DEPARTMENT OF HEALTH

Public Comment Draft of a Public Health Assessment for the Water Gremlin Facility

WHITE BEAR TOWNSHIP, RAMSEY COUNTY, MINNESOTA

Prepared by:

Minnesota Department of Health

April 26, 2022

Prepared Under a Cooperative Agreement with the

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES

Agency for Toxic Substance and Disease Registry

Division of Community Health Investigations

Atlanta, Georgia 30333

Foreword

This document summarizes public health concerns related to contamination at a site in Minnesota. It is based on a formal evaluation prepared by the Minnesota Department of Health (MDH). For a formal site evaluation, a number of steps are necessary:

- *Evaluating exposure:*
  MDH scientists begin by reviewing available information about environmental conditions at the site. The first task is to find out how much contamination is present and how people might be exposed to it. Usually, MDH does not collect its own environmental sampling data. Rather, MDH relies on information provided by the Minnesota Pollution Control Agency (MPCA), the US Environmental Protection Agency (EPA), other government agencies, private businesses, and the general public.
- *Evaluating health effects:*
  If there is evidence that people are being exposed—or could be exposed—to hazardous substances, MDH scientists will take steps to determine whether that exposure could be harmful to human health. MDH's report focuses on public health— that is, the health impact on the community as a whole. The report is based on existing scientific information.
- *Developing recommendations:*
  In the evaluation report, MDH outlines its conclusions regarding any potential health threat posed by a site and offers recommendations for reducing or eliminating human exposure to pollutants. The role of MDH is primarily advisory. For that reason, the evaluation report will typically recommend actions to be taken by other agencies—including EPA and MPCA. If, however, an immediate health threat exists, MDH will issue a public health advisory to warn people of the danger and will work to resolve the problem.
- *Soliciting community input*:
  The evaluation process is interactive. MDH starts by soliciting and evaluating information from various government agencies, the individuals or organizations responsible for the site, and community members living near the site. Any conclusions about the site are shared with the individuals, groups, and organizations that provided the information. Once an evaluation report has been prepared, MDH seeks feedback from the public. If you have questions or comments about this report, we encourage you to contact us.

Minnesota Department of Health | Site Assessment and Consultation
625 Robert St. N. | PO Box 64975 | St. Paul, MN 55164-0975
651-201-4897 | health.hazard@state.mn.us
www.health.state.mn.us

To obtain this information in a different format, call: 651-201-4897.

This publication was made possible by Grant Number 5 NU61TS000317-02-00 from the Agency for Toxic Substances and Disease Registry. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the Agency for Toxic Substances and Disease Registry, or the Department of Health and Human Services.

Contents

Figures

Tables

Purpose

The Minnesota Department of Health's (MDH) mission is to protect, maintain, and improve the health of all Minnesotans. MDH's goal is to provide information people need to protect their health and to answer community questions about environmental contaminants and health. To meet this goal, MDH health assessors evaluate public health risks at sites or facilities where chemicals have been released into the environment. MDH also evaluates environmental data and advises state and federal regulatory agencies and local governments on actions that can be taken to protect public health.

The purpose of this Public Health Assessment is to summarize and interpret all the available environmental data from the Water Gremlin investigations from 2019 to the present. This document describes how people may have been, or continue to be, exposed to chemicals from Water Gremlin and what that may mean for their health. Acknowledging and addressing community concerns shared with MDH is another important aim.

I. Summary

A. Introduction and Background

In January 2019, the Minnesota Pollution Control Agency (MPCA) discovered that the Water Gremlin Company, located at 4400 Otter Lake Road in White Bear Township (see map in Appendix A), was emitting significantly more trichloroethylene (TCE) into the air than allowed by their MPCA air permit. As a result, it was believed that some people living and working nearby were exposed to airborne TCE concentrations above MDH's health-based value for TCE inhalation. TCE use at the Water Gremlin facility stopped in January 2019.

MPCA requested MDH assistance to evaluate health risks and collaborate on community involvement activities. This document is part of that effort and attempts to record and explain events and findings most relevant to understanding the potential implications of this site for the health of the community that lives, works and plays near the Water Gremlin facility.

Water Gremlin began manufacturing lead fishing sinkers from a garage on family property in 1949. It expanded gradually, and by 1964 occupied a 12,000 square foot facility. The current facility was built in stages over the years, with major expansions occurring in the 1970s and the 1990s as the company diversified by adding custom lead parts manufacturing (Wenck, 2019). Water Gremlin fabricates lead metal products from purchased, refined lead materials. Lead acid battery terminal posts (BTPs) are currently a primary product for the company (Wenck, 2019). TCE was used as a coating for the BTPs, likely from 1992 up until January 2019. Annual estimates of tons of TCE released in the coating process varied from 21 to 120 tons per year.

On March 1, 2019, MPCA and Water Gremlin signed a Stipulation Agreement (MPCA, 2019a) that provided information about the facility's enforcement violations and description of the accepted penalties stemming from the release discovered in January. It also outlined an alternative operating scenario that allowed the company to resume coating operations using trans-1,2-dichloroethylene (t-DCE) as an alternative to TCE.

The Stipulation Agreement required Water Gremlin to conduct an environmental investigation by sampling groundwater, soil, soil vapor, sediment, surface water, and private drinking water wells. Municipal drinking water and private wells were also sampled. Five air monitors were installed surrounding the Water Gremlin facility and these continue to sample the air for volatile organic compounds (VOCs) including TCE and t-DCE.

MDH summarized public health data from the Minnesota Cancer Reporting System, the Birth Defects Information System, and the Blood Lead Information System to respond to questions about health impacts in the surrounding community and the workers at the facility. By analyzing this data, it was discovered that some Water Gremlin workers were inadvertently exposing their families to take-home lead contamination from the workplace.

MDH and many partners coordinated and collaborated on numerous community involvement and engagement activities. Other state agencies, county public health, local government, and community advocates contributed. Outreach activities included public meetings, office hours, one-on-one outreach to contact affected community members and their families, and providing translated materials in Hmong, Hispanic, Karen, and Somali.

B. Conclusions

MDH reached seven main conclusions regarding potential exposures to contaminants from Water Gremlin. The basis for each conclusion is described at the end of this Public Health Assessment, starting on page 50.

1. Past TCE air emissions may have harmed some people's health.
2. Past or current t-DCE and lead air emissions are not expected to harm people's health.
3. Groundwater contamination is not expected to harm people's health.
4. Soil vapor contamination is not a risk at properties near Water Gremlin.
5. Soil, sediment, and surface water contamination from Water Gremlin does not pose a health risk in the community.
6. Indoor air at the Water Gremlin facility may be harming or may have harmed worker's health.
7. Indoor air at the Water Gremlin facility may be harming or may have harmed worker's health.

II. Air Emissions

The primary way environmental contaminants leave the Water Gremlin facility is via air emissions. Past TCE emissions before January 2019 were both above permitted levels and expected to have exceeded health-based values in ambient air surrounding the facility. Modeling of TCE emissions was done in February 2019 to communicate to the community the nature of the release and potential dispersion to the surrounding neighborhoods. In March 2019, Water Gremlin replaced TCE with t-DCE and reduced total emissions. Since March 2019, air monitors measured levels of VOCs and lead in air on Water Gremlin's property. This section discusses the air emissions, both past and present, and provides an assessment of health risk. The TCE and t-DCE sections were first posted on the MDH website in September 2019 and May 2020, respectively.

At the time of this writing, the MPCA is continuing work to develop a new air permit for the Water Gremlin facility. The purpose of the new permit is to limit emissions to meet environmental regulations and to be protective of human health. The permit review process includes analysis of ambient air quality impacts from the facility including all sources of lead emissions. MDH evaluation of emissions allowed by the new air permit is beyond the scope of this health assessment.

A. Past TCE Air Emissions

Water Gremlin TCE Use History

Water Gremlin used TCE in a product coating process. According to a Water Gremlin air permit application, BTPs from die-cast machines were coated to provide an acid-resistant, leak-proof seal between the BTPs and battery cases. The coating solution, which contained TCE, was applied to BTPs by spraying or dipping (Braun, 1999). In a Phase I Environmental Site Assessment conducted in 1995, representatives of Water Gremlin stated that the coatings had been used since approximately 1985, and that the production of BTPs increased dramatically around 1990 (Braun, 1995). The report cites 1992 installation dates for four above ground storage tanks for TCE and mentions another solvent, 1,1,1-trichloroethane (1,1,1-TCA), was used prior to TCE (Braun, 1995). The U.S. Environmental Protection Agency (EPA) Toxics Release Inventory Program data (provided by Water Gremlin) indicates that Water Gremlin switched from 1,1,1-TCA to TCE in 1992 (U.S. EPA, 2019a). It is assumed that the 1,1,1-TCA use also resulted in air emissions and potential exposures during the time of its use.

Water Gremlin is subject to the federal Clean Air Act (through revisions signed into law in 1990) as well as Minnesota air permitting rules. They submitted an air permit application to MPCA in 1995 and referenced a 1995 due date for the application under the new federal and state air quality rules. In their permit application, Water Gremlin provided their 1994 actual TCE emissions as 119 tons/year. In 1999, they submitted a new permit application, which stated that they reduced TCE emissions through pollution prevention efforts from 87 tons/year in 1996 to 53 tons/year in 1998. The purpose of the 1999 application was to install additional coating machines and air pollution control equipment to capture and destroy at least 95% of their TCE emissions. Water Gremlin received an MPCA air permit in July 2000, which required the installation of a catalytic oxidizer, with enforceable operating conditions to destroy at least 95% of the TCE emissions from the coating process.

Although the catalytic oxidizer was installed in August 2000, the company discovered that the equipment was not working in November 2000 while attempting to conduct performance testing. They tried to fix it for a number of months, but ultimately decided to replace it with a different type of control equipment. Rather than destroy TCE emissions, Water Gremlin applied for an air permit amendment in 2001 to install a fluidized bed recovery system to recover the TCE. MPCA issued a new permit in April 2002 and required a reduction of emissions of at least 95 percent. A removal efficiency of 98.8% was reported from the performance test conducted that month. But weeks later, a breakdown was reported, followed by additional breakdowns that summer. In February 2003, the recovery system was rebuilt and put back into operation.

According to MPCA records, Water Gremlin reported multiple shutdowns and breakdowns of the pollution control equipment over subsequent years. Water Gremlin disclosed permit violations to MPCA in July 2018. MPCA discovered (MPCA, 2019) that Water Gremlin likely never met 95% control of emissions and were reusing the recovered TCE. As a result, Water Gremlin greatly exceeded the intended permit limit of 9.5 tons of TCE emissions a year. MPCA requested that Water Gremlin shut down operations that emitted TCE on January 14, 2019 and Water Gremlin agreed to voluntarily shut down that day. In February, Water Gremlin committed to permanently discontinuing the use of TCE and removed the remaining TCE from their facility.

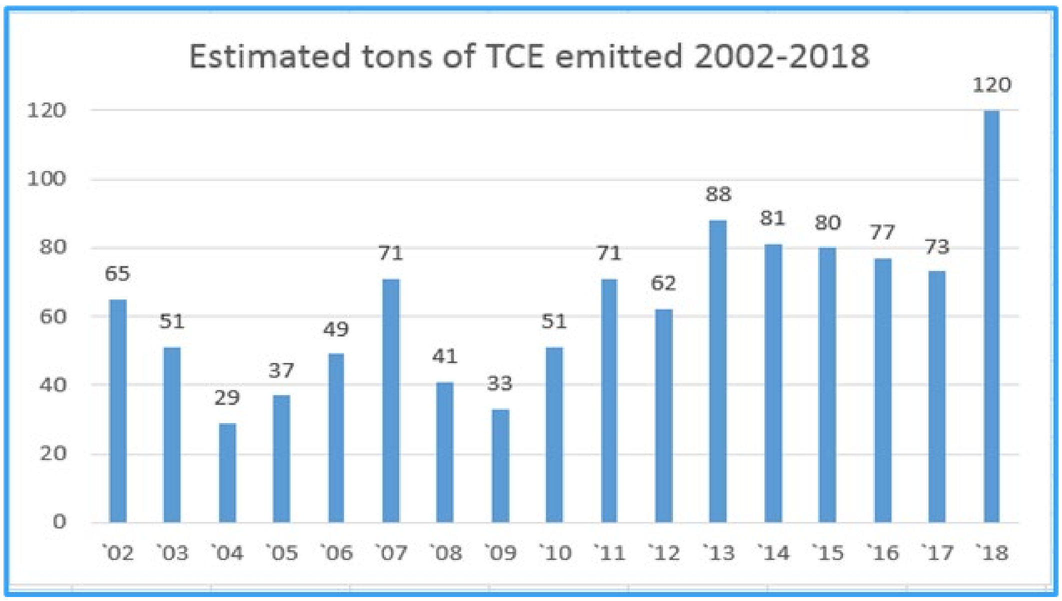
What Happens to TCE in the Air?

When TCE is emitted as a gas into the air, it spreads out and mixes in all directions. It breaks down in a matter of days to weeks. Local weather conditions affect the speed and direction of TCE movement. TCE in air typically does not settle on the soil or surface water, and any that does would evaporate back into the air quickly. TCE in air would not affect garden produce. Although TCE does not stay in the air at a location very long or build up over time, the Water Gremlin facility regularly (typically Monday to Friday) emitted it into the air.

Estimated Tons of TCE Emitted

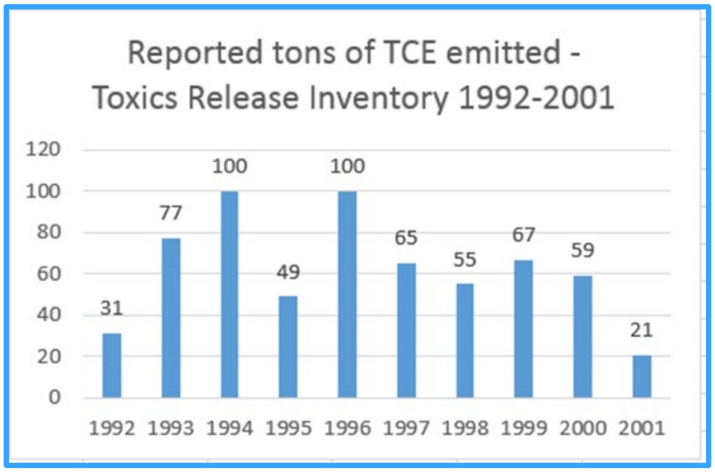
The MPCA estimated the total amount of TCE emitted to the air per year from 2002-2018 based on records from Water Gremlin (see Figure 1 below). The MPCA estimated these annual totals by calculating the difference between the amount of liquid TCE purchased and the amount of TCE removed from the facility as waste for the year.

Figure 1: Estimated tons of TCE emitted 2002-2018



The chart below (Figure 2) provides the tons of TCE emitted as reported by Water Gremlin to the U.S. EPA's Toxic Release Inventory (TRI) for the years 1992-2001. Water Gremlin's 1999 permit application, as discussed above, provides different values for the years 1994 (119 tons vs 100 tons in the TRI), 1996 (87 tons vs 100 tons in the TRI), and 1998 (53 tons vs 57 tons in the TRI). While the accuracy of these TRI data is uncertain, these annual emission estimates appear to be the best information available for estimating TCE air emissions in the surrounding area for this earlier period of TCE use.

Figure 2: Reported tons of TCE emitted – Toxics Release Inventory 1992-2001



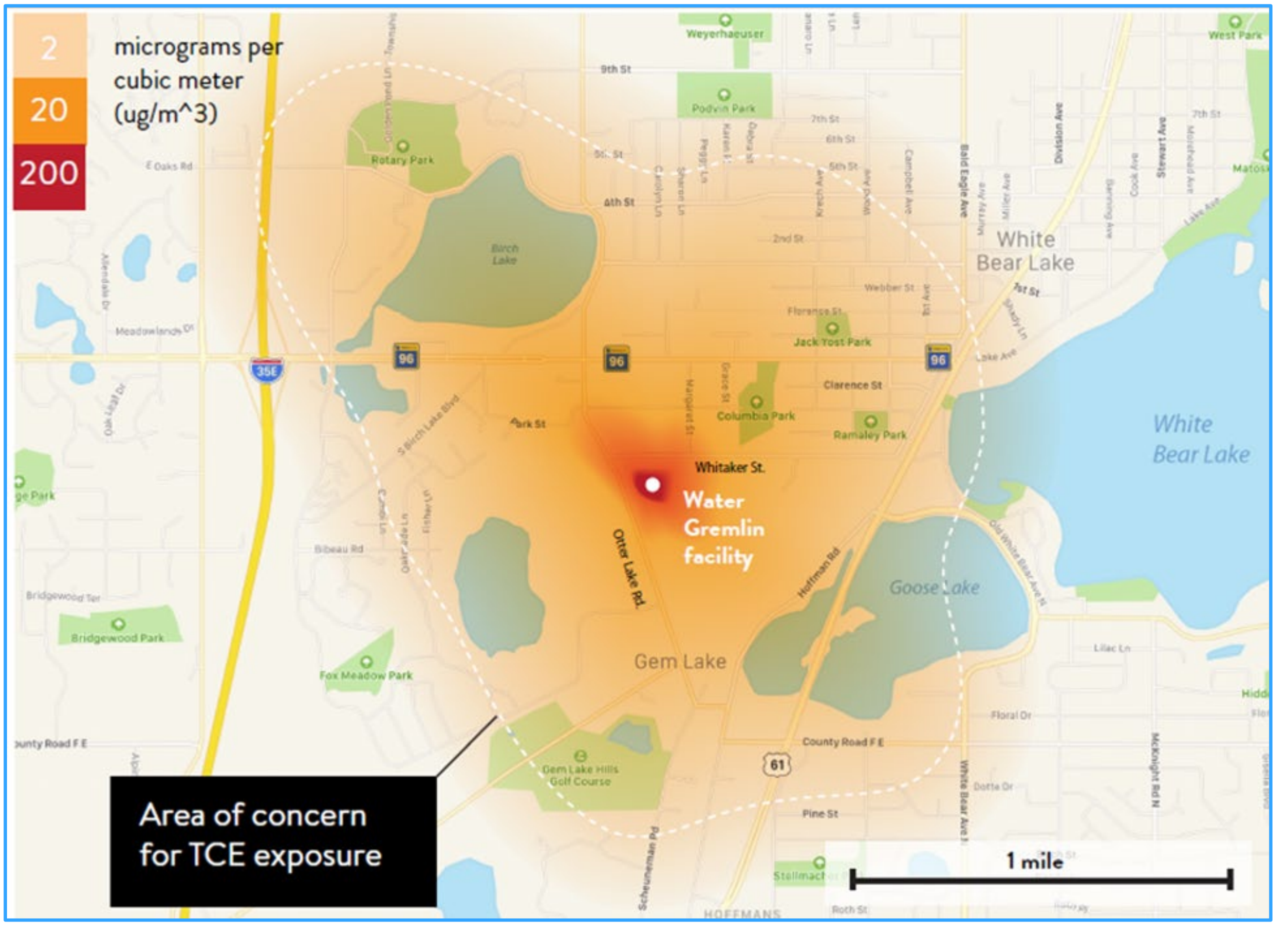
Estimating Past TCE Air Concentrations – Air Dispersion Modeling

Air quality dispersion modeling uses computer simulation to predict the concentrations of an air pollutant at different locations and distances from a source. MPCA uses the AERMOD dispersion model, developed and recommended by the U.S. EPA, to estimate the levels of air pollutants emitted from emission sources. For pollutants emitted through a stack, as occurs at Water Gremlin, AERMOD simulation considers the emission rate, stack height, stack diameter, and stack gas temperature and velocity, as well as the effect of nearby buildings and terrain. AERMOD also uses meteorological data such as temperature, wind direction, and wind speed to calculate pollutant concentrations at various locations.

MPCA provided a map of the area potentially affected by TCE in February 2019 (see Figure 3 below). The map was created by MPCA to display AERMOD dispersion modeling based on the total amount of TCE emitted by Water Gremlin in 2018. This year was chosen because TCE emissions were the highest compared to all other years. The area inside the dotted line shown on the map represents locations where estimated amounts of TCE in outdoor air were predicted to be above the MDH inhalation Health-Based Value (HBV) of 2 µg/m3 (micrograms per cubic meter). The HBV is an amount of a contaminant in air that is unlikely to lead to health effects even if sensitive members of the population are exposed to it 24 hours a day, 7 days a week, for up to a lifetime. The map was intended to represent where estimated air concentrations could have been above MDH's HBV for TCE for the purposes of inclusively notifying the community of the situation. The figure and its features were not intended to convey any information about the likelihood of actual health effects among people living within the area labelled as "Area of concern for TCE exposure."

The highest TCE concentrations were predicted for locations nearest the release point, on the Water Gremlin facility property. Outside the property boundary, at the location of the closest residence, the highest annual average TCE concentration (2018 TCE use data) was estimated to be 59 µg/m3 and amounts were predicted to decrease with increasing distance from the facility. The majority of the shaded area represented on the map above indicates annual average TCE concentrations between 2 – 20 µg/m3.

Figure 3: Map of the area potentially affected by TCE – distributed in February 2019



The map above overestimates TCE air concentrations for many of the years that Water Gremlin emitted it. If similar maps were created using AERMOD predictions for earlier years when the total amounts of TCE emitted were less (see charts on pages 8-9), the estimated amount of TCE in air would be lower than the 2018 modeled concentrations and the total affected area where TCE exceeded the MDH HBV would be smaller. Modeling earlier years could estimate how much TCE may have been present in outdoor air at various locations near the facility over time.

The map above underestimates TCE air concentrations for shorter periods of time. The TCE air concentrations estimated on the map above are annual averages, which means that there were times throughout the year when concentrations at a particular location were higher (and other times when they were lower) than the average. Daily variations are expected due largely to variability in facility operations/TCE use and weather conditions (for example, both wind speed and direction). For periods of time, TCE air concentrations above the HBV extended beyond the outline in the above map.

The results from the dispersion modeling provide the best information currently available for estimating past annual averaged TCE air concentrations due to emissions from the Water Gremlin facility. MDH collaborated with MPCA and ATSDR to create additional maps from 2009-2018 to help increase the understanding of the potential TCE air concentrations over time near Water Gremlin. These maps can be found in Appendix B.

TCE Exposure

While air modeling can estimate the TCE concentrations in outdoor air for specified times and locations, such estimates will differ from an individual's actual exposure to TCE (that is, how much TCE enters the body through breathing). The amount a person breathed in would be highly variable, depending on how much time they spent in different locations and what the TCE concentrations were during those times. In addition, other factors such as body size, breathing rate, type and level of activities, amount of time spent indoors vs outdoors, etc. could all influence how much TCE a person was exposed to. Estimated air concentrations provide limited information about real exposures individuals might have received.

TCE is also commonly detected at very low concentrations in indoor and outdoor air. Most people are exposed to small amounts of TCE, typically at levels far below those known to affect health. Most TCE used in the U.S. is released into the air by evaporation, primarily from degreasing operations (ATSDR, 2019). It is also still used as a spot cleaner at some dry cleaners. The continual release of TCE from many small sources account for its detection at very low levels in outdoor air at MPCA's metro area monitoring sites. People can also be exposed to TCE present in products such as adhesives, paint removers, cleaners, and varnishes.

Understanding TCE Air Concentrations

The following table provides additional context about the occurrence and potential risk at different TCE concentrations in air.

Table 1: Understanding TCE Air Concentrations

Description	TCE concentration (µg/m^3)
2017 average outdoor air concentration at the nearest MPCA air monitoring site (Harding High School)	0.11
Average indoor air concentrations in three Twin Cities communities in 1999	0.5
(Sexton, et al., 2004)	2
U.S. EPA (2011)/MDH Health-Based Value - poses little to no health risk over a lifetime	~20
Estimated 1 in 100,000 increased cancer risk over a lifetime	20
A small risk of fetal heart defects for pregnant women during the first eight weeks of pregnancy (U.S. EPA. 2011; based on a rodent study)	~30
Estimated 1 in 10,000 increased cancer risk over a lifetime	200
A small risk of kidney effects with continuous exposure over a long time (U.S. EPA, 2011; based on a rodent study)	~200
Estimated 1 in 1,000 increased cancer risk over a lifetime	55,000
A small risk for decreased thymus weight (immune system effects) with continuous exposure over a long time (U.S. EPA, 2011; based on a rodent study)	> 100,000
American Conference of Governmental Industrial Hygienists 8-hour worker standard	~116,000
Concentration at which some workers experienced health effects in studies, including fatigue, headache, eye irritation, and an increase in kidney cancer (U.S. EPA, 2011)	270,000

TCE Toxicity and Risk Assessment

Risk assessment is a science-based tool that is used to evaluate the potential effects of a chemical on human health. Risk assessment uses the best available scientific information, as well as professional judgment and policy, to estimate risks using standardized processes that allow estimates to be understood and compared, and ultimately to help government agencies and the public make informed decisions about preventing and reducing risks.

To determine a safe level of exposure to contaminants, scientists frequently rely on animal studies. In these studies, animals in a laboratory (often rodents) are exposed to large amounts of a chemical of interest. The amounts such animals are exposed to are converted to human equivalent concentrations, to account for the differences between humans and animals in terms of size, weight, and response to chemical exposure. Because it is unclear how well short-term, high-exposure tests on animals predict how people may respond to low levels of exposure over a longer period of time, scientists err on the side of caution when determining a safe amount for people. This is generally done by reducing the amounts shown to cause an effect in study animals by a factor of 10 to up to 3,000 when setting an amount intended to protect people. Greater reductions are used when there is less certainty. This helps to increase confidence that health effects would be extremely unlikely at the calculated safe amount, including among sensitive individuals such as children and pregnant women.

The likelihood of health effects at the 2018 modeled concentrations (2-59 µg/m3) is low. The potential effects of TCE exposure at these concentrations are an increased risk of certain cancers (kidney, and possibly liver and non-Hodgkin's lymphoma), non-cancer effects to the immune system and kidney, and a risk of heart defects during fetal development. The risk assessment basis and evidence for these potential effects are described below.

Non-Cancer Effects

In 2011, the U.S. EPA developed a safe inhalation value of 2 µg/m3 for a lifetime of exposure, based on a review of a large number of studies of animals and humans exposed to TCE (U.S. EPA, 2011). MDH also conducted a TCE review in 2013 and 2018 and concurred with EPA's inhalation value and the conclusions from their 2011 assessment, which resulted in the MDH HBV of 2 µg/m3. MDH also developed a short-term HBV of 2 µg/m3 that is protective of a 24-hour exposure for pregnant women in their first eight weeks of pregnancy.

EPA concluded that at a sufficient dose and exposure duration, TCE poses a potential human health hazard for toxicity to the central nervous system, kidney, liver, immune system, male reproductive system, and developing fetus. EPA narrowed down the studies to those considered critical effects – those showing effects at the lowest levels — to develop a safe level that is protective of the most sensitive health effects. The main effects observed at the lowest exposures involved the immune system, the developing fetus, and the kidneys.

EPA reviewed all published studies available and chose two critical rodent studies and one supporting study as the basis for calculating the safe inhalation value. The selected studies are described below.

- One critical study showed an increased risk of subtle impacts to the immune system; the thymus (a specialized organ of the immune system) weighed less than normal and there was an increase in markers associated with autoimmune disease after mice were exposed to TCE in drinking water.
    - Effect level finding -- A small risk of immune system effects may exist for people exposed to TCE at ~200 µg/m3 continuously over a long time period.

- The second critical study showed heart defects in rats whose mothers were exposed to TCE in drinking water during pregnancy.
  - Effect level finding -- For women in the first eight weeks of pregnancy exposed to TCE at ~20 µg/m3, there may be a small risk of fetal heart defects. At this level, very few women (no more than 1 in 100) would have an amount of TCE in their body that might cause a fetal heart defect less than 1% of the time.
- A third rodent study showing kidney toxicity was considered a supporting study.
  - Effect level finding -- A small risk of kidney impacts, including toxic nephropathy and increased kidney weights may exist for people exposed to TCE levels at or exceeding ~30 µg/m3 continuously over a long time period.

To be protective in accounting for uncertainty, EPA divided the effect levels from these two critical studies by uncertainty factors of 100 in the first case and 10 in the second, to arrive at the safe inhalation value of 2 µg/m3. Note however, that exposure to amounts of TCE greater than 2 µg/m3 does not mean health effects will, or are likely to, occur; although the risk of health effects increases as the amount and duration of TCE exposure increases.

Other health effects have been shown to possibly occur at much greater exposures than the effect levels in the three studies EPA chose for its evaluation — at amounts of TCE much greater than exposures that were predicted to be possible in the community due to the emissions from Water Gremlin.

Cancer Effects

Occupational studies of high TCE exposure have shown an increased risk of kidney cancer in people. There is also evidence of an association between high levels of TCE exposure in people (and rodents) and non-Hodgkin's lymphoma and liver cancer. Less evidence is found for an association between TCE exposure and some other types of cancers. According to EPA's 2011 assessment described above, breathing TCE at the following concentrations and durations may theoretically result in the following incremental cancer risks:

- Breathing 2 µg/m3 TCE continuously for a lifetime is expected to result in no more than 1 additional cancer in 100,000 exposed people;
- Breathing 20 µg/m3 TCE continuously for a lifetime is expected to result in no more than 1 additional cancer in 10,000 exposed people; and
- Breathing 200 µg/m3 TCE continuously for a lifetime is expected to result in no more than 1 additional cancer in 1,000 exposed people

Any such increase is unlikely to be measurable compared to the background cancer rate that already exists from all causes. For comparison, recent estimates show nearly half (four or five people out of ten) of Minnesotans will be diagnosed with cancer sometime in their life. Cancer -- a group of many different diseases with many different causes -- is much more common than people realize.

For an example of how risk assessors calculate increased cancer risk based on environmental exposures, see the calculation and explanation in Appendix C.

Are Some People at Greater Risk? Do I Need Medical Testing?

MDH has stated that there is no need for people to go to the doctor solely because they live near Water Gremlin or did so in the past. TCE does not accumulate or stay in the body for more than a few days after exposure stops. Also, there is no medical test to determine whether a person was exposed to TCE from Water Gremlin. There are no recommendations for any increased screening for cancer or other health effects, although people may wish to share the fact that they were or may have been exposed to TCE in air from this situation with their physicians.

There is a general lack of data demonstrating differences in health effects from TCE exposure based on factors such as age, gender, genetics, race/ethnicity, preexisting health status and lifestyle (EPA, 2011). It is not known whether children are more susceptible than adults to the effects of TCE.

Babies born to women exposed to TCE during the first eight weeks of pregnancy (when the baby's heart is forming) are considered the most sensitive. This is in part due to the possibility that TCE exposures could have been considerably higher than the annual average concentrations for shorter windows of time and may have occurred at the same time fetal heart development occurred. Regardless, no changes in regular prenatal care are recommended as a result of TCE exposures. If the fetus developed normally there is no future risk of cardiac defects.

In addition to pregnant women and the developing fetus, MDH considers infants and children, the elderly, and those with a compromised immune system generally to be more sensitive to exposure to chemicals.

What Happens to TCE in the Body?

Most of the TCE people breathe in will go into the bloodstream and other organs. While some TCE is exhaled unchanged, much of the TCE that enters the body is metabolized, or chemically broken down, primarily in the liver. Other organs and tissues, especially kidneys, also break down some TCE. Most of the TCE breakdown products leave the body in the urine within a day (ATSDR, 2014).

When the body absorbs more TCE than it can break down quickly, some of the TCE or its breakdown products can be stored in body fat for a brief period. However, once absorption stops, TCE and its breakdown products quickly leave the fat.

The health concerns attributed to TCE are generally due to the breakdown products rather than TCE itself.

B. 2019-2020 Air Emissions – trans-1,2-dichloroethylene (t-DCE)

After Water Gremlin was forced to stop TCE use in January 2019, they expressed interest in resuming coating operations with a product called FluoSolv WS in place of TCE (NuGenTec, 2019). FluoSolv is composed primarily of t-DCE, and its use in coating results in air emissions of t-DCE from the facility.

What is trans-1,2-Dichloroethylene (t-DCE)?

t-DCE is a clear liquid that is highly flammable and evaporates easily (it is categorized as a VOC). It is used as a solvent for cleaning and degreasing, as well as a propellant and blowing agent (U.S. EPA, 2019b). It has recently been used as an alternative to TCE. Exposure occurs mainly by breathing it in at workplaces where t-DCE is made or used.

What Happens to t-DCE in the Air?

When t-DCE gas is continuously released into the air there can be localized elevated air concentrations. Farther away from the source, t-DCE mixes into the atmosphere by spreading out in all directions and becomes increasingly diluted. In the atmosphere, t-DCE is broken down to half the initial amount after about five days (U.S. EPA, 2010). t-DCE is not expected to settle on soil or surface water and would evaporate back into the air quickly.

What Happens to t-DCE in the Body?

t-DCE is a volatile, fat-soluble compound that is quickly taken up through the lungs and gastrointestinal tract (ATSDR, 1996). While it is fat-soluble, there is no solid data indicating accumulation in the liver, brain, kidney, or other fat tissue following exposure. t-DCE can be metabolized in the liver, as shown by rodent studies. It is likely broken down into more water-soluble metabolites which are quickly removed by the kidneys (ATSDR, 1996; U.S. EPA, 2010). Some studies show the body can eliminate t-DCE by exhaling it (U.S. EPA, 2010).

MDH Risk Assessment Advice – January 2019

In January 2019, MPCA requested that MDH develop a site-specific air guidance value that could be used to determine a safe amount of t-DCE that Water Gremlin could release into the air. MDH derived a chronic inhalation value of 70 µg/m3 (micrograms per cubic meter) as Risk Assessment Advice (RAA), or an amount that is safe to breathe daily for up to a lifetime. The RAA was developed to be protective for immune system effects observed in mice exposed to t-DCE in drinking water. However, exposures to t-DCE in amounts greater than 70 µg/m3 does not mean health effects are likely, especially if they only occur episodically and for less-than-lifetime durations. As a general rule, the risk of health effects increases as the amount and duration of chemical exposures increase.

MDH’s RAA was unable to take into account the minor constituents of FluoSolv WS, hydrofluoroethers, because toxicological data are unavailable for them. Hydrofluoroethers are very persistent chemicals that are added to make the FluoSolv mixture non-flammable.

t-DCE Toxicology Studies and Risk Assessment

As noted earlier, risk assessment is a science-based tool used to evaluate the potential effects of a chemical on human health. The paragraphs below describe the available t-DCE toxicology studies and how air guidance values are developed by different agencies from those studies.

The U.S. EPA completed a review of t-DCE in 2010 (U.S. EPA, 2010). EPA describes that a general overview of the toxicity studies conducted indicates t-DCE displays “low toxicity.” However, a lack of information regarding the possible health effects from breathing t-DCE over long periods is also noted. EPA concluded that there was insufficient inhalation data to support deriving a safe air value for long-term (chronic) exposures. EPA also states that there is “inadequate information to assess the carcinogenic potential” of t-DCE based on the absence of human or animal cancer studies.

Although there are no chronic studies of t-DCE, several subchronic animal studies exist. Five studies exposed rodents to t-DCE by drinking water or food, and two exposed rodents by inhalation (one unpublished). Changes in liver and kidney weight were the main effects observed (U.S EPA, 2010).

The results of the two inhalation studies were inconsistent. A limitation to both was that exposures occurred intermittently (six and eight hours/day) rather than continuously. With intermittent dosing, exposure concentrations should be adjusted to reflect a continuous exposure to use for calculating health risk values. The earliest study (Fruendt et al., 1977) showed an effect of fat accumulation in the liver and liver cells in rodents exposed to t-DCE at 794,000 µg/m3 [equivalent to 200 parts per million (ppm)]. The Agency for Toxic Substances and Disease Registry (ATSDR) used this study’s results to develop acute and subchronic air values of 790 µg/m3 (dividing the effect level noted above by an uncertainty factor of 1,000) based on fat accumulation in liver cells (ATSDR, 1996). The unpublished subchronic rodent inhalation study (DuPont, 1998) did not show any effects thought be to related to exposure to t-DCE, even at doses of 15,800,000 µg/m3.

In their 2010 toxicological review, EPA determined there was enough information to derive a safe amount for oral exposure to t-DCE. A subchronic drinking water study showing immune suppression in rodents (Shopp et al., 1985) was used to derive an amount of t-DCE that people could safely consume over a lifetime (0.02 milligram/kilogram-day). EPA applied an uncertainty factor of 3,000 to account for differences between animals and humans, variability among humans, use of a subchronic study, and a lack of additional studies. In January, 2019, MDH used this oral dose to derive a chronic air guidance value, by converting the oral exposure to inhalation exposure to arrive at the 70 µg/m3 site-specific RAA for t-DCE use at Water Gremlin.

MPCA Air Modeling

As noted earlier, air quality dispersion modeling uses computer simulation to predict pollutant concentrations at different locations and distances from a source. MPCA uses the AERMOD dispersion model, developed and recommended by the U.S. EPA, to estimate the levels of air pollutants emitted from sources. MPCA conducted air modeling of proposed Water Gremlin t-DCE emissions to back-calculate an annual emission rate that would not result in long-term exceedances of the t-DCE inhalation RAA that MDH developed in January 2019. According to the MPCA's modeling, 92 tons of t-DCE could be emitted in a year without exceeding an annual average concentration of 70 µg/m3 in air outside of the property.

Restart of Coating Operations – March 2019

Water Gremlin resumed coating operations using t-DCE in place of TCE, on March 1, 2019 after MPCA and Water Gremlin signed a settlement agreement to resolve the company's air quality violations. The agreement limited Water Gremlin's total VOC emissions to 90 tons per year, calculated as a 12-month rolling sum, using a mass balance calculation that assumed all t-DCE used in operations was emitted to air, except any accounted for as liquid waste leaving the facility. Based on the air modeling described above, this 90-ton-per-year limit prevents the annual average t-DCE levels from exceeding the RAA of 70 $\mu g/m^3$ in any locations where people live.

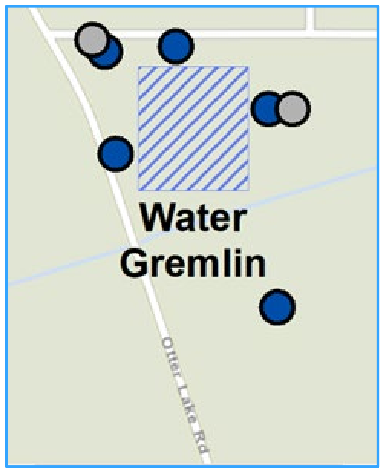
On August 22, 2019, MPCA ordered Water Gremlin to suspend the operation of the coating lines because t-DCE was found in the soil vapor beneath the company's production facility building (see section V. Remedial Investigation and Interpretation parts C. and D. for more about soil vapor). Because of this suspension, t-DCE was only used for slightly under six months in 2019. The coating lines remained shut down until January 21, 2020.

Use of the coating lines was phased back in slowly after the suspension, and some lines transitioned to a water-based coating. As a result, less t-DCE was used in 2020 each month (through March) compared to monthly active coating operations in 2019. The one-year period of t-DCE use (from March 2019- March 2020) totaled 60 tons. The 12-month rolling sum for emissions decreased in 2020 and fluctuates due to the varied amount of t-DCE used. Additional information and a chart of the t-DCE emissions as a rolling sum is available on MPCA's website at Water Gremlin air monitoring (www.pca.state.mn.us/air/water-gremlin-air-monitoring).

Air Monitoring for t-DCE – Data from March 2019 to March 2021

The 2019 settlement agreement required Water Gremlin to conduct ambient air monitoring. Five air monitors were placed on the Water Gremlin property near the property boundaries (see Figure 4 below). Beginning on March 1, 2019, 24-hour samples were collected by Pace Analytical, an independent environmental laboratory, every three days, and analyzed for a standard list of VOCs. Lab results are reported directly to the MPCA. Monitoring results have been highly variable; reflecting variation in weather (mainly wind speed and direction) and the rate of t-DCE use at the facility.

Figure 4: Locations of Air Monitors around the Water Gremlin Facility



Note: The blue circles indicate current VOC monitors, the gray circles are the former lead monitor locations.

During the period from March 1 to August 22, 2019 when FluoSolv was used, t-DCE results ranged from not detected (shown by a < symbol and a number which is the lowest level detectable) to 648 µg/m3 as summarized in Table 2 below.

Table 2: t-DCE Air Monitoring Results on Water Gremlin Property from 3/1/19 to 8/22/19 (µg/m3)

Monitor location	Minimum	Maximum	Median*	Average
East	<1.1	205	11	29
North	<1	208	5	33
Northwest	<1.1	149	5	21
South	<1.1	104	4	15
West	<1.1	648	21	86

* A median is the middle value of the results (approximately half the results are less than and half the results are greater than the median). When the monitors did not detect any t-DCE, MDH used the detection limit (rather than zero) when calculating the median and average results. This results in median and average values that are biased high (overestimations).

Air monitoring at the five monitors on the Water Gremlin property continued during the time the coating lines were shut down. During the shutdown period, low levels of t-DCE ranging from 1.2 to 5.6 µg/m3 were detected in only 16 samples out of 237 total individual samples from 48 sampling days.

Use of t-DCE resumed on January 21, 2020 at lower quantities than in 2019. Air monitoring results reflect this decline in use of t-DCE that started in 2020 (see Table 3 below).

Table 3: t-DCE Air Monitoring Results on the Water Gremlin Property

Monitor location	Minimum	Maximum	Median	Average
East	<0.6	52.4	3.4	8.3
North	<0.6	93.2	1.8	11.1
Northwest	<0.6	108	1.3	7.9
South	<0.6	50.5	1.4	6.8
West	<0.6	172	1.5	14.4

When the monitors did not detect any t-DCE, MDH used the detection limit (rather than zero) when calculating the median and average results. This results in median and average values that are biased high (overestimations).

MPCA installed additional VOC monitors at Birch Lake Elementary School (north of Water Gremlin) and Columbia Park (northeast of Water Gremlin) to provide off-site air monitoring results at locations used by the community. These locations are shown on the map in Appendix A. Two 24-hour samples were collected at these monitors in August 2019 before the t-DCE coating line shut down on August 22, 2019 (Table 4).

Table 4: t-DCE Air Monitoring Results at Birch Lake Elementary and Columbia Park Prior to Shut Down of Coating Lines (µg/m3)

Monitor location	8/13/19	8/19/19
Birch Lake Elementary	0.79	16 (estimated)
Columbia Park	1.3	3.9

Sampling continued through the end of November 2019, during the shut-down period, and yielded all nondetect results. Sampling began again on April 8, 2020 and continued through August 31, 2020 (Table 5). The majority of the results were nondetect (<2 µg/m3) and the median and average values are overestimations (see Table 5 footnote).

Table 5: t-DCE Air Monitoring Results at Birch Lake Elementary

Monitor location	Minimum	Maximum	Median*	Average*
Birch Lake Elementary	0.24	9.1	2	2.9
Columbia Park	0.04	17	2	2.8

*When the monitors did not detect any t-DCE, MDH used the detection limit (rather than zero) when calculating the median and average results. This results in median and average values that are biased high (overestimations).

MDH Risk Assessment Advice – April 2020

In 2020, MDH conducted a re-evaluation of t-DCE toxicity studies that could be used to develop an air guidance value, because an improvement in the modeling of the study data used to derive the 2019 RAA was discovered (California EPA, 2018). MDH, in consultation with the U.S. EPA, decided to use the improved study model data and updated its chronic inhalation RAA for t-DCE to 20 µg/m3. MDH also developed a subchronic inhalation value for t-DCE of 200 µg/m3. A subchronic duration is defined as a repeated exposure for greater than 30 days and up to 10% of an average human lifespan (eight years).

The 2020 RAA values are based on the amount of t-DCE (approximately 50,000 µg/m3) where an immune system effect was observed in a subchronic animal study. Therefore, it is expected that a small risk of immune system effects may exist for people exposed to t-DCE repeatedly at 50,000 µg/m3. The RAA is much lower than this to reflect uncertainties in the data and the desire to develop a safe exposure level for the population, including vulnerable subgroups.

Table 6 presents the MDH's 2019 and 2020 RAA values for t-DCE in air to compare, and illustrate the evolution of, health-based values used to evaluate air monitoring results and communicate to the public about potential for health risks due to t-DCE emissions from the Water Gremlin facility.

Table 6: MDH Risk Assessment Advice (RAA) for trans-1,2-Dichloroethylene (µg/m3)

Duration	2019 RAA	2020 RAA	Health Endpoint
Acute (up to 24 hours)	ND	ND	
Short-term (> 24 hours to 30 days)	ND	ND	
Subchronic (> 30 days to 10% of a lifetime)	ND	200	Immune System
Chronic (> 10% of a lifetime to a lifetime)	70	20	Immune System
Cancer (lifetime)	ND	ND	

ND = Not derived

Other t-DCE Air Values

EPA Screening Values

In September 2020, EPA published inhalation "screening values" for t-DCE for chronic and subchronic durations of 40 µg/m3 and 400 µg/m3, respectively (U.S. EPA, 2020). EPA determined once again that the data for t-DCE are insufficient to support deriving a toxicity value under their guidelines, however they provided the screening values they developed to assist in risk assessment. These screening values were derived using the unpublished subchronic rodent study (DuPont, 1998) mentioned above. The health endpoint was determined to be the immune system.

While there is wide agreement that toxicity data needed to derive a chronic air value for t-DCE is lacking, it is arguably helpful to have some value that limits air emissions, or provides some assessment of health risk, rather than no value at all. MDH's professional judgment about developing an inhalation value for t-DCE appears to generally be in line with decisions other states have made to address this chemical.

Occupational Values

While occupational limits can provide context for ambient air concentrations, MDH believes that some of these values are not protective of worker health over the long-term, and they certainly are not adequate to protect the general population. The Occupational Safety and Health Administration (OSHA), the National Institute for Occupational Safety and Health (NIOSH), and the American Conference of Governmental Industrial Hygienists all have adopted occupational criteria for 1,2-DCE (note this is a mixture of t-DCE and cis-1,2-DCE) of 200 parts per million in air over a workday -- equivalent to 790,000 µg/m3. NIOSH lists symptoms of occupational exposure as irritation of the eyes and respiratory system, as well as a central nervous system depression (NIOSH, 2019). These values are intended to allow workers to be able to do their work safely and may not be protective for all possible health effects for long-term exposure.

Water Gremlin t-DCE Air Emissions and Health

The outdoor air surrounding the Water Gremlin buildings and property is affected by use of t-DCE within the facility. Air concentrations measured at the five monitors on the Water Gremlin property are highly variable, based largely on weather and facility use. The t-DCE from Water Gremlin is expected to spread out in air surrounding the facility similarly to the dispersion estimated for historical TCE emissions, although current use of t-DCE is significantly lower than past use of TCE.

In 2020, MDH developed safe inhalation values for t-DCE for two different exposure durations – *chronic*, for up to a lifetime of exposure, and *subchronic*, defined as repeated exposure for greater than 30 days, up to 10% of an average lifetime (~8 years). The subchronic value was developed in response to community members' requests for help understanding the potential risks from shorter duration exposures.

While recent exposure to t-DCE from Water Gremlin is of a subchronic duration, the more appropriate and protective objective of controlling ongoing facility emissions is to remain at or below the chronic air guidance value of 20 $\mu g/m^3$. This is particularly true in a community where past emissions of TCE were excessive.

MDH does not expect health effects in the community from Water Gremlin's past or current emissions of t-DCE. Given the available air monitoring data on the Water Gremlin property, and what can be estimated from modeling, there were times when air concentrations were over the current chronic RAA value (20 $\mu g/m^3$) beyond Water Gremlin's property boundary, and very limited times when air concentrations were over the subchronic RAA value (200 $\mu g/m^3$) for a short duration. However, neither the chronic nor subchronic RAA were exceeded for a length of time that poses a potential health concern. The air monitoring results on the Water Gremlin property are also higher than actual exposures to t-DCE (how much t-DCE enters the body through breathing) experienced by people in the community.

Are Some People at Greater Risk?

MDH generally considers women who are pregnant or may become pregnant, infants and children, the elderly, and people living with chronic disease or a compromised immune system to be more sensitive to exposure to chemicals. There is no information available regarding t-DCE exposure and effects to a developing human fetus or small children. Based on the results of only one animal study, t-DCE is not currently expected to cause developmental effects in people, but the information is too limited to draw this conclusion (U.S. EPA, 2010). MDH air guidance values are developed to be protective of people who may be more susceptible.

C. Lead and Particulate Air Emissions

Water Gremlin manufactures custom lead battery terminal posts, sinkers, and ammunition components through a series of operations including die casting, hot melt molding, hot melt extrusion, cold forming, coining, gravity casting, and coating (Wenck, 2019a). No primary lead production or smelting is done. Water Gremlin melts lead bars purchased from local recycling facilities. Pollution control equipment called electrostatic precipitators (brand name "Smog Hog") are used to remove airborne lead and particulate matter before air is exhausted outside the building.

Emissions testing for lead and particulate matter was conducted in 1994 and total facility emissions were determined to be 0.5 pound per year, an amount considered an insignificant activity for permitting purposes. As a result, no regulatory controls for lead emissions were needed/required.

In November 2018, select Smog Hog control devices were tested for lead and particulate emissions to determine how well they were able to prevent contaminants from being released to the outdoor air. Results of the testing indicated that the averaged emissions were well under regulatory limits for particulates enforced by the current air permit (Pace, 2019). Airborne lead results were not compared to any regulatory limit because the facility was not subject to any such standard at the time. The MPCA is currently drafting a new air permit for the facility in which the 2018 test results have been evaluated and utilized as part of the emission characterization for the facility.

Monitoring for lead in outdoor air around the Water Gremlin facility began in September 2019 to help answer questions about possible lead exposure from the community, and ended in January 2022. Sampling occurred every six days and results were posted on the MPCA website at Water Gremlin air monitoring (www.pca.state.mn.us/air/water-gremlin-air-monitoring). Results were compared to the National Ambient Air Quality Standard of 0.15 µg/m3 set by the U.S. EPA to provide public health protection. Monitoring results indicate lead emissions have remained well below the EPA standard at the sample locations since this testing began.

It is expected that airborne lead emissions deposit to the ground near Water Gremlin's facility. Section V. B provides more information on lead in soil.

III. Remedial Investigation Data and Interpretation

The Stipulation Agreement for violations of the air quality permit required Water Gremlin to perform a remedial investigation that included sampling groundwater, surface water, soil, sediment, soil vapor, and private wells on and near their property (MPCA, 2019a). The purpose was to determine where and how much contamination was present (i.e., to define the extent and magnitude of contamination) that may have been caused by Water Gremlin's activities at their property over the years. A Phase I Environmental Site Assessment was completed in April 2019 to help identify potential areas of contamination and help select initial sampling locations. The investigation began in June 2019 and samples were analyzed for lead and volatile organic compounds (VOCs), including TCE and t-DCE. Results were submitted to MPCA in a report at the end of July 2019 (Wenck, 2019). Additional data was collected as part of subsequent sampling events needed to define the extent and magnitude of contamination in all environmental media (see Table 7 below). The remedial investigation is on-going as of April 2022.

Table 7: Remedial Investigation Activities 2019-present

Dates	Sampling Conducted as Part of the Remedial Investigation
June 2019	Groundwater, surface water, soil, sediment, and soil vapor (Wenck, 2019)
Aug 2019	Sub-slab vapor at the Water Gremlin building, soil vapor to edge of Water Gremlin property, groundwater (Wenck, 2020)
Sept 2019	Sub-slab, indoor, and outdoor air at the Water Gremlin building (Wenck, 2020)
Oct 2019	Sub-slab, indoor air, groundwater and soil within coating room footprint; additional sub-slab and indoor air in Water Gremlin building; roof runoff water from Water Gremlin building downspouts; sediment and surface water; additional soil vapor (Wenck, 2020)
Dec 2019	Soil vapor, soil, groundwater, and sub-slab vapor (Wenck, 2020)
Jan 2020	Soil vapor (Wenck, 2020)

Dates	Sampling Conducted as Part of the Remedial Investigation
Jan 2020-present	Sub-slab vapor, indoor air in the Water Gremlin building
Jan/Feb and Aug 2020	Private wells
June 2020	Groundwater (Wenck, 2021)
July 2020	Groundwater, soil, sub-slab, sediment, surface water (Wenck, 2021)
July 2021-present	Private wells, groundwater

Results of the investigations from 2019 to the present are organized below by environmental media - groundwater, soil, soil vapor, sediment, and surface water. Drinking water from both public and private wells is discussed in the following section.

MDH uses the environmental data from these investigations to evaluate whether people may be exposed to contaminants and to make recommendations to protect public health if needed.

A. Groundwater

The Water Gremlin property is located in an area where approximately 200 feet of glacial deposits overlie the bedrock. The water table is encountered within these deposits from the surface to depths of 11.5 feet below the ground surface (the water table is the surface below which all spaces in the glacial deposits and bedrock are filled with water). In most places the water table is at the same elevation as the nearby surface waters.

The area around the Water Gremlin north campus building is directly underlain by 5-10 feet of recent fill from construction activities at the site overlying 15-30 feet of water-bearing, fine sand and silty sand that thins to the south. Based on geologic and hydrologic data collected at the site, the shallow sand unit likely does not extend beyond the property boundaries. As the sands are underlain by a 45-65 foot thick “semi-confining” layer (meaning water passes through it only very slowly, if at all), the groundwater in the sands may not be connected to deeper groundwater. This semi-confining layer consists of thin layers of silt, silty sand, fine sand, clayey sand, and clay. The southern part of the Water Gremlin north campus (near Lambert Creek) and the south campus are underlain by 30-40 feet of wetland and lake deposits of peat and silty and sandy clay, which in turn overlie the semi-confining layer. Below the semi-confining layer is a 30-100 foot water-bearing sand unit referred to hereafter as the buried sand aquifer (Wenck, 2021; Minnesota Geological Survey, 1992).

Below the glacial deposits described above, the uppermost bedrock formation below the northwest part of the Water Gremlin property is the St. Peter Sandstone, which is underlain, in turn, by the Prairie du Chien group of limestone and dolomite and followed by the Jordan Sandstone. The St. Peter Sandstone is not present below the glacial deposits below the southeast parts of the Water Gremlin property, so the Prairie du Chien is the first bedrock unit encountered at this portion of the site.

Municipal wells in the area (White Bear Lake, White Bear Township, Vadnais Heights) are over 350 feet deep and draw water from the Jordan Sandstone; some of the wells also draw water from the lower units of the Prairie du Chien group. Many private (residential) drinking water wells in this area were installed before drilling records were consistently kept, but the records that are available suggest that most private wells are over 100 ft deep and draw water from the buried sand aquifer, although there are some wells completed in the St. Peter Sandstone or Prairie du Chien group bedrock aquifers. The regional direction of groundwater flow in the buried sand aquifer is generally to the west in this part of Ramsey County (Minnesota Geological Survey, 1992). However, on the local scale, groundwater flow directions may vary from the regional groundwater flow direction. There is little information regarding local groundwater flow directions in the area of the Water Gremlin property. Monitoring wells in the buried sand aquifer are needed to determine the local flow direction in this important aquifer.

Flow direction in the very shallow groundwater (less than 30 feet) is likely to be influenced by topography, nearby surface waters, and precipitation. For example, near Lambert Creek, the shallow groundwater may discharge into the creek part of the year and at other times surface water from the creek may flow outward into the shallow glacial deposits.

Since June 2019, there have been five phases of groundwater investigations on and near the Water Gremlin property. These have generally started at areas of known or suspected releases of site-related contaminants and expanded outward to define the horizontal and vertical extent of the contamination and to evaluate potential releases to nearby surface waters. Investigations in 2019 and 2020 focused on shallow groundwater with borings 50 feet below the ground surface or less, although six borings were drilled deeper (70–100 feet deep) to sample water in the buried sand aquifer. In 2021, additional borings were drilled on and off the Water Gremlin property to evaluate the water quality in the buried sand aquifer. The results of the first four investigations are described in detail in the site reports (Wenck, 2019b, 2020, 2021) and summarized here. MPCA provided the analytical results of the 2021 investigation to MDH, but a site investigation report was not available at the time this document was written.

Trichloroethylene: As shown in Figure 5, TCE was detected at most of the boring locations on the north campus property at concentrations above the MDH Health Risk Limit (HRL) of 0.4 ppb (parts per billion, which is the same as micrograms per liter). A HRL represents an amount of a contaminant that poses little or no health risk to those drinking the water daily for a lifetime, including sensitive or highly exposed people. The highest concentration detected was 189 ppb, with the greatest concentrations found beneath or near the Water Gremlin plant building. TCE was not detected in borings near the north side of Lambert Creek or in borings on the south campus. TCE also was not detected to the north, west, or northeast of the Water Gremlin plant. This suggests that TCE may have a somewhat limited extent in the shallow groundwater. TCE has not been detected to date in any samples collected from the buried sand aquifer.

Figure 5: TCE in Groundwater Sampling Results

Vinyl chloride: When TCE breaks down in the environment it does so by losing chlorine atoms, resulting in the breakdown products cis-1,2-dichloroethylene (c-DCE) and t-DCE, which then break down further to vinyl chloride and finally to ethene. Over time, TCE concentrations will decrease as the concentrations of the other compounds increase, until they also break down over many years. At five locations vinyl chloride exceeded the HRL of 0.2 ppb, with 20.1 ppb being the highest concentration detected. Vinyl chloride is of particular concern as it has an even lower HRL than TCE, was detected in multiple borings, and it may increase in concentration over time as TCE and DCE at the site degrade. Vinyl chloride was not detected in any samples collected from the buried sand aquifer.

1,4-Dioxane: 1,4-dioxane is a stablilizer used in solvents like 1,1,1-TCA and, potentially, TCE. As Figure 6 shows, 1,4-dioxane was detected in multiple borings on the Water Gremlin property including the borings near Lambert Creek. Most of these borings were shallow, but six were completed in the buried sand aquifer. 1,4-dioxane is extremely water soluble and often moves more quickly through aquifers than other contaminants, which may explain why it was found in borings near the creek but not in borings closer to the Water Gremlin plant. At 20 on- and near-site locations 1,4-dioxane exceeded the HRL of 1 ppb, with 28.5 ppb the highest concentration detected. That sample was collected from GP-34 at 97-100 feet below ground level, near the northwest corner of the south campus building.

In 2021, nine deep borings were drilled on- and off-site, with groundwater samples being collected from the upper sand, the semi-confining unit, and the buried sand aquifer as the borings were advanced. 1,4-

dioxane was detected in seven of these borings, primarily in samples from the upper sand and semi-confining unit. However, the HRL was exceeded in four borings, three of which had exceedances in samples collected from the buried sand aquifer. The concentrations in the buried sand aquifer samples were generally low (0.32–2.4 ppb). It should be noted that the deep boring north (upgradient) of the Water Gremlin (GP-37) plant also had multiple samples with detections of 1,4-dioxane including one from the base of the semi-confining unit with a concentration of 9.7 ppb. While it appears there were historic sources for 1,4-dioxane at Water Gremlin, private well sampling results (see section V.B) suggest there may be another source (or sources) of 1,4-dioxane in the area; this is being investigated by MPCA. While it is unlikely that Water Gremlin is the source of the 1,4-dioxane contamination seen in the private wells in Gem Lake based on the current data, it is not possible to state Water Gremlin did not contribute to the private well 1,4-dioxane contamination without additional data collection.

Other chemicals detected: Several other chemicals were detected during the groundwater investigations. These included chlorinated solvents and their breakdown products [1,1-dichloroethane (1,1-DCA), chloroethane, c-DCE, and t-DCE], petroleum hydrocarbons [toluene and ethylbenzene], other organic hydrocarbons [acetone, p-isopropyltoluene, chloroethane], and lead. Of these, the only chemicals that exceeded a HRL were t-DCE, which was detected above the HRL of 9 ppb in two samples (highest concentration 51.9 ppb), and toluene that was detected above the HRL of 70 ppb in one sample (101 ppb).

Figure 6: 1,4-Dioxane in Groundwater Sampling Results

For more information on the groundwater in deeper aquifers used for drinking water, see section VI. Drinking Water, below.

B. Soil

The soils nearest the Water Gremlin facility contain fill materials from construction projects over time. Lead contaminated soil southeast of the facility was removed from the property in 1995-1996 (see section G.). Land to the east and south of the facility are wetland areas.

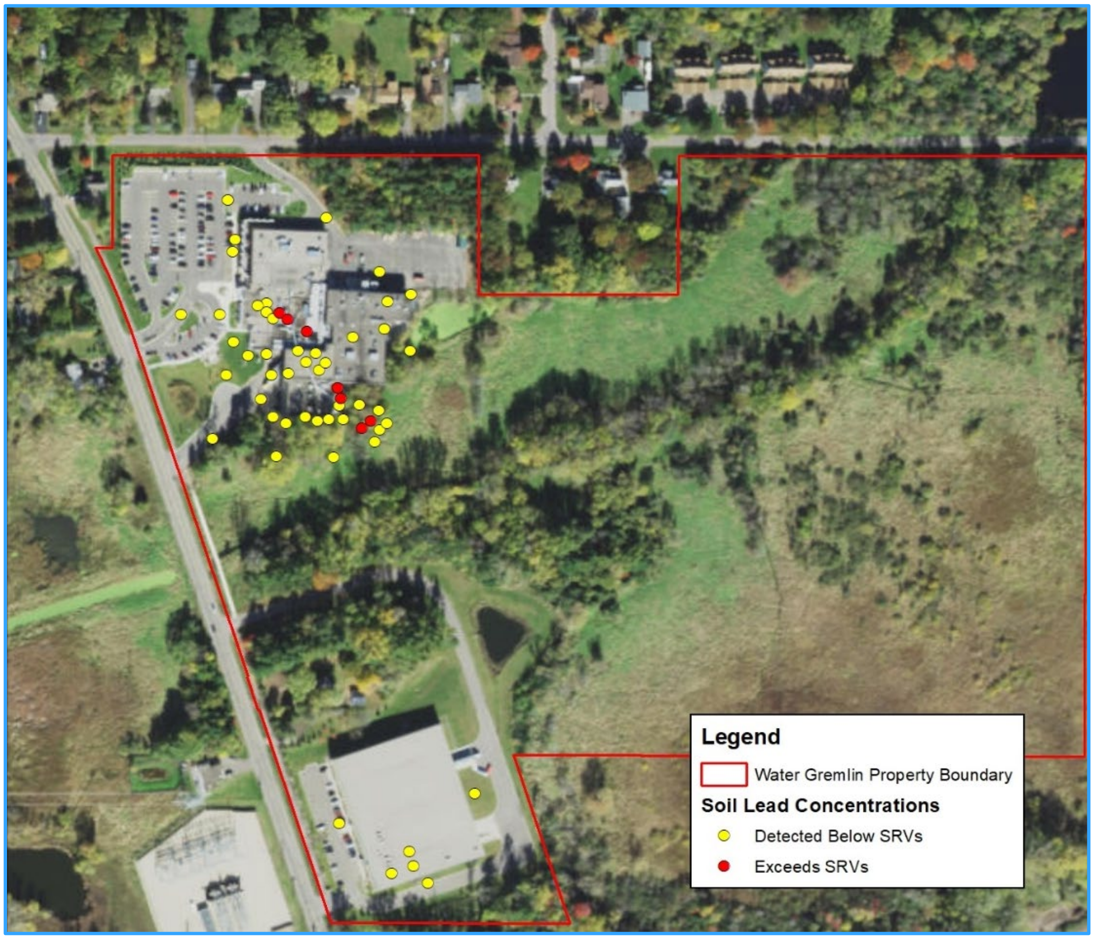
Soil sample results from the Water Gremlin property are compared to the MPCA's Industrial Soil Reference Values (SRVs). SRVs are a screening tool that may be used to evaluate potential human health risks from direct exposure to contaminated soil based on a specific land use category (MPCA, 2021). SRVs are presented in parts per million (ppm), which is the same as milligrams per kilogram (mg/kg).

In June 2019, a total of 54 soil samples were collected at various depths at 25 locations surrounding the Water Gremlin facility and analyzed for lead and VOCs (Wenck, 2019b). Lead in soil exceeded the Industrial SRV of 700 ppm in four (719-982 ppm) of 30 samples analyzed for lead (Wenck, 2019b). These four samples were all located in the top foot of soil near the southeast portion of the Water Gremlin facility (see Figure 7). No VOCs were detected in soil samples with a single exception of trace amounts of TCE and tetrachloroethylene (PCE) in one location at a depth of 2-4 feet where a lead exceedance was also found.

In October 2019, soil samples were collected from two depths in seven locations under the coating room floor (Wenck, 2020) to investigate potential contamination suspected beneath a portion of the Water Gremlin building. Samples at the seven locations 6-8 feet below the floor were analyzed for VOCs and none were detected. Lead was analyzed for in samples up to one foot deep under the floor and ranged from 17.3-13,600 ppm. Three of these samples were above the Industrial SRV for lead. The sample with the highest lead result was also analyzed for VOCs at the 0-1 foot depth and contained t-DCE and TCE (0.11-0.12 ppm) at concentrations well below the SRVs for these chemicals.

In December 2019, additional soil samples were collected from multiple depths at 10 interior locations and 11 exterior locations (Wenck, 2020). The interior samples were taken beneath the facility floor at locations outside of the coating rooms such as the gravity cast room, shipping and receiving, main die cast area, and cold forming area to see if there was evidence of any past release from use or storage of lead and VOCs in these areas. The exterior samples were placed on the northern perimeter of the property and to the south, east and west of the June soil samples to define the extent of contamination (see Figure 7). For lead at the interior locations, only one of ten samples at a depth of 0-1 feet exceeded the Industrial SRV at 1,060 ppm. None of the 13 samples at the 11 exterior soil locations contained lead above the Industrial SRV. Fourteen interior samples were also analyzed for VOCs and none were detected. Only 1 of 15 exterior samples detected VOCs - low levels of ethylbenzene, toluene, and p-isopropyltoluene.

Figure 7: Lead in Soil Sampling Results



In June/July 2020, to conclude the soil investigation, 18 soil samples were collected for analysis of VOCs and 1,4-dioxane (Wenck, 2021). There were no detections of VOCs or 1,4-dioxane in any of these samples. Three samples collected in the upper foot of soils near the South Campus building were analyzed for lead–concentrations were at natural background levels (5.7-17.8 ppm). Lead is naturally found in soil at around 15-20 ppm (ATSDR, 2019).

In summary, lead in soil is above Industrial SRVs beneath the Water Gremlin main building and in four soil samples in the top foot of soil outside the southeast portion of the building. Only trace levels of VOCs were detected in three soil samples. 1,4-dioxane was not detected in soil.

Lead is a very common soil contaminant due to its widespread historical use in gasoline and paints. To provide some context for the concentrations found at Water Gremlin, elevated lead in soil (in the hundreds of ppm) is often found near historically busy roadways from gasoline and near buildings or fences where lead-based paints may have chipped off. Lead does not degrade. It strongly adsorbs to soil, so very little is expected to be transported through runoff to surface water or leached to groundwater (ATSDR, 2019).

The soil on the Water Gremlin property is remarkably low in lead given that the facility has been using lead for decades, although lead-contaminated soil was previously excavated from the property (see section G. below) and numerous construction activities have occurred at the site. The areas of soil contamination at Water Gremlin have been defined and are limited to their own property. Given the low levels of lead present on the company's property, and the lack of access and movement off-site that could result in exposures, this limited soil contamination from Water Gremlin does not represent a health risk to the community.

C. Sub-Slab Soil Vapor – Water Gremlin Facility

What is Vapor Intrusion?

Volatile organic compounds are chemicals that easily evaporate into air. When chemicals evaporate from polluted soil and from groundwater, they rise toward the ground surface. If these vapors come into contact with a building, they may enter through cracks in the foundation, around pipes, or through a sump or drain system, and contaminate indoor air. This process—when pollution moves from air spaces in soil to indoor air—is called vapor intrusion. If chemicals are present near buildings, vapor intrusion is investigated by collecting sub-slab samples by drilling small holes through the foundation to sample soil vapor from beneath the building.

Intrusion Screening Values

MDH and MPCA develop Intrusion Screening Values (ISVs), which are compared to indoor air or sub-slab soil vapor concentrations to help determine when actions may be needed to protect health. The ISVs represent an amount of a chemical measured in micrograms per cubic meter, or µg/m3 that is safe for people to breathe. A 33X ISV value is an amount of a chemical beneath a building that is not expected to result in indoor air amounts that exceed the ISV for that chemical. These values are designed to be protective for sensitive people, including children, pregnant women, and people who already have health issues. There are two sets of ISVs—Residential and Commercial/Industrial—based largely on the amount of time people may spend at home (up to 24 hours a day, seven days a week) or in the workplace (up to 10 hours per day, five days per week). Table 8 below provides the current ISVs and 33X ISVs for TCE and trans-1,2-dichloroethylene (t-DCE).

Table 8: Intrusion Screening Values for TCE and t-DCE

Chemical	Residential ISV ($\mu g/m^3$)	Commercial/ Industrial ISV ($\mu g/m^3$)	Residential 33X ISV ($\mu g/m^3$)	Commercial/ Industrial 33X ISV ($\mu g/m^3$)
TCE	2.1	7	70	230
t-DCE*	21	70	700	2,300

*ISVs for t-DCE are based on the 2020 MDH Risk Assessment Advice.

Vapor intrusion investigation and mitigation at the Water Gremlin facility

In June 2019, TCE was found in sub-slab soil vapor samples collected from beneath Water Gremlin's facility above 33X Industrial ISVs (up to 120,000 µg/m3) in 20 of 25 samples collected (Wenck, 2019). t-DCE was also found in soil vapor beneath the building in every sample, with many samples having very high concentrations up to 530,000 µg/m3. High t-DCE soil vapor concentrations beneath the building (many located beneath the coating rooms) led to MPCA ordering Water Gremlin to suspend operation of the coating lines on August 22, 2019.

On August 23, 2019, 12 additional sub-slab samples were collected beneath the Water Gremlin building in areas that were not previously sampled to determine the extent of the high vapor concentrations (Wenck, 2020). Only three of these additional sample locations had exceedances of the Industrial ISV for TCE (236 µg/m3 to 1,920 µg/m3) and one location had a vinyl chloride exceedance at 22,100 µg/m3. There were no exceedances for t-DCE or any other compounds in the August 2019 samples.

Figure 8, shown below, is a map of the June and August 2019 sub-slab soil vapor sampling results for TCE and t-DCE. This map also shows the exterior soil vapor results around the property discussed below in section D. Soil Vapor.

Figure 8: TCE and t-DCE in Soil Vapor Sampling Results

To address the potential for vapor intrusion at the Water Gremlin facility, a temporary vapor mitigation system that included both a sub-slab depressurization system and a soil vapor extraction system was installed and began operating by mid-September (Wenck, 2020). The soil vapor extraction system was installed to remove deeper sources of volatile contamination beneath the building. The temporary systems were replaced by a permanent system in late December 2020 (M. Ginsbach, MPCA - personal communication, March 4, 2021).

Weekly sub-slab and indoor air sampling began in January 2020 and continues to this day to help better understand the soil vapor contamination on the property. Sampling results have been somewhat variable over time, but generally indicate that the mitigation system is effective.

In July 2020 and March 2021, four sub-slab vapor samples were collected beneath the Water Gremlin South Campus building, as shown on the map above. Multiple VOCs were detected in all four samples, but no results were above Industrial 33X ISVs.

For more discussion of indoor air results and Water Gremlin worker exposure from vapor intrusion, see the section below titled Worker and Worker Family Exposures – Indoor Air.

D. Soil Vapor

Because of the high concentrations of contaminants in sub-slab vapor beneath the Water Gremlin facility, additional soil vapor samples surrounding the facility were needed to determine the extent of the vapor plume and ensure it was not migrating off-site. Four rounds of soil vapor sampling covered both the MPCA-defined non-heating season (samples collected in August and October) and heating season (December and January) (Wenck, 2020).

In August 2019, 15 soil vapor samples were collected on Water Gremlin property surrounding the facility to determine if vapor was traveling off-site towards residential areas. Nine of the sampling locations did not detect TCE or t-DCE. The other six samples had levels well below the residential 33X ISVs (up to 11 µg/m3 for TCE and up to 12 µg/m3 for t-DCE) (Wenck, 2020). These low concentrations in soil vapor and the additional distance to the nearest homes indicate that people living in the area are not affected by soil vapor from Water Gremlin.

In October 2019, 8 additional soil vapor samples were collected adjacent to the Water Gremlin building, mainly to the east and south to complete sampling for soil vapor surrounding the building. Two sample locations adjacent to the building's south side exceeded a 33X ISV – one sample had TCE at 281 µg/m3; another had vinyl chloride at 559 µg/m3 (Wenck, 2020).

In December 2019, all 23 soil vapor sample locations were resampled to collect data during the heating season per the MPCA's vapor intrusion best management practices (Wenck, 2020). t-DCE was not detected in any of these samples. TCE was only detected in 3 samples, at 1.3, 1.5, and 455 µg/m3. The 33X ISV exceedance locations for TCE and t-DCE for all of the data are shown in Figure 8 above. Unexpectedly, the solvent tetrachloroethylene, or PCE, was detected in every sample and exceeded the Residential 33X ISV of 110 µg/m3 in 13 samples, up to 189 µg/m3.

The PCE exceedances were theorized to be due to contamination in the sampling or lab equipment. Because the December PCE exceedances could not be explained, 16 locations were resampled in January 2020. There were no exceedances of the 33X ISVs and only five of the samples detected PCE, up to 26.7 µg/m3. Two other 33X ISV exceedances occurred in December, one of naphthalene and one of ethylbenzene. Neither of these compounds were detected in their January samples.

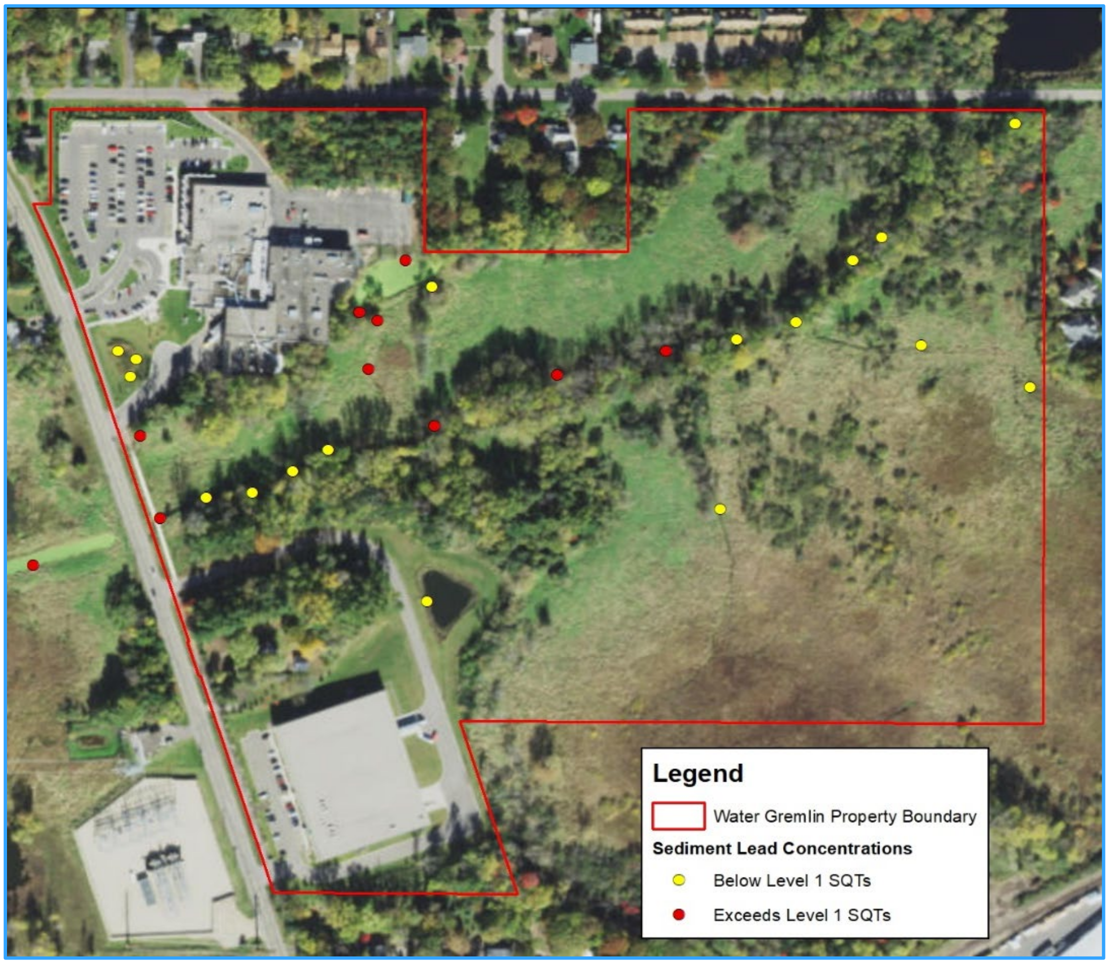
The soil vapor data collected surrounding the Water Gremlin building demonstrates that the high concentrations of sub-soil vapor at Water Gremlin are not migrating off-site. Soil vapor contamination from Water Gremlin does not cause a health risk in the community.

E. Sediment

Surface water bodies at the Water Gremlin property include Lambert Creek, three stormwater retention ponds (east, west, and south), and wetlands. Sediment sample results for lead taken from these features were compared to MPCA's Sediment Quality Targets (SQTs). Level I SQTs are contaminant concentrations in ppm that provide a high level of protection for sediment-dwelling organisms. Level II

SQTs are contaminant concentrations above which harmful effects on sediment-dwelling organisms are likely. Figure 9 shows the locations and lead concentrations of all the sediment samples.

Figure 9: Lead in Sediment Sampling Results



In June 2019, five sediment samples were collected from Lambert Creek, two sediment samples from the east stormwater pond inlets, and one sediment sample at the east stormwater pond outlet. No VOCs were detected in these sediments, but lead was found above the MPCA's Level I SQT of 36 ppm in four of the five samples in Lambert Creek (up to 113 ppm). The two stormwater pond inlet samples were above the Level II SQT of 130 ppm for lead (at 215 and 1060 ppm) while the stormwater outlet sample was at 71 ppm.

In October 2019, 14 additional sediment samples were collected and analyzed for lead. Seven of those samples were taken along the north bank of Lambert Creek and ranged from 3.1-137 ppm. Other samples were taken from creek inlets and stormwater pond discharge locations. The highest concentrations, 374 and 546 ppm, were collected between the east stormwater pond discharge and Lambert Creek.

In July 2020, five sediment samples were collected, one in Lambert Creek, three from the west stormwater pond, and one from the south stormwater pond. Lead in the Lambert Creek sample was above the Level I SQT (at 86.1 ppm), but lower in the four stormwater pond samples (4.3 to 26 ppm).

In March 2021, Water Gremlin submitted a proposed workplan that includes dredging the eastern stormwater pond to remove lead-impacted sediment and reduce additional lead that could ultimately affect Lambert Creek (Stantec, 2021). This work has not been completed as of April 2022.

Water Gremlin operations have contributed to lead concentrations in sediments, particularly in samples nearest the facility to the east and southeast. There is expected to be little to no trespassing that would result in human exposure to the lead in these sediments.

F. Surface Water

As mentioned above, the Water Gremlin property contains a portion of Lambert Creek, three stormwater retention ponds, and wetlands. The east and west retention ponds flow into Lambert Creek. Samples from these surface waters were tested for VOCs, lead, and 1,4-dioxane. Figure 10 shows the locations of the lead samples.

In June 2019, six surface water samples were collected from Lambert Creek and analyzed for VOCs and lead (Wenck, 2019). No VOCs were detected, but lead was found in three samples (up to 12.5 ppb); two of the samples exceeded MPCA's Tier 1 Surface Water Screening Criteria (SW Criteria) of 6.7 ppb. According to the MPCA Surface Water Pathway Evaluation User's Guide (MPCA, 2006) Tier 1 surface water risk evaluation "…requires the least level of effort and the most conservative standards, guidelines, and criteria. It is used to screen out sites that are not of concern." If the Tier 1 investigation identifies contaminants at levels above those standards, guidelines or criteria, additional investigation may be required depending on the magnitude and extent of the contamination.

MPCA staff conducted surface water sampling for lead testing in water bodies located in the community and well outside Water Gremlin property boundaries in September 2019. Lead was detected, but below Tier I Standards in Birch Lake, Columbia Park Pond, Goose Lake, Lambert Creek, and Rice Lake. Lead was not detected in White Bear Lake.

In October 2019, 14 additional surface water samples were collected and analyzed for lead on the Water Gremlin property (Wenck, 2020). Eight samples were from the north bank of Lambert Creek; six were from tributaries to and wetlands that drain into Lambert Creek or discharge from stormwater ponds. Lead was detected in every sample. Ten samples were below SW Criteria, ranging from 0.12 - 1 ppb, and four exceeded the criteria. Three of the samples that exceeded SW criteria were collected from the stormwater discharge from the Water Gremlin facility, and lead ranged in concentration from 26.4 - 88.1 ppb. The fourth sample that was above the SW Criteria, at 640 ppb, is the easternmost (upstream) sample on the property and was collected from a southern inlet to Lambert Creek. However, this sample may not have been filtered to remove suspended sediment, which is standard practice for surface water samples. Suspended sediments in wetland samples can increase measured concentrations of metals, which may account for the very high level of lead observed in this sample. The other sample collected from this tributary, at a location downstream less than 250 feet away, had only 0.68 ppb lead, which casts further doubt on the results for the potentially unfiltered sample collected from this location.

MPCA requested testing for lead from the Water Gremlin facility roof stormwater runoff, to see if the runoff was a source of lead contamination in the east stormwater pond. Two downspout samples were collected during a rain event in October 2019. The two results were 1.6 and 2.7 ppb lead. While these results show that small amounts of lead are coming off the facility roof, they are expected amounts and illustrate the purpose of a stormwater collection system.

In July 2020, five samples were collected from Lambert Creek and the west stormwater pond (Wenck, 2021) and tested for lead and 1,4-dioxane. All had detectable lead. The four samples from the stormwater pond exceeded the SW criteria for lead and ranged from 618 to 4,040 ppb. The sample from Lambert Creek had 0.62 ppb lead. 1,4-dioxane was detected in the Lambert Creek sample at 0.35 ppb and in one of the stormwater pond samples at 1.1 ppb.

In October 2020, MDH and MPCA staff collected seven surface water samples from Gem Lake, Rice Lake, and two unnamed ponds southwest of Rice Lake—all bodies of water beyond the Water Gremlin property boundaries. The samples were tested for 1,4-dioxane, which was not detected.

Figure 10: Lead in Surface Water Sampling Results

The shallow groundwater and Lambert Creek are directly connected with one another. Based on water level observations from a monitoring well and Lambert Creek, at times of high water the surface water in Lambert Creek may flow outward from the creek into the shallow groundwater. At other times the groundwater may be discharging to Lambert Creek. Infiltration of surface water from the stormwater ponds and Lambert Creek is likely to only affect the shallow groundwater aquifer, due to the presence of the semi-confining layer between the shallow aquifer and the buried sand aquifer. However, contaminants transported further downstream, where the semi-confining layer may not be present, could potentially infiltrate to deeper groundwater.

The limited mobility of lead in groundwater due to its strong attraction to a wide range of soil and aquifer materials (Clausen, Bostick, and Korte, 2011), makes it unlikely to pose a risk to the buried sand aquifer or private or public drinking water supply wells near the Water Gremlin facility or further downstream in the surface water system.

1,4-Dioxane is extremely mobile in groundwater, so infiltration from surface water to groundwater or transport through the surface water system theoretically could pose a risk to nearby drinking water supplies. However, 1,4-dioxane was detected in only two of the surface water samples at concentrations just above the HRL of 1 ppb in the stormwater pond (at 1.1 ppb) and below the HRL in Lambert Creek (0.35 ppb). These concentrations would be diluted as the water either infiltrates into the groundwater or travels downstream in the surface water system before possibly reaching any source of drinking water. 1,4-Dioxane was not detected in samples collected from Rice Lake or Gem Lake, so it is unlikely that surface water transport or infiltration of 1,4-dioxane currently poses a risk to public health. Given the high mobility of 1,4-dioxane in water, it is impossible to evaluate whether past transport of 1,4-dioxane in Lambert Creek surface water may have contaminated the groundwater.

Water Gremlin operations have contributed to lead concentrations above the surface water criteria in stormwater ponds and other surface waters on the company's property. Samples from the downstream portions of Lambert Creek on the Water Gremlin property were below the surface water criteria for lead, as were samples from nearby lakes. Based on these results, there is expected to be little to no human exposure to the lead in the surface water of the Creek or the noted lakes outside the boundaries of Water Gremlin property.

Water Gremlin operations have also contributed to low levels of 1,4-dioxane in stormwater ponds and other surface waters on their property, but 1,4-dioxane was not detected in nearby lakes or wetlands. There is expected to be little to no human exposure to 1,4-dioxane in the surface water on the company's property.

G. Past Remedial Investigations and Historical Actions -- 1994-2004

Soil and groundwater contamination was investigated on the Water Gremlin property in the past. Soil contaminated with lead was excavated from the property in 1995-1996. The groundwater on site was monitored for a number of compounds found in the shallow aquifer from 1997-2004. This section has been included for completeness and to acknowledge what is known about contamination from the facility in the past.

In 1994, Ramsey County Hazardous Waste staff conducted a routine site visit at the Water Gremlin facility and observed sand spilled out of a 55-gallon drum in an outside drum storage area near the southeast corner of the facility (Braun, 1994). The sand was analyzed and contained high concentrations of lead. As a result, Ramsey County requested that Water Gremlin test the surrounding soils for lead. Fourteen soil samples were collected in and around the drum storage area. Concentrations of lead in soil at the depth of 0-6 inches ranged from 32 to 4,200 ppm (Braun, 1994).

In 1995, Water Gremlin hired Braun, an environmental consultant, to conduct a Phase I Environmental Site Assessment (Braun, 1995). Braun identified four areas that may contain contamination, listed below:

- Areas of spilled, used oil, potentially contaminated with lead, were identified on the concrete floor and cinder block walls of the manufacturing building and on the gravel-paved exterior areas beneath the lead-melting pot exhaust vents.

- Small areas of stained flooring were observed in the manufacturing building near the coating operations and in the vicinity of drums of unused TCE.
- "…It is possible the leaks may have occurred in buried piping (of the above ground storage tank for fuel oil) or the base, which could have impacted soil and groundwater."
- "…The full extent of lead soil contamination was not yet been determined. The exact source of the contamination also has not been identified."

Also in 1995, Braun collected an additional 48 soil samples to the south and southeast of the Water Gremlin building as part of a Phase II Environmental Site Assessment to determine the extent of lead contaminated soils. Of the 48 samples, seven contained lead concentrations above the clean-up criteria of 400 ppm and those locations were identified for follow-up soil removal (Braun, 1996). By the fall of 1996, over 1,000 cubic yards of contaminated soil was excavated and disposed of in a landfill. Eight cubic yards of contaminated soil remained on site because it was located around subsurface infrastructure and was covered during the next facility building expansion (MPCA, 1997). In June 1997, MPCA determined that no further action was needed to address the identified release of lead in the soil.

In 1997, soil, surface water, and groundwater were sampled for VOCs near the Water Gremlin facility (Wenck, 2019a). Low levels of TCE were detected in some soil samples, but no VOCs were found in the surface water. Chlorinated solvents were found in the shallow groundwater (Wenck, 2019a). Groundwater monitoring wells were installed in six locations in the shallow aquifer around the property between 1997 and 1999 (Wenck, 2019a). Solvent breakdown products and nonchlorinated and petroleum-based compounds were also found in the groundwater (Braun, 1998). Many of the contaminants in the shallow aquifer were above the MDH HRLs for drinking water. No VOCs were detected in an additional monitoring well placed in the deeper buried glacial aquifer (Wenck, 2019a).

Samples were collected to evaluate the potential for contamination to affect groundwater used for drinking water. The White Bear Township Municipal Well #5, which is greater than 400 feet deep in the Prairie du Chien and Jordan bedrock aquifers, was sampled for VOCs in 1998 and none were detected (Braun, 1998). A groundwater receptor survey was conducted and it was determined that all drinking water wells draw from either the buried glacial aquifer or the bedrock aquifer, neither of which were found to be contaminated (Braun, 1998). Groundwater flow was shown to be flowing to the south at that time (Braun, 2004).

Groundwater sampling was conducted until 2004 and concentrations of groundwater contaminants declined over time. The data also suggested that contamination was limited to the shallow aquifer by a confining layer located below it. In 2004, MPCA issued a No Further Action letter for the identified release to the groundwater because contaminants were below the HRLs, on the condition that if property use changed, the use will need to be reevaluated (MPCA, 2004). The No Further Action letter lists 20 compounds identified as released to the groundwater: acetone, benzene, chloroethane, chloroform, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethylene, cis-1,2-dichloroethylene, trans-1,1-dichloroethylene, dichlorodifluoromethane, ethylbenzene, methyl ethyl ketone, methyl isobutyl ketone, tetrahydrofuran, toluene, 1,1,1-trichloroethane, trichloroethylene, trichlorofluoromethane, vinyl chloride and xylenes.

V. Drinking Water

A. Municipal Water

The source of drinking water for many people in the area around the Water Gremlin property is municipal wells operated by White Bear Lake (WBL), White Bear Township (WBT), or Vadnais Heights. As described earlier, these municipal drinking water wells are over 350 feet deep and draw water from bedrock aquifers (the Prairie du Chien group and Jordan Sandstone). They are not expected to be affected by shallow groundwater contamination. The three municipal systems regularly test for VOCs (which includes TCE, and other compounds detected in shallow groundwater at the Water Gremlin property) to meet federal Safe Drinking Water Act requirements. Data collected by MDH over the last 25 years shows TCE has never been detected in the municipal drinking water in WBL, WBT, or Vadnais Heights.

Water from municipal wells from all three systems was tested for 1,4-dioxane in the years shown in the table below. 1,4-Dioxane was not detected in any of the wells with the exception of Vadnais Heights in 2021. The three municipal wells tested in Vadnais Heights all had detections of 1,4-dioxane at low concentrations (0.069, 0.078, and 0.46 ppb) in December 2021. These detections are below the MDH HRL and are not a health concern. The source of the Vadnais Heights well contamination has not been identified.

Table 9: Years of 1,4-dioxane sampling of municipal drinking water

Municipal Water System	Years Sampled for 1,4-Dioxane
White Bear Lake	2014, 2015
White Bear Township	2014, 2015, 2020
Vadnais Heights	2013, 2014, 2021

Annual water quality reports for municipal drinking water systems, called Consumer Confidence Reports, describe where drinking water comes from and any regulated contaminants that are detected. They are available on the webpages for the municipalities:

- White Bear Lake Consumer Confidence Report (http://www.whitebearlake.org/pubicworks/page/consumer-confidence-report)
- White Bear Township Water Quality Report (http://www.ci.white-bear-township.mn.us/416/Water-Quality-Report)
- Vadnais Heights Water Quality Report (https://cityvadnaisheights.com/499/Water-Quality-Report)

B. Private Wells

A number of residences in the area near Water Gremlin rely on private drinking water wells. Nearly all Gem Lake residents rely on private wells for their drinking water, as their city does not own or operate a community public water supply system.

In March 2019, to provide additional reassurance to area residents, the Minnesota Department of Health (MDH) sampled 13 private wells that were selected to represent groundwater near the Water Gremlin facility. Water samples were analyzed at the MDH Public Health Laboratory for a standard list of 68 VOCs, including TCE and its breakdown products. No contaminants were detected in any of the wells sampled. A map showing the general locations of the wells sampled can be found at Water Gremlin Public Health Assessment Series - Private Well Sampling (www.health.state.mn.us/communities/environment/hazardous/docs/sites/ramsey/wgprivatewell2.pdf)

Because 1,4-dioxane was discovered in the shallow groundwater on the Water Gremlin property in December 2019, MDH collected water samples from 11 private wells in late January and early February of 2020. Three of the 11 wells had detectable levels of 1,4-dioxane, although the concentrations found (between 0.06 and 0.12 ppb) were significantly less than the HRL of 1 ppb.

In April 2020, the MPCA required Water Gremlin to sample private wells within a one-mile radius of its facility. MPCA and MDH prioritized testing locations based on the results of the sampling earlier in 2020. Water Gremlin's environmental consultant (Wenck) sent letters to 97 residents at the priority locations requesting access to collect and test a well water sample. Forty-four well owners provided access to sample in August 2020. MDH staff also collected duplicate samples from eight homes at the same time to verify test results. These MDH-collected samples were analyzed at the MDH Public Health Laboratory. The samples collected by Wenck were tested by Pace Analytical and those results were reported directly to MPCA. 1,4-Dioxane was detected in three more private well samples at concentrations of 0.23, 0.8, and 0.95 ppb. These concentrations are also below the HRL. The results of the samples collected by MDH staff from the eight homes analyzed at the Public Health Lab reported the same results (all not detected) for those homes as the lab used by Water Gremlin.

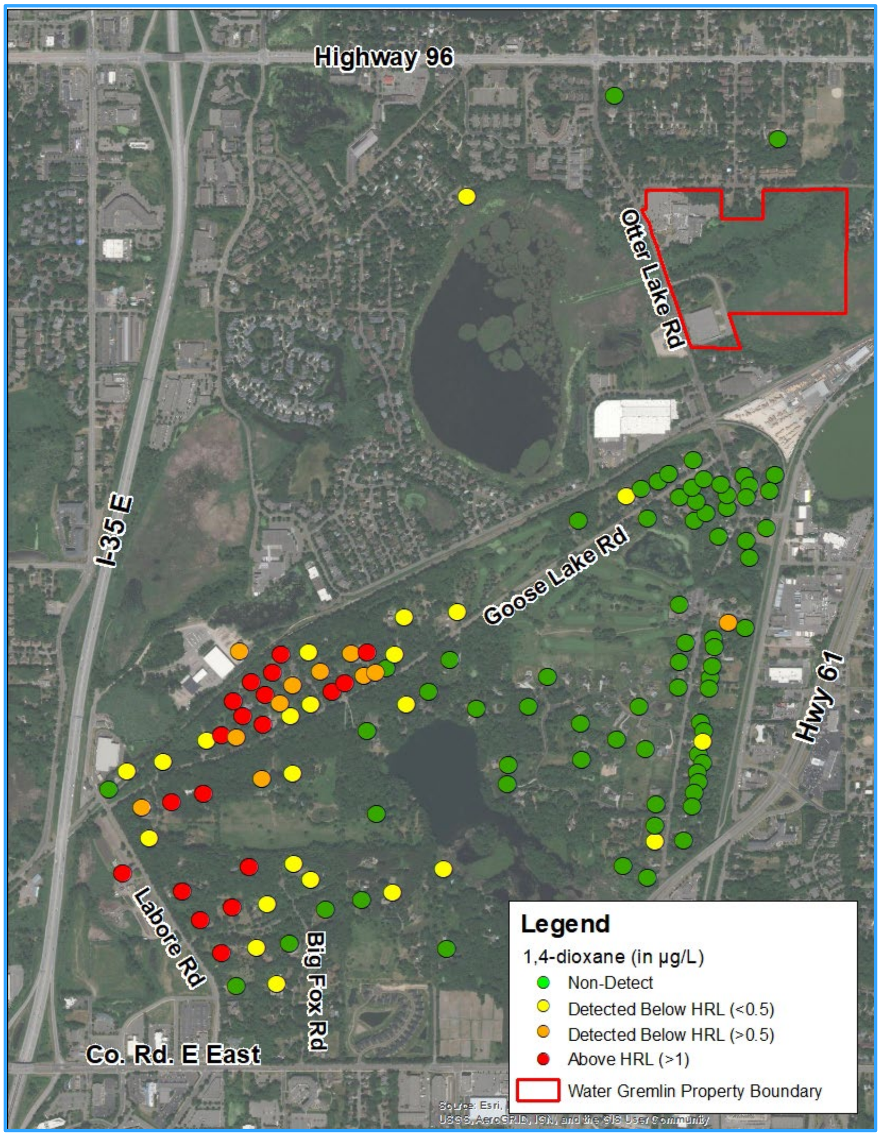
Because of the detections of 1,4-dioxane in private wells, Water Gremlin was required to conduct additional private well sampling in 2021. Water Gremlin's environmental consultant (Stantec, formerly Wenck) sent letters to 129 residents requesting permission to test their well. Letters were sent to homes beyond the one-mile radius along Goose Lake Rd where 1,4-dioxane was detected in 2020. Stantec received permission to sample the water from 49 wells on 48 properties.

Initial results of this sampling effort in July 2021 showed eight wells had 1,4-dioxane above the MDH HRL, ranging from 1.1 to 3 ppb. These results led MPCA and MDH to expand the scope of private well testing in Gem Lake. By February 2022, a total of 92 private wells have been tested; 21 wells exceeded the 1,4-dioxane HRL and in another two wells the concentration was exactly 1 ppb (see Figure 11 for general locations). MPCA and MDH sent results to all residents. All households that had 1 ppb of 1,4-dioxane or higher in their water were contacted directly and are receiving bottled water from a state-provided vendor.

It is unknown whether the 1,4-dioxane detected in the Gem Lake private wells is from Water Gremlin. Additional investigation is needed to determine the source(s). MPCA is requiring Water Gremlin to investigate how far 1,4-dioxane has spread off their property and MPCA is investigating other potential sources in the area for possible releases of 1,4-dioxane or products that may contain it.

Because the source of the 1,4-dioxane contamination is unknown, MPCA created a separate webpage to communicate with Gem Lake residents about the private well sampling located at Protecting Gem Lake residents from contaminated drinking water (https://www.pca.state.mn.us/waste/protecting-gem-lake-residents-contaminated-drinking-water). MDH and MPCA continue to sample residential wells to identify and define the area where 1,4-dioxane concentrations are above the HRL in order to protect health and ensure Gem Lake residents have a safe drinking water supply.

Figure 11: 2020-2021 Private Well Testing Results for 1,4-Dioxane



MDH 1,4-Dioxane Health Risk Limit

MDH developed a Health Risk Limit of 1 ppb for 1,4-dioxane in drinking water in 2013. The HRL represents an amount of a contaminant that poses little or no health risk to those drinking the water daily for a lifetime, including sensitive or highly exposed people. 1,4-Dioxane is considered a likely human carcinogen, based on studies of animals exposed to very high amounts. The HRL of 1 ppb is based on a negligible cancer risk of one additional cancer in 100,000 people consuming the water for a lifetime. The highest concentrations detected in well water in Gem Lake are just above the HRL and present a low health risk. Most of the wells' results are less than 1 ppb and are considered safe for household use by MDH. Appendix D presents an information sheet developed for and shared with the community about 1,4-dioxane exposure and health in Gem Lake.

Lead in Drinking Water

Community concerns were raised about the possibility of lead contamination in drinking water from Water Gremlin. Low levels of lead (up to 3.5 ppb) have been found in shallow groundwater beneath the Water Gremlin building, but this does not reach the deeper aquifers used for drinking water. The highest concentration found is below the federal action level of 15 ppb. Lead has not been detected in deeper water samples, including the samples collected from the buried sand aquifer, which is the aquifer used by most of the private wells in the area (Wenck, 2020).

Lead is not usually found in well water, although it may enter drinking water as it travels from the well through plumbing systems. For example, private wells built before 1995 may have submersible pumps that contain leaded-brass components. Lead can also enter drinking water as it passes through the house's plumbing and fixtures, particularly in homes built before 1986 when lead solder was still in use. Brass components such as faucets, coolers, and valves may contain small amounts of lead.

Private well owners are responsible for regularly testing their well's water if it is used for cooking and drinking to make sure it is safe. MDH recommends testing a home's water for lead at least once. For more information about private well testing, please see (Water Quality/Well Testing/Well Disinfection (www.health.state.mn.us/communities/environment/water/wells/waterquality/index.html).

All public water systems follow standards set by the U.S. EPA for lead testing. This information about lead testing can be found in the yearly Consumer Confidence Report. In June 2019, the City of White Bear Lake began providing public service announcements about lead in drinking water after 4 of 30 residences that were tested were found to exceed the federal action level for lead in drinking water. These results are not related to the Water Gremlin site.

General tips to avoid lead in drinking water are to let the water run 30-60 seconds before using it for drinking and cooking, use cold water, and test your water for lead. For more info, visit Lead in Well Water Systems (www.health.state.mn.us/communities/environment/water/wells/waterquality/lead.html).

VI. Worker and Worker Family Exposures

A. Indoor Air – Workplace Chemical Use and Vapor Intrusion

Workplaces in Minnesota that use chemicals are regulated by the Minnesota Occupational Safety and Health Administration (MN OSHA) under the Minnesota Department of Labor and Industry (DOLI). Workers protected under MN OSHA must be provided right-to-know training on hazardous products and chemicals and methods to help control hazards in their workplace. MN OSHA has regulatory air values that workplaces cannot exceed, which are called Permissible Exposure Limits (PELs). The MN OSHA PELs for 8-hour exposures of TCE and t-DCE are 270,000 µg/m3 and 790,000 µg/m3, respectively. MDH believes that these occupational values may not be adequately protective of worker health, because they are outdated, are not intended to protect the most sensitive workers and do not incorporate the most recent toxicological data.

t-DCE concentrations in the facility's indoor air are generally high and fluctuate significantly because of its current use in production. As described above (Section B. 2019-2020 Air Emissions – trans-1,2-dichloroethylene) toxicity data for t-DCE is limited; however, MDH has provided Risk Assessment Advice for ambient air based on the amount of t-DCE (approximately 50,000 µg/m3) where an immune system effect was observed in a subchronic animal study. Therefore, Water Gremlin workers exposed to t-DCE repeatedly at concentrations measured at their facility may be at risk of immune system effects.

When chemical exposures in the workplace occur because of vapor intrusion, commercial/industrial ISVs are used to evaluate the vapor intrusion pathway. The commercial/industrial ISVs for TCE and t-DCE are 7 µg/m3 and 70 µg/m3, respectively. As discussed in section V. Remedial Investigation and Interpretation, part C. above, weekly sub-slab and indoor air sampling has been conducted at the Water Gremlin facility from January 2020 to the present. TCE was found in indoor air over the ISV of 7 µg/m3 occasionally. In January 2020, MDH requested that Water Gremlin notify its employees of TCE in indoor air, despite indications that the source was most likely from past TCE use in the facility rather than vapor intrusion. MDH provided notification language for the company to use (see Appendix E) and also provided the notification translated into Hmong, Karen, and Somali at Water Gremlin's request. TCE concentrations in indoor air within the Water Gremlin facility have decreased over time and most commonly are non-detect or in the single digits below the ISV of 7 µg/m3 (M. Ginsbach, personal communication, November 8, 2021).

B. Lead and Take-Home Lead

Lead poisoning may cause learning, behavior, and health problems in young children. Exposure to lead before or during pregnancy has been linked to miscarriages, premature births, and stillbirths as well as poor brain and nervous system development in infants. Early symptoms of lead poisoning among adults include fatigue, upset stomach or stomach cramps, poor appetite, irritability/nervousness/depression, headache, sleeplessness, metallic taste in the mouth, reproductive problems, high blood pressure, lack of concentration, and muscle and/or join pain.

During the manufacturing process, people who work at Water Gremlin may be exposed to lead dust. Workers can bring lead dust on clothes, shoes, body, and personal items into homes. This is called take-home lead. DOLI is responsible for enforcing requirements regarding lead exposures to employees. There are a number of requirements that need to be met to assure that employees are not exposed to lead greater than the OSHA PELs. The requirements are also meant to ensure that lead is not leaving the facility where it can put employee family members at risk.

MDH and DOLI took court action in late October 2019 to temporarily shut down Water Gremlin's lead casting operations due to 12 cases of elevated blood lead levels (EBLs) in children of Water Gremlin employees. MDH and Ramsey County encouraged Water Gremlin employees to keep children away from work clothes and shoes and to clean entryways, closets, and vehicles. Free blood lead testing was provided to employees and each member of their family. A majority of Water Gremlin workers tested had high blood lead levels. Through blood lead testing and additional efforts to identify children of Water Gremlin employees in MDH's blood lead testing database, an additional 12 children of workers with EBLs were discovered, bringing the total to 24 children.

On November 22, 2019, a Ramsey County District Court ordered Water Gremlin to take additional measures to reduce lead exposure and prevent take-home lead to protect the health and safety of its workers and their families. These measures include routine cleaning and testing of lead levels at the Water Gremlin facility, monthly refresher training in languages understood by the employees, lead wipe testing on employees clothing, skin and hair upon exiting for the day, installing new changing and locker room facilities, and an employee vehicle cleaning program. As a result, data from 2019 to 2021 show that blood lead levels in workers appear to be declining.

In addition, MDH provided a notice of potential residential lead contamination for current and former employees (within the last two years) along with information on how to clean up lead dust in a home and information on lead exposure during pregnancy and breastfeeding. The Court ordered Water Gremlin to offer home lead testing, and if needed, home cleaning. Water Gremlin appealed the residential testing and cleaning, but a ruling in 2020 upheld this requirement. Stantec, on behalf of Water Gremlin, initiated contact in mid-2021 for nine employees who requested this service. The identities of the nine employees were withheld from Water Gremlin.

Starting in mid-2021, MDH is receiving approximately $1.3 million per year in additional General Funds to conduct in-home lead risk assessments for all children in Minnesota with an elevated blood lead level above 5 micrograms of lead per deciliter of blood (the current CDC definition of an elevated blood lead level). This is a significant public health equity measure, as until now only children living in Minneapolis and Ramsey County received this important service due to inadequate funds for case investigations outside those two jurisdictions. The new legislation permits this work for children up to age 18, as well as provides new enforcement authority for cases where the lead exposure originated outside the home--as in the Water Gremlin situation.

VII. Minnesota Public Health Data

MDH collects public health data on various diseases and conditions in order to provide Minnesotans with meaningful statistics on rates and trends across the state. This data can also inform health professionals and citizens about risks and, when warranted, provide a more complete and accurate profile of health outcomes for communities having questions or concerns about disease rates in their area. Collecting this data is mandated by state law.

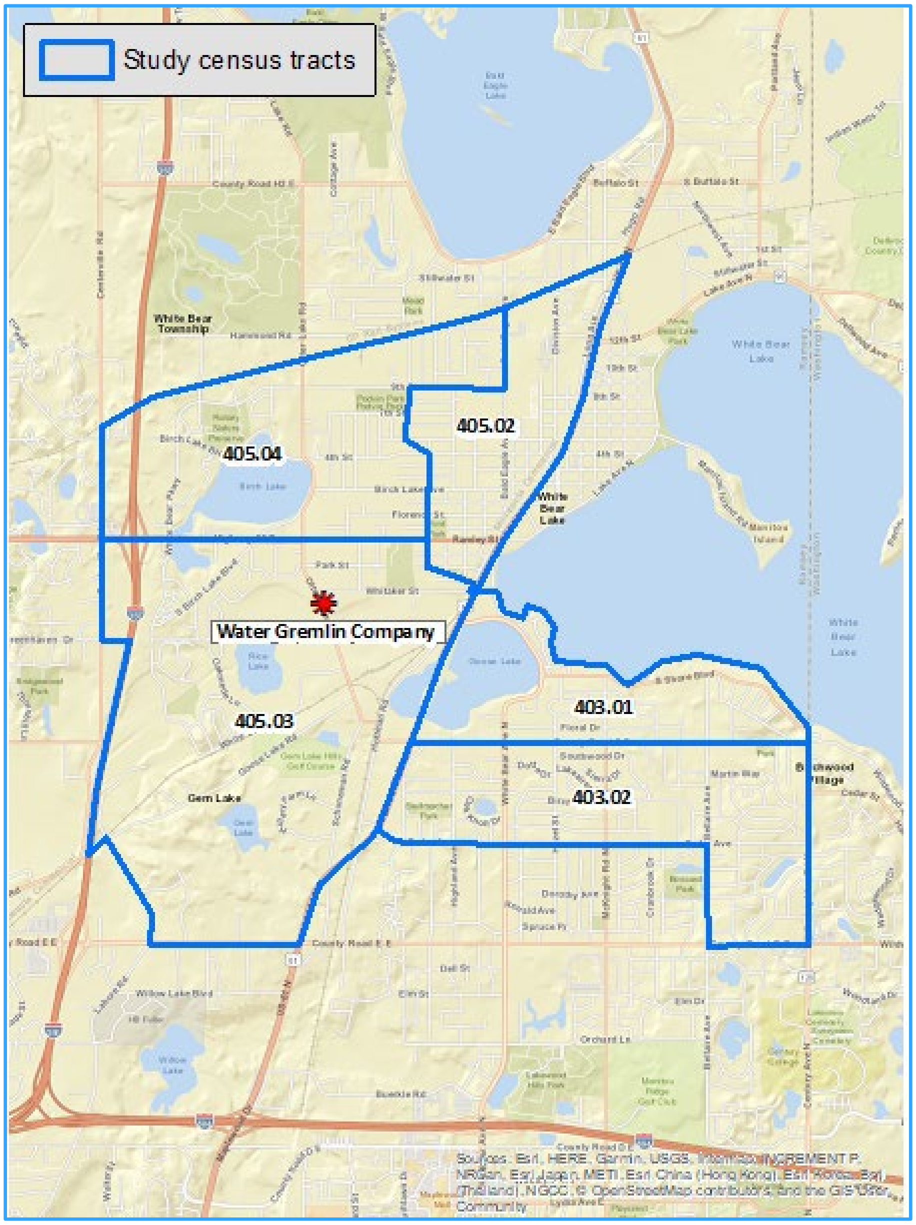
Surveillance data for certain cancers, birth defects, and blood lead test results collected by MDH were of particular interest following the discovery of a history of airborne release of TCE and other issues at Water Gremlin. Several MDH programs responded to inquiries and concerns about various potential health outcomes among people who live, or previously lived, near the facility.

Findings from the Minnesota Cancer Reporting System, the Birth Defects Information System, and the Blood Lead Information System evaluated to respond to community concerns are summarized below along with the limitations of each data analysis. More information on these programs and health statistics, and many others, can be found on the MN Public Health Data Access Portal (https://data.web.health.state.mn.us/web/mndata).

A. Cancer

The Minnesota Cancer Reporting System (MCRS) completed a cancer occurrence report in March 2019 that analyzed cancer occurrence for the most recent 10-year period for which complete data were available (2006-2017). The study area (see Figure 12 below) was comprised of five census tracts surrounding the Water Gremlin facility. The geography represented by the tracts is larger than the area where annual average TCE concentrations in outdoor air (based on reported total TCE emissions in 2018) were predicted to be above the MDH health-based value (HBV) of 2 µg/m3, but smaller groupings of cancer occurrence and population were not available in the MCRS database for use in the analysis.

Figure 12: Study Area for the Cancer Occurrence Report



Overall cancer rates in the study area were found to be virtually identical to cancer rates in the seven-county Twin Cities Metro area. For both genders combined, 970 cancers were diagnosed in residents living in the study area over the 10-year period (2006-2017), compared to the expected number of 978 cancers. Additionally, none of the cancers specifically analyzed for in male or female residents of the five-census tract study area showed significantly greater cancer rates in the 10-year assessment period compared to expected rates. This includes the three types of cancers (kidney, liver, and non-Hodgkin lymphoma) most believed to be associated with TCE exposures.

While the conclusions drawn from this data analysis provides some assurance that cancer rates in the study area are not unusual for the study period, it is important to know that the MCRS data have limitations, including those described below.

- This analysis of cancer rates does not specifically address potential health risks from environmental exposures to TCE. Because TCE is commonly used, it is not unusual for people to frequently encounter small amounts of TCE in air from many sources. Cancer surveillance data by itself is not enough to establish the extent that an environmental exposure may be contributing to cancer occurrence.
- The estimates of expected cases are based only on age and gender distribution of the study area population. The rates do not account for the many other risk factors – such as family history, smoking history, occupation, and diet – that affect whether cancer rates are high or low in a community at a point in time.
- The MCRS only collects information on residence at the time of diagnosis. The location recorded for place of residence does not necessarily indicate an exposure causing the illness also occurred at or near that location. For example, a person diagnosed with cancer who previously lived near the Water Gremlin facility and left, would not be identified in the selected geographies if they moved outside the study area. Likewise, a person who moved into the area before a diagnosis, may be counted as living in the study area. This would contribute to the observed cancer rates, even though potential exposures to many cancer risk factors likely occurred before living in the study area. In addition, people may be exposed to hazards that affect their health at workplaces or other locations that are distant from their place of residence.

The full report, Cancer Occurrence Report for White Bear Township, White Bear Lake and Gem Lake Area Five Census Tracts, 2007-2016, is in Appendix F. MDH does not expect to see meaningful changes in cancer patterns and trends in this community in the future, especially over the short term. Nevertheless, MDH would consider a reanalysis of Minnesota Cancer Reporting System data at a later time (e.g., in 10 years) if the situation warrants and community interest remains high.

B. Birth Defects

TCE from the Water Gremlin facility was released in the southern part of zip code 55110. Because of potential exposures to residents in this area and the potential link between TCE and cardiac birth defects in animal studies, MDH reviewed available data from the Minnesota Birth Defects Information System (BDIS). Since monitoring birth defects among babies born in Minnesota began in May 2005, the earliest available population-based data on congenital heart defects is for babies born in 2006.

For the purposes of this evaluation, the mother’s residence in zip code 55110 at the time she delivered her baby was chosen as a proxy for possible exposure to TCE in air. This geography most closely corresponds to the area where people who were most likely to be exposed regularly to airborne TCE dispersed from the Water Gremlin facility would live. Smaller geographical units were not available in the BDIS for this analysis.

The frequency of congenital heart defects diagnosed and reported for births to mothers living in zip code 55110 were compared to the frequency of the same defects that occurred in other parts of the state from the 2006 to 2019 birth cohorts. MDH conducted an analysis of the 2006 to 2017 birth cohorts in 2019; the analysis was updated in 2021 to include births through 2019--the period when pregnant women were potentially exposed to TCE from the Water Gremlin facility. The addition of 2018 and 2019 birth cohorts did not change the results of the analysis.

Based on the timeline of reported TCE emissions from the Water Gremlin facility, about 400 infants were born annually to women living in this area at the time of delivery for the 2006 to 2019 birth cohorts (recall that congenital heart defects data were not recorded before 2006). Of these, about 3 infants per yearly cohort (range: 0-7) were diagnosed with congenital heart defects. These observed numbers do not appear different from expected numbers (range: 2-5) based on prevalence estimates available for Minnesota.

The numbers of septal defects (affecting atria or ventricles) – the most common congenital heart defects in Minnesota – were consistent in babies born to residents in zip code 55110 over the 14 birth cohorts as compared to other parts of the state.

While the conclusions drawn from this data analysis should provide some assurance that the number of congenital heart defects for the 2006 to 2019 birth cohorts in the 55110 zip code is not unusual, it is important to know that the BDIS data also have limitations.

- Minnesota's birth defects surveillance program is in an early stage of development. It takes many years to collect enough data to be able to identify trends in the occurrence of birth defects because they are relatively rare; and therefore, small, random changes can appear to have a significant effect on such rates in the short term.
- Unless the differences were large, it would be difficult to discern any differences in occurrence from one location to another given the low numbers of congenital heart defects and the small population potentially exposed to TCE from the facility (in the southern portion of zip code 55110).
- There are many possible sources of environmental exposures that could contribute to birth defects risk and are unknown and unaccounted for in a population group as large as the zip code 55110.
- Residence within a zip code is an imprecise proxy for potential exposure to TCE from Water Gremlin and variability in exposures among pregnant women who lived in the 55110 zip code would likely be considerable (potentially ranging from no exposure to the highest estimates predicted).
- The origin of congenital heart defects is complex and poorly understood.

C. Community Blood Lead Levels

Community members expressed concern that lead from Water Gremlin's operations could have been mishandled (including allegations of illegal dumping on or off site) and asked whether the public may have been exposed to harmful amounts of lead from the facility. MDH's lead surveillance program was asked whether lead testing results compiled in the Blood Lead Information System (BLIS) database could help address these concerns.

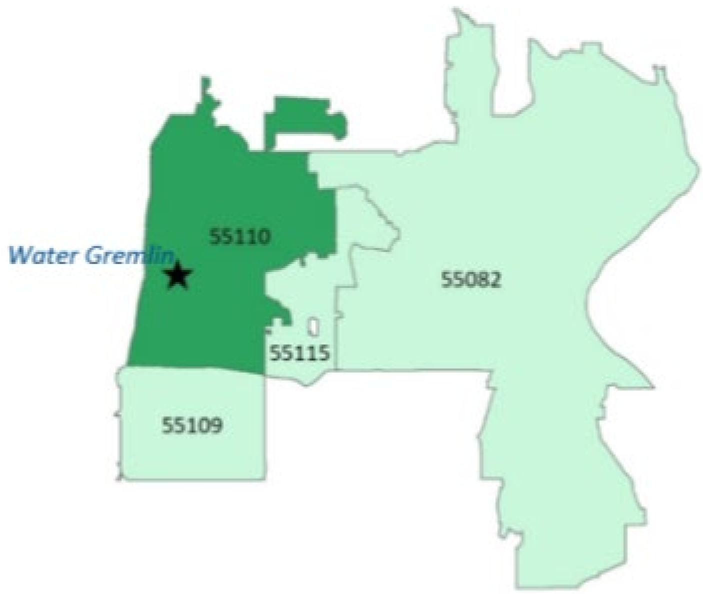
MDH evaluated BLIS data for the 55110 zip code (see Figure 13 below). Because most lead exposure in Minnesota can be traced back to lead-based paint in older homes, MDH used the bordering zip codes of 55082, 55109, and 55115 for comparison because housing ages and median household incomes were similar to 55110.

MDH obtained data from BLIS for blood specimens drawn between January 1, 2000 and March 18, 2019 for residents of these four zip codes. An elevated blood lead level (EBLL) was defined as 5 micrograms per deciliter (µg/dL) or greater – the value currently used by the U.S. Centers for Disease Control and Prevention to identify children who have higher levels of exposure to lead than most children.

EBLL rates decreased in all four zip codes over time. For adults, the 55110 zip code showed higher EBLL rates than the comparison zip codes. However, when known employees of Water Gremlin were excluded from the analysis, there were no significant differences in EBLL between 55110 and the comparison zip codes. People known to be employees of Water Gremlin were twice as likely to live in 55110 as the comparison area, which accounts for this trend.

Children under six years of age represented the majority of individuals tested in the data analyzed for this report. There was no significant difference in children's EBLL rates between zip code 55110 and the comparison area. However, addresses of 3.6% of children with an EBLL were matched to the address of a known Water Gremlin employee who also was tested for lead and had their place of work reported to the BLIS database. A discussion of take-home lead and the steps taken to prevent this from occurring among Water Gremlin workers and their families is found in section VII. B. above.

Figure 13: Zip Codes Where Blood Lead Information System Data was Evaluated



Interpretation of the results are limited for several reasons.

- EBLL rates for an area are a non-specific measure. They must be combined with additional information, such as case manager interviews and environmental sampling, to be able to determine the most likely source(s) of lead for the individuals with EBLLs.
- Adult blood lead data are very limited as most adults are not routinely tested for lead, and those who are do not represent the general adult population.
- Employees of a company who have received a blood lead test are not necessarily representative of all employees of that company.
- MDH receives test results but does not receive a roster of company employees who work with lead, so matching employee addresses to children's addresses is a rough approximation of children who might be exposed to take-home lead.
- The reference level for EBLLs (cutoff where a measurement is defined as "elevated") was lowered from 10 µg/dL to 5 µg/dL in 2012. This implies that tests in 5 – 9.9 µg/dL range would likely have gone unconfirmed prior to 2012 and not recorded in MDH's blood lead information system as elevated.

IX. Responding to Community Concerns

Over the course of three years, MDH staff coordinated and collaborated with many partners and stakeholders to engage community members that live near and are concerned about environmental releases from the Water Gremlin facility. These collaborations included state agencies (mainly the MPCA and Department of Labor and Industry), county public health, city and township government, and community advocates.

Many channels for communication were established and used for various audiences and different topics. A general email address and phone line were widely promoted as a mechanism for the public to contact MDH about this site. Calls and emails were logged, shared with partners as needed to develop responses, and used to identify topics of growing concern to be addressed by communication and outreach efforts and products. In a year's time starting on January 31, 2019, MDH staff recorded 133 inquiries from individuals concerned about the site. Staff and partners attended several, large community-wide meetings, met with selected audiences and local officials on many occasions, and participated in regular meetings with an advocacy group (the Neighborhood Concerned Citizens Group [NCCG]) over the course of several years thus far. To offer opportunities for community members to ask their questions more directly and privately, MDH and MPCA staff held a series of listening sessions at different locations in the area. Translated materials (in Hmong, Spanish, Karen, and Somali) were provided to ensure company employees had access to understandable information.

News media coverage and interviews with community members provided further examples of questions, comments, and concerns expressed by people who wanted to know if or believed their health was affected in ways that were or could be attributable to contaminants from the site. MDH also responded to questions from health care providers about health effects of TCE inhalation and the advisability of seeking testing for patients. The following lists, organized by whether the issues are addressed in the PHA document or beyond its scope, summarize the main categories of topics and gives examples of the questions, requests, and comments community members shared.

A. Community Inquiries

Topics addressed in this document

- Biological testing. How to get tested to assess exposure to TCE; inquiries about and requests for community-level screening for such exposure.
- Health studies. Requests for health effects surveillance in the surrounding community; requests for health studies to assess the consequences of site contaminants in the community; questions about the Minnesota Cancer Reporting System data for the community.
- Health effects. Reports of symptoms or diagnosed health problems (various cancers, skin irritation, asthma, etc.) --usually accompanied by questioning whether effects could be caused by anything released from the facility; requests for explanation of potential risk for and type of health effects possible for people living at specific locations during specific time periods; requests for information or advice about health concerns from and among former Water Gremlin employees or their family members.
- Environmental contamination. Requests for more detailed accounting of how much TCE was released to air and when; requests for information about how much TCE (or tDCE) was present in air at specific locations and times; questions about potential impact of airborne TCE on the soil and

garden produce and consumers; inquiries about potential contamination of surface water bodies (Birch Lake, Birch Lake Ponds, Goose Lake, wetlands/ponds near Water Gremlin site, and a drainage ditch); allegations of past waste disposal by Water Gremlin or others into Birch lake and nearby wetlands; calls for evidence to demonstrate safety of drinking water (e.g., City of White Bear Lake public water system, White Bear Township public water system, or any private non-community or residential wells nearby, and even the potential for the drainage ditch to carry contaminants from Water Gremlin's property and affect drinking water in areas served by the Saint Paul Municipal water supply system).

- Environmental testing. Questions about private well testing and replies to access requests for permission to sample private wells.

Topics outside this document's scope

- Illness or death of pets
- Intent to file complaints or report health effects
- Questions about seeking compensation for perceived damages
- Distrust of company's self-reporting of emissions and monitoring data results
- Safety of handling Water Gremlin battery terminal posts
- Complaints about odors and requests for investigation

Other topics and responses

- Requirements for disclosure of Water Gremlin releases in residential real estate transactions and questions about safety of moving into specific locations in the area.
  - MDH response: Because there is no residual contamination from Water Gremlin's releases in the surrounding residential neighborhoods, there is no need to disclose proximity to the company's property. Private well sampling results must be disclosed to prospective buyers. As is the case for any property purchase decision, buyers are encouraged to educate themselves about the environment where they intend to locate.
- Residential indoor air quality testing.
  - MDH response: No residual contamination from past releases of airborne TCE should affect residential indoor air. MDH's webpage, Guidelines for Selecting an IAQ Consultant *(www.health.state.mn.us/communities/environment/air/mold/selectingiaq.html) contains information on indoor air quality considerations and testing.
  - MDH recommends all Minnesotans test their homes for radon. Radon is a colorless, odorless soil vapor that is produced from the natural decay of uranium that is present in nearly all soils. When inhaled, it gives off radioactive particles that can damage the cells of the lung and cause lung cancer. Radon is the leading cause of lung cancer in non-smokers. Over 21,000 lung cancer deaths in the U.S. each year are from radon. Radon is a common problem in Minnesota where 2 in 5 homes have radon levels that pose a significant health risk. See the MDH website for more information about Radon Testing (www.health.state.mn.us/communities/environment/air/radon/radontestresults.html).

B. Health Study Requests

MDH received many requests to conduct a "health study" that could determine whether exposures to TCE in air from Water Gremlin affected the health of people who have lived near the facility. When people refer to health studies they may mean different activities, including collecting self-reported health information, conducting medical screening or reviewing medical records, or conducting biomonitoring in community members. A health study may also refer to an epidemiological investigation designed to collect measures of exposure and health outcomes to determine if sufficient statistical evidence can be found to conclude an association, suggestive of a causal relationship, exists between an exposure and an effect. There are many reasons for wanting a health study – from documenting the health of the community, to contributing to research about health effects of TCE, to support litigation, to gaining information that will help address potential health concerns in the future.

However, scientific health studies are often very challenging to conduct and often are disappointing because of their inability to identify a connection between exposures and health outcomes. Major challenges to conducting a health study in the community surrounding the Water Gremlin property include the following:

- The amount of TCE individuals were exposed to is unknown, in part because historical data on air concentrations does not exist. Exposures were also likely to be highly variable depending on time spent in different locations.
- TCE exposures may be too low to cause any observable health effects for most if not all people who lived or were regularly near the Water Gremlin facility. Slightly or moderately increased rates of health effects can be hard to identify against the existing background rates of the same effects from all causes that affect the community.

As described in the TCE Toxicity and Risk Assessment section on page 12, some animal studies show exposure to TCE in air may increase the risk of immune system and kidney effects, or heart defects in the developing fetus. However, it appears unlikely that exposures to TCE from Water Gremlin have occurred at levels sufficient to cause observable health effects in the community or broader population of the area. Based on the modeled estimates of TCE in air from Water Gremlin, MDH expects that any increase in cancer is unlikely to be recognized or measurable compared to the background rate of cancer that already exists from all causes. However, it is possible that past exposures to TCE in air near the facility may have been sufficient to increase the risk of health effects in a small number of the most exposed individuals.

MDH staff were asked to consider whether a health study for the community near Water Gremlin is feasible, but concluded that a valid, scientific study is not possible given the challenges. For more explanation of the challenges of health studies and two excellent resources for communities, please see Community Health Studies and Environmental Contamination in Appendix G. MDH is available to explore and discuss what efforts may be feasible that help meet the goals and objectives of the community.

C. Stress

When people learn their community's water, soil, or air may not be safe because of contamination from a nearby source, many difficult questions can surface. Is my health at risk? How can I protect myself and my loved ones? Is it safe to stay in my home? Where can I get reliable information about what's happening?

Community members living with environmental contamination may experience chronic stress for various reasons (e.g., health concerns, uncertainty, and community conflict), which can be compounded by feeling dismissed, powerless, unheard, or unsupported. It's hard to wait for answers, especially if you don't know who to trust. And people may not agree about how to handle the situation, even among family and friends. Stress is a normal reaction to environmental contamination; it is not a mental health disorder. However, chronic stress can pose physiological health risks on top of the health risks that may be associated with exposure to contaminants (ATSDR, 2021).

Resources

- ATSDR's online Community Stress Resource Center (www.atsdr.cdc.gov/stress/community_members.html) was created to acknowledge stress and worry related to environmental contamination and offer ideas for managing stress.
- MDH's webpage offers an information sheet created for people in the community concerned about the Water Gremlin contamination: Coping with the stress that environmental contamination can cause (www.health.state.mn.us/communities/environment/hazardous/docs/stresscontsites.pdf).

D. Cumulative Risks

Cumulative risk assessment (CRA) is a concept that aims to consider the many factors, both chemical and non-chemical, that may affect health in a community. At its simplest, CRA attempts to add risks from multiple environmental chemical exposures and includes all the exposure pathways (ingestion, inhalation, dermal, etc.) in multiple media (drinking water, air, soil, etc.) from all sources (other facility emissions, naturally occurring contaminants, traffic emissions, etc.) over time. This approach of adding health risks of single chemicals may overestimate or underestimate risks, although risk assessment is intended to take into account that certain individuals or populations can be more sensitive to the effects of chemicals than others. Real-world chemical mixtures are complex and data from either animal or human studies on combined effects of exposures to mixtures is generally lacking.

A multitude of other, non-chemical stressors can also affect health. These factors can include noise, poor nutrition, stress, crime, etc. Of particular importance are factors that make populations more vulnerable to contamination due to health disparities--such as lack of access to health care, poverty, education inequity, etc.

The complexity of accounting for all these factors makes it difficult to quantify risk or create a single approach to assessing health risk. The U.S. EPA is expected to release an updated CRA guidance document in the coming months. MDH staff will review this document and look for ways to incorporate its concepts to further acknowledge all the factors that may affect health in a community.

This Public Health Assessment reviews all the possible exposure pathways in all environmental media affected by known contamination from the Water Gremlin facility. Ongoing t-DCE air exposure adds additional risk to that from past TCE air exposures. Workers at Water Gremlin experienced high levels of solvent and lead exposures, and may also face health disparities. Finally, other chemical exposures from all sources people may encounter and non-chemical stressors that could impact individuals' health also are expected to exist within this community.

XI. Conclusions

MDH reached seven main conclusions regarding potential exposures to contaminants from Water Gremlin, followed by next steps/recommendations. Items that MDH will continue to address are described by the Public Health Action Plan below.

Conclusion 1: Past TCE air emissions may have harmed some people's health.

Basis for Conclusion 1: It is possible that past exposures to TCE in air near the facility may have been sufficient to increase the risk of health effects in a small number of the most exposed individuals. However, TCE exposures may be too low to cause any observable health effects for most if not all people who lived or were regularly near the Water Gremlin facility. The potential health effects of TCE exposure at the expected concentrations are an increased risk of certain cancers (kidney, and possibly liver and non-Hodgkin's lymphoma), non-cancer effects to the immune system and kidney, and a risk of heart defects during fetal development. Increased cancer risk using a reasonable maximum exposure scenario is estimated to be an additional 1.5 cases of cancer in 10,000 people (see Appendix C).

MDH completed an analysis of the data from the Minnesota Cancer Reporting System and overall cancer rates in the Water Gremlin study area were virtually identical to cancer rates in the seven-county Twin Cities Metro area. MDH also evaluated congenital heart defects cases from the Birth Defects Information System and found that the observed numbers in the area surrounding Water Gremlin do not appear different from what is expected based on prevalence estimates available for Minnesota.

Next Steps/Recommendations: MDH staff do not expect to see meaningful changes in cancer patterns and trends in this community, especially over the short term. Nevertheless, due to the lag time between the time of highest TCE exposure and the possible occurrence of cancer, MDH would consider a reanalysis of Minnesota Cancer Reporting System data in the future (e.g., 10 years) if the situation warrants it at that time and community interest remains high.

In response to questions from community members and elected officials, MDH considered the possibility of conducting a health study to address concerns about exposures to contamination from Water Gremlin but concluded that a scientifically valid health study is not feasible given the many challenges posed by such efforts, especially when historical information necessary to estimate past exposures does not exist. MDH remains available to explore and discuss what efforts may be feasible that may help to meet the goals and objectives of the community.

Conclusion 2: Past or current t-DCE and lead air emissions are not expected to harm people's health.

Basis for Conclusion 2: The outdoor air surrounding Water Gremlin is affected by use of t-DCE at the facility. The t-DCE from Water Gremlin is expected to spread out in air surrounding the facility similarly to past TCE emissions, although current use of t-DCE is significantly lower than past use of TCE. Given the available air monitoring data from sampling locations on the Water Gremlin property, and what can be estimated from modeling, t-DCE air concentrations were over the current chronic Risk Assessment Advice (RAA) value (20 µg/m3) beyond Water Gremlin's property boundary at times. In a very limited number of times air concentrations were over the subchronic RAA value (200 µg/m3) for short durations. However, neither the chronic nor subchronic RAA were exceeded for a length of time that poses a health concern. Also, the air monitoring results represent locations on the Water Gremlin property that are higher than actual exposures to t-DCE (how much t-DCE enters the body through breathing) experienced by people in the community.

Monitoring for lead in outdoor air on the Water Gremlin property began in September 2019 and indicates lead emissions are, and have been, well below the National Ambient Air Quality Standard of 0.15 µg/m3 set by the U.S. EPA to protect public health. Lead emissions are expected to deposit to the ground near Water Gremlin's facility. MDH's Blood Lead Information System (BLIS) database was queried and confirmed rates of elevated blood lead for children in zip code 55110 did not differ significantly from a comparison area, suggesting the community was not exposed to harmful amounts of lead from facility air emissions.

Next Steps/Recommendations: MDH recommends that MPCA continue to closely evaluate air emissions from Water Gremlin's facility and ensure adherence to the new air permit when it is final. MDH will continue to monitor new toxicological information for t-DCE to ensure the MDH air Risk Assessment Advice is protective of public health.

Conclusion 3: Groundwater contamination is not expected to harm people's health.

Basis for Conclusion 3: Municipal drinking water in White Bear Lake and White Bear Township is not affected by Water Gremlin groundwater contamination. 1,4-Dioxane was detected below the MDH HRL in municipal wells in Vadnais Heights from an unknown source. There are private wells in Gem Lake contaminated with 1,4-dioxane above MDH's HRL, but the concentrations of 1,4-dioxane are low and not expected to result in health effects. Households with wells with 1,4-dioxane concentrations exceeding the HRL have been notified and are provided bottled water to limit exposure. The source of the Gem Lake contamination is also unknown.

Next Steps/Recommendations: Water Gremlin is responsible for defining the extent and magnitude of the groundwater contamination from releases or threatened releases from their facility. MDH recommends MPCA continue to investigate the source of the 1,4-dioxane groundwater contamination found in Gem Lake private wells and the Vadnais Heights municipal wells. MPCA and MDH will continue to sample private wells and provide bottled water as needed to well owners with contamination above the HRL for 1,4-dioxane.

Conclusion 4: Soil vapor contamination is not a risk at properties near Water Gremlin.

Basis for Conclusion 4: TCE and t-DCE were found at high levels in soil vapor beneath the Water Gremlin facility and a mitigation system was installed to protect workers. Soil vapor sampling around the facility show that high levels of vapors are not migrating to neighboring homes.

Conclusion 5: Soil, sediment, and surface water contamination from Water Gremlin does not pose a health risk to the community.

Basis for Conclusion 5: The areas of soil contamination at Water Gremlin have been defined and are limited to the company's property. Water Gremlin operations have contributed to lead concentrations in sediments, particularly in samples from wetlands nearest the facility to the east and southeast. There is expected to be little to no human exposure to the lead in these sediments. Water Gremlin operations have contributed to lead and 1,4-dioxane in stormwater ponds and other surface waters on the company's property, but there is expected to be little to no human exposure to these surface water bodies. Currently, there is not enough information to determine whether past transport of 1,4-dioxane in surface water may have contaminated the groundwater.

Next Steps/Recommendations: In March 2021, Water Gremlin submitted a proposed workplan that includes dredging the eastern stormwater pond to remove lead-impacted sediment and reduce additional lead that could ultimately affect Lambert Creek.

Conclusion 6: Indoor air at the Water Gremlin facility may be harming or may have harmed worker's health.

Basis for Conclusion 6: During the vapor intrusion investigation at the Water Gremlin facility, TCE was found in indoor air above the Minnesota commercial/industrial Intrusion Screening Value (ISV) of 7 µg/m3. MDH requested that Water Gremlin notify its employees of TCE in indoor air, although data indicated the source was most likely from past TCE use in the facility, and not vapor intrusion. MDH provided the notification in several languages.

t-DCE concentrations in the facility's indoor air are generally high and fluctuate significantly because of its current use in production. Water Gremlin workers exposed to t-DCE repeatedly at concentrations measured at their facility may be at risk of immune system effects.

Next Steps/Recommendations: As required under OSHA, MDH recommends that Water Gremlin notify its workers about workplace hazards and protect the health and safety of its workforce.

Conclusion 7: Exposure to lead may have harmed the health of Water Gremlin workers and their families.

Basis for Conclusion 7: In 2019, MDH identified 24 children of Water Gremlin workers with elevated blood lead levels, defined as venous blood lead of at least 5 micrograms/deciliter.

Next Steps/Recommendations: To protect the health and safety of its workers and their families, a number of measures were required of Water Gremlin in order to reduce employee lead exposure and prevent take-home lead. MDH will continue to review elevated blood lead results from routine testing to identify results that may be related to Water Gremlin in collaboration with local public health departments. New legislation passed in 2021 provides MDH additional funding to conduct in-home lead risk assessments for all children in Minnesota with elevated blood lead levels and provides new enforcement authority for cases where the lead exposure originated outside of the home, as in the Water Gremlin situation. If children of Water Gremlin workers are identified with elevated blood lead, MDH and local public health will take appropriate actions to investigate and mitigate lead hazards.

Note: The majority of Water Gremlin workers who received blood lead tests in 2019 had high blood lead levels, though they appear to be declining. Assessment and control of worker lead blood lead levels are beyond the scope of the PHA and is a matter that is regulated by the Minnesota Department of Labor and Industry.

XII. Public Health Action Plan

The bullets below are actions MDH will take to protect the health of the community into the future.

- MDH will review any additional site investigation reports completed as part of the remedial investigation for Water Gremlin and will share information about any potential health concerns with the community if identified in the future.

- MDH will continue to monitor new toxicological information to ensure MDH's t-DCE inhalation Risk Assessment Advice is protective.
- MDH may consider a reanalysis of Minnesota Cancer Reporting System data or other data in the future (e.g., 10 years) if the situation warrants and community interest remains high.
- MDH remains available to explore and discuss what efforts may be feasible that may help to meet the goals and objectives of the community in absence of a health study.
- In collaboration with local public health departments, MDH will continue review of elevated blood lead results from routine testing to identify results that may be connected to Water Gremlin. New legislation enacted in 2021 provides MDH additional funding to conduct in-home lead risk assessments for all children in Minnesota with elevated blood lead levels and provides new enforcement authority for cases where the lead exposure originates outside of the home.
- MDH staff will review the upcoming US EPA cumulative risk assessment guidance and look for ways to incorporate its concepts to further acknowledge all the factors that may affect health in a community.

XIII. References

ATSDR (2021). Community Stress Resource Center (https://www.atsdr.cdc.gov/stress/index.html). Accessed on August 10, 2021.

ATSDR (2019). Toxicological Profile for Trichloroethylene (https://www.atsdr.cdc.gov/toxprofiles/tp19.pdf). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

ATSDR (1996). Toxicological Profile for 1,2-dichloroethene (https://www.atsdr.cdc.gov/toxprofiles/tp87.pdf). U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry. Accessed on April 14, 2020 at Toxicological Profile for 1,2-dichloroethene.

Braun Intertec Corporation (2004). Additional Groundwater Monitoring Assessment, Water Gremlin Company, 1610 Whitaker Avenue, White Bear Lake, Minnesota. Letter report to Mr. David Zinschlag, Water Gremlin Company on May 6, 2004.

Braun Intertec Corporation (1999). Air Emission Permit Application for Major Amendment, Prepared for Water Gremlin Company. September 22, 1999.

Braun Intertec Corporation (1998). Environmental Soil and Groundwater Evaluation – Report 2, Water Gremlin Company, 1610 Whitaker Avenue, White Bear Lake, Minnesota.

Braun Intertec Corporation (1996). Phase II Environmental Site Assessment. Prepared for Water Gremlin Company, March 26, 1996.

Braun Intertec Corporation (1995). Phase I Environmental Site Assessment. Prepared for Water Gremlin Company, April 10, 1995.

Braun Intertec Corporation (1994). Environmental Soils Evaluation. Prepared for Water Gremlin Company, November 28, 1994.

California EPA (2018). Public Health Goals Cis- and Trans-1,2-Dichloroethylene in Drinking Water (https://oehha.ca.gov/media/downloads/water/chemicals/phg/phg12-dce072018.pdf). Pesticide and

Environmental Toxicology Branch Office of Environmental Health Hazard Assessment, California Environmental Protection Agency. July 2018. Accessed on April 14, 2020.

Clausen, JL, Bostick, B, and Korte, N (2011). Migration of Lead in Surface Water, Pore Water, and Groundwater with a Focus on Firing Ranges, Critical Reviews in Environmental Science and Technology, 41:15, pp 1397-1448.

DuPont (1998). Trans-1,2-Dichloroethylene: 90-day inhalation toxicity study in rats, dated December 1, 1998. E.I. duPont de Nemours and Company, Haskell Laboratory for Toxicology and Industrial Medicine. Laboratory Project ID: HL-1998-00952.

Freundt KJ, Liebaldt GP, Lieberwirth E (1977). Toxicity Studies on Trans-1,2-Dichloroethylene. Toxicology 7:141-153.

MDEQ (2016). Initial Threshold Screening Level Memo (http://www.deq.state.mi.us/aps/downloads/ATSL/156-60-5/156-60-5_annual_ITSL.pdf). Michigan Department of Environmental Quality Interoffice Communication. January 20, 2016. Accessed on December 5, 2019.

MPCA (2021). Soil Reference Value Technical Support Document (https://www.pca.state.mn.us/sites/default/files/c-r1-05.pdf). Accessed on March 16, 2022.

MPCA (2019a). State of Minnesota, Minnesota Pollution Control Agency, In the Matter of Water Gremlin Company Stipulation Agreement (https://www.pca.state.mn.us/sites/default/files/aq-ei6-01b.pdf). March 1, 2019. Accessed on August 15, 2019

MPCA (2019b) Synthetic minor permit limits (https://www.pca.state.mn.us/air/synthetic-minor-permit-limits). Accessed on August 22, 2019.

MPCA (2019c) Maximizing the Flexibility of Your Air Permit (https://www.pca.state.mn.us/sites/default/files/aq2-12.pdf). Accessed on August 22, 2019.

MPCA (2007). Guidance for the Use and Application of Sediment Quality Targets for the Protection of Sediment-Dwelling Organisms in Minnesota (https://www.pca.state.mn.us/sites/default/files/tdr-gl-04.pdf).

MPCA (2006). Working Draft Surface Water Pathway Evaluation User's Guide (https://www.pca.state.mn.us/sites/default/files/c-s4-01.pdf). Minnesota Pollution Control Agency Remediation Programs. January 30, 2006.

MPCA (2004). Water Gremlin Site, 1610 Whitaker Avenue, White Bear Lake, Minnesota, MPCA Project Number 32VP5540, No Further Action Determination. Letter to Mr. David Zinschlag, Water Gremlin Company on May 14, 2004.

MPCA (2000). Letter to Mr. Paul Moss from James E Robin, MPCA, RE: Comments on Water Gremlin Company's Draft Air Emission Permit. July 20, 2000.

MPCA (1997). Correspondence to Douglas A Johnson, Manager, Water Gremlin Company from James Warner, Division Manager, Ground Water and Solid Waste Division, June 20, 1997.

Minnesota Geological Survey (1992). County Geological Atlas Series, Ramsey County, Atlas C-7, University of Minnesota.

NIOSH (2019). The National Institute for Occupational Safety and Health Pocket Guide to Chemical Hazards (https://www.cdc.gov/niosh/npg/npgd0195.html). Accessed on September 11, 2019.

NuGenTech (2019). FluoSolv WS Heavy Duty Cold Cleaning Solvent and Carrier Fluid. Accessed at https://www.nugentec.com/fluosolv-ws-cold-cleaning-carrier-fluid on September 11, 2019.

Pace Analytical (2019). Comprehensive Emissions Test Report. Water Gremlin Particulate and Lead Compliance Testing, Testing Dates: Nov. 20-21 & 26-29, 2018. Report Date: January 10, 2019.

Sexton K, Adgate JL, Ramachandran G, Pratt GC, Mongin SJ, Stock TH, Morandi MT (2004). Comparison of Personal, Indoor, and Outdoor Exposures to Hazardous Air Pollutants in Three Urban Communities. Environmental Science & Technology, Vol. 38, No. 2 p 423-430.

Shopp GM, Sanders VM, White KL, Munson AE (1985). Humoral and Cell-Mediated Immune Status of Mice Exposed to trans-1,2-Dichloroethylene. Drug Chem. Tox., 8(5):393-407.

Stantec (2021). DRAFT Additional Remedial Investigation Work Plan – Water Gremlin Company, White Bear Township. Prepared for: Water Gremlin. Prepared by: Stantec Consulting Services, Inc. March 24, 2021.

U.S. EPA (2021). Risk Assessment Guidance (https://www.epa.gov/risk/risk-assessment-guidance). Accessed on May 18, 2021.

U.S. EPA (2020). Provisional Peer-Reviewed Toxicity Values for trans-1,2-Dichloroethylene (https://www.epa.gov/pprtv/provisional-peer-reviewed-toxicity-values-pprtvs-assessments)(CASRN 156-60-5). U.S. EPA Office of Research and Development, Center for Public Health and Environmental Assessment. September 2020. Accessed on November 2, 2021.

U.S. EPA (2019b). Proposed Designation of trans-1,2-Dichloroethylene (CASRN 156-60-5) as a High Priority Substance for Risk Evaluation. August 22, 2019. Accessed on October 4, 2019 at Proposed Designation of trans-1,2-Dichloroethylene (CASRN 156-60-5) as a High Priority Substance for Risk Evaluation (https://www.epa.gov/sites/production/files/2019-08/documents/trans-12-dichloroethylene_156-60-5_high-priority_proposeddesignation_082319.pdf)

U.S. EPA (2019a). Toxic Release Inventory Explorer (https://enviro.epa.gov/triexplorer/release_fac_profile?TRI=55110WTRGR1610W&TRILIB=TRIQ1&FLD=&FLD=RELLBY&FLD=TSFDSP&OFFDISPD=&OTHDISPD=&ONDISPD=&OTHOFFD=&YEAR=2017). Accessed on September 10, 2019.

U.S. EPA (2014). Memorandum: Removal of the trans-1,2-Dichloroethylene (CASRN 156-60-5) Provisional Peer-Reviewed Toxicity Value (PPRTV) assessment from the Electronic Library. From Scott Wesselkamper, Director, Superfund Health Risk Technical Support Center (STSC) EPA/ORD/NCEA. June 17, 2014. Accessed on March 17, 2022 at Memorandum: Removal of the trans-1,2-Dichloroethylene (CASRN 156-60-5) Provisional Peer-Reviewed Toxicity Value (PPRTV) assessment from the Electronic Library (https://archive.epa.gov/region9/superfund/web/pdf/removal_memo.pdf)

U.S. EPA (2011). Toxicological Review of Trichloroethylene in Support of Summary Information on the Integrated Risk Information System (IRIS). September 2011.

U.S. EPA (2010). Toxicological Review of cis-1,2-Dichloroethylene and trans-1,2-Dichloroethylene In Support of Summary Information on the Integrated Risk Information System (IRIS). September 2010.

Wenck (2021). Additional Supplemental Remedial Investigation Summary Report - Water Gremlin Company, White Bear Lake Township. Prepared for: Water Gremlin. Prepared by: Wenck Associates, Inc. March 2021.

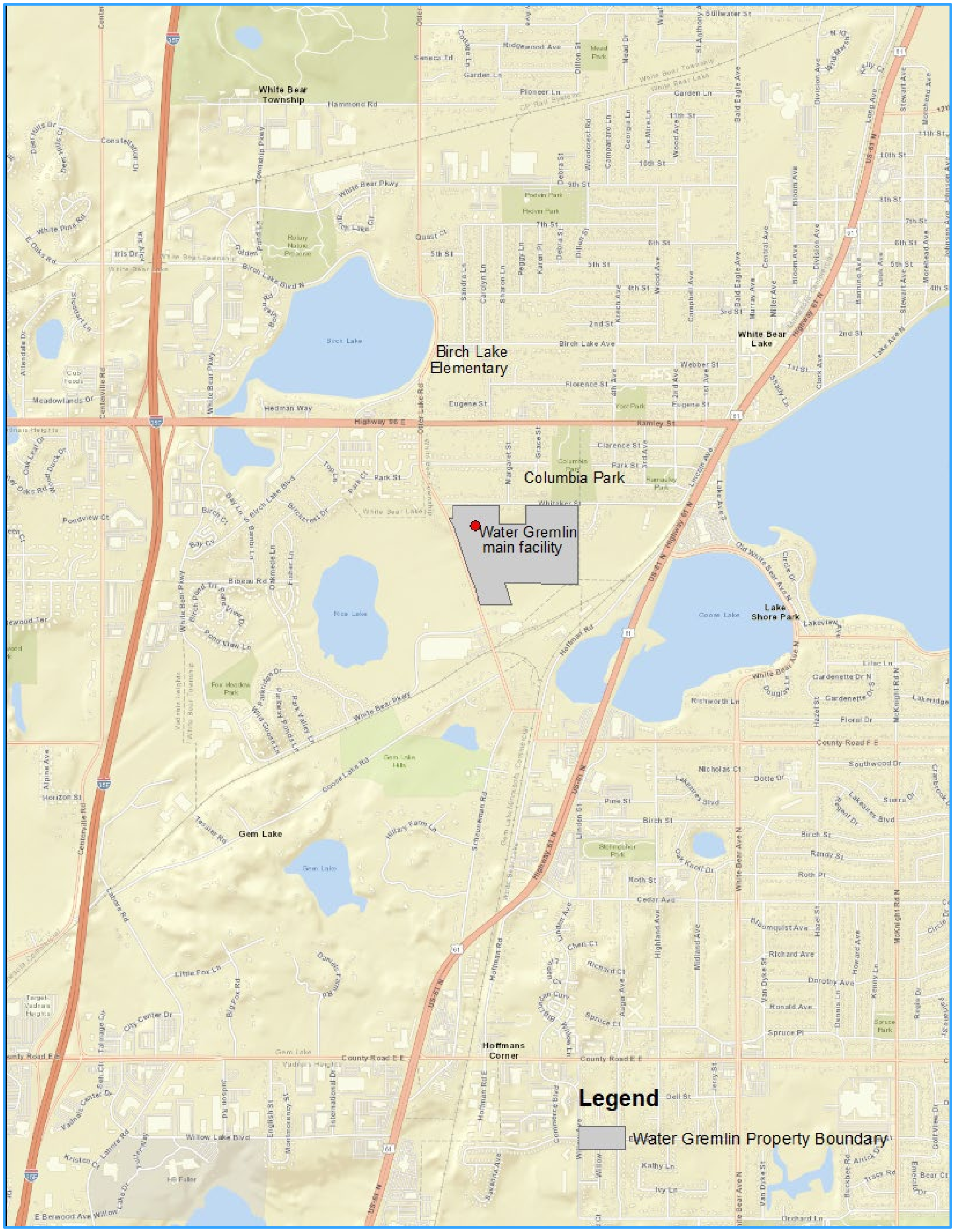
Wenck (2020). Supplemental Remedial Investigation Summary Report – Water Gremlin Company, White Bear Lake Township. Prepared for: Water Gremlin. Prepared by: Wenck Associates, Inc. Dated February 2020, finalized in July 2020.

Wenck (2019b). Remedial Investigation Summary - Water Gremlin Company, White Bear Lake Township. Prepared for: Water Gremlin. Prepared by: Wenck Associates, Inc. July 2019.

Wenck (2019a). Phase I Environmental Site Assessment, Water Gremlin Company. April 23, 2019.

Appendices

Appendix A – Water Gremlin Location Map



Appendix B - 2009-2018 TCE in Air Maps

DEPARTMENT OF HEALTH

Water Gremlin

HEALTH ASSESSMENT SERIES I 2009-2018 TCE IN AIR MAPS

Maps of estimates of TCE in air from the Water Gremlin facility from 2009-2018, based on MPCA air dispersion modeling data, are now available. The maps were created to provide a better understanding of estimated annual average TCE concentrations over time. The 2018 map is very similar to the map distributed in February 2019. To see the original map and for information about TCE and health, go to the TCE Air Emissions and Health document found at www.health.state.mn.us/communities/environment/hazardous/docs/sites/ramsey/wgtceairemisum.pdf.

What do the maps show?

The maps show the range of estimated annual average amounts of TCE in outdoor air at different locations. These locations were predicted by air quality dispersion modeling to be above the MDH inhalation Health-Based Value (HBV) of 2 $\mu g/m^3$ (micrograms per cubic meter). The HBV is an amount, or concentration, of a contaminant in air that is unlikely to lead to health effects even if sensitive members of the population are exposed to it 24 hours a day, 7 days a week, for a lifetime. The highest TCE amounts were predicted to be on the Water Gremlin property. The highest annual average concentration at a residential property was estimated and noted on each map.

What is air quality dispersion modeling?

Air quality dispersion modeling uses computer simulation to predict the amount of a pollutant in air at different locations and distances from a source. MPCA used the AERMOD dispersion model, developed and recommended by the U.S. EPA, to estimate the concentrations of air pollutants emitted from Water Gremlin. AERMOD simulation typically considers the emission rate, stack height, stack diameter, and stack gas temperature and velocity, as well as the effect of nearby buildings and terrain. AERMOD also uses meteorological data such as temperature, wind direction, and wind speed.

Why is the shape of the 2018 map slightly different on earlier versions?

Meteorological data, such as temperature, wind direction, and wind speed, are used in the model to calculate TCE concentrations at various locations. Most meteorological data comes from surface weather observation stations at airports. The meteorological data used to model Water Gremlin emissions earlier this year was from the Minneapolis/St. Paul International Airport. The updated map shows results when meteorological data from the Crystal, MN airport were used. The Crystal airport data are thought to represent conditions near Water Gremlin better. Each map year uses meteorological data from the year of the map, with the exception that the 2017 and 2018 maps use 2016 data, which was the latest meteorological data available at the time the modeling was conducted.

Were TCE air concentrations greater over shorter time periods?

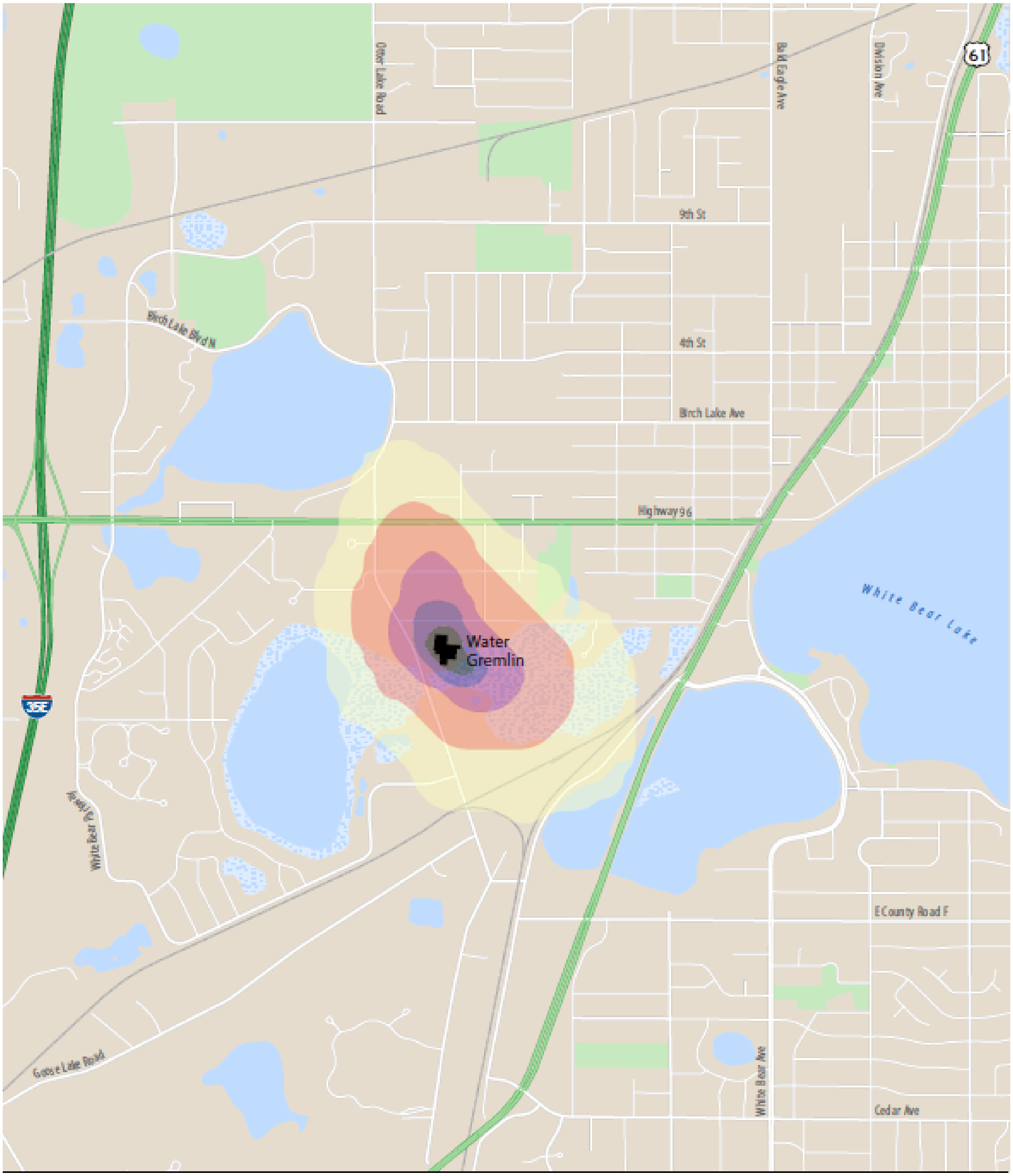
The map underestimates TCE air concentrations for shorter periods of time (e.g., monthly, daily). Because the TCE air estimates are annual averages, it is expected that there were times throughout the year when concentrations at a particular location were higher or lower than the annual average. For example, daily variations are expected due largely to variability in TCE use and weather conditions like wind speed and direction. For periods of time, TCE air concentrations above the HBV extended beyond the outlined area shown in the maps.

Minnesota Department of Health | Site Assessment and Consultation Unit

Phone: 651-201-4897 | Email: health.hazard@state.mn.us | www.health.state.mn.us To obtain this information in a different format, call: 651-201-4897

01/07/2020

2009 Estimated Annual Average Amount of TCE in Air from the Water Gremlin Facility



Amount of TCE in air in micrograms per cubic meter (µg/m³) at or above MDH's Health Based Value of 2 µg/m³

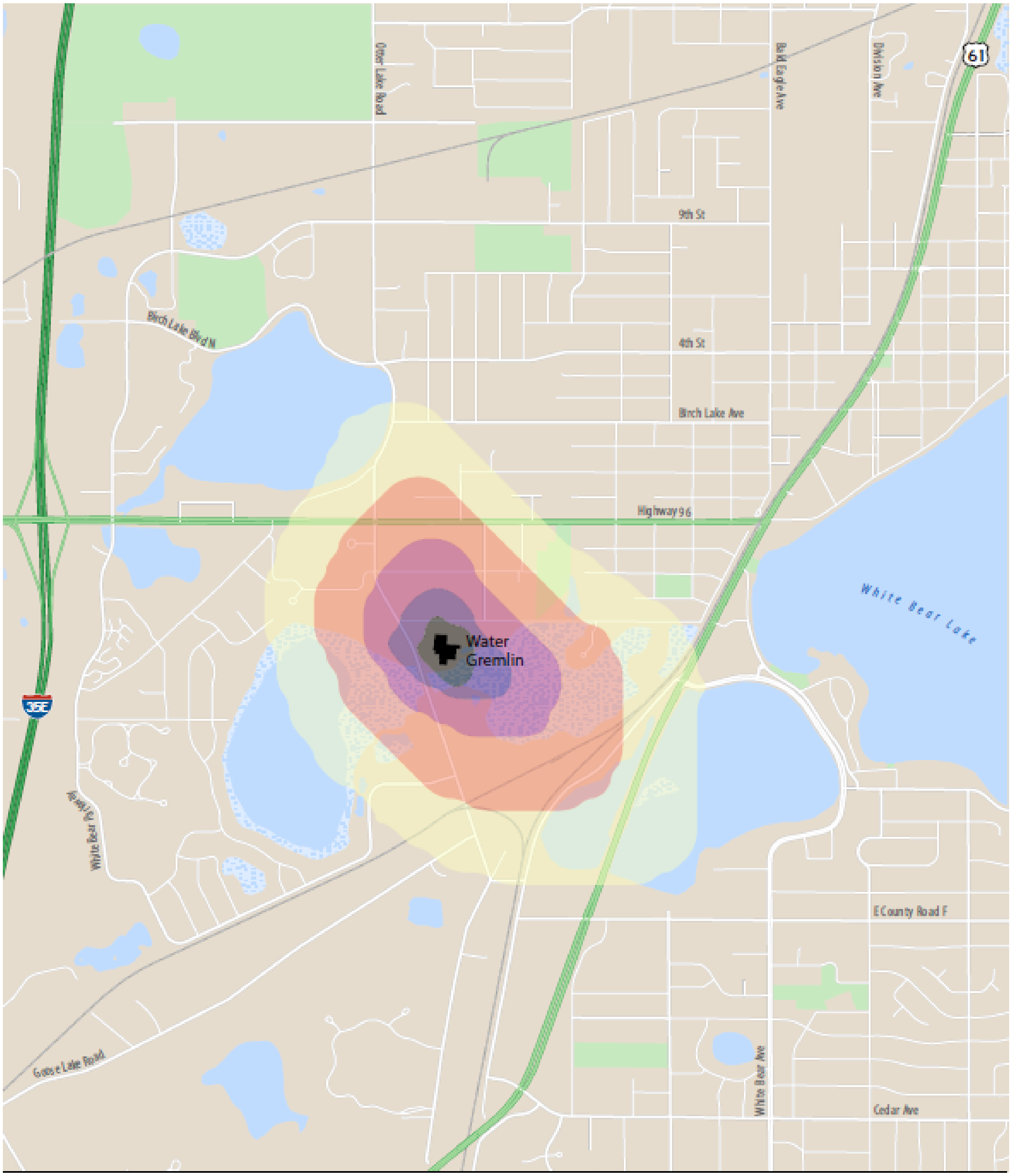
2 to 4	4 to 8	8 to 16	16 to 32	32 to 122

Note: The highest annual average amount at a residential property was estimated to be 13 µg/m3

0 Feet 2,000

N

2010 Estimated Annual Average Amount of TCE in Air from the Water Gremlin Facility



Amount of TCE in air in micrograms per cubic meter (µg/m³) at or above MDH's Health Based Value of 2 µg/m³

2 to 4	4 to 8	8 to 16	16 to 32	32 to 195

Note: The highest annual average amount at a residential property was estimated to be 22 µg/m3

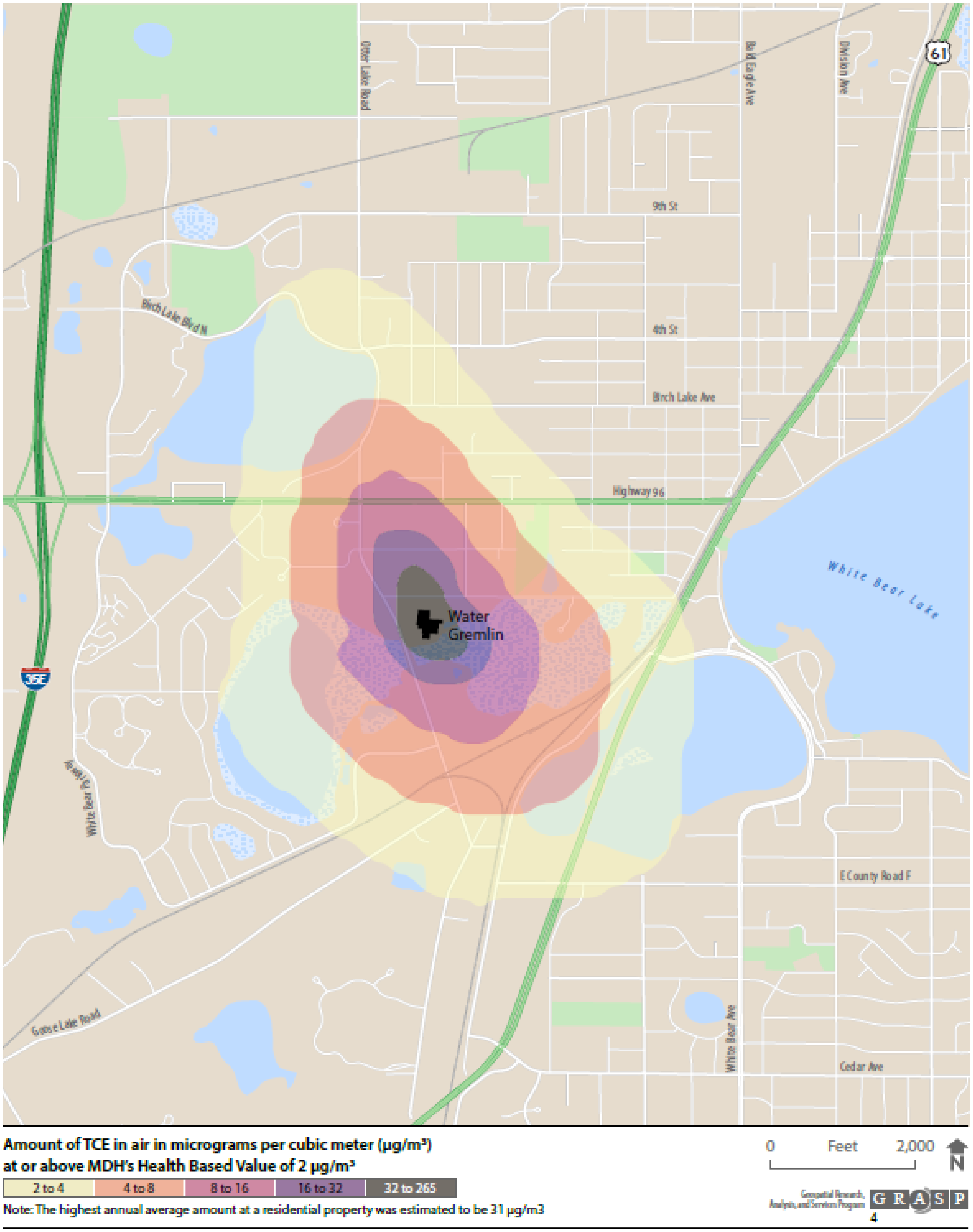
0 Feet 2,000 N

Geospatial Research, Analysis, and Services Program GRASP

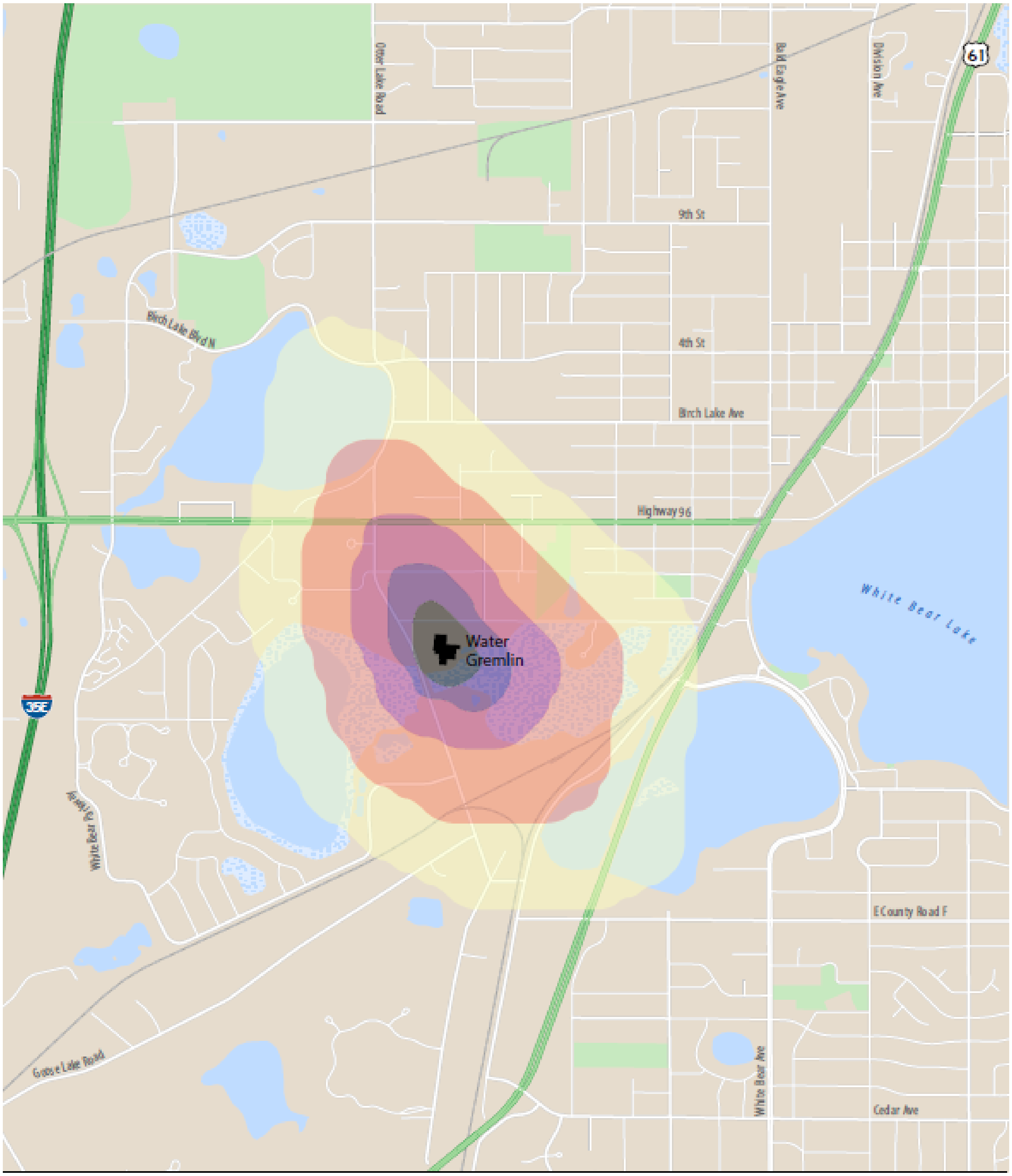
PROJECTION EPSG 26915

DATE 2019-12-10 PRJ ID 05661 AUTHOR W. Hartnett

2011 Estimated Annual Average Amount of TCE in Air from the Water Gremlin Facility



2012 Estimated Annual Average Amount of TCE in Air from the Water Gremlin Facility



Amount of TCE in air in micrograms per cubic meter (µg/m³) at or above MDH's Health Based Value of 2 µg/m³

2 to 4	4 to 8	8 to 16	16 to 32	32 to 238

Note: The highest annual average amount at a residential property was estimated to be 29 µg/m3

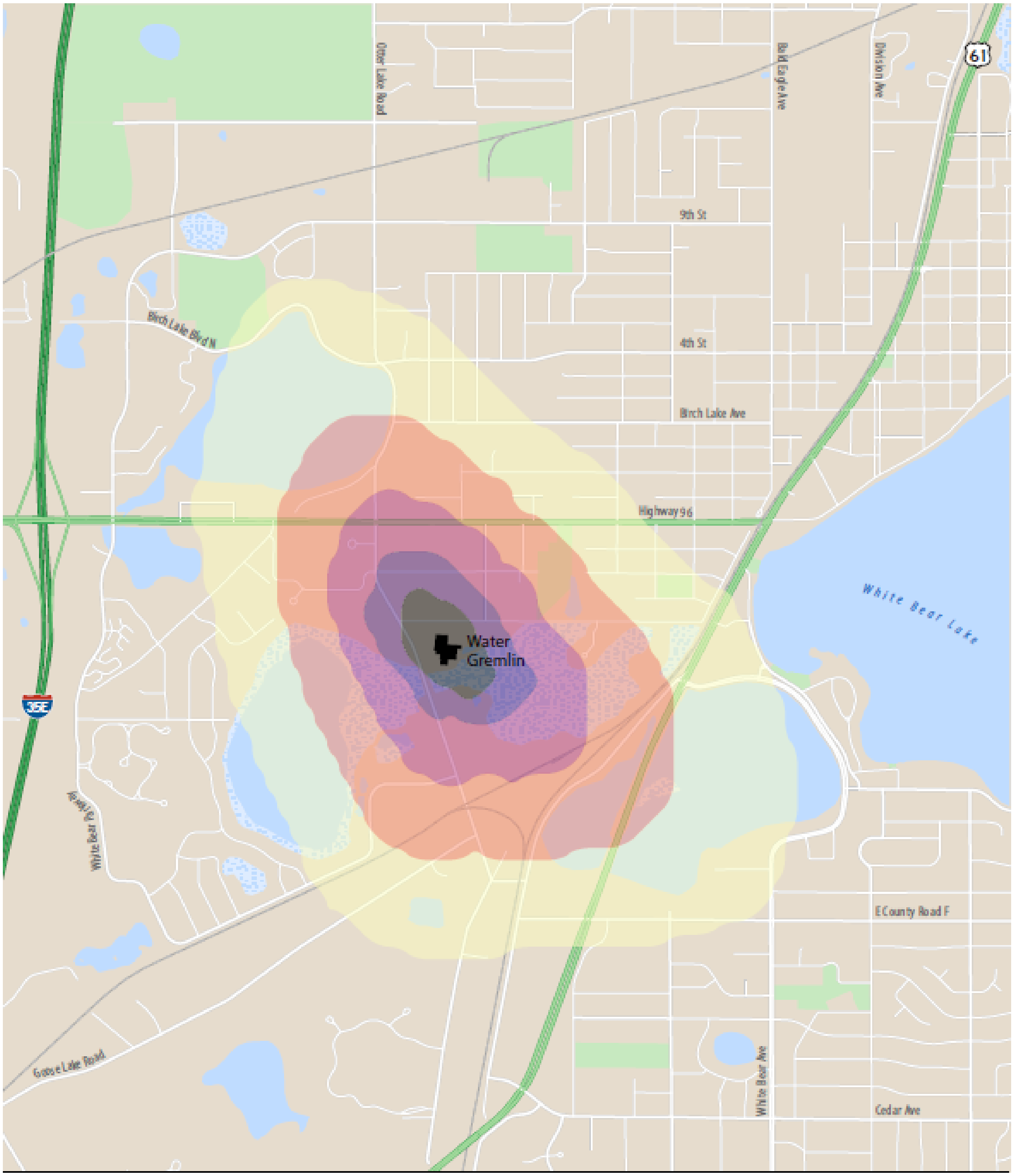
0 Feet 2,000 N

Geospatial Research, Analysis, and Services Program GRASP

PROJECTION EPSG 26915

DATE 2019-12-10 PRJ ID 05551 AUTHOR W. Hartnett

2013 Estimated Annual Average Amount of TCE in Air from the Water Gremlin Facility



Amount of TCE in air in micrograms per cubic meter (µg/m³) at or above MDH's Health Based Value of 2 µg/m³

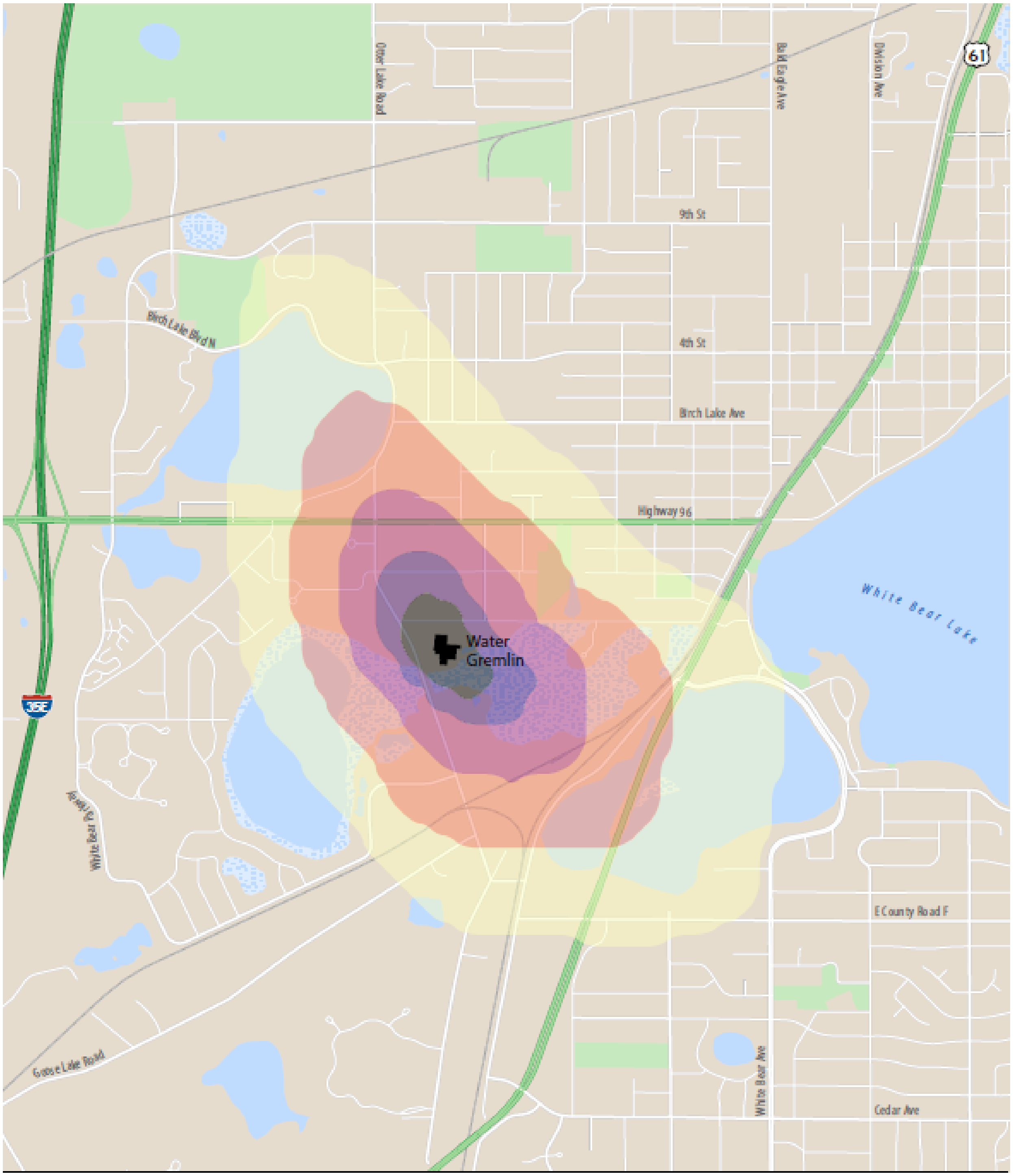
2 to 4	4 to 8	8 to 16	16 to 32	32 to 326

Note: The highest annual average amount at a residential property was estimated to be 41 µg/m3

0 Feet 2,000 N

Geospatial Research, Analysis, and Services Program GRASP

2014 Estimated Annual Average Amount of TCE in Air from the Water Gremlin Facility



Amount of TCE in air in micrograms per cubic meter (µg/m³) at or above MDH's Health Based Value of 2 µg/m³

2 to 4	4 to 8	8 to 16	16 to 32	32 to 310

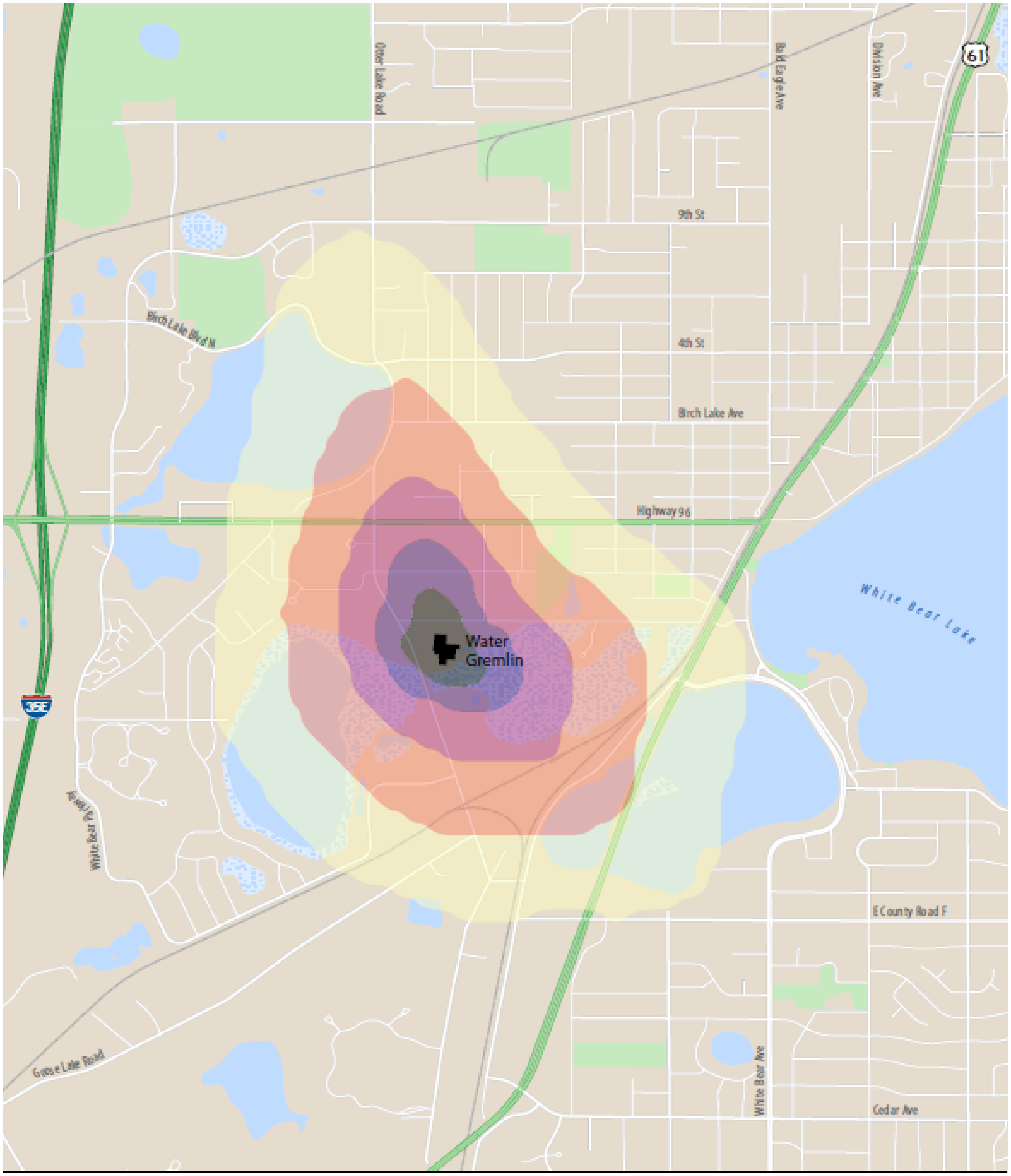
Note: The highest annual average amount at a residential property was estimated to be 35 µg/m3

0 Feet 2,000

N

Geospatial Research, Analysis, and Services Program GRASP

2015 Estimated Annual Average Amount of TCE in Air from the Water Gremlin Facility



Amount of TCE in air in micrograms per cubic meter (µg/m³) at or above MDH's Health Based Value of 2 µg/m³

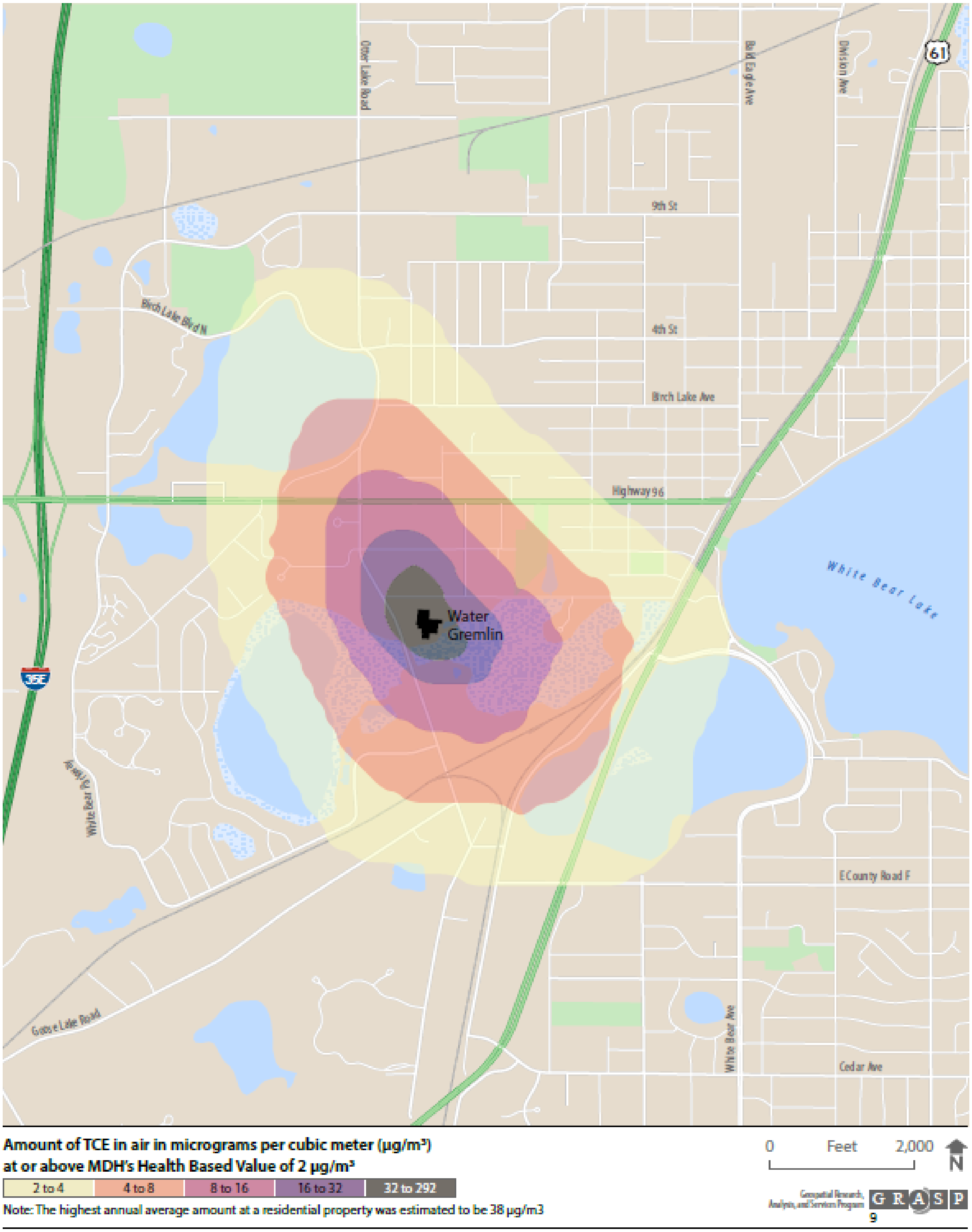
2 to 4	4 to 8	8 to 16	16 to 32	32 to 312

Note: The highest annual average amount at a residential property was estimated to be 33 µg/m3

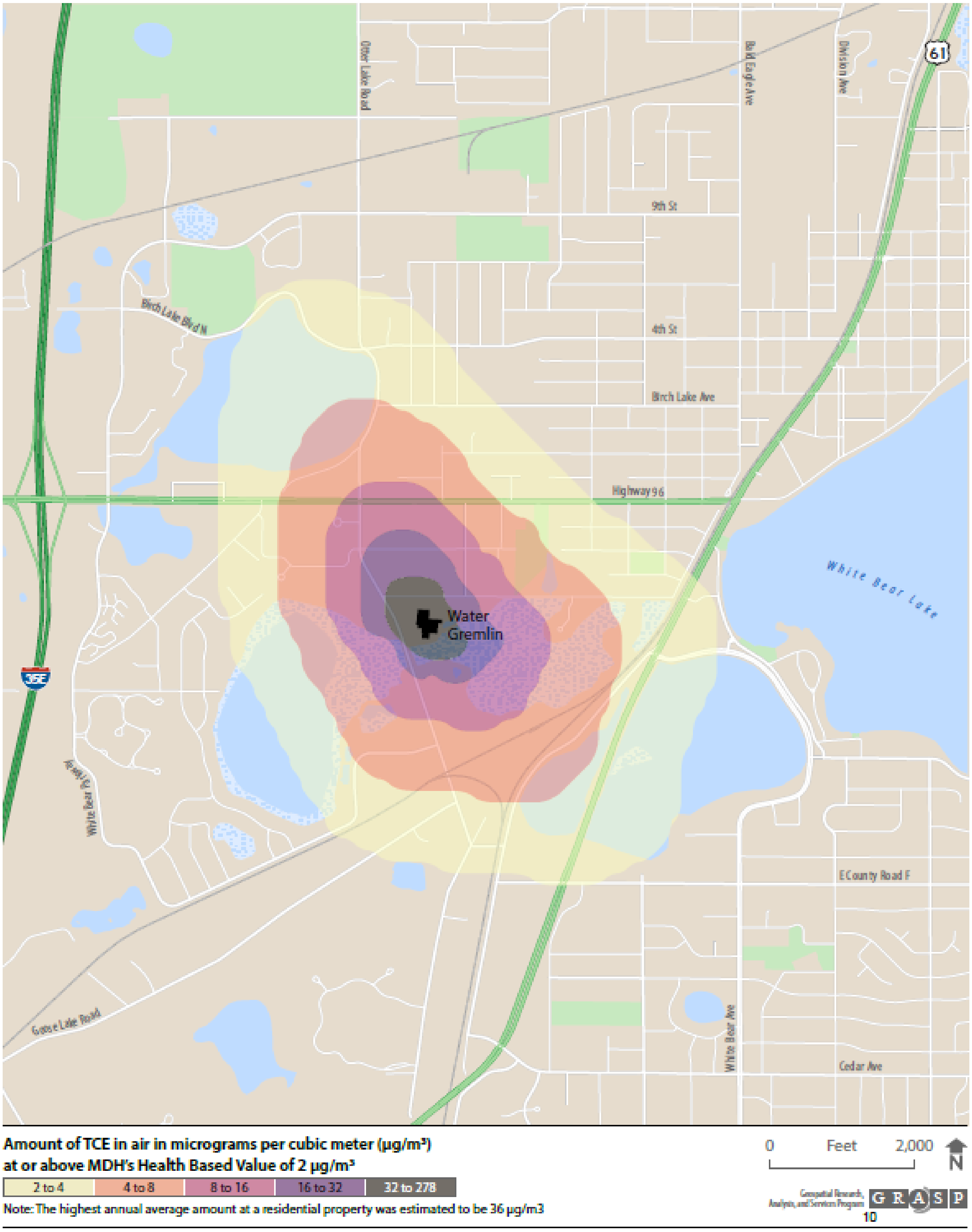
0 Feet 2,000 N

Geospatial Research, Analysis, and Services Program GRASP

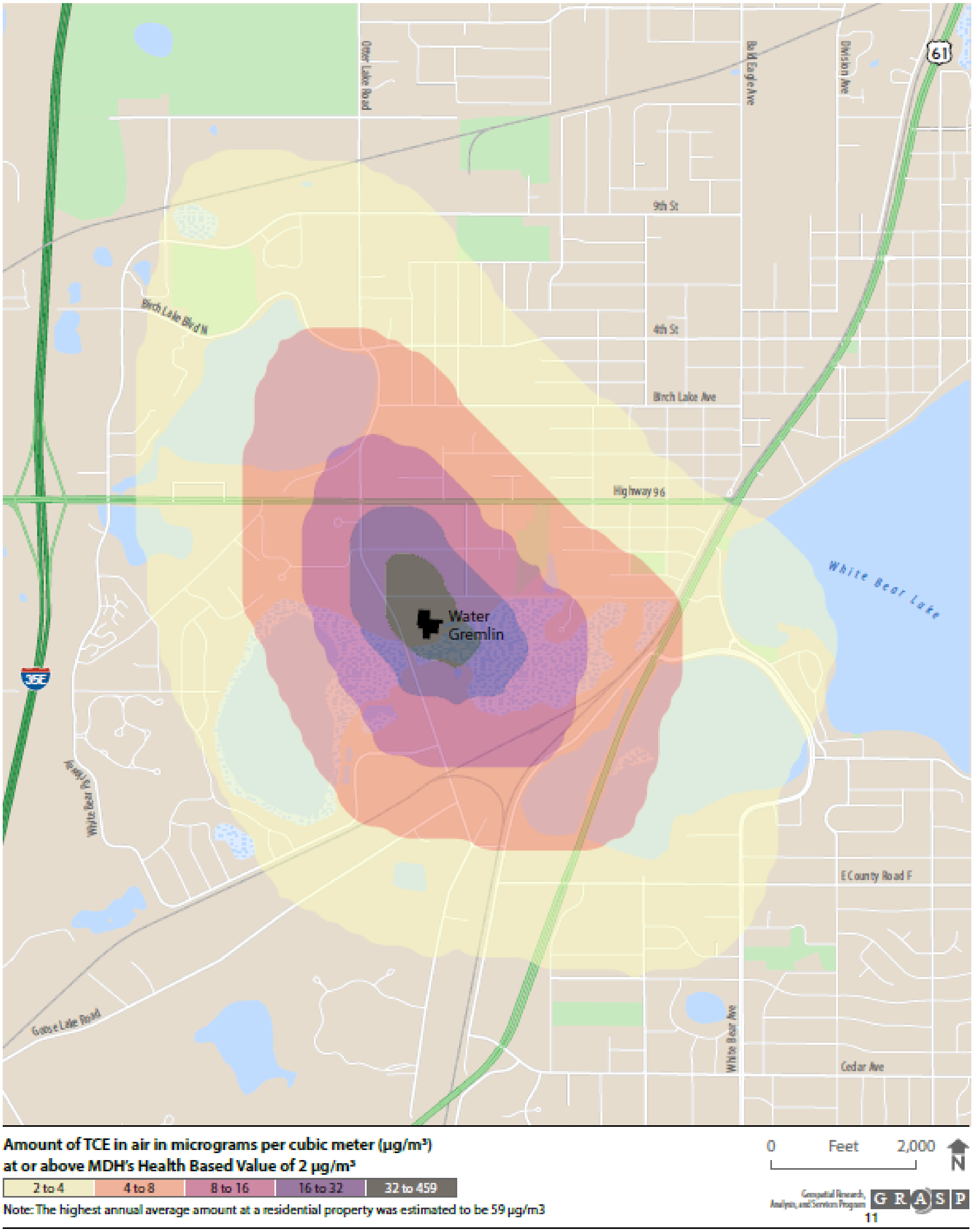
2016 Estimated Annual Average Amount of TCE in Air from the Water Gremlin Facility



2017 Estimated Annual Average Amount of TCE in Air from the Water Gremlin Facility



2018 Estimated Annual Average Amount of TCE in Air from the Water Gremlin Facility



Appendix C - Cancer Risk Assessment Calculation

Health assessors use a process called risk assessment to evaluate potential effects of chemicals on health. Risk assessments use the best available scientific information, as well as professional judgement and policy, to estimate risks in a consistent, standardized manner that is useful for decision making about managing risks. The paragraphs below describe the process MDH used to estimate cancer risk for a hypothetical, highly exposed resident of the area near the Water Gremlin facility. Many of the inputs and processes MDH uses are adopted from widely followed guidance from the U.S. EPA (U.S. EPA, 2021).

In 2011, EPA derived an inhalation unit risk (IUR) for TCE of 4.1E-06 (µg/m3)-1 for three cancer types combined–by using the measured increase in human kidney cancer risk and adjusting for potential increased risk of non-Hodgkin's lymphoma and liver cancer (EPA, 2011). An IUR is an estimate of the increased cancer risk from inhalation exposure to a concentration of 1 µg/m3 of a substance for a lifetime. For risk assessment purposes, this means an estimated 4.1 cases of cancer might occur due to this exposure if a million people consistently breathe air containing one microgram of TCE per cubic meter of air for 70 years.

The EPA also recommends combining cancer IURs with age-dependent adjustment factors (ADAFs) to account for greater early-life susceptibility for chemicals that cause cancer by a mutation, whenever the toxicity values are calculated from studies that only involve exposures in adults. EPA developed ADAFs of 10, 3, and 1 for application to the age groups of 0-2 years, 2-16 years, and 16-70 years, respectively (EPA, 2005). For TCE, EPA recommends applying ADAFs only to the kidney cancer portion of the total cancer risk estimate, because only that tumor type had sufficient evidence to conclude that TCE induces cancer through a mutation (EPA, 2011). However, as shown in the calculation below, MDH takes an even more protective approach by applying ADAFs to the full inhalation unit risk, not just the kidney cancer portion.

To estimate community health risks, risk assessors often calculate risk for what is called a "reasonable maximum exposure" (RME) scenario. For the purpose of assessing exposure to TCE in air surrounding the Water Gremlin facility, the RME scenario is considered to last from birth to 27 years (the amount of time Water Gremlin is thought to have released TCE into the air; 1992-2018). The RME scenario also uses an exposure point concentration (EPC) of 34 µg/m3 to represent an amount of TCE in the air that people breathed in this scenario. The EPC was calculated by averaging the TCE concentrations predicted at the highest residential location from 2009 through 2018 (as indicated on the maps in Appendix B).

The cancer risk calculation is shown below for the RME scenario assumptions described above. The partial risk estimates are derived by multiplying the IUR by the age-specific ADAFs, the estimated EPC, and exposure duration adjustments (age group years divided by a 70 year lifetime averaging time). The lifetime risk of 1.5E-04 is the sum of the partial risks.

Cancer Risk Calculation

Age Range	IUR (µg/m3)$^{-1}$	ADAF	EPC (µg/m^3)	Duration Adjustment	Partial Risk
0 to < 2 years	0.0000041	10	34	2 years/70 years	3.98E-05
2 to <16 years	0.0000041	3	34	14 years/70 years	8.36E-05
16 to 27 years	0.0000041	1	34	11 years/70 years	2.19E-05
				Lifetime Risk	1.5E-04

Using the assumptions just described, the increased cancer risk is estimated to be an additional 1.5 cases of cancer in 10,000 people exposed in this hypothetical scenario. If such exposures were to occur, this cancer risk would exceed Minnesota's acceptable cancer risk level of 1 additional cancer case in 100,000 exposed people, but would be indistinguishable from the lifetime background rate in Minnesota of 1 cancer case in every 2-3 people. Since this calculation is for the RME, the risk would be much lower for the majority of plausible exposures (scenarios that involve fewer years of exposure, exposure to lower TCE concentrations, etc.) among people who lived, worked or otherwise might have spent time in the area surrounding the Water Gremlin facility.

Appendix D - 1,4-Dioxane in Private Wells – Gem Lake and the White Bear Area

DEPARTMENT OF HEALTH

1,4-Dioxane in Private Wells - Gem Lake and the White Bear Area

8/24/2021

Recent private well sampling in Gem Lake has detected the chemical 1,4-dioxane above the Minnesota Department of Health (MDH) drinking water guidance value.

What is 1,4-dioxane?

The main use of 1,4-dioxane was as a stabilizer for the chlorinated solvent 1,1,1-trichloroethane (often used for industrial purposes). 1,4-dioxane can also be an unintended contaminant in the production of certain products, including some cleaners, detergents, adhesives, inks, automotive fluids, etc. Groundwater contaminated with 1,4-dioxane is largely caused by the historical use and disposal of chlorinated solvents.

How can I be exposed to 1,4-dioxane?

Drinking contaminated water is the primary way people are exposed. Minor sources of exposure are food prepared with contaminated water and incidental ingestion and inhalation of water vapor during showering. Absorption through the skin is also thought to be insignificant.

MDH Health Risk Limits

Minnesota Department of Health (MDH) uses Health Risk Limits (HRLs) to protect people's health from drinking water contaminants. The table below shows three HRL values for 1,4-dioxane set by MDH, for differing time frames and possible health endpoints they are based on.

The 1,4-dioxane HRL of 1 part per billion (ppb) represents an amount of a contaminant that poses little or no health risk to those drinking the water daily for a lifetime, including sensitive or highly exposed people.

MDH Health Risk Limits for 1,4-Dioxane

Duration	HRL (ppb) *	Health Endpoint
Subchronic (>30 days up to 10% of a lifetime)	300	Liver, kidney, and respiratory systems
Chronic (>10% of a lifetime)	100	Liver, kidney, and respiratory systems
Lifetime (0-70 years)	1	Cancer

*HRLs are shown in units of parts per billion (ppb). This is the same as micrograms per liter (µg/L).

Potential Health Effects

Concentrations detected in well water in Gem Lake are just above the HRL of 1 ppb and present a very low health risk. Information about the health effects of 1,4-dioxane comes mainly from studies of laboratory animals. 1,4-Dioxane is considered a likely human carcinogen, based on studies of animals exposed to very high amounts. There are currently no human studies that show a direct link between exposure to 1,4-dioxane and cancer. The HRL of 1 ppb is based on a negligible cancer risk of one additional cancer in 100,000 people consuming the water on a daily basis for a lifetime.

Frequently Asked Questions

Is there more cancer in Gem Lake because of this contamination?

We would not expect to see an increase in cancer in the community from the exposures found. In addition, MDH completed an analysis of the data from the Minnesota Cancer Reporting System in 2019 and overall cancer rates in the Water Gremlin study area (which encompassed Gem Lake) were virtually identical to cancer rates in the seven-county Twin Cities Metro area.

Should I get tested for exposure to 1,4-dioxane? Should I see my doctor?

1,4-dioxane breaks down in the body and eliminated quickly – on the order of hours to days. Tests to measure 1,4-dioxane or metabolites are not readily available to physicians. MDH advises that there is no need to go to the doctor solely because of this exposure in drinking water. There are no recommendations for any increased screening for cancer or other health effects.

Is it okay for my dogs/cats to drink the well water?

Dogs and cats are expected to have similar health risks as people.

Can I water my garden vegetables with my well water?

It is possible that plants watered with well water may be a very minor source of exposure, but this has not been well studied.

Minnesota Department of Health | Site Assessment and Consultation | www.health.state.mn.us
health.hazard@state.mn.us| 651-201-4897

08/24/21 *To obtain this information in a different format, call: 651-201-4897.*

Appendix E - Water Gremlin Facility – TCE in Indoor Air Notification

DEPARTMENT OF HEALTH

Water Gremlin Facility – TCE in Indoor Air

Testing in January 2020 showed that trichloroethylene (TCE) remains in the indoor air, likely from its past use. Levels of TCE in the chemical storage and coating areas are above the Minnesota Department of Health's (MDH's) safe screening levels, especially for women who are pregnant or may become pregnant.

Breathing TCE during the first trimester of pregnancy may increase the risk of heart defects to the baby. If you are pregnant or may become pregnant, MDH recommends that you avoid spending time in the chemical storage and coating areas until levels of TCE in indoor air decline.

While pregnant women are the most sensitive to effects of TCE exposure, other adults may also be affected by breathing TCE. In particular, high exposures over long periods of time could result in effects to the immune system and kidneys.

Where can I get more information?

MDH Site Assessment and Consultation Unit
Call (651) 201-4897
Email health.hazard@state.mn.us
On the web at www.health.state.mn.us/divs/eh/hazardous/topics/vaporintrusion.html

Appendix F - Cancer Occurrence Report for White Bear Township, White Bear Lake and Gem Lake Area Five Census Tracts, 2007-2016

DEPARTMENT OF HEALTH
MINNESOTA CANCER REPORTING SYSTEM

Cancer Occurrence

WHITE BEAR TOWNSHIP, WHITE BEAR LAKE AND GEM LAKE AREA
FIVE CENSUS TRACTS, 2007-2016

03/28/2019

Cancer Occurrence in White Bear Township, White Bear Lake and Gem Lake area

Minnesota Department of Health
Minnesota Cancer Reporting System PO
Box 64882
St. Paul, MN 55164-0822
651-201-5900
health.mcrs@state.mn.us
www.health.state.mn.us

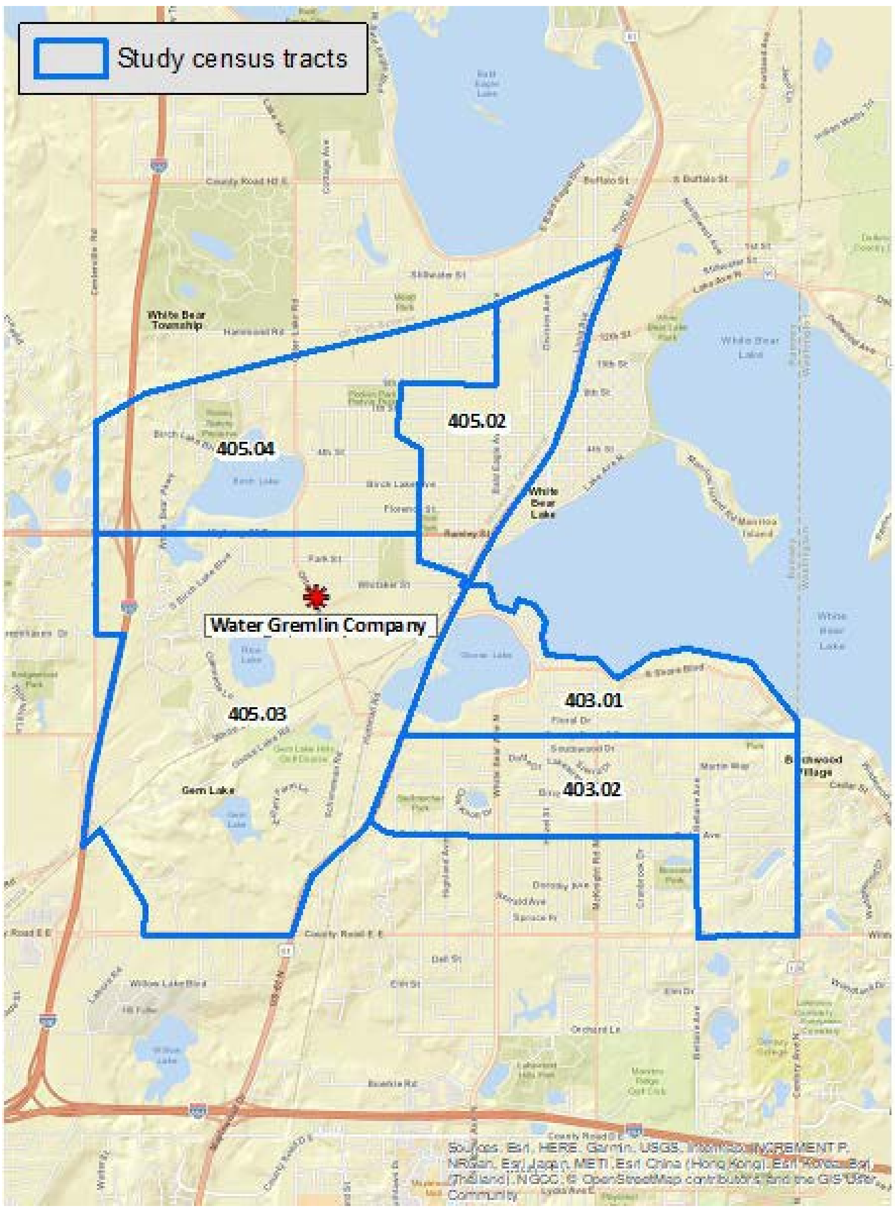
To obtain this information in a different format, call 651-201-5900. Printed on recycled paper.

Contents

Main Finding

A detailed study encompassing ten years of cancer data firmly establishes that overall cancer incidence rates in five census tracts in the White Bear Township, White Bear Lake and Gem Lake area are virtually identical to cancer rates in the Twin Cities Metro area.

Area of Analysis



Summary

There have been cancer concerns among many White Bear Township, White Bear Lake and Gem Lake area residents related to past releases of Trichloroethylene (TCE) to the air by the Water Gremlin facility (see map location above). The purpose of this report is to provide a complete and accurate profile of cancer occurrence among residents living in the five census tracts surrounding the Water Gremlin facility. Data from the Minnesota Cancer Reporting System (MCRS) was used to compare cancer rates among individuals living in the census tracts surrounding the facility at the time of their diagnosis with cancer rates in the seven county Twin Cities metropolitan area during the most recent 10-year period for which complete data were available (2007-2016).

Overall cancer rates in the area of analysis were virtually identical to Metro-area rates. For both genders combined, 970 cancers were diagnosed over the 10-year period, compared to the expected number of 978.

Due to their smaller numbers and greater variability (over time or from one location to another), the rates of specific types of cancer at a community (or even county) level are generally much less stable or informative and permit few conclusions. No excesses or deficits of cancers were observed in the ten years of data. The number of residents in the study area currently living with any history of cancer likely exceeds 940 individuals.

While environmental contaminants are the frequent focus of community cancer concerns, the primary determinants of cancer risk include smoking, obesity, diet, lack of exercise, UV radiation, alcohol, viruses, genetics, reproductive history, medications, and occupation.

Background

The Minnesota Pollution Control Agency (MPCA) and the Minnesota Department of Health (MDH) have published documents describing the release of TCE from the Water Gremlin facility and related actions. They can be found at the following web sites.

MPCA:

Water Gremlin trichloroethylene (TCE) Area of Concern

MDH:

Water Gremlin Site - Community concern (TCE)

Data Sources and Methods

The MCRS is Minnesota's statewide cancer registry (database) and has operated since 1988. It collects diagnostic and related data on all cancer diagnoses among Minnesota residents. The data come from hospitals, clinics, and pathology laboratories and are carefully reviewed for completeness and accuracy. Independent audits estimate completeness of the MCRS at over 99%.

Cancer cases for the five census tracts in the White Bear Township, White Bear Lake and Gem Lake area were identified from the MCRS for the most recent 10-year period for which complete data were available: 2007-2016. Five census tracts (040301, 040302, 040502, 040503, 040504) were used to identify residents who received a new diagnosis of cancer in that period and resided near the Water Gremlin facility in the area of analysis.

When examining cancer rates in a community or county with a relatively small population, the preferred approach is to compare the actual "observed" number of newly occurring cancers to the estimated "expected" number (calculated with the assumption that the community had the same cancer rates as some larger comparison population). For this analysis, cancer rates for the seven-county Twin Cities Metro area during 2007-2016 were used for comparison to the census tracts. The "expected" number of cancers was estimated by applying Metro area cancer rates (by age and gender) to the population of the five census tracts from the 2010 census. Eighteen age categories were used to estimate expected cancer cases separately for males and females. Only the age and gender distributions of the population are taken into account when determining "expected" cancers since these important risk factors alone are known. However, other significant determinants of cancer risk such as smoking history, medical history, family history, obesity, diet, occupation, reproductive history, infectious agents (e.g. human papilloma virus, hepatitis viruses), or other established risk factors are unknown and cannot be taken into account.

For ease of comparison, the observed number of cancers divided by the expected number gives an observed-to-expected ratio (also called the Standardized Incidence Ratio). If the two numbers were identical (which only rarely happens), this ratio would be 1.00. If there were twice as many cancers as expected, the ratio would be 2.00; if there were half as many cancers as expected, the ratio would be 0.50. For each such ratio, a 95% confidence interval was calculated and is also shown in this report. The confidence intervals represent a range in which the ratio is expected to be 95% of the time; this means there is a 5% chance that the ratio could be outside the range. The confidence intervals give an additional measure of the variability and uncertainty that is encountered when examining cancer rates in a community and comparing them to expected rates.

If a confidence interval does not encompass a value of 1.00, the ratio is considered "statistically significant" – meaning that the difference is less likely to be due to random chance. However, there is still some further uncertainty that is not reflected in the confidence intervals which do not take into account random differences which can be expected whenever multiple comparisons are made (e.g., comparing a large number of different types of cancer) or the effects of errors in estimating the population of the community.

This report provides information about total cancers for males and for females, as well as 20 specific types of cancers among males and 22 types of cancer among females (representing about 93% of the total cancer incidence for each gender).

Findings

Cancer incidence describes the rates and number of newly diagnosed cancers over a specified time period. Table 1 shows the observed and expected numbers of cases for all cancers combined and for the most frequent types of cancer among males in the five census tracts in the area of analysis. The observed-to-expected ratios and statistical 95% confidence intervals are also shown. Table 2 provides the same information for females. The same ratios and confidence intervals are also shown graphically in Figure 1 and Figure 2 for males and females, respectively.

For all cancers combined over the 10-year period 2007-2016, there were no significant differences between the observed and expected numbers of cancers (based on Metro area rates) for males or for females. For males, there were 471 newly diagnosed cancers versus 478 expected cancers (ratio of 0.98). For females, there were 499 observed cancers compared to 500 expected cancers (ratio of 1.00). For both genders combined, there were 970 newly diagnosed cancers over the 10-year time period, compared to the expected number of 978 for an overall ratio of 0.99. In short, the overall cancer rate in five census tracts in the area of analysis is virtually identical to the Metro area rate.

Strengths and Limitations

The major strength of this analysis is the use of data from the MCRS to examine and compare cancer incidence rates. All newly diagnosed cancers among Minnesota residents are reported to the MCRS. MCRS data has been shown to meet the highest standards of data completeness and accuracy. Examining rates of newly diagnosed cancers provides the most detailed and complete profile of cancer occurrence among Minnesota residents statewide.

Detailed population data (18 age categories for each gender) for the requested census tracts were required to determine the expected number of new cancers. Data from 2010 United States Census were used to provide an approximate population distribution for the ten year time period. There are fluctuations in populations over time but the US census is the most accurate account of the population. MCRS data are available at the census tract level which correspond exactly with the population data.

While this study provides a relatively clear picture of overall cancer incidence among these residents living in the area of analysis, the picture is much less stable or informative for many specific types of cancer due to the small numbers of cases at a community level. This problem was partially overcome by aggregating cancer data over a ten year period.

Finally, these cancer data represent the occurrence of cancer among people who lived in the community at the time of diagnosis (cancer incidence) during the period 2007-2016. However, the time period for the development of cancer (latency period) is typically several decades. Many cancers diagnosed today are possibly due to exposures and lifestyle experiences that began or occurred many years ago. As in any community, there will be migration from one neighborhood to another as well as migration into and out of these communities over time.

Usefulness and Limitations of Community Cancer Rates in Addressing Environmental Cancer Concerns

The MCRS is a vital tool for examining cancer rates and trends in Minnesota and MCRS data are extremely useful in facilitating epidemiologic studies of specific cancers, quality of care studies, evaluating screening and prevention programs, and many other purposes. While community cancer rates have a high degree of statistical uncertainty and must be interpreted cautiously, such data are also very useful in addressing public concerns over cancer rates in a county or a community by providing a more complete and accurate profile of cancer occurrence. However, for many reasons, analyses of community cancer rates are rarely useful in documenting potential cancer risks from low levels of environmental pollutants.

- Cancer is not a single disease but a group of more than 100 different diseases. Cancers differ in their rates of occurrence, risk factors, treatment, and survivorship. Unfortunately, cancer is not a rare disease, especially when considered in terms of lifetime risk. Not including the most common forms of skin cancer, the average lifetime risk of developing some type of cancer (in situ or malignant) is approximately 44% among males and 41% among females (National Cancer Institute: The Cancer Query System). On average then, almost one in two people will have a diagnosis of cancer during their lifetimes. For any individual, of course, the lifetime risk will be dependent on many personal factors such as smoking history, obesity, alcohol use, family history, and other risk factors.

- The time period for the development of cancer (latency period) is typically several decades, such that many cancers diagnosed today are due to exposures and lifestyle experiences that began or occurred many years ago. Unfortunately, it is often not possible to know when and to what extent newly identified contaminants would have created the potential for exposure in a community. Furthermore, due to the high mobility of our population, many residents in a community may not reside there for more than five years prior to their diagnosis of cancer. Thus, community cancer rates are frequently comprised of individuals who differ in their residential histories in the community, their personal risk factors for cancer, as well as in their potential exposures to environmental contaminants.

- While we have no control over risk factors such as age, race, family history, and genetics, much of our cancer risk is strongly influenced by lifestyle factors that we can control. Such lifestyle risk factors include cigarette smoking, obesity, alcohol consumption, ionizing and solar radiation, certain infectious agents (e.g., hepatitis viruses), occupation, and physical inactivity (Figure 3). Those factors account about 60% of cancer deaths in the U.S. Other lifestyle factors that increase risk include reproductive patterns, sexual behavior, and medications. However, even when no modifiable risk factors are known that can reduce the risk of developing a cancer, screening and early diagnosis may prevent or reduce the risk of death.

- While little is known about the causes of some types of cancer (e.g., brain tumors), for many types of cancer, specific risk factors have been identified. For some cancers, these known risk factors account for a significant proportion of cancer occurrence (e.g., 85-90% of lung cancer is attributable to smoking; 95% of cervical cancer is due to the Human Papilloma Virus). Communities and counties can vary widely in terms of known risk factors for cancer, contributing to the variability of cancer rates. While age and gender distributions in a community can routinely be accounted for, lack of information about other known determinants of cancer incidence (such as smoking histories) in a given population makes it difficult to attribute any observed excess or deficit in cancer rates to a given cause.

- Well-designed epidemiological studies, in addition to toxicological research, are necessary to answer questions about the extent to which an environmental exposure may be contributing to the occurrence of cancers in human populations. Indeed, most known human carcinogens have been identified through epidemiologic studies of occupational groups. Cancer risks are much more likely to be detected in the workplace rather than in a community setting since (1) occupational exposures are generally much greater than community exposures; (2) it is frequently possible to estimate past exposures in a workplace using industrial hygiene data, job histories, and other data; and (3) it is usually possible to identify all the people who worked at a workplace for a particular time period using personnel records.

- State and federal regulatory standards and guidelines are intended to limit exposures to potential carcinogens to very low risks, for example, one additional cancer in 100,000 people with lifetime exposure. This level of cancer risk is purposefully many thousands of times lower than cancer risks that can be detected by epidemiologic studies or examination of community cancer rates.

Table 1. Observed and Expected Cancer Incidence Among Males

Cancer	Observed Cases	Expected Cases	Observed to Expected Ratio	95% Confidence Interval of Ratio
All Cancers Combined	471	478	0.98	(0.90, 1.08)
Bladder	43	35	1.24	(0.89, 1.66)
Brain	8	7	1.12	(0.49, 2.21)
Colorectal	39	41	0.96	(0.68, 1.31)
Esophagus	6	7	0.84	(0.31, 1.82)
Hodgkin Lymphoma	4	3	1.37	(0.37, 3.51)
Kidney	23	21	1.12	(0.71, 1.68)
Larynx	3	5	0.60	(0.12, 1.76)
Leukemia	18	20	0.89	(0.53, 1.41)
Liver	8	10	0.80	(0.35, 1.58)
Lung	46	57	0.81	(0.59, 1.07)
Melanoma	26	32	0.81	(0.53, 1.19)
Multiple Myeloma	10	8	1.26	(0.60, 2.32)
Non-Hodgkin Lymphoma	28	26	1.09	(0.73, 1.58)
Oral	12	16	0.73	(0.38, 1.28)
Pancreas	14	13	1.07	(0.59, 1.80)
Prostate	150	128	1.17	(0.99, 1.37)
Soft tissue	4	4	1.08	(0.29, 2.76)
Stomach	7	8	0.91	(0.37, 1.88)
Testes	5	6	0.91	(0.29, 2.12)
Thyroid	7	6	1.26	(0.51, 2.60)

Figure 1. Cancer Rates Among Males

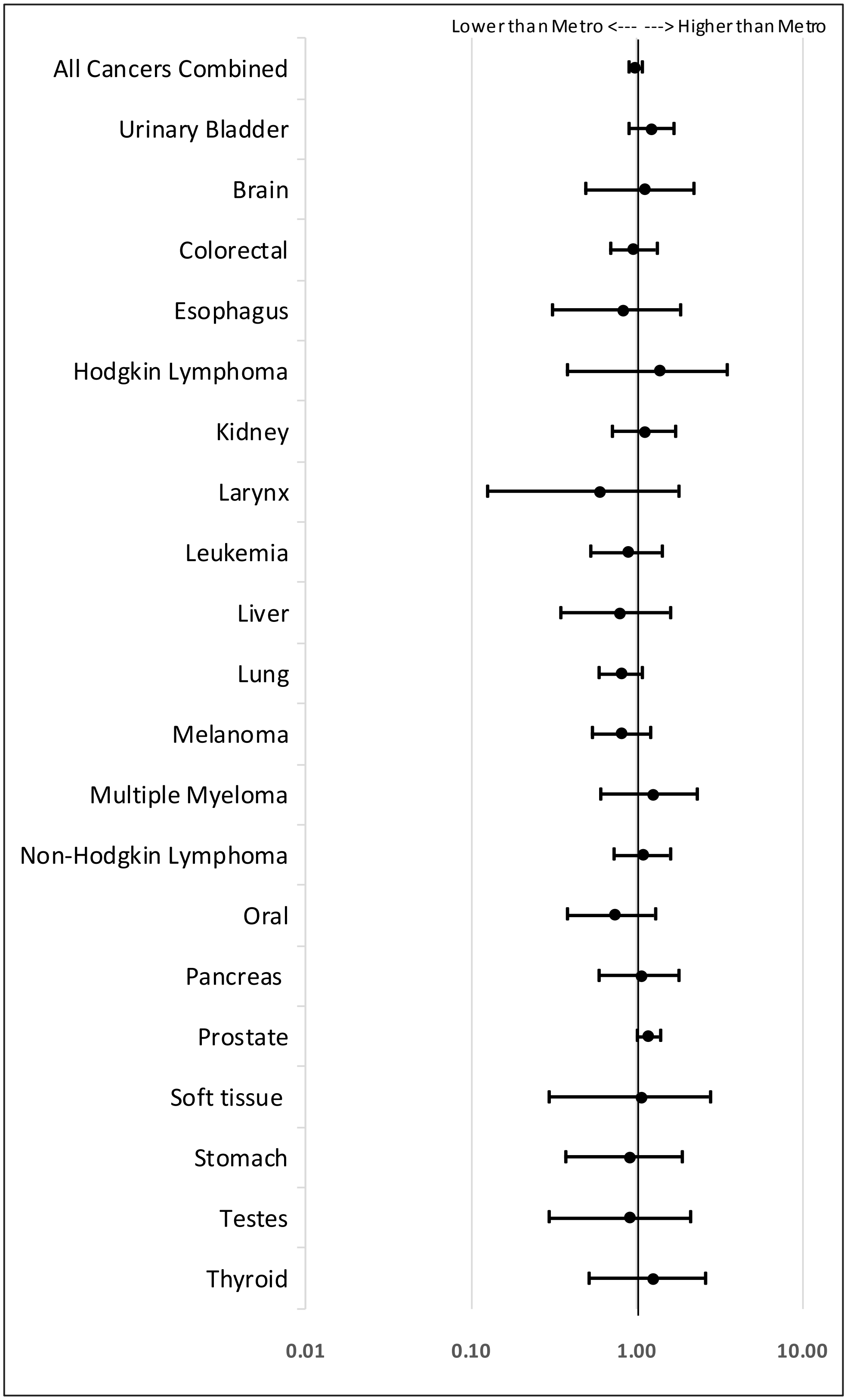


Table 2. Observed and Expected Cancer Incidence Among Females

Cancer	Observed Cases	Expected Cases	Observed to Expected Ratio	95% Confidence Interval of Ratio
All Cancers Combined	499	500	1.00	(0.91, 1.09)
Bladder	8	12	0.67	(0.29, 1.32)
Brain	4	6	0.67	(0.18, 1.73)
Breast	166	152	1.09	(0.93, 1.27)
Cervix	5	5	0.92	(0.30, 2.15)
Colorectal	47	45	1.05	(0.77, 1.39)
Esophagus	1	3	0.38	(0.01, 2.13)
Hodgkin Lymphoma	4	2	1.74	(0.47, 4.45)
Kidney	7	12	0.60	(0.24, 1.23)
Larynx	3	1	2.38	(0.49, 6.96)
Leukemia	13	14	0.91	(0.48, 1.55)
Liver	2	5	0.41	(0.05, 1.49)
Lung	69	65	1.07	(0.83, 1.35)
Melanoma	29	25	1.14	(0.76, 1.64)
Multiple Myeloma	6	6	0.94	(0.35, 2.05)
Non-Hodgkin Lymphoma	23	22	1.05	(0.67, 1.58)
Oral	5	8	0.59	(0.19, 1.38)
Ovary	12	13	0.93	(0.48, 1.62)
Pancreas	13	13	1.00	(0.53, 1.70)
Soft tissue	1	3	0.32	(0.01, 1.81)
Stomach	3	5	0.63	(0.13, 1.85)
Thyroid	10	17	0.60	(0.29, 1.10)
Uterus	34	35	0.98	(0.68, 1.37)

Figure 2. Cancer Rates Among Females

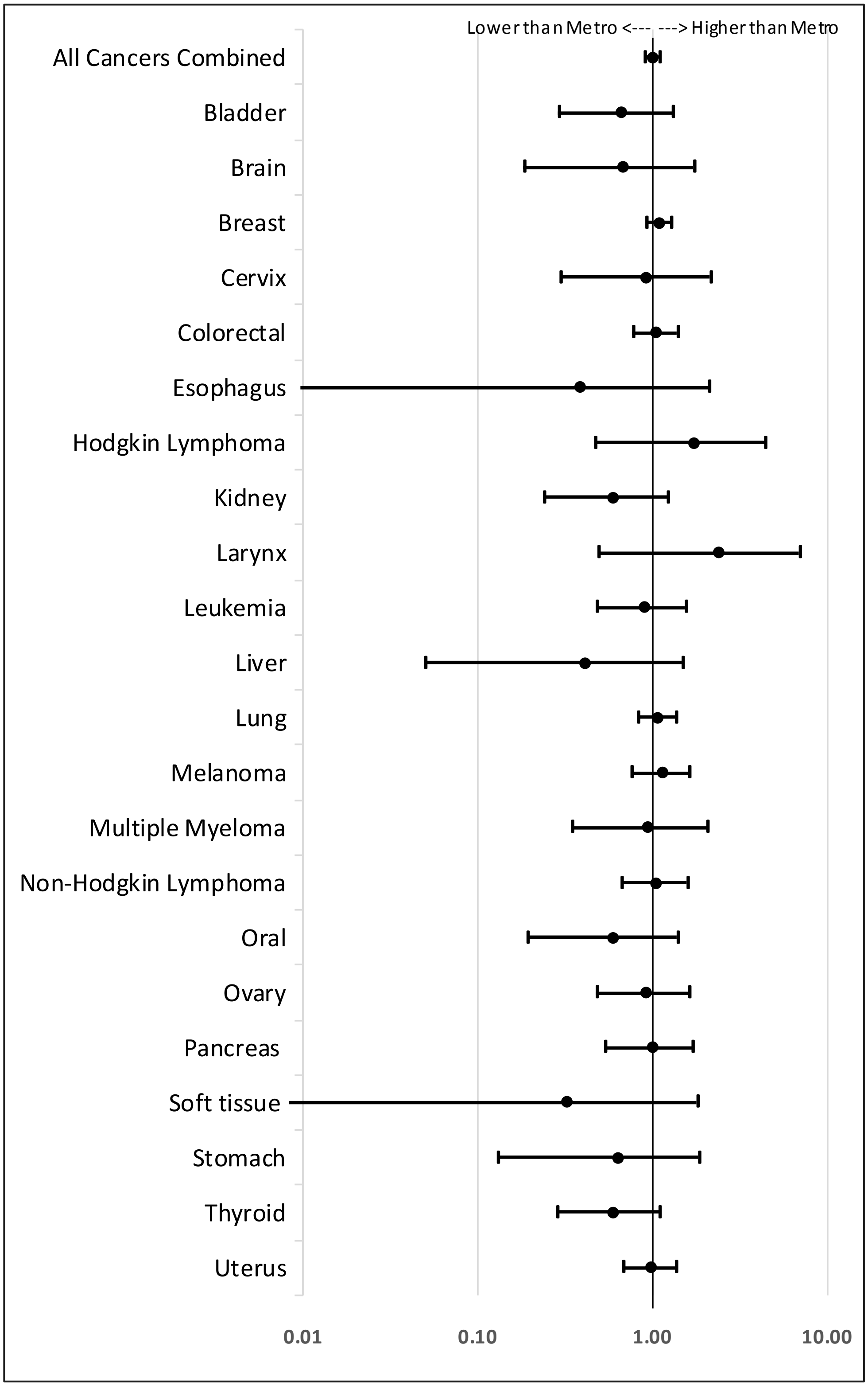
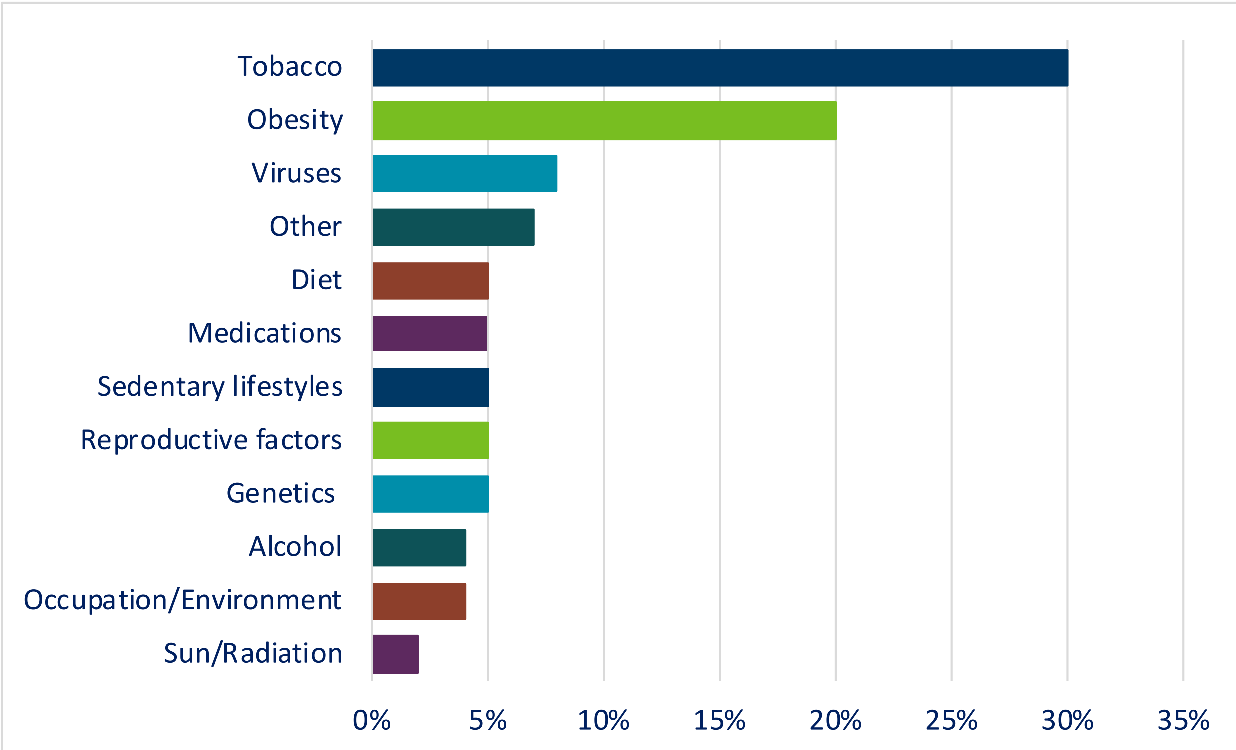


Figure 3. Estimate of U.S. cancer mortality attributable to various known risk factors



Colditz G.A., Wei E.K. Relative Contributions of Biologic and Social and Physical Environmental Determinants of Cancer Mortality. Annual Review of Public Health, 2012;33:137-156.

Appendix G - Community Health Studies and Environmental Contamination

DEPARTMENT OF HEALTH

Community Health Studies and Environmental Contamination

Communities may want or request health studies from their local or state health departments in response to news of environmental contamination and/or perceived high rates of disease.

What is a health study?

A health study is a study that can potentially inform you and your community about health risks and outcomes that are related to environmental exposures. Health studies look for evidence of a shared experience (exposure to a chemical) that is capable of causing a disease of concern.

Challenges to Conducting Health Studies

Health studies are not commonly carried out. They are only worthwhile if there is a strong possibility that the study could find a link between exposure and illness. There are many challenges to conducting health studies, including, but not limited to:

Information needed is unavailable

- The amount of contaminants people are exposed to is hard to know; exposures can be short-term and intermittent.
- Because surveillance data doesn't exist for most chronic diseases, it is difficult to determine the expected rate of health conditions for comparison to determine whether the rate in a particular area is increased.

Health studies may be unable to produce results

- Environmental exposures are often too low to cause observable health effects. Elevated rates of health effects are very hard to identify unless very high exposures occurred, similar to occupational exposures.
- Diseases typically have multiple causes. Health studies are not able to identify or establish the cause of any individual's illness. At best, they would only be able to find a correlation (association) between and exposure and an outcome – this is not the same as proof of cause and effect.
- A study that is unable to demonstrate a link between exposures and disease can be frustrating and disappointing and may be viewed as evidence of no

relationship.

- Diseases can take a long time to develop

Costs

- Any study would be very costly. It would require a large effort to develop the study design (identifying clear and focused objectives), and collect and analyze data.

Alternatives to Health Studies

Before pursuing a health study, the goal of the study should be clear. What do you want to know and why do you want to know it? A health study may not help your community achieve its goal. There may be other ways that community members' efforts can make a difference in their community. Organizing community members to make sure their voice is heard on a variety of decision-making, educational, and pollution prevention opportunities may create a larger benefit.

Resources

Is a Health Study the Answer for Your Community?

This health study guide from the Boston University School of Public Health is an excellent resource for community groups who think that some form of environmental health investigation or study may be useful in their community.

Is a health study the answer for your community? A guide for making informed decisions
https://www.bu.edu/sph/files/2015/03/HSG_Ch1to4_withcover_1-26-16.pdf

From Exposure to Illness: Community Health Studies and Environmental Contamination

This website from the California Department of Public Health was created to share the experience and perspective of public health staff dedicated to studying links between environmental exposure to chemicals and health effects in California communities.

Environmental Health Investigations Branch (EHIB)
http://communityhealthstudies.cdph.ca.gov/content/welcome.html

Minnesota Department of Health
Site Assessment and Consultation Unit
625 Robert Street N. | PO Box 64975 | St. Paul, MN 55164-0975
Phone: 651-201-4897 or toll-free 1-800-657-3908

Email: health.hazard@state.mn.us | www.health.state.mn.us

05/13/2019

To obtain this information in a different format, call: 651-201-4897.