# Health Consultation

(Evaluation of Wells at the Jesse Beer School and Nearby Residential Area)

JESSE BEER / BAHL AVENUE WELLS SITE
MANSFIELD, RICHLAND COUNTY, OHIO

Prepared by
Ohio Department of Health

SEPTEMBER 9, 2013

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Atlanta, Georgia 30333

## Health Consultation: A Note of Explanation

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

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

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## SUMMARY

**Introduction**

Man-made chemicals called volatile organic compounds (VOCs) have been detected at slowly increasing concentrations in the water supply well at the Madison Early Childhood Leaning Center (aka Jesse Beer School) located at 103 Bahl Avenue, Mansfield, Ohio for the past several years. The school now uses an alternative source of water for drinking and cooking. Because of concerns about nearby private wells that provide the drinking water supply for residences in the neighborhood, well sampling was conducted for VOCs in this part of Madison Township, east of Mansfield, in Richland County.

In this Health Consultation, the Ohio Department of Health (ODH) evaluates the public health implications of exposure to the VOCs TCE (trichloroethylene) and cis-1,2-DCE (cis-1,2-dichloroethylene) that have been detected in the public water supply at the Jesse-Beer Child Care Center and the nearby private water wells of residences in Madison Township.

**Conclusion:**

Exposure to TCE in private water supply wells sampled in Madison Township is not expected to harm people's health under typical conditions of water use. However, children and adults—particularly pregnant women—who take longer showers (30 minutes or more) might be at increased risk of noncancer health effects. The estimated risk of developing cancer due to exposure to TCE is predicted to be low but increases with longer shower times.

**Basis for Decision:**

Exposure doses estimated for children and adults using water from nine of the wells sampled were above U.S. EPA's reference dose (RfD) for chronic (long-term) daily exposure. Further evaluation indicates that these site-specific exposure doses were below levels actually known to result in harmful noncancer health effects. However, there is a health concern for children or adults who take showers longer than the average 10-15 minutes, because the doses approach harmful levels. Pregnant women who take longer showers (30 minutes or more) might increase the risk of having a child with a fetal heart malformation. Children and adults who take longer showers could potentially increase the likelihood of noncancer health effects, such as immunological effects and kidney toxicity. The cancer risk is estimated to be low, but increases when longer shower times of 30 minutes or more are considered and assumed over a lifetime.

**Next Steps:**

ODH and the Mansfield/Ontario/ Richland County Health Department (MORCHD) are recommending that residents with VOC levels above the federal and state maximum contaminant level (MCL) of 5 parts per billion (ppb) stop using their wells as a drinking water supply. Bottled water should be used for drinking and cooking until whole-house treatment systems can be installed or the homes can be hooked up to the regional public water supply. MORCHD has contacted the U.S. EPA in Region 5 for additional assistance.

**For More Information** Residents can obtain information about water treatment by contacting the Mansfield/Ontario/Richland County Health Department at (419) 774-4500 or ODH Private Water Systems Program staff at (614) 466-1390. Questions about the Ohio EPA investigation can be obtained from the Ohio EPA Public Information Office at (614) 644-2160.

## PURPOSE AND STATEMENT OF ISSUES

The Health Assessment Section (HAS) at the Ohio Department of Health (ODH) evaluated the public health implications of exposure to environmental contaminants in well water at the Jesse-Beer Child Care Center and nearby residences in Madison Township (East Mansfield), Richland County, Ohio. This health consultation provides the results of that evaluation, which was conducted through a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is a federal public health agency of the U.S. Department of Health and Human Services.

## BACKGROUND

### Site Description and History

Figure 1. Site Location Map


The Madison Early Childhood Learning Center, also known as the Jesse-Beer School, a prekindergarten in the Madison Local School District, is located at 103 Bahl Avenue in Madison Township east of Mansfield, Richland County, Ohio. Trichloroethylene (TCE) and cis-1,2-dichloroethylene (cis-1,2-DCE) have been detected in the school's public water supply well since 1991. The Ohio Environmental Protection Agency (EPA) Division of Environmental Response and Revitalization (DERR) notified HAS that TCE in the school well had increased to a level slightly above the federal and state drinking water standard of 5 parts per billion (ppb) in early 2012. In June 2012, the school began using an alternative source of water for drinking and cooking. The Ohio EPA conducted a site assessment to identify a suspected source(s) of contamination. Because of concerns regarding the safety of nearby private wells that provide the drinking water supply for residences in the neighborhood, ODH and the Mansfield/Ontario/Richland County Health Department (MORCHD) sampled six private wells in the area on October 11, 2012. After finding elevated levels of TCE in three of these wells, Ohio EPA, ODH, and MORCHD tested an additional 33 private water wells in the Bahl Avenue and Park Avenue East area in Madison Township (East Mansfield) on December 5, 2012. In February 2013, ODH and Ohio EPA sampled 15 additional private wells located further north and south of the Jesse Beer site to address data gaps and further delineate the extent of the private well contamination.

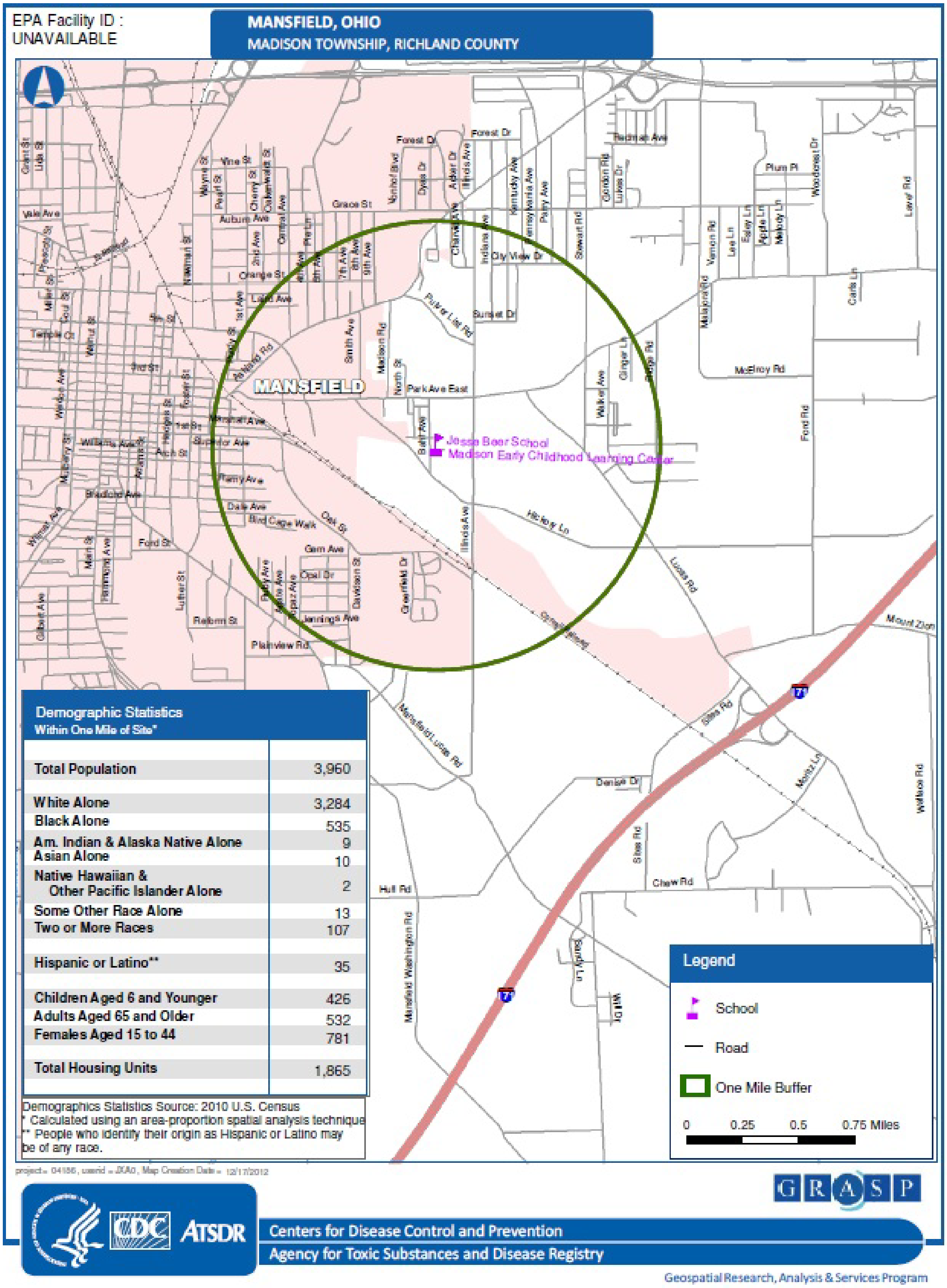
**Demographics and Land Use**

Madison Township is a part of the Mansfield Metropolitan Statistical Area. The 2010 Census found 11,168 people living in the township. The Madison Township population is 95% white and 2.1% Black or African American. According to the 2007-2011 American Community Survey, 14% of all people living within this area's zip code (44905) have incomes below the poverty level—similar to the U.S. average.

According to U.S. Census 2010 data, approximately 3,960 people reside within a one-mile radius of the affected well at the Jesse Beer School site is (Figure 2). The population in this area includes the following potentially sensitive groups: 781 (19.7%) women of childbearing age and 426 (10.8%) children aged 6 and younger. Land use in the area is primarily residential and commercial. A number of potential sources of chlorinated VOCs are located within a quarter-mile radius of the child care center. These include auto/truck repair and body shops, machine shops, tool and electric motor supply shops, and an exterminator (Site Assessment Work Plan, Ohio EPA 2012).

The area is unincorporated and consists of mostly single-family homes that obtain their drinking water from private wells. Most wells obtain their drinking water from a water-bearing sandstone bedrock aquifer separated from the ground surface by 30–40 feet of clay-rich glacial soils. Typical yields in area wells range between 10–45 gallons per minute (gpm), averaging about 15 gpm (ODNR well logs).

**Figure 2. Jesse Beer School Site Area Map and Demographic Information**




**Demographic Statistics**
Within One Mile of Site*

| | |
|---|---|
| Total Population | 3,960 |
| White Alone | 3,284 |
| Black Alone | 535 |
| Am. Indian & Alaska Native Alone | 9 |
| Asian Alone | 10 |
| Native Hawaiian & Other Pacific Islander Alone | 2 |
| Some Other Race Alone | 13 |
| Two or More Races | 107 |
| Hispanic or Latino** | 35 |
| Children Aged 6 and Younger | 426 |
| Adults Aged 65 and Older | 532 |
| Females Aged 15 to 44 | 781 |
| Total Housing Units | 1,865 |

Demographics Statistics Source: 2010 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.

## DISCUSSION

### Exposure Pathways

In order for residents to be exposed to chemical contaminants, such as volatile organic compounds (VOCs), they must come into direct contact with the contaminants through a completed exposure pathway. A completed exposure pathway consists of five main parts:

1. A **Source** of the hazardous chemicals (i.e., VOC-contaminated groundwater).
2. A method of **Environmental Transport** which allows the chemicals to move from the source area and bring it into contact with people (i.e., groundwater).
3. A **Point of Exposure** where people come into direct contact with the chemical of concern (i.e., residential wells of impacted homes).
4. A **Route of Exposure** which is how people come into contact with the chemical of concern (i.e., drinking contaminated well water and breathing vapor-phase VOCs during showering).
5. A **Population at Risk**, which are the people who come into contact with the chemical of concern (i.e., residents with contaminated well water).

Physical contact with the chemical contaminant does not necessarily result in adverse health effects. A chemical's ability to affect the health of an individual is also controlled by a number of other factors that include

- How much of a chemical a person is exposed to (dose),
- How long a person is exposed to the chemical (duration of exposure),
- How often a person is exposed to the chemical (frequency of exposure), and
- How toxic the chemical is (how it affects the body).

Other factors affecting a chemical's likelihood of causing adverse health effects upon exposure include the individual's

- History of past exposure to chemicals;
- Smoking, drinking, or taking of certain medicines or drugs;
- Current health status;
- Age and gender; and
- Family medical history.

#### *Groundwater Pathway*

Based the available environmental sampling data, ODH identified the use of private well water contaminated with trichloroethylene (TCE) for drinking and showering as the main pathway of concern at the Jesse Beer School site.

#### *Vapor Intrusion Pathway*

Vapor intrusion is the movement of volatile chemicals and gases from soil and groundwater into the indoor air of homes and commercial buildings. At this time, it is uncertain that this pathway would have any significance at this site due to the local geology and hydrogeology, i.e., 1) local geology consists of 30–40 feet of mostly clay till overlying a fractured bedrock sandstone aquifer; 2) the depth to the water table appears to be >25 feet in most places; and 3) the relatively low levels of TCE detected in the groundwater feeding the off-site wells (<10.4 ppb). All of these factors would suggest a geological and hydrogeological environment not likely to promote upward migration of vapor phase TCE into area homes. At the request of the local health department, Ohio EPA and U.S. EPA conducted a vapor intrusion investigation at the end of April 2013.

**Environmental Data**

***Madison Early Childhood Learning Center (Jesse Beer School)***

TCE and cis-1,2-DCE have been detected in the school's well, a public water supply well, since 1991and exceeded the federal and state drinking water maximum contaminant level (MCL) of 5 ppb for TCE for the first time in February 2012, when it reached 5.1 ppb. Based on the most recent four quarters of sample results of the school's water supply well, the running average for TCE for 2012 is about 4.8 ppb. In June 2012, the Madison Local School District ceased using the well as a drinking water supply and began providing bottled water for drinking and cooking for students and staff.

***Private Wells***

Water samples were collected from six private wells in Madison Township on October 11, 2012. Sampling results show detections of TCE at four locations (1.18, 9.04, 9.23, and 10.4 ppb) and cis-1,2-DCE at three locations (1.63, 2.56, and 2.81 ppb). TCE exceeded the MCL in three wells, which were located on Bahl Avenue (Figure 3). The maximum concentration of TCE found was 10.4 ppb. While results in the Bahl Avenue area showed the presence of TCE and cis-1,2-DCE, results for two wells located on South Illinois Avenue about 1,000 feet east of Bahl Avenue did not show the presence of these chlorinated compounds. After finding elevated levels of TCE in private wells sampled in October 2012, Ohio EPA, ODH, and MORCHD tested an additional 33 private water wells in the Bahl Avenue and Park Avenue East area in Madison Township (East Mansfield) in December 2012. Two additional wells were found to exceed the MCL for TCE. In February 2013, ODH and Ohio EPA sampled 15 additional private wells located further north and south and discovered three additional wells exceeding the MCL for TCE.

Overall, a total of 22 private wells used by 24 residences had detectable levels of TCE and 8 of these wells exceeded the MCL for TCE. The results are summarized in Table 1 and in Figure 3. Based on the monitoring history of the school's well, it is possible that TCE and cis-1,2-DCE have also been present in the nearby private wells since at least 1991. It is also likely that the concentrations of these chemicals have been increasing over that time period.

***Data Evaluation***

Upon starting this assessment, the HAS conducted a screening of the detected chemical concentrations with health-based comparison values (CVs) for these chemicals. CVs can be based on either carcinogenic or non-carcinogenic effects. A contaminant detected at a concentration higher than its respective CV does not necessarily represent a health threat. Instead, the contaminant is selected for further evaluation to determine if health impacts may occur. For chronic (long-term) childhood exposures, ATSDR has derived a reference dose media evaluation guide (RMEG) of 5 ppb for TCE and a RMEG of 20 ppb for cis-1,2-DCE. RMEGs represent concentrations of substances to which people may be exposed without experiencing noncancerous, adverse health effects. For cancer effects, ATSDR has derived a cancer risk evaluation guide (CREG) of 0.76 ppb for TCE. CREGs are used to identify concentrations of cancer-causing substances that are unlikely to result in a significant increase of cancer rates in an exposed population. ATSDR's CREGs use a target risk level of $10^{-6}$, which represents a calculated risk of 1 excess cancer cases in an exposed population of 1 million persons.

The U.S. EPA has set safe drinking water standards as part of the Safe Drinking Water Act. The levels set are called maximum contaminant levels (MCLs). Although the U.S. EPA standards apply to public water systems, the Ohio Department of Health has applied these same standards to private water systems for making recommendations for water treatment and water use precautions. The U.S. EPA's and Ohio's MCL for TCE in drinking water is 5 ppb; the MCL for cis-1,2- DCE is 70 ppb. The levels found in eight of the private wells exceeded the 5 ppb standard for TCE. As indicated below, the highest level of cis-1,2-DCE detected was 4.0 ppb—far below ATSDR's CV and EPA's MCL (Table 1).

Based on the initial screening, TCE exceeded these comparison values, and was selected for further evaluation. The site-specific evaluation for TCE is discussed in detail in Appendix A. Cis-1,2-DCE did not exceed its comparison values and was not selected for further evaluation (Table 1).

**Table 1: Detections in Private Wells in 2012 and 2013**[1]

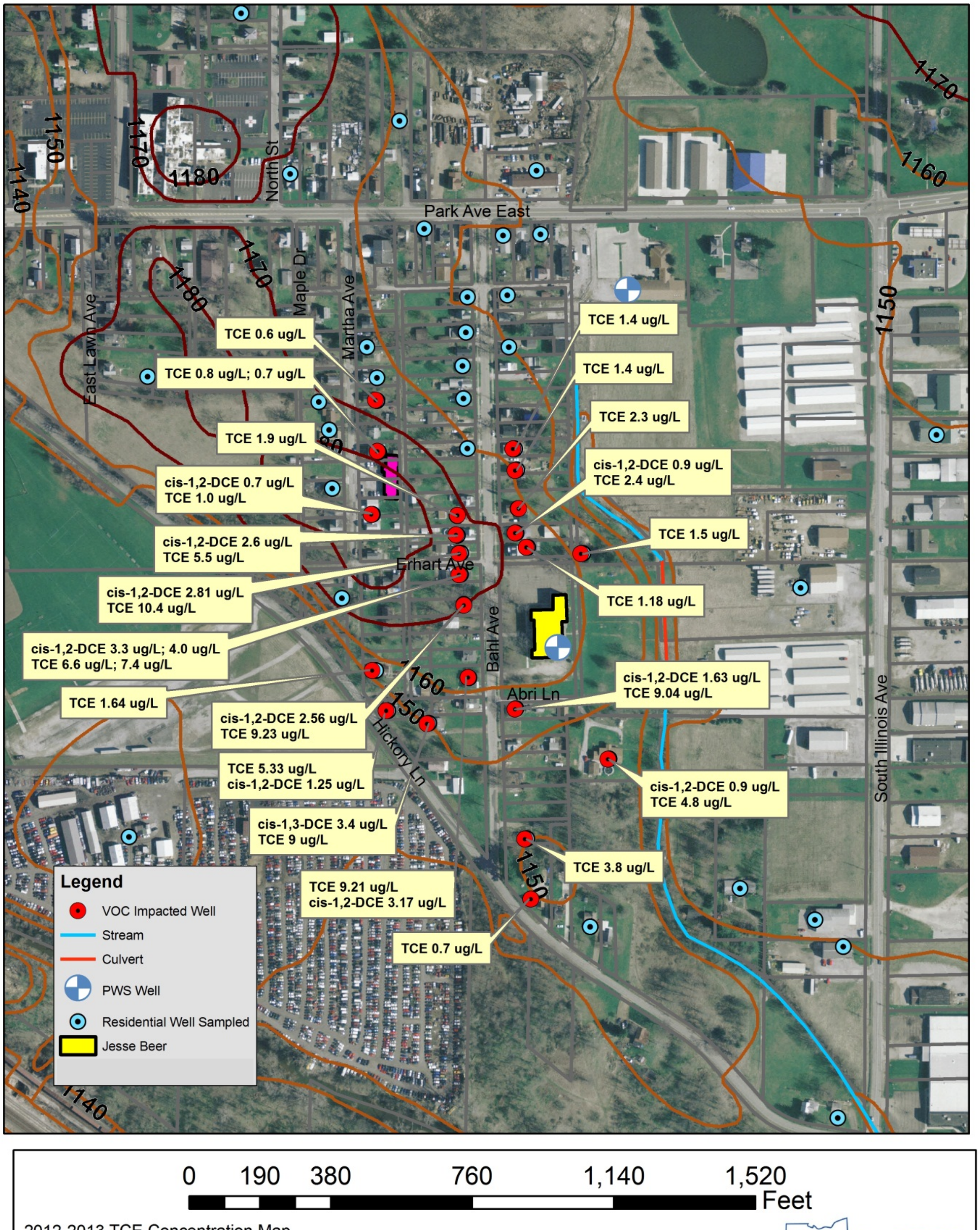
| ***Chemical*** | ***Range of Detections (ppb)*** | ***Frequency of Detections*** | ***Noncancer Comparison Value (ppb) – Type*** | ***Cancer Comparison Value (ppb) – Type*** | ***MCL (ppb)*** | ***Selected for Further Evaluation?*** |
|---|---|---|---|---|---|---|
| TCE | 0.6–10.4 | 22/52 | 5 – $RMEG_{(child)}$ | 0.76 – CREG | 5 | Yes |
| cis-1,2-DCE | 0.7–4.0 | 10/52 | 20 – $RMEG_{(child)}$ | NA* | 70 | No |

Source: Ohio EPA 2012; 2013

ppb – parts per billion or micrograms per liter
TCE – trichloroethylene
cis-1,2-DCE – cis-1,2- dichloroethylene
RMEG – reference dose media evaluation guide (ATSDR)
CREG – cancer risk evaluation guide
MCL – maximum contaminant level (EPA)
*NA = not applicable—not classified as a human carcinogen

[1] Methylene chloride (dichloromethane), a known laboratory contaminant, was detected in the third round of sampling in February 2013. In April 2013, ODH and Ohio EPA re-sampled the seven affected private wells, and results indicated no detections of this chemical artifact (with the exception of one site on S. Illinois Avenue). Therefore, almost all of the previous detections of methylene chloride can be regarded as a laboratory error.

**Figure 3. Private Well Sample Locations with TCE Detections**




2012-2013 TCE Concentration Map
Private Well Locations Sampled
Madison Twp. Richland County

## Public Health Implications

### *General Information on TCE*

Trichloroethylene (trichloroethene or TCE) is a clear, man-made liquid that will readily vaporize to a gas upon exposure to air (= VOC). TCE is used mainly as a solvent to remove grease from metal parts. Its use has been closely associated with the automotive and metal-fabricating industries from the 1950's through the 1970's. If TCE is spilled on the ground, most of it will evaporate but some of it may leak down into the ground. When it rains, TCE can sink through the soils and into the ground and contaminate groundwater. With time and depth in an oxygen-poor environment, the buried TCE will break down into different chemicals such as 1,2-dichloroethylene (1,2-dichloroethene or 1,2-DCE) and vinyl chloride. (The presence of cis-1,2-DCE in groundwater at the Jesse Beer site is most likely due to the biodegradation of TCE present in the groundwater.)

### *Health Effects*

Available human and animal studies have shown that exposure to TCE poses a potential human health hazard for noncancer toxicity to the central nervous system, the kidney, the liver, the immune system, the male reproductive system, and the developing fetus. Three toxicological studies using rodents form the basis of the U.S. EPA's newly revised reference dose (RfD). They include observations of immune system effects (decreased thymus weight) in female mice, problems with immune system development (increased delayed-type hypersensitivity) in mouse pups, and fetal heart malformations in rat fetuses whose mothers were exposed to TCE in drinking water (ATSDR 2013).

Human and animal studies have shown that TCE is associated with kidney and liver cancer and with non-Hodgkin lymphoma (NHL), a cancer of the blood. Limited evidence from a few studies suggests that other cancers might be possible. For example, a study of residents in Woburn, Massachusetts associated excessive cases of acute lymphocytic leukemia in male children with their mothers' exposure to elevated levels of TCE (and other chlorinated solvents) in a public drinking water well over a course of 5 to 10 years. 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 (ATSDR 1997). The U.S. EPA has characterized TCE as "carcinogenic in humans by all routes of exposure" (U.S. EPA 2011). The International Agency for Research on Cancer (IARC) has recently classified TCE as carcinogenic to humans (Group 1) (Guha 2012). The National Toxicology Program (NTP) determined that TCE is reasonably anticipated to be a human carcinogen (NTP 2011).

### *Site-Specific Assessment*

<u>Noncancer Health Effects</u>

Exposure doses were estimated for residents with impacted wells in Madison Township and compared to EPA's newly issued RfD of 0.0005 mg/kg/day for chronic oral exposure to TCE

(See Appendix A). The RfD is an estimate, with uncertainty or safety factors built in, of the daily lifetime dose of a substance that is unlikely to cause noncancerous health effects in humans. ATSDR has recently adopted the RfD as its minimal risk level (MRL) for TCE (ATSDR 2013). Past exposures to children at the school drinking 1 liter of water per day with a maximum detected concentration of 5.1 ppb TCE for 5 days a week is calculated to be 0.00023 mg/kg/day—below the reference dose of 0.0005 mg/kg/day. In October 2012, December 2012, and February 2013, sampling results of private wells in the Bahl Avenue area also indicated the presence of TCE and cis-1,2-DCE. Using the maximum concentration of 10.4 ppb TCE detected in residential wells, the exposure dose for a child was calculated to be about twice as high as the RfD, based on ingestion, and non-ingestion exposures (drinking and bath use). For an adult drinking and showering with water contaminated with 10.4 ppb TCE, the exposure dose was estimated to be slightly above the RfD (See Appendix A). Exposure doses estimated for children and/or adults indicate that a total of nine wells were above U.S. EPA's reference dose (RfD) for chronic (long-term) daily exposure. (These include eight wells exceeding the 5 ppb MCL for TCE and one well with a TCE concentration of 4.8 ppb.) If you consider the safety factors built into the RfD, it is not expected that exposures to TCE in private drinking water at this site will cause harmful noncancer health effects to residents (See Figure A-1). However, pregnant women or children who take much longer showers than the average 10–15 minutes could have exposure doses to vapor-phase TCE that approach harmful levels. This could increase the likelihood of noncancer health effects, such as fetal heart malformations, immunological effects, and kidney effects.

Cancer Risk

An estimate of increased cancer risk was calculated using the current U.S. EPA cancer slope factor for TCE and the highest concentration of TCE detected in drinking water in private wells in the Bahl Avenue area of Mansfield. The estimated cancer risk was determined to be $3 \times 10^{-5}$ and represents a possible 3 excess cancer cases in a population of 100,000 over a lifetime. This estimate is considered to be low and within the cancer risk range typically used by the U.S. EPA ($1 \times 10^{-6}$ to $1 \times 10^{-4}$). However, the calculated cancer risk increases when longer showers (e.g., 30 minutes or more) are taken. The cancer risk may be slightly underestimated, as age dependent adjustment factors (ADAFs)—specific to the kidney cancer portion of the overall risk—were not applied in this estimate. The calculated cancer risk may be less if the actual duration of exposure to TCE-contaminated well water is less than a lifetime (=70 years). See Appendix A for more details on the estimation of cancer risk.

**Child Health Considerations**

In communities faced with air, water, or food contamination, the many physical differences between children and adults demand special emphasis. Children could be at greater risk than are adults from certain kinds of exposure to hazardous substances. A child's lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Finally, children are dependent on adults for access to housing, for access to medical care, and for risk identification. Thus adults need as much information as possible to make informed decisions regarding their children's health.

## CONCLUSIONS

Exposure to TCE in private water supply wells sampled in Madison Township is not expected to harm people's health under typical conditions of household water use. However, children and adults—particularly pregnant women—who take longer showers (30 minutes or more) might be at increased risk of noncancer health effects. The estimated risk of developing cancer due to exposure to TCE is predicted to be low but increases with longer shower times. Exposure doses estimated for children and adults using water from nine of the wells sampled were above U.S. EPA's reference dose (RfD) for chronic (long-term) daily exposure. Further evaluation indicates that these site-specific exposure doses were below levels actually known to result in harmful noncancer health effects. However, there is a health concern for children or adults who take showers longer than the average 10-15 minutes, because the doses approach harmful levels. Pregnant women who take longer showers (30 minutes or more) might increase the risk of having a child with a fetal heart malformation. Children and adults who take longer showers could potentially increase the likelihood of noncancer health effects, such immunological effects and kidney toxicity. The estimated cancer risk is calculated to be low but increases when longer shower times of 30 minutes or more are considered and assumed over a lifetime.

## RECOMMENDATIONS

1. Immediate efforts should be taken to reduce exposure to TCE in household water that exceeds the drinking water standard. Residents whose household water exceeds the drinking water standard should use bottled water for drinking and cooking until water treatment or alternate water supply solutions are obtained. Residents should keep shower times short to avoid the potential health risks associated with inhalation of TCE during showers lasting longer than 30 minutes.

2. For the long-term, public water should be provided to residents in the impacted area to be protective of public health, until the source of the groundwater contamination can be isolated and contained or eliminated.

## PUBLIC HEALTH ACTIONS

1. As of June 2012, the Madison Local School District discontinued use of the school's public well water and is providing bottled water for drinking and cooking for students and staff at the Madison Early Childhood Learning Center.

2. ODH and the Mansfield/Ontario/Richland County Health Department (MORCHD) sampled six private wells in the area on October 11, 2012. In November 2012, ODH's Residential Water and Wastewater Program provided the sampling results in letters to the residents.

3. MORCHD has contacted the U.S. EPA in Region 5 for additional assistance regarding a safe drinking water supply for residents affected by the contamination.

4. Ohio EPA, ODH, and MORCHD tested an additional 33 private water wells in the Bahl Avenue and Park Avenue East area in Madison Township on December 5, 2012.

5. In February 2013, ODH and Ohio EPA sampled 15 additional private wells located further north and south of the Jesse Beer site to address data gaps and further delineate the extent of the VOC contamination.

6. On April 24, 2013, ODH and Ohio EPA re-sampled seven private wells because of methylene chloride detections in the February 2013 sampling event.

7. The U.S. EPA conducted a vapor intrusion assessment at the end of April 2013 at the request of the local health department.

## REPORT PREPARATION

This Public Health Consultation was prepared by the Ohio Department of Health under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved agency methods, policies, and procedures existing at the date of publication. Editorial review was completed by the cooperative agreement partner. ATSDR has reviewed this document and concurs with its findings based on the information presented.

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## Appendix A. Estimation of Human Exposure Doses and Determination of Health Effects

The Health Assessment Section (HAS) of the Ohio Department of Health (ODH) evaluated exposures to groundwater at the Jesse Beer School site in Mansfield, Ohio and nearby private residential wells. While ingestion of contaminated water is a significant exposure pathway, showering or bathing with contaminated water can also result in exposure to volatile organic compounds (VOCs). When showering in chlorinated hydrocarbon-contaminated water, a resident may be exposed from (1) breathing the portion of the contaminant that is released into the air and (2) absorbing the contaminant through the skin. Studies in humans have demonstrated that the internal dose of VOCs from showering (inhalation plus dermal) can be comparable to the exposure dose resulting from drinking the water (ATSDR 2005).

### Deriving Exposure Doses

To obtain an estimate of exposure to VOCs, the ingestion exposure was doubled to account for additional exposure from inhalation and dermal exposures. Default assumptions were used for the amount of water consumed per day by an average adult weighing 70 kg (2 liters per day) and a child weighing 16 kg (1 liter per day). This approach will underestimate the total exposure dose if a child or an adult drinks more water per day or takes longer showers. The following equation and the detected concentrations of contaminants in the tap water were used to calculate exposure:

$$ED = 2 \times \frac{C \times IR \times EF}{BW}$$

where:
ED: Exposure dose expressed in mg/kg/day
C: Maximum concentration in parts per million (mg/L)
IR: Intake rate of contaminated water: adult = 2 liters per day; child = 1 liter per day
EF: Exposure factor (unitless)
BW: Body weight (kg): adult = 70 kg; child = 16 kg

Example:

$$ED_{TCE} = 2 \times \frac{0.0104 \text{ mg/L} \times 2 \text{ L/day} \times 1}{70 \text{ kg}} = 0.00059 \text{ mg/kg/day}$$

### Estimation of Cancer Risk

The U.S. EPA has recently characterized TCE as carcinogenic to humans by all routes of exposure in its TCE toxicological review and on its Integrated Risk Information System (IRIS) (U.S. EPA 2011). HAS calculated the estimated increase in cancer risk from exposure to TCE-contaminated water, assuming a 70-year (lifetime) exposure. The exposure scenario assumed a 70 kg adult exposed to the maximum concentration TCE detected. The estimated cancer risk from exposure to TCE was calculated by multiplying the estimated exposure dose with the cancer slope factor (CSF) for TCE. This calculation estimates the excess cancer risk expressed as a proportion of the population that may be affected by a carcinogen during a lifetime of exposure. For example, an estimated cancer risk of $1 \times 10^{-5}$ represents a possible 1 additional cancer case in a population of 100,000. The following equation was used to estimate possible excess cancer risk in a population:

ER = CSF x ED

where:
ER: Estimated cancer risk (unitless)
CSF: Cancer slope factor expressed in $(mg/kg/day)^{-1}$
ED: Estimated exposure dose expressed in mg/kg/day

**Using Exposure Doses to Evaluate Health Hazards**

Exposure doses were estimated for the affected residents in Mansfield and compared to EPA's newly issued reference dose (RfD) of 0.0005 mg/kg/day for chronic oral exposure to TCE. The RfD is an estimate, with uncertainty or safety factors built in, of the daily lifetime dose of a substance that is unlikely to cause noncancerous health effects in humans. The RfD for TCE is based on decreased thymus weight in female mice; decreased plaque-forming cell response, increased delayed-type hypersensitivity in mice; and increased fetal cardiac malformations in rats. Uncertainty or "safety" factors of 100, 1,000, and 10 were applied, respectively. For adult residents drinking water having the maximum detected TCE concentration (10.4 ppb), the exposure dose was estimated to be slightly above the reference dose. For children, the exposure dose was calculated to be about twice as high as the RfD (see Table A-1).

Because TCE is considered to be a human carcinogen, an estimate of increased cancer risk was calculated using the current U.S. EPA cancer slope factor of $4.6 \times 10^{-2}$ per mg/kg/day for TCE and the highest concentration (10.4 ppb) of TCE detected in drinking water in private wells in the Bahl Avenue area of Mansfield. The estimated cancer risk was determined to be $2.7 \times 10^{-5}$ and represents about 3 excess cancer cases in a population of 100,000 over a lifetime. This estimated cancer risk is considered to be low and within the cancer risk range typically used by the U.S. EPA ($1 \times 10^{-6}$ to $1 \times 10^{-4}$). The calculated cancer risk is expected to be higher if longer showers (several times the average 10–15 minutes) are considered and assumed over a lifetime.

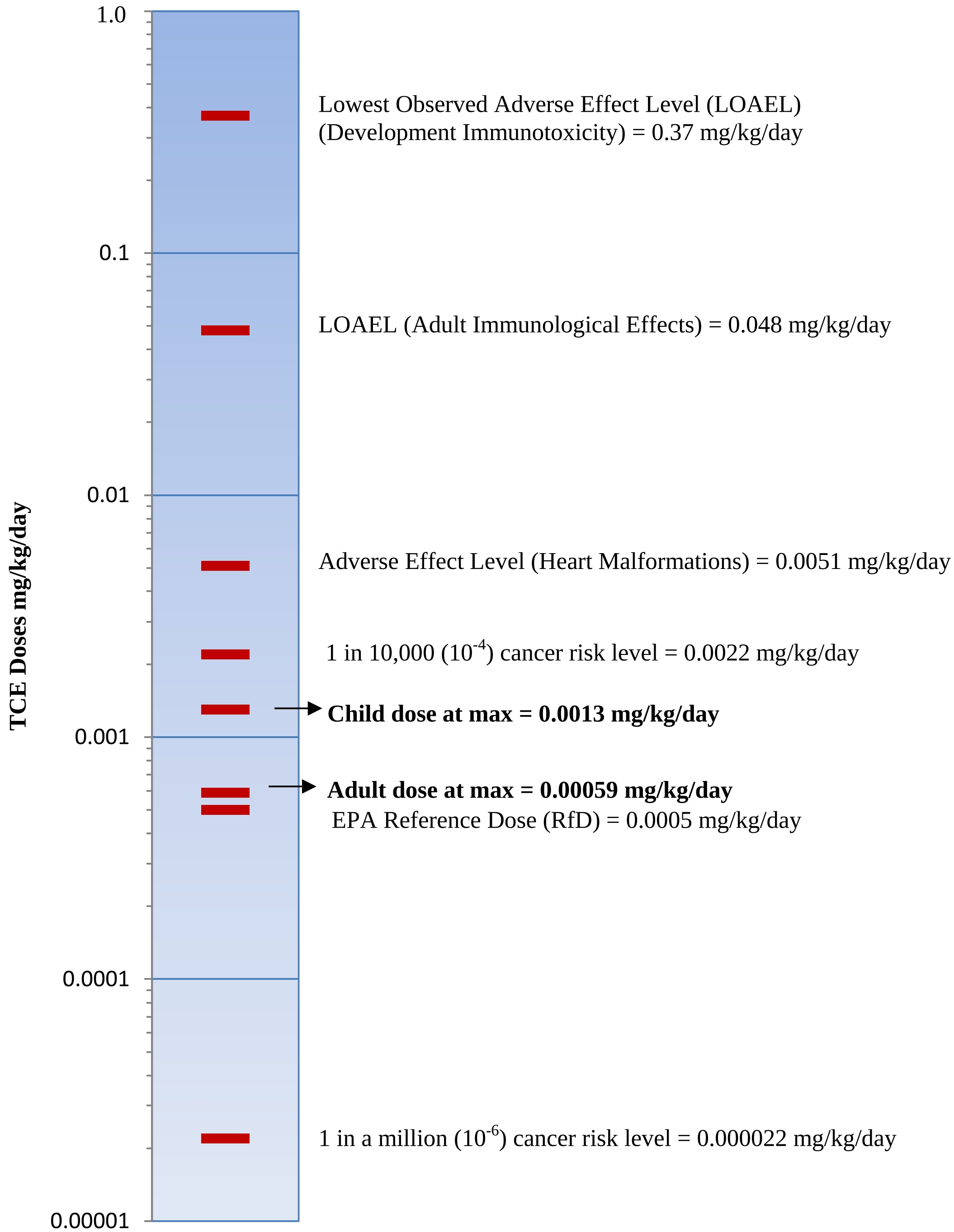
**Table A-1. Estimated Exposure Doses and Cancer Risk**

| *Chemical* | *Maximum Detected Concentration (ppb)* | *Estimated Exposure Dose (mg/kg/day)* | | *Reference Dose (RfD) (mg/kg/day)* | *Exceeds RfD?* | *Estimated Cancer Risk (Adult)* |
|---|---|---|---|---|---|---|
| | | *Adult* | *Child* | | | |
| TCE | 10.4 | 0.00059 | 0.0013 | 0.0005 | Yes | $2.7 \times 10^{-5}$ |

ppb – parts per billion or micrograms per liter
TCE – trichloroethylene

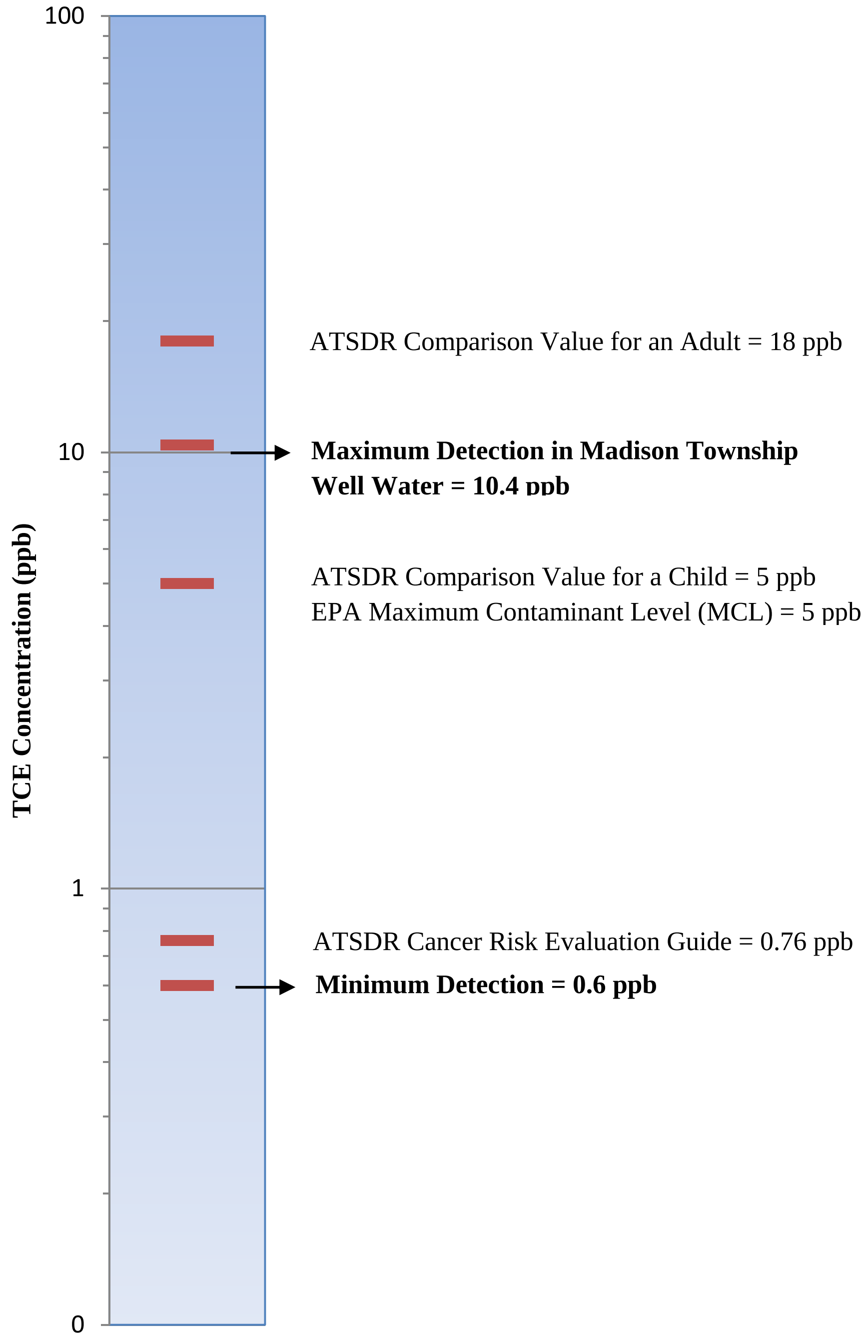
Figure A-1 shows the exposure dose from groundwater exposure at the maximum level detected (10.4 ppb) relative to doses associated with adverse health effects in animals and health-based comparison values. Figure A-2 shows how TCE concentrations detected in wells in Mansfield compare to drinking water standards and ATSDR drinking water comparison values.

**Figure A-1. TCE Doses from Well Water Relative to Health Guidelines and Health Effect Levels**




mg/kg/day = milligrams of chemical per kilogram of body weight per day (exposure dose).

**Figure A-2. TCE Concentrations in Well Water (ppb) Relative to EPA Drinking Water Standards and ATSDR Comparison Values**




ppb = parts per billion

# Appendix B. Fact Sheets

**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 a man-made chemical that is not naturally found in the environment. TCE is a non-flammable (does not burn), colorless liquid with a somewhat sweet odor and sweet, "burning" taste. It is mainly used as a cleaner in industry to remove grease from metal parts. TCE can also be found in common household items such as 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 or when we use common household products that contain TCE. It can also contaminate soils and groundwater (underground drinking water) as the result of spills or improper disposal.

## What happens to TCE in the environment?

- Upon contact with the air, TCE quickly evaporates and breaks down in the sunlight and oxygen.
- TCE quickly evaporates from the surface waters of rivers, lakes, streams, creeks and puddles.
- If large amounts of TCE are spilled on the ground, some of it will evaporate and some of it may leak down into the soils. When it rains, TCE can be carried through the soils and into the groundwater (drinking water).
- When TCE-contaminated groundwater is in an anaerobic (without oxygen) environment and with time, it will break down into different chemicals such as 1,2 Dichloroethene (1,2 DCE) and Vinyl Chloride (VC).
- TCE does not build up in plants and animals.
- 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?

- Breathing (Inhalation): TCE can get into your body by breathing air contaminated with TCE vapors. The vapors can be released from the industrial use of TCE, from using household products that contain TCE, or by TCE contaminated water evaporating in the shower.
- Drinking (Ingestion): TCE can get into your body by drinking TCE contaminated water.
- Skin (Dermal): Small amounts of TCE can get into your body through skin contact. This can take place when using TCE as a cleaner-degreaser or by contact with TCE contaminated soils.

## Can TCE make you sick?

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

- 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 does TCE affect your health?

### Breathing (Inhalation):

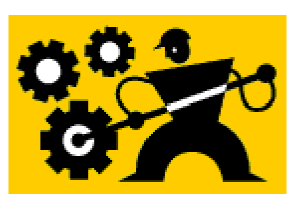
- Breathing high levels of TCE may cause headaches, lung irritation, dizziness, poor coordination (clumsy) and difficulty concentrating.
- Breathing very high levels of TCE for long periods may cause nerve, kidney and liver damage.

### Drinking (Ingestion):

- Drinking high concentrations of TCE in the water for long periods may cause liver and kidney damage, harm the immune system and damage fetal heart development in pregnant women.
- 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 irritation and rash.



## Does TCE cause cancer?

In September of 2011 the U.S. EPA revised their Integrated Risk Information System (IRIS) numbers for cancer and non-cancer effects for Trichloroethylene (TCE). The U.S. EPA newly revised IRIS document has classified TCE as "carcinogenic to humans." This classification is used when there is evidence between human exposure and cancer.

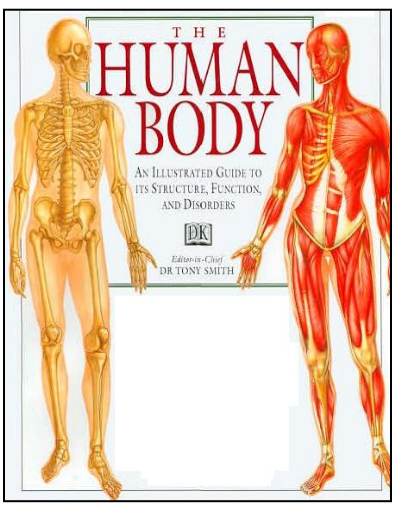
The National Toxicology Program's 12th Report on Carcinogens list TCE as *Reasonably Anticipated to be a Human Carcinogen*. **NOTE:** The 12th Report on Carcinogens was released prior to the release of the new EPA IRIS revision. It is likely the next Report on Carcinogens will reflect the EPA IRIS number changes.

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

Yes, medical testing is available to determine recent exposure(s).

- TCE can be measured in your breath, but only if you have been exposed to ***large*** amounts (part per million -- ppm levels).
- Blood or urine samples can also be used, but only if you have been exposed to ***large*** amounts (part per million -- ppm levels).

## TCE in the human body:




When chemicals enter the human body, they typically get broken down and eliminated through normal bodily functions. Some of the break down products (called metabolites) of TCE can be measured in your blood or urine. However, some of the same metabolites in your blood and urine can also be produced as a result of exposure to similar chemicals and other sources (diet, medications, environment, etc.). For this reason, blood and urine testing is not always an accurate measure of exposure to TCE.

It is important to note TCE and TCE's metabolites usually leave the body shortly after exposure, so the testing would only be useful for recent exposures. Also, testing may not be useful or reliable in determining whether people have been exposed to low-doses of TCE or whether they will experience any harmful health effects.

## 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:

- ✓ On 09/28/2011 the U.S. EPA revised their Integrated Risk Information System (IRIS) numbers for Trichloroethylene (TCE) (CASRN 79-01-6) -- see below reference section for link --
- The Environmental Protection Agency (EPA) has set a maximum contaminant level (MCL) for TCE in drinking water at 0.005 milligrams per liter (0.005 mg/L) or 5.0 parts of TCE per billion parts water (5.0 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 a healthy adult, 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/ToxProfiles/tp.asp?id=173&tid=30

Report on Carcinogens, Twelfth Edition; U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program, 2011 (electronic at http://ntp.niehs.nih.gov/ntp/roc/twelfth/roc12.pdf)

U.S. EPA Integrated Risk Information System (IRIS) for Trichloroethylene (TCE) (CASRN 79-01-6) http://www.epa.gov/iris/subst/0199.htm

**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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ATSDR AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

| Bureau of Environmental Health<br>Health Assessment Section<br>"To protect and improve the health of all Ohioans" | 1,2-Dichloroethene<br>(also called cis- and trans- 1,2 DCE )<br>Answers to Frequently Asked Health Questions |
|---|---|

## What is 1,2 DCE?

1,2-Dichloroethene (1,2 DCE) is a highly-flammable, chlorinated, colorless liquid that has a sharp, harsh odor. There are no known products you can buy that contain 1,2 DCE. 1,2 DCE is used when mixing other chlorinated chemicals and is most often used to produce chemical solvents.

## How does 1,2 DCE enter the environment?

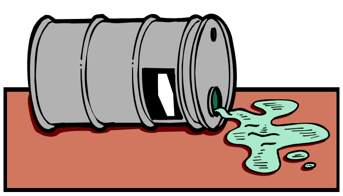
1,2 DCE is released to the environment from chemical factories that make or use this chemical, from landfills and hazardous waste sites that have a spill or leak, from chemical spills, from burning vinyl and from the chemical breakdown of other chlorinated chemicals in the underground drinking water (groundwater).

## What happens to 1,2 DCE when it enters the environment?

**Air:** When spilled on moist soils or in rivers, lakes and other bodies of water, most of the 1,2 DCE quickly evaporates into the air. 1,2 DCE quickly breaks down by reacting with the sunlight. In the air, it usually takes about 5-12 days for half of any amount spilled to break down.

**Water:** The 1,2 DCE found below soil surfaces in landfills or hazardous waste sites may dissolve in water during rain events and leak deeper in the soils, possibly contaminating the groundwater. Once in groundwater, it takes about 13-48 weeks for half of any amount spilled to break down.

**Soils:** Some 1,2 DCE trapped under ground may escape as soil-gas vapors. These vapors can travel through soils, especially if the soils are sandy and loose or have a lot of cracks (fissures). The vapors can then enter a home through cracks in the foundation or into a basement with a dirt floor or concrete slab. 1,2 DCE in groundwater will eventually break down into vinyl chloride and other chemicals, some of which are more hazardous to people than the 1,2 DCE.



## How can I be exposed to 1,2 DCE?

People who live in cities or suburbs are more likely to be exposed to 1,2 DCE than people living in rural areas. Most people who are exposed through air or water are exposed to very low levels, in the parts per billion (ppb) range. **Notes: "ppb" is a unit of measurement. Example: 1 part per billion (1 ppb) would be equal to having one bean in a pile of one billion beans.**

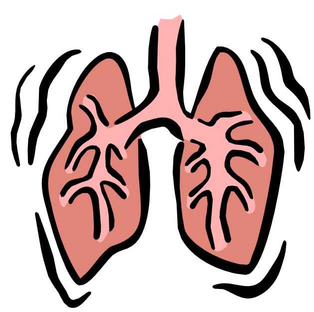
Human exposure to 1,2 DCE usually happens where the chemical has been improperly disposed of or spilled. Exposure mainly happens by breathing contaminated air or drinking contaminated water. If the water in your home is contaminated, you could also be breathing 1,2 DCE vapors while cooking, bathing or washing dishes.

The people who are most likely to be exposed to 1,2 DCE are people who work at factories where this chemical is made or used, people who work at a 1,2 DCE contaminated landfill, communities that live near contaminated landfills and hazardous waste sites.

## How does 1,2 DCE enter and leave my body?

Most 1,2 DCE enters the body through your lungs when you breathe contaminated air (inhalation), through your stomach and intestines when you eat contaminated food or water (ingestion), or through your skin upon contact with the chemical (dermal).

Once breathed or swallowed, it enters your blood rapidly. Once in your blood, it travels throughout your body. When it reaches your liver it is changes into several other break-down chemicals. Some of these chemicals are more harmful than 1,2 DCE.



## Can 1,2 DCE make me sick?

Yes, you can get sick from exposure to 1,2 DCE. However, getting sick will depend on many factors such as:

- <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>How toxic</u> is the chemical of concern.
- <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 can exposure to 1,2 DCE affect my health?

Most information about exposure to 1,2 DCE is from occupational studies where workers were exposed at very high levels. Most environmental exposures to 1,2 DCE are at much lower than those in the workplace.

The short-term occupational studies of workers exposed to breathing <u>high levels</u> of 1,2 DCE found workers became nauseous (upset stomach) and drowsy/tired.

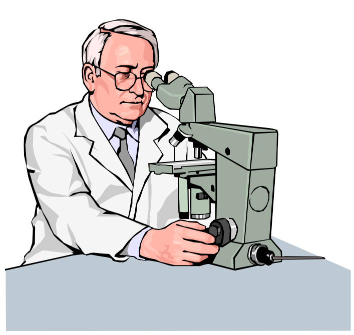
The long-term human health effects after exposure to low concentrations of 1,2 DCE are not known.

## Will exposure to 1,2 DCE cause cancer?

The U.S. EPA classifies 1,2 DCE as a Class D carcinogen. The U.S. EPA Class D category is used when the chemical is not classifiable to its human carcinogenicity (ability to cause cancer). This classification is made because there is no solid data that this chemical causes cancer in humans or animals.

## Is there a test to find out if I have been exposed to 1,2 DCE?

Tests are available to measure concentrations of 1,2 DCE in blood, urine and tissues. However, these tests aren't normally used to determine whether a person has been exposed to this compound. This is due to the fact that after you are exposed to 1,2 DCE, the breakdown products in your body that are detected with these tests may be the same as those that come from exposure to other chemicals. These tests aren't available in most doctors' offices, but can be done at special laboratories that have the right equipment.



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

The federal government has developed regulatory standards and guidelines to protect people from possible health effects of 1,2 DCE in water and air.

**Water:** The EPA has established water quality guidelines to protect both aquatic life and people who eat fish and shellfish. The EPA Office of Drinking Water has set a drinking water regulation that states that water delivered to any user of a public water system shall not exceed 70 ppb for cis-1,2 DCE and 100 ppb trans-1,2 DCE. For very short-term exposures (1 day) for children, EPA advises that concentrations in drinking water should not be more than 4 ppm for cis-1,2 DCE or 20 ppm for trans-1,2 DCE. For 10-day exposures for children, EPA advises that drinking water concentrations should not be more than 3 ppm for cis-1,2 DCE or 2 ppm for trans-1,2 DCE. For industrial or waste disposal sites, any release of 1,000 pounds or more must be reported to the EPA.

**Air:** The National Institute for Occupational Safety and Health (NIOSH) and the American Conference of Governmental Industrial Hygienists (ACGIH) have established guidelines for occupational exposure to cis- or trans-1,2 DCE. Average concentrations should not exceed 200 ppm in the air.

## References:

Agency for Toxic Substances and Disease Registry (ATSDR). 1996. Toxicological profile for 1,2-Dichloroethene. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

U.S. Environmental Protection Agency, Integrated Risk Information System, II.A.1. Weight-of-Evidence Characterization

## Where Can I Get More Information?

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

**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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