosphere and it dissolves slightly in water. If released to soil, 1,1,1-trichloroethane is expected to be highly mobile and has the potential to leach into the groundwater (ATSDR 2006). 1,1,1-TCA was one of the major contaminants found in the groundwater and in the soil gas at the Delphi site.

Acute Effects
1,1,1-Trichloroethane is one of many solvents intentionally inhaled by some people to alter mood or consciousness. Solvent abuse of this type is associated with "sudden sniffing death" syndrome. Breathing very high levels (1,000,000 ppb or higher) of 1,1,1-trichloroethane can cause dizziness, lightheadedness, and possibly a loss of coordination (ATSDR 2006). ATSDR has derived an MRL of 2,000 ppb for acute-duration inhalation exposure (14 days or less) to 1,1,1-trichloroethane, based on a Lowest-Observed-Adverse-Effect-Level (LOAEL) of 175,000 ppb associated with reduced performance in coordination tests in human volunteers (ATSDR 2006).

Chronic Effects (Noncancer)
It not known whether or not breathing low levels of 1,1,1- trichloroethane for a long time causes harmful effects. ATSDR has derived an MRL of 700 ppb for intermediate-duration inhalation exposure (15–364 days) to 1,1,1-trichloroethane (ATSDR2006). HAS used 700 ppb as a short-term action level for this chemical in air for the Delphi Home Avenue site.

ATSDR did not derive a chronic-duration (365 days or more) inhalation MRL because suitable studies including tests for subtle neurological effects were not available. However, HAS applied a concentration of 400 ppb for indoor air as a long-term screening level for residential structures at the Delphi Home Avenue site. This was based on indoor air target concentrations obtained from the U.S. EPA OSWER Draft Subsurface Vapor Intrusion Guidance (U.S. EPA 2002). The sub-slab long-term screening level employed at this site was 4,000 ppb in soil gas, which is higher than the levels that would trigger action for the other contaminants of concern.

> HAS recommended a long-term screening level of 400 ppb for 1,1,1- trichloroethane in indoor air and 4,000 ppb for the sub-slab soil gas. Of the residences tested near the Delphi site, none were found to have levels of 1,1,1-TCA above these screening levels.

It is highly unlikely that exposure to the levels of 1,1,1-trichloroethane found near the Delphi site would result in any adverse health effects. The highest levels of 1,1,1-TCA found in indoor air during the initial testing of 10 properties in 2007 was 1.5 ppb.

Cancer Risk
Available information does not indicate that1,1,1-trichloroethane causes cancer. The International Agency for Research on Cancer (IARC) has determined that 1,1,1-trichloroethane is not classifiable as to its carcinogenicity in humans. EPA has also determined that 1,1,1-trichloroethane is not classifiable as to its human carcinogenicity (ATSDR 2006).

<u>Chloroform</u>

Discussion
Chloroform is a colorless liquid with a pleasant, nonirritating odor and a slightly sweet taste. In industry, nearly all the chloroform made in the U.S. is used to make other chemicals. Chloroform is also formed as a disinfection by-product when chlorine is added to drinking water and waste water. Chloroform evaporates very quickly into the air and breaks down very slowly in air. Chloroform is unstable when exposed to air, light, and/or heat, which cause it to break down into phosgene, hydrogen chloride, and chlorine (NTP 2005). Chloroform dissolves easily in water but does not stick to the soil very well and can travel through soil to groundwater, where it may remain for a long time. Chloroform does not appear to accumulate in plants and animals but small amounts may be found in foods. Chloroform is mostly metabolized by the liver to phosgene, which is more toxic than chloroform, and eventually to carbon dioxide (ATSDR 1997c). People who swim in swimming pools can absorb chloroform through their skin.

People can generally smell chloroform when the levels are in the range of 200,000 ppb to 300,000 ppb (Williams 2000). The amount of chloroform normally expected to be in the outside air has been estimated to be about 0.04 ppb (ATSDR 1997c).

Acute Effects
Exposures to large amounts of chloroform can affect the central nervous system (brain), liver and kidneys. Breathing high levels (about 900,000 ppb) for a short time can cause fatigue, dizziness, and headache. Chloroform was used extensively as an anesthetic during surgery for many years before its harmful effects on the liver and kidneys were recognized.

Chronic Effects (Noncancer)
If you breathe, eat, or drink water containing high levels of chloroform over a long period of time, it may damage your liver and kidneys. ATSDR has calculated a chronic-duration inhalation minimal risk level (MRL) of 20 ppb for chloroform based on liver effects in humans (ATSDR 1997c). The chronic MRL is an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of harmful health effects (excluding cancer) if exposed for a year or more.

> An intermediate exposure MRL of 50 ppb was provided by HAS as a short term action level for chloroform in the indoor air. The levels of chloroform detected in the indoor air of the homes near the Delphi site in Dayton, Ohio are in the single-digit ppb range (below 1 ppb to 3.3 ppb) and are not expected to cause any short-term health effects in area residents.

Cancer Risk
The U.S. Department of Health & Human Services (DHHS) has determined that chloroform is "*reasonably anticipated to be a human carcinogen*" (NTP 2005). IARC has determined that chloroform is "*possibly carcinogenic to humans" (Group 2B).* The U.S. EPA has also determined that chloroform is a *probable human carcinogen* (U.S. EPA 2001).

> HAS recommended a long-term screening level of 2.2 ppb for chloroform in indoor air, based on a calculated theoretical 10^{-4} cancer risk. Of the residences tested near the Delphi site, one home had exceeded this value and received a sub-slab vapor abatement system.

<u>Mixture Assessment</u>

Exposures to mixtures of perchloroethylene, 1,1,1-trichloroethane, trichloroethylene, and chloroform are likely to be additive in nature in producing nervous system effects or non-cancer kidney or liver effects (ATSDR Interaction Profiles 2004; 2007). However, the levels of these volatile organic compounds measured in indoor air in homes sampled as part of the Delphi investigation were all below ATSDR's Minimal Risk Levels for non-cancer health effects. Even the combination of these VOCs would not be expected to produce non-cancer health effects on the central nervous system, liver or kidney in area residents. Exposures to mixtures of TCE, PCE, and chloroform - the three chemicals of concern that are suspected to cause cancer - are also likely to be additive in nature in producing cancer.

Community Health Concerns

In a letter dated April 10, 2008, the Southwest Priority Board, representing the interests of residents in the neighborhood surrounding Delphi Home Avenue, had some additional concerns that they wanted to see addressed. Following are the questions posed in the letter and Public Health - Dayton & Montgomery County (PHDMC) and ODH/HAS responses which were sent in a joint letter to the Southwest Priority Board on May 21, 2008 (PHDMC & HAS 2008).

1. **How does this long-term exposure affect our health today?**

   The health effects likely from exposures to low-levels of the chemicals detected at the Delphi Home Ave. site are largely unknown. Long-term exposures to the chemicals of concern found at the Delphi Home Ave. site may lead to an increased risk of developing cancer. To be conservative and protective of public health, the risk for developing cancer was evaluated assuming a person is exposed to a chemical 24 hours per day, 350 days per year, over a period of 30 years.

   The purpose of the U.S. EPA investigation is to determine if the vapors from the contamination are impacting the sub-slab (the space under the basement or concrete slab) and the indoor air of area homes and to determine if the levels pose a public health threat.

   The spilled chemicals near the Delphi Home Ave. site may have been impacting the neighborhood for a long period of time. However, there is no data available for public health officials to evaluate and determine if levels in the past may have posed a health threat.

   Currently, based on the low-levels of chemicals that have been found in the basements of the homes near the Delphi Home Ave. site during the recent sampling by Delphi and the U.S. EPA, these exposures are not expected to cause non-cancer health effects.

2. **Where can the residents in the affected area (or the public) go to get medical monitoring if they suspect health problems?**

   If a resident in the Delphi Home Ave. community believes they have a health problem or a medical condition, they should discuss their health problems with their family doctor or a qualified medical professional so he/she can properly diagnose and treat their illness. If someone does not have a primary care physician, an appointment to see a physician may be made at the Charles R. Drew Health Center or the Good Samaritan Hospital Medical Residents Clinic. Information on these providers is available by calling the offices of Public Health – Dayton & Montgomery County.

   It is important to note that the Ohio Department of Health (ODH) and the Agency for Toxic Substances and Disease Registry (ATSDR) does not recommend “medical monitoring” for exposure to low levels of TCE, PCE, and chloroform at the Delphi Home Ave. site. Since these chemicals quickly break down and are not stored by the body, only recent high-dose exposures would likely result in detects. These tests are not helpful detecting low-levels of these chemicals in your body and the data provided from U.S. EPA’s sampling indicate only low-level detections of these chemicals in a limited number of area homes. The results of these tests simply indicate recent exposure to these chemicals and cannot be used to predict future adverse health impacts that may or may not result from exposures. It is also important to note that these tests are not routinely available at your doctor's office and medical insurance may not pay for these tests.

3. What can these residents expect in the future?

As of May 2008, twenty seven (27) homes have been tested, seven (7) have vapor abatement systems installed or to be installed and seven (7) locations have been identified for further investigation with quarterly monitoring. Fourteen (14) homes have been sampled and require no further action. There are eight (8) homes in the area where there has been unsuccessful attempts to contact the homeowners and eight (8) more homes that lack utilities or are otherwise uninhabitable and subject to City of Dayton housing department enforcement orders.

At the request of the community during a November 14, 2007 public meeting, HAS staff requested the ODH Chronic Disease and Behavioral Epidemiology Section conduct a community cancer assessment for the Delphi Home Avenue neighborhood. PHDMC supported this request and provided population statistics for Delphi-area census tracts needed for the study.

HAS, supported by PHDMC, also requested the ATSDR address the community request for a health study. We hope to have the results of the community cancer assessment available in August, 2008 and we hope to have the ODH Chronic Disease and Behavioral Epidemiology Section and the ATSDR both available to answer questions and concerns at a community meeting (meeting date and time to be determined) at that time.

4. If the monitoring does not control the vapor, what are their options to keep their families (and our community) safe?

The purpose of a vapor abatement system is to remove the chemicals from under the homes and keep them from entering the indoor air. After the systems are installed, there are a series of tests conducted to see if the system is performing properly. Homes are tested at 30 days, 60 days, 180 days, and annually thereafter. If at any time the sampling detects chemicals at levels above the established ATSDR screening values, adjustment to the system will be made until the levels are below the established values.

The homes that have been put on a quarterly monitoring schedule will be considered clean/safe when four consecutive quarters of indoor air results are below the recommended indoor air screening levels. The homes that tested below the screening value levels require no further action.

In addition to treating individual homes, the source of contamination is currently being addressed by Delphi. We believe that eliminating the source of contamination, such as contaminated soils, soil-gas and groundwater is the best long-term solution to vapor intrusion problems. To accomplish this, Delphi installed a Soil Vapor

Extraction (SVE) system on the Delphi Home Ave. property to capture soil-gas before it migrates off their property and under the adjacent residential neighborhood. The SVE system removes chemical vapors through four extraction wells that are spaced around the contaminated area. The Ohio EPA oversees the operation of the SVE system and they track performance by reviewing monthly performance reports. Operation of the SVE system over the next several years should continue to reduce on-site and off-site soil vapor levels, which could eventually eliminate the need for residential mitigation systems. In the meantime, potential off-site exposures by the vapor intrusion pathway are being controlled by the vapor abatement systems installed in the individual residents' homes.

Child Health Issues

A public health concern was raised because children could be potentially exposed at this site. Children can be 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.

CONCLUSIONS

Based on environmental information of the Delphi VOC plume site and the extent of vapor intrusion into residences, the HAS concluded that the site poses a **public health hazard**. Conclusions for site conditions over time are as follows:

- The Delphi VOC plume site poses a ***public health hazard*** for exposure of nearby residents to contamination by vapor intrusion *at the present.* Seven residential locations exceeded the long-term screening levels for TCE, PCE and/or chloroform. The U.S. EPA and Delphi have taken actions that will prevent vapors from entering homes by installing vapor abatement systems (VAS) so that vapor phase solvents now pose no apparent public health hazard for these locations.

- The Delphi VOC plume site posed an ***indeterminate public health hazard*** for exposure of nearby residents to contamination *in the past*. Historic spills of TCE, PCE, and chloroform may have impacted these properties for an extended period of time; however there were no data documenting the vapor intrusion hazard until recently.

- The Delphi VOC site poses a ***potential or indeterminate public health hazard*** *in the future* to residents whose homes have not been tested and do not have sub-slab vapor abatement systems. For those locations where they have been installed, the vapor abatement systems should address the removal of the chemicals from under homes and the indoor air, as long as they are properly operating and maintained. Other homes have been put on a quarterly monitoring schedule, which will be considered complete when four consecutive quarters of indoor air results are below the recommended indoor air screening levels, while others required no further action. The potential for contamination by vapor intrusion will continue until the source of the contamination is eliminated. The soil vapor extraction system (SVE), fully operational since July 2007, is already having an impact on reducing soil gas levels of the chemicals of concern in the residential area, as indicated by recent evaluation of soil gas levels on-site and off-site.

RECOMMENDATIONS

1. U.S. EPA should continue to take interim measures at affected properties to disrupt the vapor intrusion pathway into homes and buildings and conduct follow-up sampling to determine if the systems are reducing levels to below HAS/ATSDR screening levels.

2. Delphi should continue to operate the on-site SVE system until sampling indicates levels of chemicals on-site no longer are a viable source of off-site contamination.

PUBLIC HEALTH ACTIONS

Planned Actions

1. Delphi, with oversight from U.S. EPA, will be conducting follow-up sampling of the residences' indoor air to insure continued effective operation of the installed vapor extraction systems.

2. HAS and ATSDR will evaluate results to confirm that indoor air levels detected in area homes no longer pose a health concern.

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Certification

The Ohio Department of Health prepared this Health Consultation, Delphi Home Avenue Site (Vapor Intrusion), under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). At the time this Health Consultation was written, it was in accordance with the approved methodologies and procedures. Editorial review was completed by the Cooperative Agreement partner.

Technical Project Officer, Cooperative Agreement Team, CAPEB, DHAC, ATSDR

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

Team Leader, Cooperative Agreement Team, CAPEB, DHAC, ATSDR

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TABLES

Table 1. Sub-slab Sample Results
Delphi VOC Site Phase 1

Sample ID	*TCE (ppb)*	*PCE (ppb)*	*Chloroform (ppb)*	*1,1,1-TCA (ppb)*
EPA-01	ND	2.1	ND	
EPA-02	NA	NA	NA	NA
Delphi-02	**36**	13	ND	930
EPA-03	**182**	110	7.1	
Delphi-03	**74**	65	ND	1,100
EPA-04	**778**	**20,900**	**81.6**	
Delphi-04	**270**	**3,600**	**58**	1,200
EPA-05	ND	ND	ND	
EPA-06	ND	2.1	ND	
EPA-07	**316**	4.3	**295**	
Delphi-07	**73**	ND	**71**	2.3
EPA-08	**2,630**	8.8	**6,580**	
Delphi-08	**1,300**	ND	**4,700**	
EPA-09	NA	NA	NA	
EPA-10	NA	NA	NA	
11	**200**	ND	**220**	6.9
12	**110**	ND	**200**	6.4
13	**---**	---	**---**	
14	**52**	**180**	**56**	
15	**11**	ND	0.24	5
16	**13**	ND	0.6	1.7
17-1	**140**	ND	**260**	ND
17-2	**22**	0.95	**88**	0.41
18	3.2	0.18	3.6	ND
19-1	**5.3**	0.56	3.1	
19-2	**5.3**	0.55	3.2	
20	**---**	---	---	

Sources: U.S. EPA 2007; Haley & Aldrich 2007, 2008
ppb = parts per billion (ppb); Results in bold type exceed long-term screening levels.
ND = Not Detected
NA = Not Applicable
NS = No Sample Results Available
PCE = Perchloroethylene, also known as tetrachloroethylene
TCE = Trichloroethylene
1,1,1-TCA = 1,1,1-Trichloroethane

Sub-slab Screening Levels for VOCs in Residential Structures

Screening Level	*TCE (ppb)*	*PCE (ppb)*	*Chloroform (ppb)*	*1,1,1-TCA (ppb)*
Sub-slab Short-term Action Level (ppb)	1,000	2,000	500	7,000
Sub-slab Long-term Screening Level (ppb)	4	120	22	4,000

Table 2. Indoor Air Sample Results
Delphi VOC Site Phase 1

EPA ID	***TCE (ppb)***	***PCE (ppb)***	***Chloroform (ppb)***	***1,1,1-TCA (ppb)***
EPA-01	---	---	---	
EPA-02	**0.78**	2.7	ND	
Delphi-02	0.23	0.64	ND	1
EPA-03	ND	1.3	ND	
Delphi-03	ND	0.32	ND	0.36
EPA-04	0.25	8	0.18	
EPA-04-dup	0.27	8.2	0.18	
Delphi-04	**0.58**	**19**	0.5	1.5
EPA-05	---	---	---	
EPA-06	---	---	---	
EPA-07	0.16	0.19	0.29	
Delphi-07	**0.6**	ND	1	ND
EPA-08	0.2	0.35	0.31	
Delphi-08	0.26	ND	0.58	
EPA-09	0.16	0.09	0.31	
EPA-10	ND	0.59	0.16	
11	0.23	ND	0.43	ND
12	**0.58**	0.23	0.81	ND
13	NA	NA	NA	
14	0.20	0.66	0.33	
15-1	ND	ND	ND	ND
15-2	ND	ND	ND	ND
16-1	ND	ND	ND	ND
16-2	ND	ND	ND	ND
17	0.29	ND	0.26	ND
18	**3**	0.18	**3.3**	ND
19-1	0.39	0.34	0.63	
19-2	**0.44**	0.36	0.66	
20	**---**	---	---	

Sources: U.S. EPA 2007; Haley & Aldrich 2007, 2008
ppb = parts per billion (ppb); Results in bold type exceed long-term screening levels.
ND = Not Detected
NA = Not Applicable
PCE = Perchloroethylene, also known as tetrachloroethylene
TCE = Trichloroethylene
1,1,1-TCA = 1,1,1-Trichloroethane

Indoor Air Screening Levels for VOCs in Residential Structures

Screening Level	***TCE***	***PCE***	***Chloroform***	***1,1,1-TCA***
Indoor Air Short-term Action Level (ppb)	100	200	50	700
Indoor Air Long-term Screening Level (ppb)	0.4	12	2.2	400

Table 3. Sub-slab Sample Results
Delphi VOC Site Phase 2

EPA ID	*TCE (ppb)*	*PCE (ppb)*	*Chloroform (ppb)*
21	ND	0.63	ND
22	ND	ND	ND
23	0.49	0.42	ND
25	ND	0.29	1.3
27	ND	0.70	0.34
29	ND	ND	0.38
35	**360**	2.0	12
36	0.73	1.8	ND
37	**10,000**	ND	**2,200**
45	**9.9**	39	0.15
46	NA	NA	NA
47	ND	0.18	ND

Source: U.S. EPA 2008; Haley & Aldrich 2008

ppb = parts per billion (ppb) by volume
(Results in bold type exceed long-term screening levels)
ND = Not Detected
NA = Not Applicable
PCE = Perchloroethylene, also known as tetrachloroethylene
TCE = Trichloroethylene

Sub-slab Screening Levels for VOCs in Residential Structures

Screening Level	*TCE (ppb)*	*PCE (ppb)*	*Chloroform (ppb)*
Sub-slab Short-term Action Level (ppb)	1,000	2,000	500
Sub-slab Long-term Screening Level (ppb)	4	120	22

Table 4. Indoor Air Sample Results
Delphi VOC Site Phase 2

EPA ID	*TCE (ppb)*	*PCE (ppb)*	*Chloroform (ppb)*
21	ND	ND	ND
22	ND	ND	ND
23	ND	ND	ND
25	ND	ND	ND
27	ND	1.3	0.19
29	ND	ND	ND
35	**2.5**	0.12	0.21
36	0.34	0.15	ND
37	**4.2**	ND	0.67
45	ND	0.14	ND
46	ND	ND	ND
47	ND	ND	ND

Source: U.S. EPA 2008; Haley & Aldrich 2008

ppb = parts per billion (ppb) by volume
(Results in bold type exceed screening levels)
ND = Not Detected
NA = Not Applicable
PCE = Perchloroethylene, also known as tetrachloroethylene
TCE = Trichloroethylene

Indoor Air Screening Levels for VOCs in Residential Structures

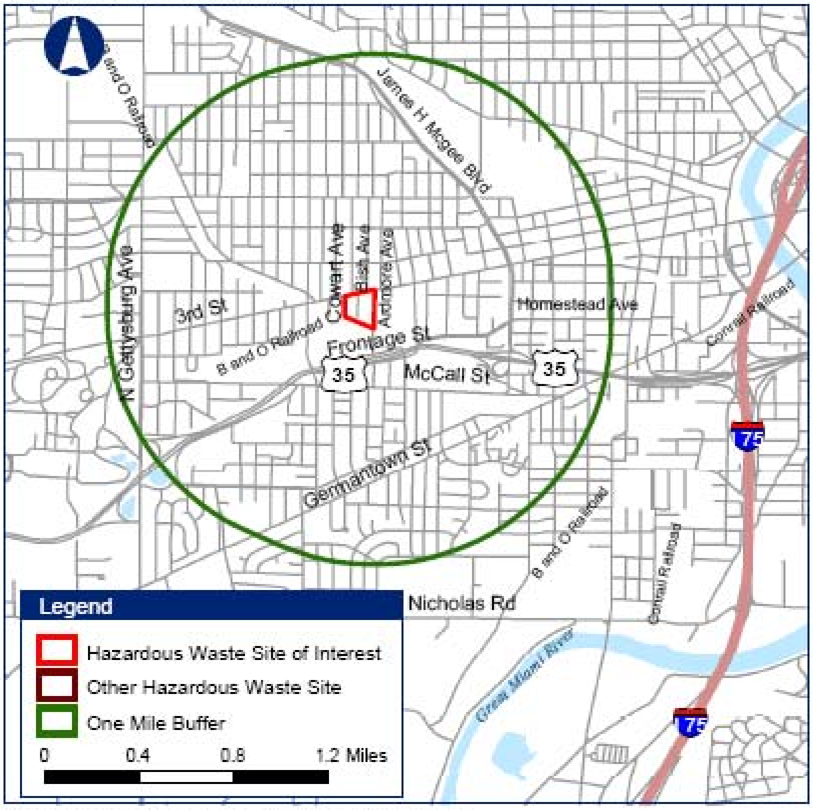
Screening Level	*TCE (ppb)*	*PCE (ppb)*	*Chloroform (ppb)*
Indoor Air Short-term Action Level (ppb)	100	200	50
Indoor Air Long-term Screening Level (ppb)	0.4	12	2.2

FIGURES

Figure 1. INTRO MAP

Delphi Facility
Dayton, OH

EPA Facility ID: OHN000510205



Site Location: Montgomery County, OH

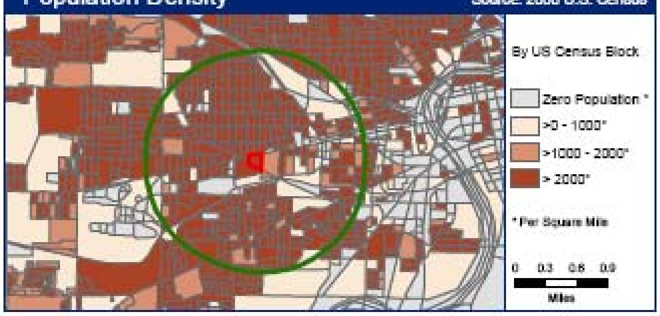
Demographic Statistics
Within One Mile of Site*

Total Population	17,407
White Alone	293
Black Alone	16,749
Am. Indian & Alaska Native Alone	34
Asian Alone	21
Native Hawaiian & Other Pacific Islander Alone	6
Some Other Race Alone	92
Two or More Races	213
Hispanic or Latino**	151
Children Aged 6 and Younger	2,060
Adults Aged 65 and Older	2,707
Females Aged 15 to 44	3,765
Total Housing Units	8,664

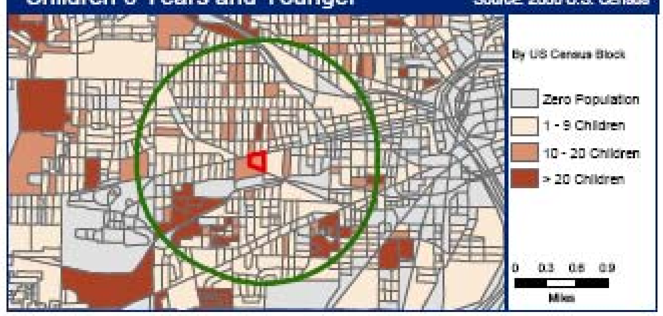
Base Map Source: Geographic Data Technology, May 2005.
Site Boundary Data Source: ATSDR Geospatial Research, Analysis, and Services Program, Current as of Generate Date (bottom left-hand corner).
Coordinate System (All Panels): NAD 1983 StatePlane Ohio South FIPS 3402 Feet

Demographics Statistics Source: 2000 U.S. Census
* Calculated using an area-proportion spatial analysis technique
** People who identify their origin as Hispanic or Latino may be of any race.

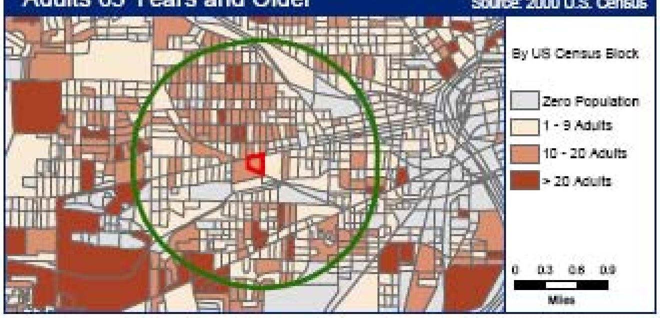
Population Density Source: 2000 U.S. Census



Children 6 Years and Younger Source: 2000 U.S. Census



Adults 65 Years and Older Source: 2000 U.S. Census



Females Aged 15 to 44 Source: 2000 U.S. Census

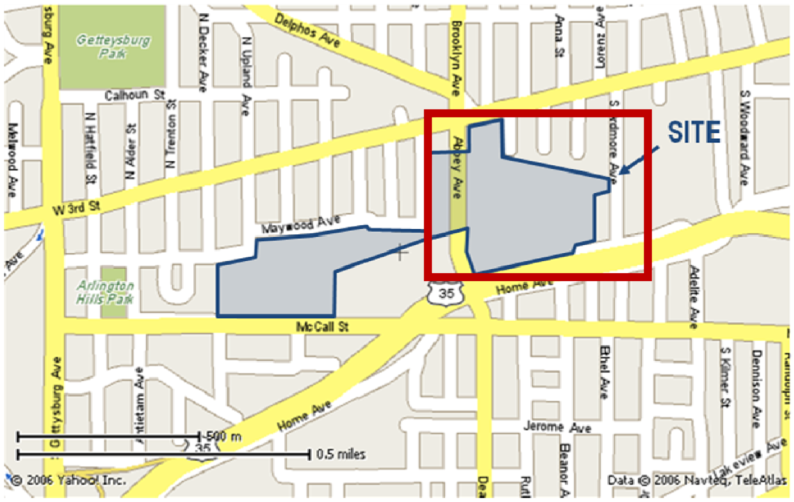
<project=03175><userid=JXAD><geo=Montgomery County, OH><keywords=OHN000510205, Delphi, Facility>

FOR INTERNAL AND EXTERNAL RELEASE

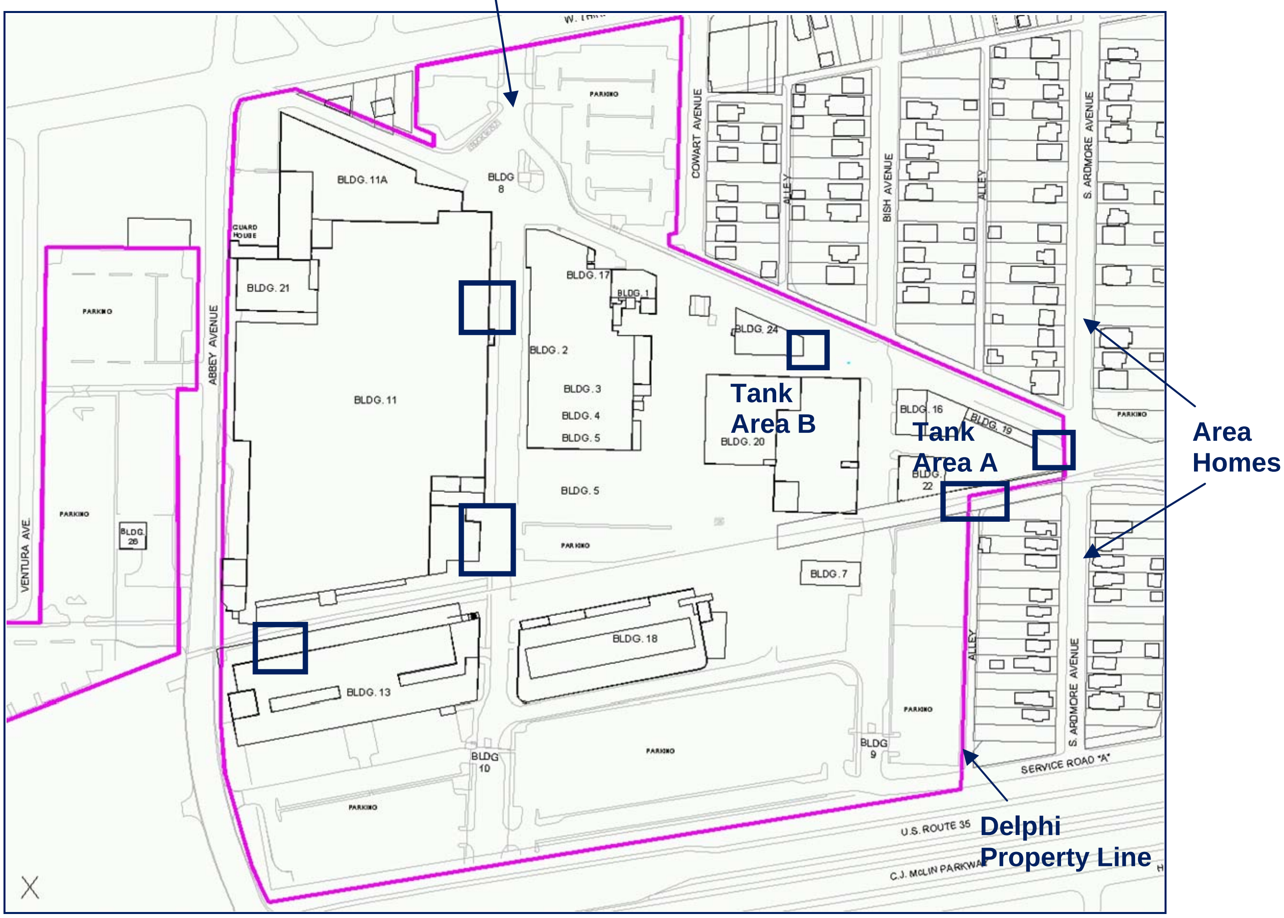
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY | UNITED STATES DEPARTMENT OF HEALTH AND HUMAN SERVICES

Figure 2. Delphi VOC Plume Site

Delphi Facility
Dayton, Ohio

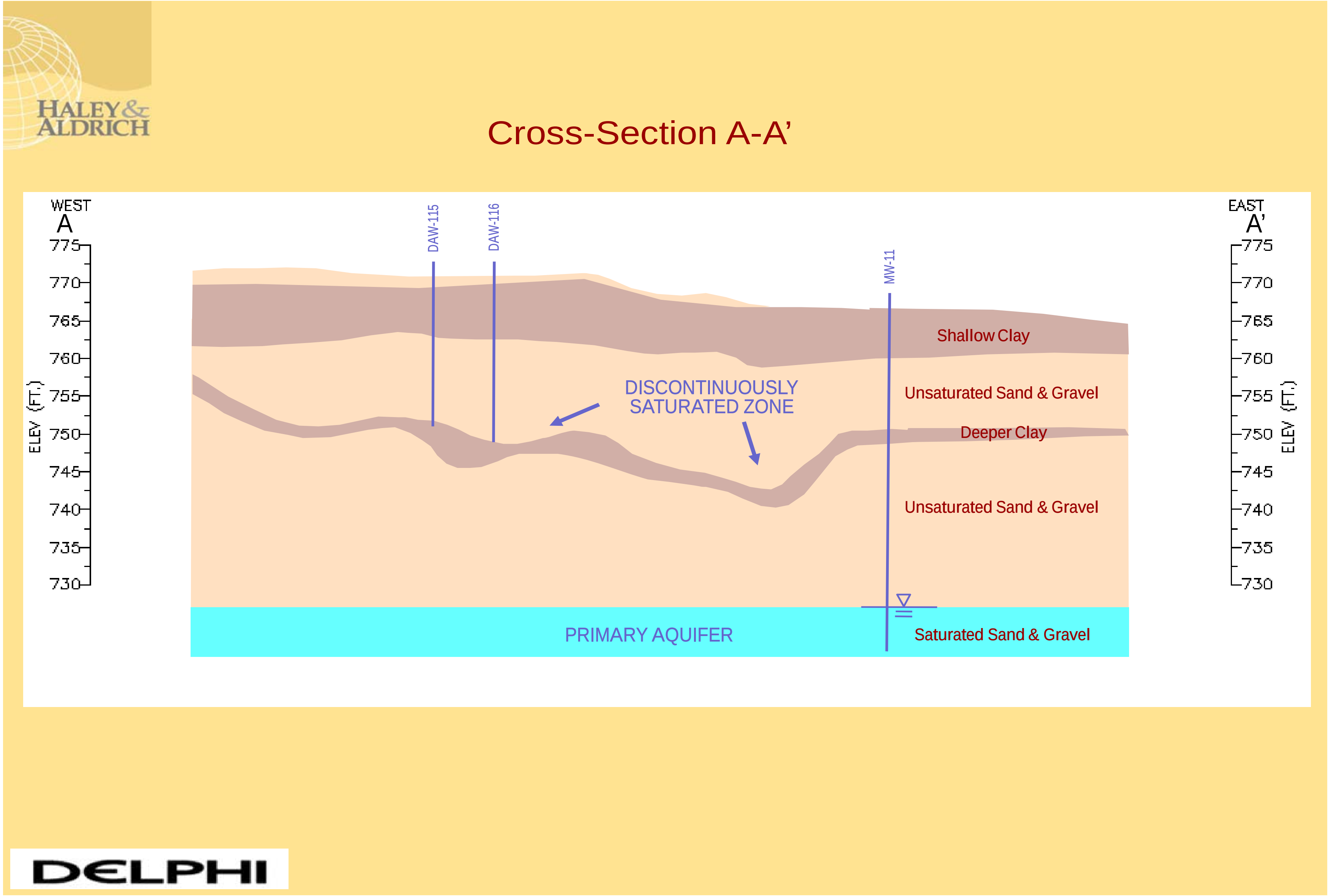


Former Underground Storage Tanks (UST):



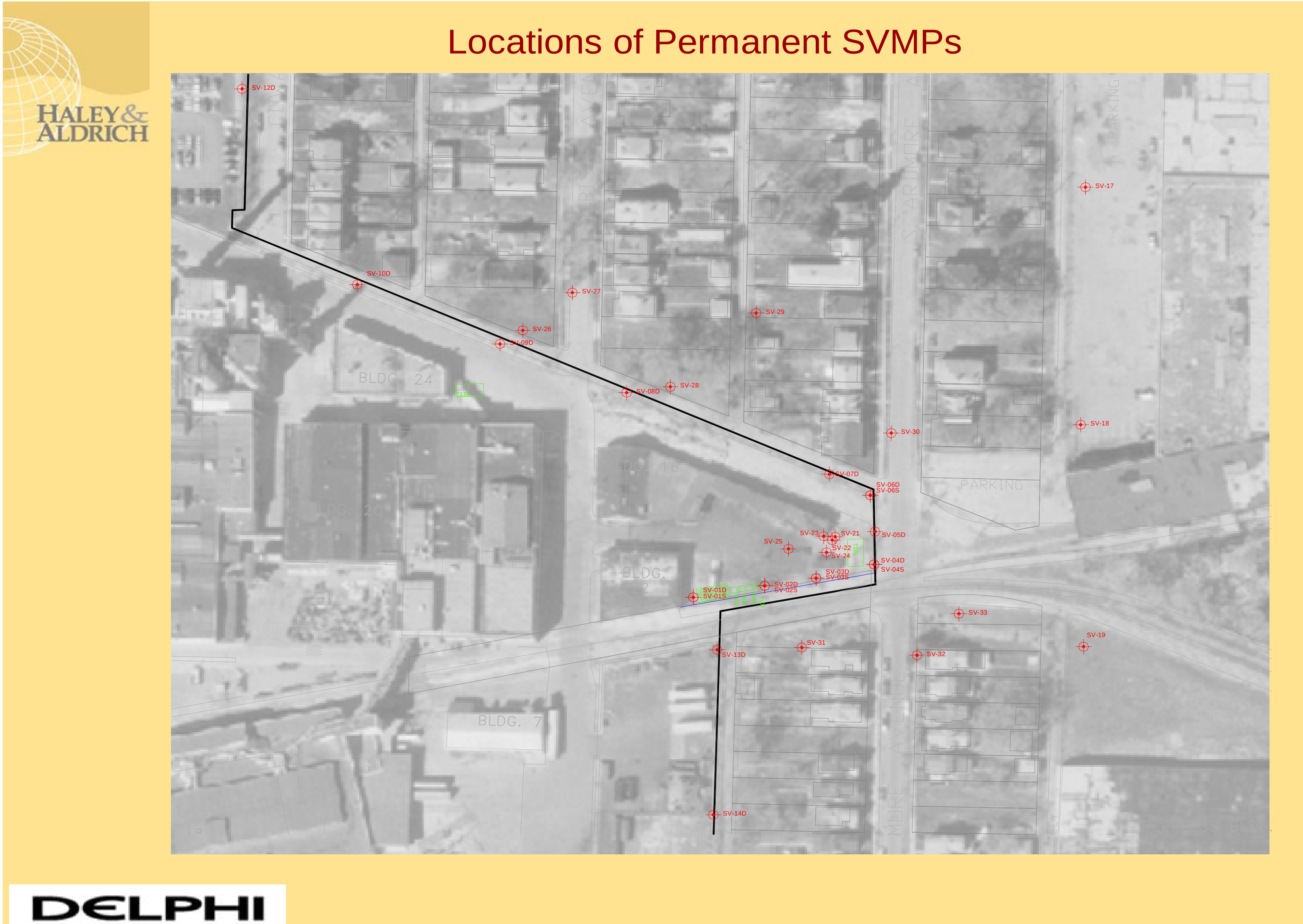
Source: Haley & Alrich 2007

Figure 3. Cross Section of Delphi VOC Pume Site



Source: Haley & Aldrich 2007

Figure 4. Delphi Permanent Soil Gas Probes



Source: Haley & Aldrich 2007

APPENDICES

Appendix A. Letter

OHIO DEPARTMENT OF HEALTH

Ted Strickland / Governor | Alvin D. Jackson, M.D., Director of Health

June 4, 2007

Steven L. Renninger
U.S. Environmental Protection Agency
Emergency Response Section
26 West Martin Luther King Drive (G41)
Cincinnati, OH 45268

Steve,

Per your recent request, presented below are our recommendations for health-based guidance numbers to be used to evaluate the results of sampling of indoor air and sub-slab soil gas media for the volatile chemical compounds Chloroform, Perchloroethylene (PCE), 1,1,1 Trichloroethane, and Trichloroethylene (TCE) in residential and commercial properties in the vicinity of the Delphi Home Avenue site on the west side of the city of Dayton, Montgomery County, Ohio.

The numbers presented are consistent with previous recommendations made for U.S. EPA vapor intrusion investigations at the Springfield Street, Troy VOC Plume, and Behr-Dayton sites over the course of the past year. All of these sites present very similar vapor intrusion exposure scenarios, ie. significant concentrations of VOCs (> 100 ppb) in shallow groundwater; chemicals of concern that are chlorinated solvents; a depth to the water table of less than 25 ft below the ground surface; close proximity (< 1,000 ft) to a likely source; urban density residential areas with a variety of single-family homes; and intervening vadose zone soils that consist of highly porous and permeable sand and gravels. The Delphi site may present a somewhat different picture than these three previous sites due to the presence of a surficial clay layer in the area and a source of vapor-phase solvents that is more likely contaminated soils than contaminated groundwater.

The recommended screening levels presented are based on the understanding that exposures to the below listed chemicals of concern have likely been going on for some period of time and that removal of the source material will likely require an extensive effort that may not be accomplished in the near future. For these reasons, we have applied screening levels that are based more on chronic (longer term) rather than acute exposures to these chemicals. These are provided for residences, schools, public buildings, and commercial buildings. The application of these screening levels is considered by ODH and ATSDR to be protective of public health.

Long-term screening levels are based on a 10^{-4} cancer risk as the threshold for the Emergency Response program to take action. Not meeting this threshold does not mean that no further action should be considered. Properties that exceed 10% of the long-term screening levels should be referred to the remedial programs at US EPA and/or Ohio EPA for further evaluation.

Table 1
Recommended "Action Levels" for Volatile Organic Compounds Residential Structures – Delphi Home Avenue Site, Dayton, Montgomery County, Ohio

Residential	Short-term Action Level[1] (ppbv)	Short-term Action Level (ppbv)	Long-term Screening Level[2] (ppbv)	Long-term Screening Level (ppbv)
Chemical	**Indoor Residential**	**Sub-slab Residential**	**Indoor Residential**	**Sub-slab Residential**
Perchloroethylene	200	2,000	12	120
Trichloroethylene	100	1,000	0.4	4.0
Chloroform	50	500	2.2	22
1,1,1 Trichloroethane	700	7,000	400	4,000

ppbv = Parts per billion per volume of air

[1] = The "Short-term Action Levels" are derived from ATSDR Intermediate Environmental Media Evaluation Guide (EMEG) values for these chemicals in air. These "Short-term Action Levels" denote a level that would trigger immediate action to be taken to reduce exposure levels, either through the installation of a sub-slab depressurization system, improved ventilation, or some other action that could be implemented to reduce exposure until the source could be remediated. The "Intermediate" ATSDR EMEG value is used here rather than the "Acute" EMEG as these exposures more than likely represent something greater than 14 days but less than a lifetime (NOTE: Perchloroethylene uses the ATSDR Acute EMEG value). An exceedence of these action levels does not necessarily indicate that the home would be unsafe for occupancy, necessitating the evacuation of the residents. These numbers represent fairly conservative screening criteria.

[2] = The "Long-term Screening Levels" are derived from values given for these specific compounds in the U.S. EPA OSWER Draft Guidance document for Vapor Intrusion (2002). Perchloroethylene, Trichloroethylene, and Chloroform are all considered to be "Probable" human carcinogens by US EPA and described as "Reasonably anticipated to be human carcinogens" by the National Toxicology Program (2005). The values presented for these compounds are based on a calculated 10^{-4} cancer risk number (US EPA, 2002, Table 2a). This calculation is based on a very conservative exposure scenario that assumes an adult resident is exposed to the chemical in air in his residence for 350 days per year over a period of 30 years. 1,1,1 Trichloroethane is

considered to be a non-carcinogen and risk value for this chemical is based on a chronic hazard index of 1.0.

Table 1 presents the action and screening numbers for residential structures. In evaluating the sub-slab air samples, a 10-fold attenuation factor is applied to these values, based on the US EPA OSWER draft Vapor Intrusion Guidance (2002). Sub-slab values here correspond to shallow soil gas values in Table 2a of the Guidance document.

Table 2 provides corresponding values for non-residential commercial structures. These are derived by adjusting the exposure time from the residential values (Table 1). A factor of 4.2 is applied to adjust from a 168-hour week for the residential exposure to a 40-hour work week for the non-residential exposure. These "commercial structures" include public buildings, non-manufacturing businesses, and industries where these chemicals of concern are not used as part of the manufacturing process.

Table 2
Recommended "Action Levels" for Volatile Organic Compounds Commercial Structures – Delphi Home Avenue Site, Dayton, Montgomery County, Ohio

Commercial	Short-term Action Level (ppbv)	Short-term Action Level (ppbv)	Long-term Screening Level (ppbv)	Long-term Screening Level (ppbv)
Chemical	**Indoor Commercial**	**Sub-slab Commercial**	**Indoor Commercial**	**Sub-slab Commercial**
Perchloroethylene	840	8,400	50	500
Trichloroethylene	420	4,200	1.7	17
Chloroform	210	2,100	9.2	92
1,1,1 Trichloroethane	2,940	29,400	1,690	16,800

If you have any questions with regard to these values, please contact me (email: bob.frey@odh.ohio.gov or phone: 614-466-1069) or Mark Johnson (email: Johnson.Mark.@epamial.epa.gov or phone 312-353-3436).

Sincerely,

Robert C. Frey, Ph.D.
Chief, Health Assessment Section
Bureau of Environmental Health

cc: Mark Johnson, Ph.D., DABT
Senior Environmental Health Scientist
Agency for Toxic Substances and Disease Registry
Region 5 Office, 77 W. Jackson Blvd.
Chicago, IL 60604

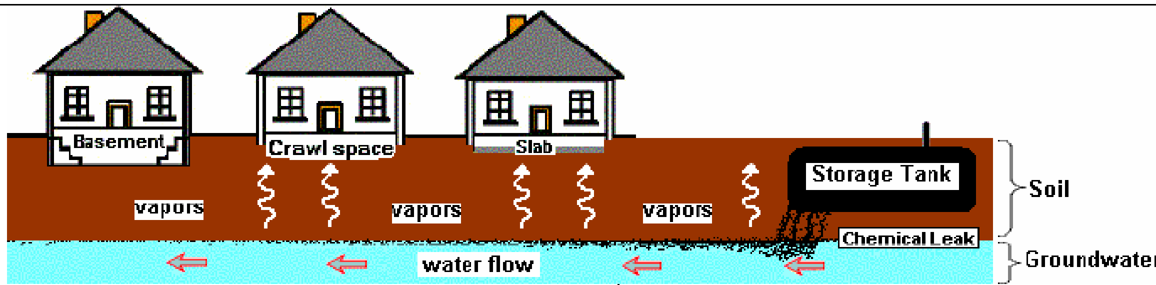
Appendix B. Fact Sheets

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)

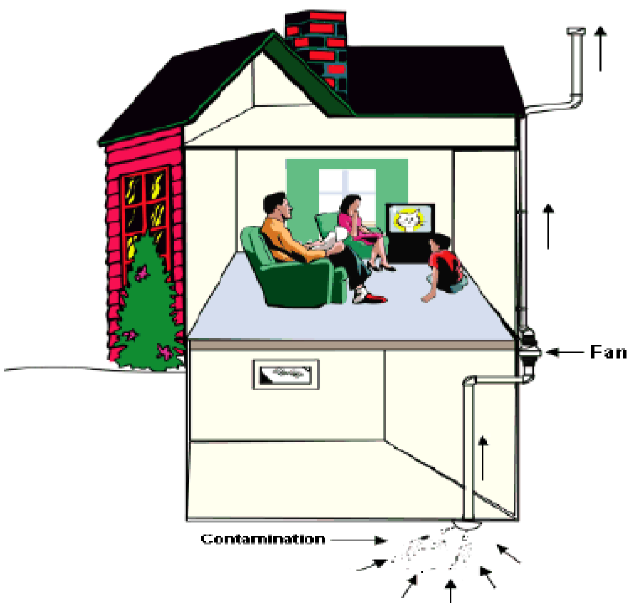
How is vapor intrusion investigated? (continued)

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

Bureau of Environmental Health
Health Assessment Section

"To protect and improve the health of all Ohioans"

Tetrachloroethylene (PERC)

Other names for tetrachloroethylene include perchloroethylene, PCE, and tetrachloroethene.

What is tetrachloroethylene (PERC)?

Tetrachloroethylene (PERC) is a man-made chemical that is widely used for dry cleaning clothes and for metal degreasing. It is also used to make other chemicals and can be found in some household products such as water repellents, silicone lubricants, fabric finishers, spot removers, adhesives and wood cleaners. It evaporates easily into the air and has a sharp, sweet odor. PERC is a nonflammable (does not burn) liquid at room temperature.

How does tetrachloroethylene (PERC) get into the environment?

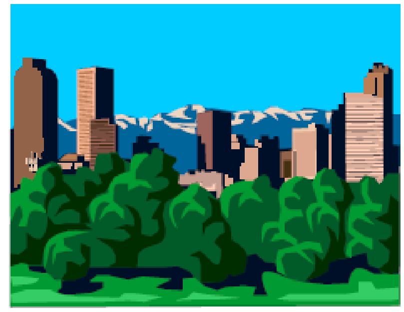
Tetrachloroethylene (PERC) can evaporate into the air during dry cleaning operations and during industrial use. It can also be released in air if it is not properly stored or was spilled. If it was spilled or leaked into the soil, it may be found in groundwater (or underground drinking water).

People can be exposed to tetrachloroethylene (PERC) from the environment, from household products, from dry cleaning products and from their occupation (work). Common environmental levels of tetrachloroethylene (called background levels) can be found in the air we breathe, in the water we drink and in the food we eat. In general, levels in the air are higher in the cities or around industrial areas where it is used more than rural or remote areas.

The people with the greatest chance of exposure to tetrachloroethylene are those who work with it. According to estimates from a survey conducted by the National Institute for Occupational Safety and Health (NIOSH), more than 650,000 U.S. workers may be exposed. However, the air close to dry cleaning business and industrial sites may have levels of tetrachloroethylene higher than background levels. If the dry cleaning business or industry has spilled or leaked PERC on the ground, there may also be contaminated groundwater as well.

What happens to tetrachloroethylene (PERC) in the environment?

Much of the tetrachloroethylene (PERC) that gets into surface waters or soil evaporates into the air.



However, some of the PERC may make its way to the groundwater. Microorganisms can break down some of the PERC in soil or underground water. In the air, it is broken down by sunlight into other chemicals or brought back to the soil and water by rain. PERC does not appear to collect in fish or other animals that live in water.

How can tetrachloroethylene (PERC) enter and leave my body?

Tetrachloroethylene (PERC) can enter your body when you breathe contaminated air or when you drink water or eat food containing the chemical. If PERC is trapped against your skin, a small amount of it can pass through into your body. Very little PERC in the air can pass through your skin into your body. Breathing contaminated air and drinking water are the two most likely ways people will take in PERC. How much enters your body in this way depends on how much of the chemical is in the air, how fast and deeply you are breathing, how long you are exposed to it or how much of the chemical you eat or drink.

Most PERC leaves your body from your lungs when you breathe out. This is true whether you take in the chemical by breathing, drinking, eating, or touching it. A small amount is changed by your body (in your liver) into other chemicals that are removed from your body in urine. Most of the changed (PERC) leaves your body in a few days. Some of it that you take in is found in your blood and other tissues, especially body fat. Part of the tetrachloroethylene that is stored in fat may stay in your body for several days or weeks before it is eliminated.

Can tetrachloroethylene (PERC) make you sick?

Yes, you can get sick from contact with PERC. But getting sick will depend upon:

- How much you were exposed to (dose).
- How long you were exposed (duration).
- How often you were exposed (frequency).
- General Health, Age, Lifestyle Young children, the elderly and people with chronic (on-going) health problems are more at risk to chemical exposures.

How can tetrachloroethylene (PERC) affect my health?

Exposure to very high concentrations of tetrachloroethylene (particularly in closed, poorly ventilated areas) can cause dizziness, headache, sleepiness, confusion, nausea, difficulty in speaking and walking, unconsciousness, and death. Skin irritation may result from repeated or extended contact with it as well. These symptoms occur almost entirely in work (or hobby) environments when people have been accidentally exposed to high concentrations or have intentionally used tetrachloroethylene to get a "high." Normal background levels (or common environmental levels) will not cause these health affects.

Is tetrachloroethylene (PERC) a carcinogen (cause cancer)?

In the United States, the National Toxicology Program (NTP) releases the *Report on Carcinogens* (RoC) every two years. The NTP is formed from parts of several different government agencies, including the National Institutes of Health (NIH), the Centers for Disease Control and Prevention (CDC), and the Food and Drug Administration (FDA). The *Report on Carcinogens* (RoC) identifies two groups of agents: "Known to be human carcinogens" & "Reasonably anticipated to be human carcinogens." Tetrachloroethylene (PERC) has been shown to cause liver tumors in mice and kidney tumors in male rats. The RoC has determined that PERC may reasonably be anticipated to be a carcinogen.

Reference:

Agency for Toxic Substances and Disease Registry (ATSDR). 1997. Toxicological Profile for tetrachloroethylene. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service

Is there a medical test to show whether you have been exposed to tetrachloroethylene (PERC)?

One way of testing for tetrachloroethylene (PERC) exposure is to measure the amount of the chemical in the breath, much the same way breath-alcohol measurements are used to determine the amount of alcohol in the blood. Because PERC it is stored in the body's fat and slowly released into the bloodstream, it can be detected in the breath for weeks following a heavy exposure. Also, PERC and trichloroacetic acid (TCA), a breakdown product of tetrachloroethylene, can be detected in the blood. These tests are relatively simple to perform but are not available at most doctors' offices and must be done at special laboratories that have the right equipment. Because exposure to other chemicals can produce the same breakdown products in the urine and blood, the tests for breakdown products cannot determine if you have been exposed to PERC or the other chemicals that produce the same breakdown chemicals.

What has the federal government made recommendations to protect human health?

The EPA maximum contaminant level for the amount of tetrachloroethylene that can be in drinking water is 0.005 milligrams tetrachloroethylene per liter of water (0.005 mg/L).

The Occupational Safety and Health Administration (OSHA) has set a limit of 100 ppm for an 8-hour workday over a 40-hour workweek.

The National Institute for Occupational Safety and Health (NIOSH) recommends that tetrachloroethylene be handled as a potential carcinogen and recommends that levels in workplace air should be as low as possible.

The Ohio Department of Health is in cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), Public Health Service, U.S. Department of Health and Human Services.

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Created 10-15-04

Bureau of
Environmental Health
Health Assessment Section

"To protect and improve the health of all Ohioans

Trichloroethylene (TCE)

(try- klor'oh eth'uh- leen)

Answers to Frequently Asked Health Questions

What is TCE?

TCE is man-made chemical that is not found naturally in the environment. TCE is a non-flammable (does not burn), colorless liquid with a somewhat sweet odor and has a sweet, "burning" taste. It is mainly used as a cleaner to remove grease from metal parts. TCE can also be found in glues, paint removers, typewriter correction fluids and spot removers.

The biggest source of TCE in the environment comes from evaporation (changing from a liquid into a vapor/gas) when industries use TCE to remove grease from metals. But TCE also enters the air when we use common household products that contain TCE. It can also enter the soil and water as the result of spills or improper disposal.

What happens to TCE in the environment?

- TCE will quickly evaporate from the surface waters of rivers, lakes, streams, creeks and puddles.
- If TCE is spilled on the ground, some of it will evaporate and some of it may leak down into the ground. When it rains, TCE can sink through the soils and into the ground (underground drinking) water.
- When TCE is in an oxygen-poor environment and with time, it will break down into different chemicals such as 1,2 Dichloroethene and Vinyl Chloride.
- TCE does not build up in plants and animals.
- The TCE found in foods is believed to come from TCE contaminated water used in food processing or from food processing equipment cleaned with TCE.

How does TCE get into your body?

- TCE can get into your body by breathing (inhalation) air that is polluted with TCE vapors. The vapors can be produced from the manufacturing of TCE, from TCE polluted water evaporating in the shower or by using household products such as spot removers and typewriter correction fluid.
- TCE can get into your body by drinking (ingestion) TCE polluted water.
- Small amounts of TCE can get into your body through skin (dermal) contact. This can take place when using TCE as a cleaner to remove grease from metal parts or by contact with TCE polluted soils.

Can TCE make you sick?

Yes, you can get sick from TCE. But getting sick will depend on the following:

- <u>How much</u> you were exposed to (dose).
- <u>How long</u> you were exposed (duration).
- <u>How often</u> you were exposed (frequency).
- <u>General Health, Age, Lifestyle</u> Young children, the elderly and people with chronic (on-going) health problems are more at risk to chemical exposures.

How does TCE affect your health?

Breathing (Inhalation):

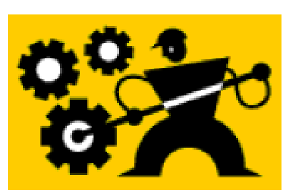
- Breathing <u>high</u> levels of TCE may cause headaches, lung irritation, dizziness, poor coordination (clumsy) and difficulty concentrating.
- Breathing <u>very high</u> levels of TCE for long periods may cause nerve, kidney and liver damage.

Drinking (Ingestion):

- Drinking <u>high</u> concentrations of TCE in the water for long periods may cause liver and kidney damage, harm immune system functions and damage fetal development in pregnant women (although the extent of some of these effects is not yet clear).
- It is uncertain whether drinking low levels of TCE will lead to adverse health effects.

Skin (Dermal) Contact:

- Short periods of skin contact with high levels of TCE may cause skin rashes.



Does TCE cause cancer?

The National Toxicology Program's 11th Report on Carcinogens places chemicals into one of two cancer-causing categories: *Known to be Human Carcinogens* and *Reasonably Anticipated to be Human Carcinogens*.

The11th Report on Carcinogens states TCE is *"Reasonably Anticipated to be Human Carcinogen."*

The category *"Reasonably Anticipated to be Human Carcinogen"* gathers evidence mainly from animal studies. There may be limited human studies or there may be no human or animal study evidence to support carcinogenicity; but the agent, substance or mixture belongs to a well-defined class of substances that are known to be carcinogenic.

There are human studies of communities that were exposed to high levels of TCE in drinking water and they have found evidence of increased leukemia's. But the residents of these communities were also exposed to other solvents and may have had other risk factors associated with this type of cancer.

Animal lab studies in mice and rats have suggested that high levels of TCE may cause liver, lung, kidney and blood (lymphoma) cancers.

As part of the National Exposure Subregistry, the Agency for Toxic Substances and Disease Registry (ATSDR) compiled data on 4,280 residents of three states (Michigan, Illinois, and Indiana) who had environmental exposure to TCE. ATSDR found no definitive evidence for an excess of cancers from these TCE exposures.

The U.S. EPA is currently reviewing the carcinogenicity of TCE.

Is there a medical test to show whether you have been exposed to TCE?

If you have recently been exposed to TCE, it can be detected in your breath, blood, or urine. The breath test, if done soon after exposure, can tell if you have been exposed to even a small amount of TCE.

Exposure to larger amounts is measured in blood and urine tests. These tests detect TCE and many of its breakdown products for up to a week after exposure. However, exposure to other similar chemicals can produce the same breakdown products in the blood and urine so the detection of the breakdown products is not absolute proof of exposure to TCE.

These tests aren't available at most doctors' offices, but can be done at special laboratories that have the right equipment. **Note:** Tests can determine if you have been exposed to TCE but cannot predict if you will experience adverse health effects from the exposure.

Has the federal government made recommendations to protect human health?

The federal government develops regulations and recommendations to protect public health and these regulations can be enforced by law.

Recommendations and regulations are periodically updated as more information becomes available. Some regulations and recommendations for TCE follow:

- The Environmental Protection Agency (EPA) has set a maximum contaminant level for TCE in drinking water at 0.005 milligrams per liter (0.005 mg/L) or 5 parts of TCE per billion parts water (5 ppb).
- The Occupational Safety and Health Administration (OSHA) have set an exposure limit of 100 ppm (or 100 parts of TCE per million parts of air) for an 8-hour workday, 40-hour workweek.
- The EPA has developed regulations for the handling and disposal of TCE.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 1997. Toxicological profile for TCE (electronic at http://www.atsdr.cdc.gov/tfacts19.html)

Report on Carcinogens, Eleventh Edition; U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program, 2005 (2005 electronic at http://ntp.niehs.nih.gov/ntp/roc/toc11.html)

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Bureau of
Environmental Health
Health Assessment Section

"To protect and improve the health of all Ohioans"

Chloroform

Answers to Frequently Asked Health Questions

What is chloroform?

Chloroform, also called trichloromethane or methyltrichloride, is a colorless liquid with a pleasant, non-irritating odor and a slightly sweet taste. As a volatile organic compound (VOC), chloroform easily vaporizes (turns into a gas) in the air. Chloroform does not easily burn, but it will burn when it reaches very high temperatures. Chloroform was one of the first inhaled anesthetics to be used during surgery, but it is not used in anesthesia today.

Where do you find chloroform?

In order to destroy the harmful bacteria found in our drinking water and waste waters, the chemical chlorine is added to these water sources. As a by-product of adding chlorine to our drinking and waste waters, small amounts of chloroform are formed. So small amounts of chloroform are likely to be found almost everywhere.

In industry, nearly all the chloroform made in the U.S. is used to make other chemicals. From the factories that make or use this chemical, chloroform can enter the air directly or it can enter the air from the evaporation (changing from liquid to a gas) of chloroform-contaminated waters and soils. Chloroform can also enter the water and soils from industry storage and waste sites spills and leaks.

Not only does chloroform evaporate very quickly when exposed to air, it also dissolves easily in water and does not stick to the soils very well. This means chloroform can easily travel through the soils to groundwater, where it can enter a water supply. Chloroform lasts a long time in both the air and in groundwater. Most of the chloroform in the air eventually breaks down, but it is a slow process. Chloroform does not appear to build up in great amounts in plants and animals, but we may find some small amounts of chloroform in foods.

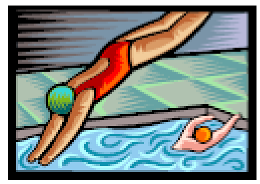
How do you come in contact with chloroform? Who is more at risk?

You are most likely to be exposed to chloroform by drinking contaminated water and/or by breathing contaminated indoor or outdoor air. Chloroform is found in nearly all public drinking water supplies. Chloroform is also found in the air from all areas of the United States. You are probably exposed to small amounts of chloroform in your drinking water and/or in beverages that are made using water that contains chloroform.

People who are at greater risk to be exposed to chloroform at higher-than-normal levels are people who work at or near chemical plants and factories that make or use chloroform. Higher exposures might occur in workers at drinking water treatment plants, waste water treatment plants, and paper and pulp mills. People who operate waste-burning equipment may also be exposed to higher than normal levels. People who swim a lot in swimming pools may also be exposed to higher levels.

How does chloroform enter and leave your body?

- Chloroform can enter your body if you breathe contaminated air (inhalation)
- Chloroform can enter your body if you eat/drink contaminated food or water (ingestion)
- Chloroform can also enter your body through the skin (dermal).



If you take a bath, shower or swim in a pool with chloroform-contaminated water, it can enter your body through inhalation and dermal contact.

Studies in humans and animals show that after you breathe contaminated air or eat contaminated food, the chloroform can quickly enter your bloodstream from your lungs and intestines. Inside your body, chloroform is carried by the blood to all parts of your body, such as the liver, kidneys and fat cells.

Some of the chloroform that enters your body leaves unchanged in the air you breathe out and some of it is broken down into other chemicals. These chemicals are known as breakdown products or metabolites, and some of them can attach to other chemicals inside the cells of your body and may cause harmful effects if they collect in high enough amounts in your body. Some of the metabolites will leave the body in the air you breathe out and small amounts of the breakdown products leave the body in the urine and stool.

How does chloroform affect health?

In humans, large amounts of chloroform can affect the central nervous system (brain), liver and kidneys. Breathing high levels for a short time can cause fatigue, dizziness, and headache. If you breathe air, eat food, or drink water containing elevated levels of chloroform, over a long period, the chloroform may damage your liver and kidneys. Large amounts of chloroform can cause sores (lesions) when the chloroform touches your skin.

Lab studies have shown chloroform caused reproductive problems in animals (mice and rats). However, there is no evidence that show whether chloroform causes harmful reproductive effects or birth defects in humans.

Does chloroform cause cancer?

Based on animal studies, the Department of Health and Human Services (DHHS) has determined that chloroform may reasonably be anticipated to be a carcinogen (a substance that causes cancer). The International Agency for Research on Cancer (IARC) has determined that chloroform is possibly carcinogenic to humans (2B). The EPA has also determined that chloroform is a "probable" human carcinogen.

Results of studies of people who drank chlorinated water showed a possible link between the chloroform in the chlorinated water and the occurrence of cancer of the colon and urinary bladder. Rats and mice that ate food or drank water that had large amounts of chloroform in it for a long period of time developed cancer of the liver and kidneys. However, there is no evidence that shows whether chloroform causes liver and kidney cancer in humans.

Is there a medical test to show whether you have been exposed to chloroform?

Although we can measure the amount of chloroform in the air you breathe out and in blood, urine, and body tissues, we have no reliable test to determine how much chloroform you have been exposed to or whether you will experience any harmful health effects.

The measurement of chloroform in body fluids and tissues may help to determine if you have come into contact with large amounts of chloroform. However, these tests are useful only a short time after you are exposed to chloroform because it leaves the body quickly.

What has been done to protect human health?

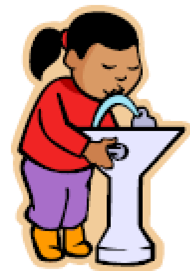
The amount of chloroform normally expected to be in the air ranges from 0.02 to 0.05 parts of chloroform per billion parts (ppb) of air and from 2 to 44 ppb in treated drinking water.

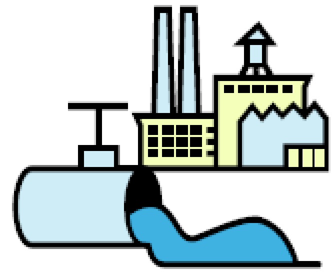
Notes: The below unit of measurement will be found in the ppb (parts per billion) range. Examples: One part per billion (1 ppb) would be equal to having one bean in a pile of one billion beans, or one ppb would be equal to one second of time in 32 years.

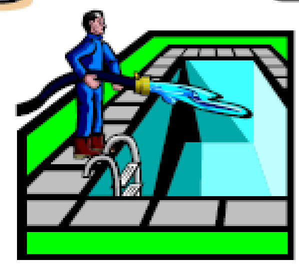
The Environmental Protection Agency (EPA) has a set the drinking water limit for total trihalomethanes (THMs), a class of chemicals that includes chloroform, at 80 ppb.

The Occupational Safety and Health Administration (OSHA) has set a permissible 50,000 ppb exposure limit of air in the workplace during an 8-hour workday, 40-hour week.

The EPA requires chloroform spills or accidental releases into the environment of 10 pounds or more of be reported to the EPA.







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Reference:

Agency for Toxic Substances and Disease Registry (ATSDR). 1997. Toxicological profile for chloroform. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

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AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

Created 04/10/07

Bureau of
Environmental Health
Health Assessment Section

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1,1,1-Trichloroethane (1,1,1-TCA)

Answers to Frequently Asked Health Questions

What is 1,1,1-TCA?

1,1,1-TCA, also called methyl chloroform, is a man-made chemical that you will not find naturally in the environment. It is a colorless liquid with a sweet, sharp odor. 1,1,1-TCA dissolves very little in water and quickly evaporates (turns into a gas) when exposed to the air. 1,1,1-TCA burns easily when it comes in contact with a spark or flame.

Note: After January 1, 2002, no 1,1,1-TCA is to be manufactured for use in the U.S. because it may affect the earth's ozone layer.

How was 1,1,1-TCA used?

1,1,1-TCA was mainly used as a degreaser in industry, removing oil and grease from metal parts. It was also used as a solvent to dissolve other substances such as glues and paints. 1,1,1-TCA also had many common household uses as well. In the home, it was found in common products such as spot removers, cleaners, glues and aerosol sprays.

Where do you find 1,1,1-TCA in the environment?

1,1,1-TCA can be found in soil, water and air. Because it evaporates easily, it is most commonly found in the air. 1,1,1-TCA will also evaporate quickly from water and soil. It does not bind (stick) to soils, so it may easily leak into the under ground water (groundwater). Many cities in Ohio use groundwater as their drinking water supply. 1,1,1-TCA does not appear to build up in plants, animals or fish.

What happens to 1,1,1-TCA in the environment?

Most of the 1,1,1-TCA released into the environment enters the air. Once in the air, it can travel to the upper part of the earth's atmosphere, called the stratosphere (also called the ozone layer). There, sunlight breaks it down into other chemicals that may reduce the Earth's protective ozone layer.

How are you exposed to 1,1,1-TCA?

1,1,1-TCA can quickly enter your body if you breathe contaminated air (inhalation) and/or drink and eat contaminated food or water (ingestion). Very small amounts can be absorbed by skin contact (dermal).

1,1,1-TCA has been found in air samples taken from all over the world. However, normally you are not exposed to large enough amounts to cause health problems. Because 1,1,1-TCA was used so frequently in home and office products, much higher levels were found in the air inside the home or office than in the outdoor air.

If 1,1,1-TCA is released to surface and ground-water, individuals may be exposed through contaminated drinking water.

Occupational exposure to 1,1,1-TCA can occur during the use of metal degreasing agents, paints, glues, and cleaning products.

Regardless of how 1,1,1-TCA enters your body, nearly all of it quickly leaves your body in the air you exhale. The small amount that is not breathed out can be changed in your body into other substances, known as metabolites. Most of the metabolites leave your body in the urine and breath within a few days.

Can you get sick from 1,1,1-TCA?

Yes, you can get sick. But getting sick will depend on the contact (exposure) you had with the chemical.

Exposure:

- How much you were exposed to (dose).
- How long you were exposed (duration).
- How often you were exposed (frequency).
- General Health, Age, Lifestyle Young children, the elderly and people with chronic (on-going) health problems are more at risk to chemical exposures.

What are some of the health problems caused by 1,1,1-TCA?

If you breathe high levels of 1,1,1-TCA for a short time, you may become dizzy, lightheaded and possibly lose your balance and coordination. These health effects quickly end when you stop breathing the contaminated air. If you breathe much higher levels of 1,1,1-TCA, you may become unconscious, your blood pressure may lower to dangerously low levels and your heart may stop beating.

We do not know if breathing low levels of 1,1,1-TCA for a long time causes harmful effects. Animals studies (mice and rats) show that breathing very high levels of 1,1,1-TCA damages the breathing passages, causes mild effects in the liver and affects the nervous system. There are no human studies that show that eating food or drinking water contaminated with 1,1,1-TCA could harm health.

The likelihood is very low that exposure to 1,1,1-TCA levels found near most hazardous waste sites would cause significant health effects.

Does 1,1,1-TCA cause cancer?

The EPA has classified 1,1,1-TCA as a Group D chemical, not classifiable as to human carcinogenicity. The Group D classification is based on no reported human data and inadequate animal data to suggest that exposure to this chemical can cause cancer.

The International Agency for Research on Cancer (IARC) has also determined that exposure to 1,1,1-TCA has not resulted in cancer in humans.

Is there a test to show whether you have been exposed to 1,1,1-TCA?

Samples of your breath, blood and urine can be tested to determine if you have recently been exposed to 1,1,1-TCA. To be of any value, samples of your breath or blood have to be taken within hours after the exposure and the urine samples have to be taken within 2 days after exposure.

In some cases, these tests can estimate how much 1,1,1-TCA has entered your body. However, these tests will not tell you whether your health will be affected by the exposure to 1,1,1-TCA.

These tests are not routinely done in your doctor's office, hospital and/or clinics because they require special lab equipment.

What has been done to protect human health?

The U.S. Environmental Protection Agency (U.S. EPA) has established a "maximum contaminant level" (MCL) for chemicals in water. If chemicals are found to be above the MCL, your water supplier must take steps to reduce the amount of chemicals so it falls below the level established by the EPA. **Note:** The MCL for 1,1,1-TCA is 200 parts per billion (ppb). In other words: 200 parts of 1,1,1-TCA per one billion parts of water.

After January 1, 2002, no 1,1,1-TCA is to be manufactured for use in the U.S. because it may affect the earth's ozone layer.

References:

Agency for Toxic Substances and Disease Registry (ATSDR). *Toxicological Profile for 1,1,1-Trichloroethane. (Update)*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA. July, 2006

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U.S. Environmental Protection Agency. *Methyl chloroform (1,1,1-Trichloroethane) 71-55-6*. Technology Transfer Network Air Toxics Website. Rev. January 2000.

Where can I get more information?

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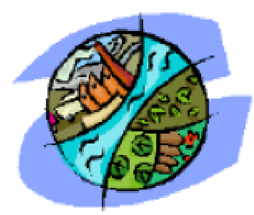

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