Health Consultation

PUBLIC COMMENT RELEASE

HEMPHILL ROAD TCE NPL SITE

Evaluation of TCE in Drinking Water

HEMPHILL ROAD TCE
GASTONIA, GASTON COUNTY, NORTH CAROLINA
EPA ID: NC0002374445

Prepared by the
North Carolina Department of Health and Human Services

OCTOBER 28, 2019

COMMENT PERIOD ENDS: NOVEMBER 27, 2019

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

Foreword

The North Carolina Department of Health and Human Services (DHHS), Division of Public Health (DPH) Health Assessment, Consultation and Education (HACE) program has prepared this Health Consultation in cooperation with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the U.S. Department of Health and Human Services and is the principal federal public health agency responsible for the health issues related to hazardous waste. This health consultation was prepared in accordance with the methodologies and guidelines developed by ATSDR and DPH.

The purpose of this health consultation is to identify and prevent harmful health effects resulting from exposure to hazardous substances in the environment. Health consultations focus on health issues associated with specific exposures that have happened in the past, are currently taking place, or are believed to be possible in the future based on current site conditions. The HACE program evaluates sampling data collected from a hazardous waste site, determines whether exposures have occurred or could occur in the future, reports any potential harmful effects, and then recommends actions to protect public health. The findings in this report are relevant to conditions at the site during the time this health consultation was conducted and may not be applicable if site conditions or land uses change in the future.

For additional information or questions regarding the contents of this health consultation please contact:

HACE Program
Occupational and Environmental Epidemiology Branch
Division of Public Health
North Carolina Department of Health and Human Services
1912 Mail Service Center
Raleigh, NC 27699-1912
Phone: (919) 707-5900
Fax: (919) 870-4807
e-mail at: nchace@dhhs.nc.gov

HEALTH CONSULTATION

Public Comment Release

HEMPHILL ROAD TCE NPL SITE
Evaluation of TCE in Drinking Water

GASTONIA, GASTON COUNTY, NORTH CAROLINA
EPA ID: NC0002374445

Prepared by the
North Carolina Department of Health and Human Services
Division of Public Health
Occupational and Environmental Epidemiology Branch
under a Cooperative Agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry
Division of Community Heath Investigations
Atlanta, Georgia 30333

This information is distributed by the Agency for Toxic Substances and Disease Registry for public comment under applicable information quality guidelines. It does not represent and should not be construed to represent final agency conclusions or recommendations.

Table of Contents

INTRODUCTION

The Hemphill Road TCE (trichloroethylene) National Priority List site is located at 5009 Hemphill Road (SR 2421) in Gastonia, North Carolina. Groundwater contamination was initially detected on the site in 1989. In May 2013, the site was proposed to the United States Environmental Protection Agency's (EPA) National Priorities List (NPL), commonly referred to as the "Superfund" list. This listing prompted the North Carolina Division of Public Health's (DPH) Health Assessment Consultation & Education program (HACE), to initiate a public health consultation for the site. The principal contaminant of concern is the organic solvent trichloroethylene (TCE). The suspected source of the TCE is related to chemical drum recycling operations that took place on the site by a former owner from approximately 1950-1957. Contaminated groundwater has moved away from the site toward private residential drinking water wells and privately-owned community water systems. Off-site drinking water wells were first identified as contaminated in 1988 at one private residence and in 1989 an additional private well and an on-site supply well were identified as having TCE contamination. The on-site supply well was taken off-line, and filtration systems were to the two private wells. Subsequently, contamination from the site was identified in additional private residential drinking water wells and community water systems that use groundwater as their drinking water source. These were identified by the North Carolina Department of Environmental Quality (DEQ) and the United States Environmental Protection Agency's (EPA) investigations. People may have been exposed in the past to contaminants in drinking water wells by drinking the contaminated water, getting the contaminated water on their skin, or breathing in chemicals that are able to escape from the water into the air. While there are no known current exposures to residents that could harm health, the potential exists for the health of people living in the six private residences identified with TCE-contaminated well water to experience adverse health effects if water treatment is not continued and maintained.

This public health consultation includes an evaluation of potential health effects associated with exposures to contaminated drinking water. N.C. DPH analyzed data collected from 1988, when groundwater contamination was first identified, through 2015. The data includes samples from private residential drinking water wells, privately-owned community water systems and an on-site well. There are limitations

	inherent to the public health assessment process. These include the availability of analytical data collected for a site, the type and quantity of health effect information, and the risk estimation process itself. Health-protective exposure assumptions are used in this assessment to account for some of these limitations.
CONCLUSION #1	**Using untreated water for drinking and showering from two private residential drinking water wells, one privately-owned community well system, or the on-site supply well contaminated with TCE near the Hemphill Road NPL site for several years in the past could have harmed some people's health.**
BASIS FOR DECISION	Concentrations of trichloroethylene in the past were elevated in private wells, community well water systems, and the on-site supply well. Estimated doses of TCE by people using these water sources over the course of several years prior to installation of filtration systems exceed health guidelines, posing a possible health risk for both cancer and non-cancer health effects based on the most health-protective exposure scenarios. People with greater than average water usage are at higher risk for potential health effects. For those who drank the greatest amounts of water and took lengthy showers, there may be increased risks of immune effects for adults and children and potential fetal heart defects among babies born to mothers who were exposed.
CONCLUSION #2	**Current and ongoing use of water for drinking and showering from six private residential drinking water wells that are being treated to remove TCE or two privately-owned community well systems contaminated with TCE near the Hemphill Road NPL site is not expected to harm people's health. Future harmful exposure could occur if filtration is not maintained on private wells or if levels of TCE increase in the community wells.**
BASIS FOR DECISION	Concentrations of TCE were elevated in private wells and in community well water systems. Current maintenance of whole-house filtration systems has reduced TCE levels in the private well drinking water. However, TCE in source water must continue to be filtered to remain safe for drinking and household use which requires proper monitoring and maintenance of filtration systems in place at this time.
NEXT STEPS	N.C. DPH recommends: - EPA and DEQ continue monitoring of drinking water wells in the area of the groundwater plume, testing for TCE, PCE, and

their degradation products and taking actions, as needed, to protect health.

- EPA consider providing municipal water to the affected areas to reduce the potential for people to be exposed to contaminated drinking water through private wells.
- Residents with affected wells continue to use an alternative clean water source such as bottled water or a properly maintained whole-house filter system specifically designed to remove organic chemicals, until they can be connected to a municipal water system.
- EPA conduct routine sampling of drinking water at homes that have filter systems to ensure filter systems are removing the volatile organic chemicals.
- Operators of the community water system consider updating water treatment to reduce levels of TCE in the drinking water as a precaution to ensure that exposures of potential health concern do not occur in the future.

N.C. DPH will coordinate with the Gaston County Health and Human Services Department to communicate potential health concerns and provide health education to current residents who use the private wells and to people that may have been exposed to TCE through the three privately-owned community water systems.

FOR MORE INFORMATION	If you have concerns about your health, contact your personal doctor. Staff from the N.C. Division of Public Health is available to assist you in talking to your doctor. Contact us by calling (919) 707-5900, or sending an email to nchace@dhhs.nc.gov and ask for information on the Hemphill Road TCE NPL site.

BACKGROUND AND STATEMENT OF ISSUES

Site Description

The Hemphill Road TCE National Priorities List (NPL) site ("the site") is located on the east side of Hemphill Road (State Road 2412) north of Forbes Road in southeast Gastonia, Gaston County, North Carolina. Geographic coordinates for the site are 35.1978240 North latitude and -81.1898540 West longitude. The site consists of two adjacent land parcels totaling approximately 16 acres (Figure 1).

In May 2013, the site was proposed to the United States Environmental Protection Agency's (EPA) National Priorities List (NPL), commonly referred to as the "Superfund" list. This listing prompted the North Carolina Division of Public Health's (DPH) Health Assessment, Consultation & Education (HACE) program, to initiate a public health consultation for the site. HACE is a cooperative agreement program of the Agency for Toxic Substances and Disease Registry (ATSDR). The purpose of the public health evaluation is to evaluate the health impacts of exposure to trichloroethylene in drinking water wells and community water systems. HACE has reviewed vapor intrusion data and health implications in a previous report [DPH 2017].

Until late 2012, the site was identified as the Gastonia Industrial Truck ("GIT") site. The name was changed because the site contamination was determined to not be associated with GIT operations, but rather is believed to be related to improper disposal of waste chemicals by a drum-recycling operation on the property in the 1950s. Currently a small portion of the property is partially developed for industrial use. Most of the remaining undeveloped areas of the property are forested. The site is not fenced. There is a gate across the access path to the business operating on the site. The area surrounding the property is semi-rural and contains a number of individual single-family homes and several residential developments. The nearest residence is approximately 200 feet from the area that is believed to be the origin of the historical contamination [ESI 2012].

Site History

Most of the site and surrounding areas were used for agriculture during the 1960s and later became wooded. Gastonia Industrial Truck (GIT) has operated on the site since 1983. GIT services and sells forklifts and other industrial trucking equipment. The owner of GIT purchased the northwest parcel in 1972 and the southeast parcel in 1988. In 1976, a driveway and building were constructed on the 6-acre northwest parcel. GIT constructed a garage south of the main structure in 1990. The 10-acre southeast parcel remains wooded and undeveloped.

According to local residents, the southeast parcel had been used for storage and disposal of industrial waste materials during the 1950s. Alleged site activities included storage of large quantities of cardboard waste and recycling of several thousand chemical drums. Local residents and children of the owner of the facility at that time reported that drum residue was dumped on the ground; the drums were rinsed, then burned and flattened for sale as scrap metal. Several alleged sources of the drums have been identified, including a former textile facility and a chemical company. There were also reports of drums buried on the property and reports of disposal of trash on the southeast parcel before it changed hands in 1988. The current property owner has noted that he has encountered buried debris on the southeast parcel [SRR 2012, ESI 2012].

Groundwater and Soil Characteristics of the Site

Gaston County is located within the Piedmont Plateau physiographic province of NC and lies intermediate between the Coastal Plain physiographic province to the east and the Mountain physiographic province to the west. The piedmont topography consists primarily of well-rounded hills and northeast-southwest trending ridges, with a few more prominent mountains. Soil at the site is classified as clay and sandy clay loam. Bedrock beneath the site consists of granite with quartz veins.

The North Carolina Department of Environmental Quality (DEQ) has stated that groundwater under the site is unconfined[1] and located primarily within fractured bedrock. Most of the wells in the area are believed to be in the bedrock aquifer. Groundwater below the site moves from the southeast to the northwest toward the unnamed tributary flowing east to west on the northern property boundary (Figure 1). Measured groundwater depths have ranged from approximately 15 to 36 feet below ground surface. Studies by DEQ indicate that the groundwater contaminant plume characteristics are consistent with historical dumping of the recycled drum residual chemicals on the ground surface during the 1950s and downward movement to the groundwater. By the late 1980s, the contaminants had impacted the on-site GIT production well and two nearby private wells on the west side of Hemphill Road across from the site. By 1997, the groundwater contamination had moved further away from the site toward additional private wells and the Kensington Estates neighborhood community wells to the west [ESI 2012].

The Gastonia NC Municipal Water Supply

The municipality of Gastonia obtains its water supply from surface water intakes in Mountain Island Lake which is located several miles to the east/northeast of Gastonia. Municipal water lines extend to within approximately 0.7 miles northwest of the site (Figure 1). The Hemphill Road NPL site is surrounded by approximately nine subdivisions and mobile home parks that rely on privately maintained community water systems and individual residential private wells for drinking water (Figure 1). Community demographics can be found in Appendix A.

1 An aquifer is an underground layer of water-bearing soil, gravel or rock from which groundwater can be extracted using a well. In an unconfined aquifer there is not a water-impermeable layer between the aquifer and the ground surface that prevents substances from the ground surface to make their way to the underground water supply.

Community Health Concerns

The drinking water concerns of local residents include contamination of local groundwater drinking water sources by chemicals from past operations on the Hemphill Road NPL site. Current and past local residents have also expressed concerns with potential exposures in the stream bordering the northern edge of the site. They have indicated that in the 1950s and 1960s the stream was dammed adjacent to the current location of the Hemphill Road NPL site. The surface water collected behind the dam was used by local children as a swimming hole and by adults for church-related activities. No surface water data exists prior to 2012 to assess this potential past exposure pathway. EPA has taken surface water samples during recent investigations, but the data is limited and would not reflect past exposures when the stream was dammed and used recreationally.

DISCUSSION

The ATSDR health effects evaluation process

This section provides a summary of the ATSDR health effects evaluation process. A discussion of exposure dose equations and parameters is provided in Appendix B.

The first stage of the ATSDR health effects evaluation process involves screening drinking water data by comparing site contaminant concentrations to comparison values. Comparison values (CVs) are developed by ATSDR as chemical concentrations in environmental media (in this case, drinking water). CVs are set at levels that are highly health protective, well below concentrations known or anticipated to result in adverse health effects. Contaminant concentrations at or below the CV require no additional evaluation. When chemicals are found on a site at concentrations greater than the CV, it does not mean that adverse health effects would be expected, but it does identify that a more in-depth evaluation is warranted. TCE is the only site-related contaminant detected at levels above a CV.

The second stage of the process is the “health guideline comparison” and involves looking more closely at site specific exposure conditions, estimating exposure doses, and comparing the dose estimates to health guideline values. An exposure dose is an estimate of the amount of a substance a person may come into contact with in the environment during a specific time period, expressed relative to body weight. Health guideline values represent daily human exposure levels to a substance that is likely to be without appreciable risk of adverse health effects during a specified exposure duration. Important factors in determining exposure dose estimates include the concentration of the chemical, the duration and frequency of exposure, the route of exposure, and the health status of the exposed person or population. Highly health protective site-specific dose estimates[2] are developed for both children and adults [Andelman 1990, ATSDR 2016a, 2016b]. Site-specific doses are then compared to ATSDR or EPA health guideline values. In this document, the ATSDR Minimal Risk Level (MRL) for TCE is used which is equivalent to the EPA Reference Dose. ATSDR defines the MRL as an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse non-cancer health effects over a specified duration of exposure, in this case, over several years. If a substance has the potential to cause cancer as is the case for TCE, then the cancer risk is estimated by multiplying the dose by the substance's cancer slope factor and averaged over a lifetime. For mutagenic carcinogens such as TCE, age-dependent adjustment factors (ADAFs) are applied to account for infants and children's increased susceptibility to these types of effects. See Appendix D for a more detailed description of the cancer risk evaluation process.

To determine if adverse (negative) health effects are possible for the site-specific exposure doses calculated for children and adults, these values are compared to data collected in human health effect and animal laboratory studies for the chemicals of concern. The health study data are generally taken from ATSDR or EPA references that summarize human and animal studies that have undergone extensive validation review. Comparisons are made on the basis of the exposure route (ingestion/eating, inhalation/breathing, or dermal/skin contact) and the length of the exposure. Preference is given to human study data and chemical doses or concentrations where no adverse health effects were observed. If no human data or no-adverse-effect data are available, animal data or the lowest chemical dose where adverse health effects were observed may be used.

Responses of people to potentially harmful substances may vary with the individual or group of individuals, such as children, the elderly, or people with weakened immune responses, or other chronic health issues. These susceptible populations may have different or heightened responses as compared to most people exposed at the same concentration to a particular chemical in the environment. Reasons for these differences include genetic makeup, age, health status, nutritional status, and exposure to other toxic substances (such as cigarette smoke or alcohol). These factors may limit a person's ability to detoxify or eliminate the harmful chemicals from their body or may increase the effects of damage to their organs or physiological systems. Child-specific exposure situations and susceptibilities are considered in our health evaluations.

Long term daily exposures were considered for children and adults living near the Hemphill Road TCE NPL site. There are limitations inherent to the public health assessment process. These include the availability of analytical data collected for a site, the type and quantity of health effect information, and the risk estimation process itself. To minimize the impact of these

[2] To remain protective of human health, DPH considers realistic high-end exposure scenarios including 95th percentile ingestion rate, daily exposure, and a long-term time frame, consistent with a permanent resident using tap water from wells at their home as the main water source.

limitations, the parameters selected for exposure estimates (amount consumed, frequency of exposure, years of exposure) were all selected to be health protective, representing a realistic maximum exposure for people to the environmental contamination that may exist on the site (See Exposure Assumptions section).

The comparison value and health guideline value used in this document were developed by ATSDR (CV and MRL) for chronic (>1 year) daily exposure to TCE, consistent with drinking water from a private well over many years living at a particular residence. See Appendix B for equations and exposure parameters used to estimate exposure doses for residents near the Hemphill Road TCE NPL site. It should be noted that the exposure scenarios considered in this health consultation assumed year-round residence and daily ingestion for exposed populations (age-specific drinking water ingestion rates are provided in Appendix B).

Exposure pathway analysis

An exposure to a chemical and the possibility of adverse (harmful) health effects requires people to come into contact with the chemical through ingestion (eating or drinking), inhalation (breathing the chemical), or absorbing the chemical through the skin (dermal absorption). Having contact with a chemical does not necessarily result in adverse health effects. A chemical's ability to result in adverse health effects is influenced by a number of factors, including the amount of a chemical that a person is exposed to (dose), how often and how long a time a person is exposed to the chemical (frequency and duration), and the amount and type of damage the chemical can cause in the body (toxicity). Knowing or estimating the frequency with which people have contact with hazardous substances is essential to assessing the public health implications of these contaminants.

The exposure pathway (how people may come into contact with contaminants in their environment) is evaluated to determine if people have come into contact with site contaminants, or if they may in the future. An exposure pathway is one that contains a source of contamination, the movement of the contaminant through environmental media such as groundwater, a point of exposure where people come in contact with the contaminated media such as drinking water, a route of exposure like drinking contaminated well water, and a population of people that can come in contact with the contaminants.

This health consultation focuses on the population of people living near the Hemphill Road TCE NPL site that rely on private or community wells for residential drinking water. This population may be exposed to site related contaminants (e.g. TCE) via ingestion of drinking water and inhalation of TCE as it volatilizes from the water during use, such as during showers. Dermal exposure to TCE in drinking water was not evaluated quantitatively because dermal uptake of VOCs (including TCE) is minimal.

Exposure Assumptions

Since it is uncertain when the drinking water may have first been contaminated, it was assumed that the contamination began in 1955 when the drum recycling began. Drinking water samples were collected intermittently over the years, and the exact time-frame of TCE break-through of the whole-house filter systems is uncertain. To be health-protective, the maximum measured TCE concentration in each well was used for health risk estimates. This method may over-predict the level of risk the people living in these residences would have experienced but is intended to represent a reasonable maximum level of health risks. Actual risks will be lower if the maximum TCE concentrations are greater than the actual exposure concentrations over the projected time period. Actual risks may be higher if people were exposed for longer time periods or at greater exposure concentrations. The data are not available to more accurately identify past TCE exposure concentrations or periods. A shower model was used to estimate the dose of TCE inhaled by people during showering, and this dose was added with the estimated drinking water ingestion TCE dose. This model does not take into account possible inhalation of volatilized TCE during other water use, such as cooking, washing dishes, or doing laundry. The estimated total dose from ingestion and inhalation exposures was used to compare exposure to the oral MRL. The estimated total dose was also used in cancer risk calculations. For all estimated dose calculations, two doses were estimated: the central tendency estimate (CTE) which uses average exposure factors such as ingestion rates, and a reasonable maximum exposure (RME) estimate using the 95th percentile exposure factors [ATSDR 2016a]. This provides a range of results for making public health conclusions.

For users of the six private wells that had elevated concentrations of TCE, estimated exposure doses and cancer risk were calculated using two age groups: people living at a residence from birth to age 21 (children), and people living at a residence for 33 years as an adult. TCE is known to have a mutagenic mode of action, which may make children more susceptible to its cancer-causing effects, therefore, ADAFs were applied (See Appendix D for cancer risk calculation and explanations). Additionally, due to their smaller size and higher relative ingestion and inhalation rates, estimated doses for children are greater than those for adults.

For people using water from the privately-owned community systems, estimated exposure doses and cancer risk were calculated using two age groups: children from birth and adults. The length of exposure varied by water system. For Kensington Estates, an exposure period of 2.5 years was used because that was the time from well installation to closing. For Wesley Acres, an exposure period of 14.25 years was used to include the time from the last sampling before the TCE level increased above the CV to the time of the assessment. For Cedar Grove, an exposure period of 6.33 years was used to include the time from the last sampling before the TCE level increased above the CV to the time of the assessment.

Since it is not known when the GIT production well may have first become contaminated, the contamination was assumed to have been present throughout the time the well was used as a drinking water source (7 years, 1983-89). A single groundwater sample was collected from the production well before it was closed, and the contaminant concentrations detected in that sample (January 1989) were used to represent concentrations present in the well water throughout the 7-year period. Only adult exposures via ingestion were considered for this water source.

Site-related Environmental Investigations Conducted Through 2016

Investigation into groundwater and drinking water contamination at the Hemphill Road TCE NPL site began in the 1980s. A summary of major investigations follows. A summary of TCE concentrations for wells that had TCE levels above the ATSDR Cancer Risk Evaluation Guide (CREG) of 0.43 µg/L can be found in Tables 1-2. Tetrachloroethylene was detected in some private well water samples, but at levels much lower than the CV. One well, HH-116, had detections of five VOCs above CVs (chloroform, bromodichloromethane, carbon tetrachloride, dibromochloromethane, and methylene chloride), but the EPA noted that numerous empty and full to partially full containers of paint, solvents, strippers, and various other chemicals were disposed of on the ground in one area in the footprint of a dilapidated former shed [EPA 2016]. The local health department confirmed that this well is no longer used as a drinking water source and it is not connected to the house, so there is no current public health risk associated with this well.

During the late 1980s and early 1990s, Gaston County Environmental Health Services (GCEHS) collected water samples from the GIT facility's production well and two domestic wells at locations denoted as HH-070 and HH-107 (Figure 1). The results revealed a high concentration of TCE. Upon being notified of the contamination, the homeowners installed carbon filtration units on their respective domestic wells, and the GIT facility stopped using its production well for potable water.

The EPA and NC Superfund Section conducted a 1999 Combined Preliminary Assessment/Site Inspection (cPA/SI) to evaluate the exposure hazard to the Kensington Estates residential subdivision, under construction across Hemphill Road from GIT. The two Kensington Estates community drinking-water wells were operating within 1,000 feet west-northwest from the GIT property. In May 1999, North Carolina Superfund Section personnel reviewed sample analytical reports on the Kensington Estates community wells, on file at the North Carolina Public Water Supply Section. The results indicated TCE contamination in both of the Kensington Estates community wells, ranging above 10 micrograms per liter (µg/L) and exceeding federal benchmarks and state groundwater standards. The County and DWQ Morrisville Regional Office (MRO) shut down both Kensington Estates community wells, provided a temporary alternative drinking water supply to the residents and subsequently connected the subdivision to two existing community wells at the neighboring Amy Acres subdivision.

In July 1999, sampling by the NCDWQ detected TCE breakthrough at the domestic well carbon filtration units at wells denoted as HH-107 and HH-070 (Figure 1). In response, the property owners replaced the saturated filtration media in each well.

In 2009, MRO notified the North Carolina Superfund Section that TCE contamination existed in additional community wells near the site. TCE reportedly existed in the two community wells supplying the Wesley Acres subdivision, located directly across Forbes Road, south of Kensington Estates. In 2008, TCE had also appeared in the two community wells supplying the Cedar Grove subdivision, located approximately 1.5 mile southeast of GIT. MRO reported that TCE concentrations in the affected wells had been increasing, approaching the 5.0 µg/l federal Maximum Contaminant Level (MCL).

EPA assigned an On Scene Coordinator (OSC) who visited the site on July 28, 2009. The OSC sampled the GIT facility production well, two of the on-site monitoring wells, and the domestic wells denoted as HH-107, HH-070, and HH-066 (Figure 1). Sampling revealed that TCE breakthrough had occurred again in the carbon filters at HH-107 and HH-070; the OSC arranged for replacement of the filtration media in both units. Sample data at GIT and HH-066 were consistent with results from previous investigations.

In February 2012, the North Carolina Superfund Section conducted a well survey in the areas within approximately one-half mile of the GIT property. In addition to seven community wells, approximately 150 homes served by private drinking water wells were identified within this one-half mile radius. In March 2012, North Carolina Superfund Section personnel conducted an ESI sampling event at the Hemphill Road TCE site. During the ESI sampling event, a total of nine monitoring wells, one production well, seven community wells, 76 private wells, and five surface water locations were sampled.

In May 2012, North Carolina Superfund Section notified the EPA Emergency Response and Removal Branch (ERRB) of the preliminary sampling results from the March 2012 ESI sampling event. Based on these results, ERRB replaced existing filter systems at HH-107 and HH-070 with new systems. In addition, a new filter system was added to the drinking water well located at the denoted as HH-069 (Figure 1).

Since the site was listed on the NPL in 2012, EPA contractors have repeatedly sampled drinking water wells in the area. Potable groundwater samples were collected from 80 private wells and seven community wells located on the GIT property and surrounding neighborhood from sampling events in May 2014, June 2015, August 2016, and October 2016. In addition to the wells listed above, wells denoted as HH-110 and HH-111 (Figure 1) had TCE detections above the ATSDR Cancer Risk Evaluation Guide (CREG) of 0.43 µg/L.

Evaluation of Potential Public Health Issues

Private Residential Well Waters -

While there are no known current exposures to residents that could harm health, the potential exists for the health of people living in the six private residences identified with TCE-contaminated well water to experience adverse health effects if water treatment is not continued and maintained. Actual risks may be higher or lower depending on how representative the exposure concentrations and exposure periods used in this health evaluation are of the actual exposure conditions. The estimated total dose from ingestion and inhalation exposures was used to evaluate risk to public health for each water source. The maximum concentration was used to evaluate exposures because of the short window of TCE exposure (3 weeks) associated with fetal heart development.

Location HH-070 – The well water at location known as HH-070 (Figure 1) was analyzed for volatile organic chemicals 14 times from 1988 through 2015. TCE was detected nine times, and eight detections exceeded an ingestion comparison value (Table 1). An increased estimated cancer risk (1 to 20 additional cancers 10,000 people) is indicated when ingesting water at the maximum TCE concentration (170 µg/L TCE) for the maximum exposure periods (Table 3). Average exposures are estimated to be at least an order of magnitude less. Non-cancer doses for all age groups exceeded the non-cancer health guideline, the ATSDR MRL (Table 3). Further evaluation of the available toxicological data indicates estimated doses received by residents using this water source exceed study effects levels, and may have put babies of mothers exposed at an increased risk for developmental effects as well as decreased immune function among adults and children [EPA 2011c]. It is important to note that the most recent samples have much lower levels of TCE, and therefore lower levels of potential human health risks. However, breakthrough of the whole house filtration system is still possible and may occasionally occur, as evidenced by the March 2015 detection. This supports the recommendation for continued maintenance of the filtration system at this location.

Location HH-107 – The well water at this location (Figure 1) was analyzed for volatile organic chemicals 13 times from 1989 through 2015. All six TCE detections exceeded an ingestion comparison value (Table 1). Non-cancer health risks and increased cancer risks (2 to 20 additional cancers in 10,000 people) are indicated for all age groups for the maximum TCE concentration (220 µg/L TCE), with average exposures likely to be at least an order of magnitude less (Table 4). Estimated doses received by residents using this water source exceed health effects levels, and may have put babies of mothers exposed at an increased risk for developmental effects or decreased immune function among adults and children [EPA 2011c]. It is important to note that the most recent samples have not detected TCE, and therefore potential human health risks are currently mitigated. However, breakthrough of the whole house filtration system is still possible, and it is recommended that continued maintenance of the filtration system occur at this location.

Location HH-066 – The well water at this location (Figure 1) was analyzed for volatile organic chemicals (VOCs) eight times from 1989 through 2015. Four of seven TCE detections exceeded an ingestion comparison value (Table 1). The estimated exposure dose for children exposed to the maximum level of TCE is greater than the MRL, but below the effects levels. There is a very low increased cancer risk (1 to 10 additional cancers in 1,000,000 people) indicated for residents using this water for long periods of time (Table 5).

Location HH-111 – The well water at this location (Figure 1) was analyzed for volatile organic chemicals five times from 2011 through 2015. All five detections exceeded an ingestion comparison value. The estimated exposure dose for children exposed to this level of TCE is greater than the MRL, but below the effects levels. There is a very low increased cancer risk (1 to 20 additional cancers in 1,000,000 people) indicated for residents using this water for long periods of time (Table 6).

Location HH-069– The well water at this location (Figure 1) was analyzed for volatile organic chemicals six times from 2012 through 2015. TCE was detected in March 2012 prior to filter installation at a level exceeding an ingestion comparison value, but has not exceeded the screening level in filtered water since. Estimated doses received by residents using this water source prior to the installation of the filter exceeded the MRL, but were below the effects levels. There is a low increased cancer risk (4 to 60 additional cancers in 1,000,000 people) indicated for residents using this water for long periods of time (Table 7).

Location HH-110 - The well water at this location (Figure 1) was analyzed for volatile organic chemicals three times from 2014 through 2015. One of two detections exceeded an ingestion comparison value. The estimated exposure dose for children exposed to this level of TCE is greater than the MRL, but below the effects levels. There is a very low increased cancer risk (<1 to 6 additional cancers in 1,000,000 people) indicated for residents using this water for long periods of time (Table 8).

Privately-owned Community Water Systems –

TCE was detected in three neighborhoods with privately-owned community water systems near the Hemphill Road NPL site. The neighborhoods are Kensington Estates, Wesley Acres and Cedar Grove. The well water data are summarized in Table 2. Potential health risks from ingestion and inhalation of TCE in drinking water are discussed below.

Kensington Estates - The maximum concentration of TCE in the well water during the exposure period (11.55 µg/L TCE) indicates potential immune effects for children using this water based on the most health-protective exposure scenarios (e.g. drinking 1-2 liters of water daily and taking approximately 45-minute showers). Under the reasonable maximum exposure scenario, there may be increased risks of potential fetal effects for pregnant women using this water. Potential health risks are only indicated for the maximum exposure scenario, and people with more typical, or average, water consumption and showering times were not considered to be at risk for these effects. Indications of increased cancer risks for ingestion were very low (1 to 50 additional cancers in 1,000,000 people) (Table 9).

Wesley Acres – The estimated exposure dose for children exposed to 3.9 µg/L of TCE is greater than the MRL, but below the effects levels. Indications of increased cancer risks for ingestion were very low (1 to 40 additional cancers in 1,000,000 people) (Table 10).

Cedar Grove – The estimated exposure dose for all age groups exposed to 4.2 µg/L of TCE is greater than the MRL, but below the effects levels. Indications of increased cancer risks for ingestion were very low (1 to 30 additional cancers in 1,000,000 people) (Table 11).

GIT Production Well –

Using the single detected TCE concentration (288 µg/L) in the GIT production well in 1989, non-cancer risks are indicated for adults that may have worked at the GIT facility for the 7 years the well was used as a drinking water source (Table 12). There is uncertainty in these risk estimates because only one well water sample was collected and it is not known when the well became contaminated. Ingestion exposure TCE concentration of 288 µg/L over 7 years would result in a low increased cancer risk to the workers (2 additional cancers in 100,000 people) (Table 12). Past exposures to workers who drank water from this well may have posed a public health risk, but the data is not available to fully evaluate these exposures.

Trichloroethylene (TCE)

Non-cancer Health Effects of TCE –

Ingestion and inhalation studies in animals indicate that one of the principal targets of TCE exposure include harmful effects to the immune system because of damage to the thymus gland. Additional studies in animals indicated that TCE exposure in pregnant mice resulted in developmental problems (fetal heart malformations) in their offspring. A human study supported the cardiac (heart) effects observed in animals and concluded that offspring of mothers breathing TCE had increased incidence of heart defects. The heart defects were observed at lower concentrations relative to other adverse effects and were selected as the most sensitive health effect in humans for development of health-based reference values. Long-term exposure to high concentrations of TCE may also harm the kidneys, nervous system, liver and the reproductive system. It may also cause changes in mood or sleep patterns. Breathing high concentrations for shorter periods may cause headaches, lung irritation, dizziness, poor coordination, and difficulty concentrating [ATSDR 2013, EPA 2012]. In 2011, USEPA published an updated reference dose (RfD) for TCE, 0.0005 milligram per kilogram per day (mg/kg/d). ATSDR has adopted EPA's RfD as their minimal risk level (MRL). The RfD and MRL values are estimates, with safety factors built in, of a continuous exposure that is unlikely to cause non-cancer health effects.

Cancer Health Effects of TCE –

The National Toxicology Program (NTP) classifies TCE as "known to be a human carcinogen" based on epidemiological studies linking kidney cancer to exposure to TCE and supporting toxicological studies showing that TCE exposures causes cancer in several tissues [NTP 2015]. The International Agency for Research on Cancer (IARC) has determined that TCE is carcinogenic to humans based on epidemiological studies showing increased rates of kidney cancer, liver cancer, and non-Hodgkin's lymphoma in humans exposed to TCE, and animal studies showing increased numbers of liver and kidney tumors upon oral administration [IARC 2014]. The EPA's Integrated Risk Information System (IRIS)[3] program characterizes TCE as carcinogenic to humans by all routes of exposure [EPA 2011a; EPA 2011b]. This conclusion is based on human epidemiologic studies showing associations between human exposure to TCE and kidney cancer, non-Hodgkin's lymphoma, and liver cancer. EPA published an updated adult-based cancer potency factor for TCE in 2011 of 0.046 $(mg/kg\text{-}d)^{-1}$. ATSDR has adopted EPA's value as their cancer potency factor. EPA's cancer potency factor was calculated from human inhalation studies that identified kidney cancer as the sensitive cancer endpoint. EPA also identified that the adult-based potency factor does not reflect presumed increased early-life susceptibility to kidney tumors and recommends the application of age-dependent adjustment factors [ATSDR 2013].

Two TCE factsheets are included in Appendix A. The first provides information for the general public and the second for health-care providers.

Child Health Considerations

In communities faced with air, water, or food contamination, the many physical differences between children and adults demand special emphasis. Children could be at greater risk than adults of certain kinds of exposures to hazardous substances. Children play outdoors and sometimes engage in hand-to-mouth behaviors that increase their exposure potential to environmental contaminants. Children are shorter than are adults; this means they potentially breathe more dust, soil, and vapors close to the ground. A child's lower body weight and higher

[3] IRIS is accessible at: http://www.epa.gov/iris/index.html

water intake rate results in a greater dose of hazardous substance per unit of body weight. If toxic exposure levels are high enough during critical growth stages, the developing body of children can sustain permanent damage. Finally, children are dependent on adults for access to housing, access to medical care, and risk identification. Thus, adults need as much information as possible to make informed decisions regarding their children's health.

ATSDR and EPA consider children's exposures as they develop contaminant health guidelines. Specifically, ATSDR also publishes child-specific health-comparison values. When children may have been exposed, HACE uses child-specific values to screen contaminants for further evaluation and evaluate child-specific exposure calculations and risk estimates. HACE considered health impacts and sensitivities specific to children. Children are considered to be particularly sensitive to the mutagenic[4] effects of trichloroethylene and its potential to cause kidney cancer. HACE used the EPA age-dependent adjustment factors (ADAF) to adjust increased cancer risk estimates for TCE for children less than 16 years old.

CONCLUSIONS

After reviewing the available environmental data, N.C. DPH concludes:

1. Using untreated water for drinking and showering from two private residential drinking water wells, one privately-owned community well system, or the on-site supply well contaminated with TCE near the Hemphill Road NPL site for several years in the past could have harmed some people's health.

   Concentrations of trichloroethylene in the past were elevated in private wells, community well water systems, and the on-site supply well. Estimated doses of TCE by people using these water sources over the course of several years prior to installation of filtration systems exceed health guidelines, posing a possible health risk for both cancer and non-cancer health effects based on the most health-protective exposure scenarios. People with greater than average water usage are at higher risk for potential health effects. For those who drank the greatest amounts of water and took lengthy showers, there may be increased risks of immune effects for adults and children and potential fetal heart defects among babies born to mothers who were exposed.

2. Current and ongoing use of treated water for drinking and showering from six private residential drinking water wells that are being treated to remove TCE or two privately-owned community well systems contaminated with TCE near the Hemphill Road NPL

[4] A mutagen is a substance that causes mutations. A mutation is a change in a cell's DNA sequence. Mutations can lead to birth defects, miscarriages and cancer.

site is not expected to harm people's health. Future harmful exposure could occur if filtration is not maintained on private wells or if levels of TCE increase in the community wells.

Concentrations of TCE were elevated in private wells and in community well water systems. Current maintenance of whole-house filtration systems has reduced TCE levels in the private well drinking water. However, TCE in source water must continue to be filtered to remain safe for drinking and household use which requires proper monitoring and maintenance of filtration systems in place at this time.

RECOMMENDATIONS

N.C. DPH recommends:

- EPA and DEQ continue monitoring of drinking water wells in the area of the groundwater plume, testing for TCE, PCE, and their degradation products and taking actions, as needed, to protect health.
- EPA consider providing municipal water to the affected areas to reduce the potential for people to be exposed to contaminated drinking water through private wells.
- Residents with affected wells continue to use an alternative clean water source such as bottled water or a properly maintained whole-house filter system specifically designed to remove organic chemicals, until they can be connected to a municipal water system.
- EPA conduct routine sampling of drinking water at homes that have filter systems to ensure filter systems are removing the volatile organic chemicals.
- Operators of the community water systems consider updating water treatment to reduce levels of TCE in the drinking water as a precaution to ensure that exposures of potential concern do not occur in the future.

PUBLIC HEALTH ACTION PLAN

Actions Completed

HACE staff has:

- Participated in a public meeting hosted by EPA with residents who live near the site to determine health concerns of the community.
- Reviewed groundwater and drinking water data and made recommendations to EPA for follow up testing and actions to reduce exposure to TCE from the site.

Actions Planned

HACE staff will:

- Coordinate with other agencies involved on this site (EPA, DEQ) to monitor site environmental and health information to ensure the health of the community is protected.
- Coordinate with the Gaston County Health and Human Services Department to communicate potential health concerns and provide health education to current residents using the private wells and people that may have been exposed to TCE through the three privately-owned community water systems.
- Conduct a community meeting or other community outreach during the public comment period for this document.

REPORT PREPARATION

The North Carolina Department of Health and Human Services prepared this Health Consultation for the Hemphill Road TCE NPL site, located in Gastonia, Gaston County, North Carolina. This publication was made possible by Grant Number NU61TS000291 under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). The North Carolina Department of Health and Human Services evaluated data of known quality using approved methods, policies, and procedures existing at the date of publication. ATSDR reviewed this document and concurs with its findings based on the information presented by the North Carolina Department of Health and Human Services.

Author

Beth Dittman
Public Health Assessor
North Carolina Department of Health and Human Services
Division of Public Health
Occupational and Environmental Epidemiology Branch

State Reviewers

Jamie Pritchett, MTox, N.C. DHHS/DPH/OEEB
Mina Shehee, PhD, N.C. DHHS/DPH/OEEB
Ken Rudo, PhD, N.C. DHHS/DPH/OEEB
Rick Langley, MD, N.C. DHHS/DPH/OEEB
Mercedes Hernandez-Pelletier, MPH, N.C. DHHS/DPH/OEEB

ATSDR Cooperative Agreement Coordinator and Technical Project Officer

Trent LeCoultre, MSEH, REHS, CPH
Cooperative Agreement Coordinator
Division of Community Health Investigations

Audra Henry, MS
Technical Project Officer
Division of Community Health Investigations

ATSDR Regional Representatives

John Wheeler, PhD
Region 4 Director, Division of Community Health Investigations

References

[Andelman 1990] *Total Exposure of Volatile Organic Compounds in Potable Water*. In: Significance and Treatment of Volatile Organic Compounds in Water Supplies, Chapter 20. Lewis Publishers, Chelsea, MI.

[ATSDR 1996] ATSDR (Agency for Toxic Substances and Disease Registry). Toxicological Profile for 1,2-Dichloroethene. August 1996.

[ATSDR 1997] ATSDR. Toxicological Profile for Trichloroethylene (TCE). September 1997.

[ATSDR 2005] – *Public Health Assessment Guidance Manual (Update).* January 2005. https://www.atsdr.cdc.gov/hac/phamanual/toc.html.

[ATSDR 2013] ATSDR. Addendum to the Toxicological Profile for Trichloroethylene. January 2013.

[ATSDR 2016a] Agency for Toxic Substances and Disease Registry. 2016. Exposure Dose Guidance for Water Ingestion, Version 2. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, October 26.

[ATSDR 2016b] Agency for Toxic Substances and Disease Registry. 2016. Exposure Dose Guidance for Body Weight. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, October 26.

[DPH 2017] *Letter Health Consultation: Vapor Intrusion Investigation – September 2016 Sampling Event*. June 2017. North Carolina Division of Public Health, Department of Health and Human Services.

[EJ 2014] EJ View Tool, U.S. Environmental Protection Agency, Accessed: August 5, 2014, https://www.epa.gov/ejscreen.

[EPA 2011a] US Environmental Protection Agency, Office of Research and Development. Exposure factors handbook: 2011 edition. EPA/600/R-090/052F. Washington, DC.

[EPA 2011c] US Environmental Protection Agency, Office of Research and Development. IRIS toxicological review of trichloroethylene. Washington, DC. Available from URL: http://www.epa.gov/iris/supdocs/0199index.html.

[EPA 2016] U.S. Environmental Protection Agency. Amended: Hemphill Rd TCE Groundwater Sampling Report. December 13, 2016.

[ESI 2012] Expanded Site Inspection Hemphill Road TCE NC0002374445 Gastonia, Gaston County, NC. Sept. 2012. North Carolina Department of Environment and Natural Resources Division of Waste Management.

[FAR 2012] Final Analytical Report, Project: 12-0610, Hemphill Road TCE, Superfund Remedial, August 30, 2012. U.S. Environmental Protection Agency Region 4 Science and Ecosystem Support Division, Athens, GA.

[HRS 2013] Hazard Ranking System (HRS) Documentation Record, Hemphill Road TCE, NC. Doc ID 10941809, May 1, 2013. U.S. Environmental Protection Agency.

[IARC 2014] International Agency for Research on Cancer. IARC monographs on the evaluation of carcinogenic risks to humans, volume 106: Trichloroethylene, tetrachloroethylene, and some other chlorinated agents. Lyon 2014.

[NTP 2015] National Toxicology Program. Report on Carcinogens: Monograph on Trichloroethylene. National Toxicology Program, US Department of Health and Human Services. January 30, 2015.

[PWS 2014] North Carolina Department of Environment and Natural Resources Public Water Supply Section. Records accessed July 2014 at: http://www.ncwater.org/pws/pws_data.htm#Schedules.

[QAPP 2013] Amended Quality Assurance Project Plan (QAPP), Hemphill Road TCE aka Gastonia Industrial Truck Site. EPA ID# NC0 002 374 445. Gastonia, Gaston County, NC. February 28, 2013.

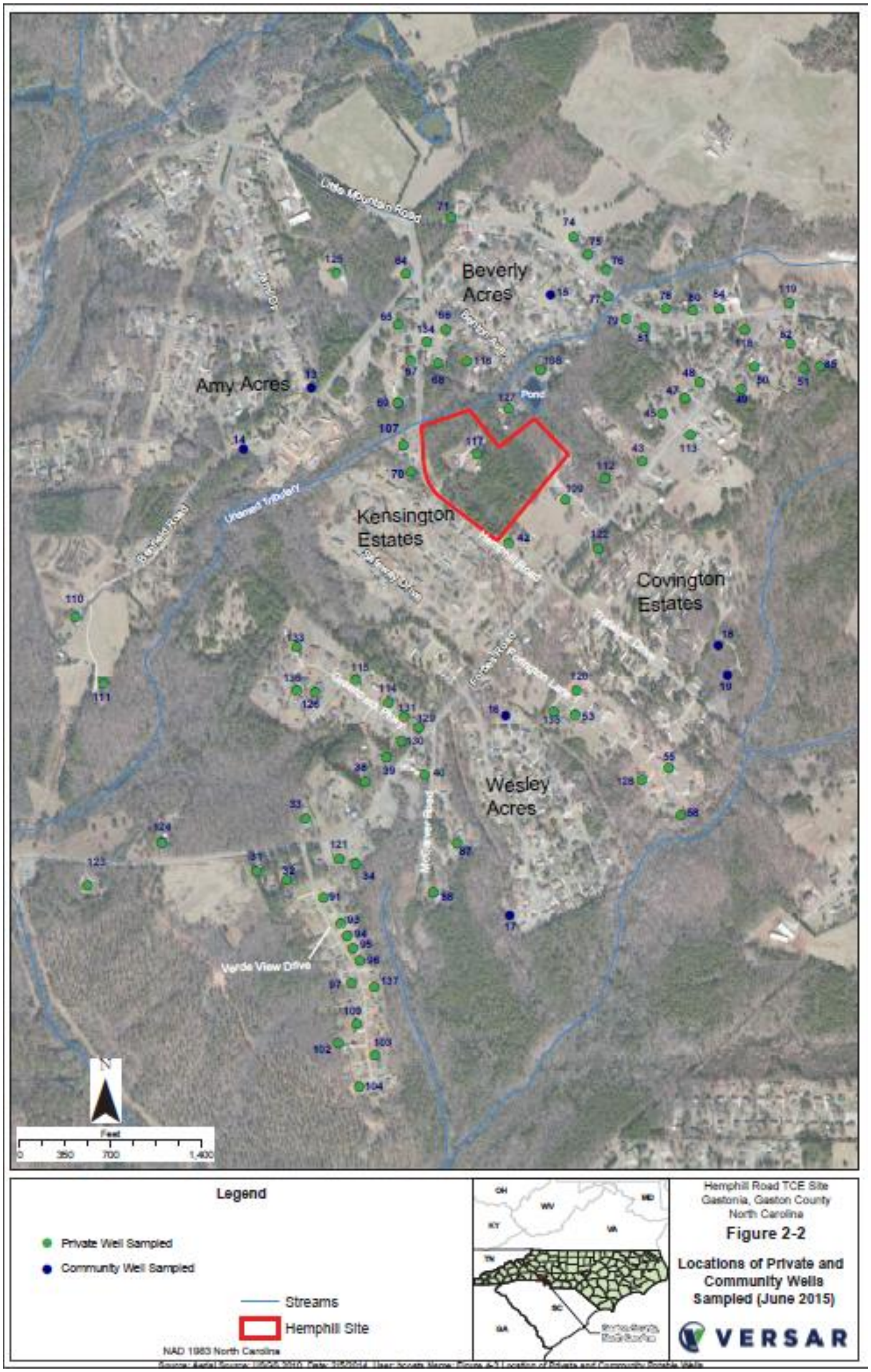
[RSL 2013] US Environmental Protection Agency. Regional Screening Tables. Available at: https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables-may-2016.

[SRR 2012] Site Re-Assessment Report Gastonia Industrial Truck. January 2012. North Carolina Department of Environment and Natural Resources Division of Waste Management.

[USCB 2010] US Census Bureau (2010), Interactive population search, Accessed: August 5, 2014, http://www.census.gov/2010census/popmap/.

Figures

Figure 1. Location of the Hemphill Road National Priorities List site, Gastonia, Gaston County, North Carolina. The site was formerly identified as the Gastonia Industrial Truck site. Residential well sampling locations near the Hemphill Road NPL site and nearby community water systems. Groundwater under the NPL site flows from the southeast to the north/ northwest. Source: Draft HHRA 2017.



Tables

Table 1. Summary of private residential well water data for the Hemphill Road TCE NPL site. Includes wells with trichloroethylene (TCE) detections above health comparison values. Wells listed by location code from Figure 1. Only post-filter data are listed where applicable. TCE concentrations in µg/L (parts-per-billion). Ingestion comparison value analysis summaries included.

Reported TCE Concentrations[1] - Private Residential Wells

Sample Collection Date	HH070	HH107	HH066	HH111	HH069	HH110
Sept. 1988	13.6	NA	NA	NA	NA	NA
Jan. 1989	NA	49.1	1.1	NA	NA	NA
April 1989	8.3	NA	NA	NA	NA	NA
May 1989	NA	0.7	NA	NA	NA	NA
Feb. 1990	NA	1.6	NA	NA	NA	NA
May 1993	2.7	6.9	NA	NA	NA	NA
Sept. 1993	NA	ND	NA	NA	NA	NA
June 1999	153	200	0.5	NA	NA	NA
July 1999	150	NA	NA	NA	NA	NA
July 2009	170	220	0.18	NA	NA	NA
July 2011	NA	NA	NA	1.1	NA	NA
March 2012	41	NA	0.34	NA	5.0	NA
August 2012	ND	ND	NA	NA	NA	NA
Nov. 2012	ND	ND	ND	1.2	NA	NA
May 2014	0.057J	ND	0.39J	1.2J	0.058J	ND
August 2014	ND	ND	NA	NA	ND	NA
Nov. 2014	ND	ND	0.6	1.5	ND	0.14J
March 2015	3.0	NA	NA	NA	NA	NA
June 2015	ND	ND	0.57	1.0	ND	0.56
Maximum Exposure Concentration	170	220	1.1	1.5	5.0	0.56
Number detects > ingestion CV[2]	8/9	6/6	4/7	5/5	1/2	1/2

[1] TCE in µg/L (micrograms per liter or parts-per-billion, ppb)

[2] Ingestion Comparison Value (CV) = 0.43 µg/L (Cancer Risk Evaluation Guide)

J = estimated concentration

NA = not applicable (no sample collected on indicated date for this location)

ND = not detected

Table 2. Community water system TCE data summary. Includes DEQ Public Water Supply Section monitoring program data through August 2014.

Community Water System (Population)	Well No.	Date	TCE (µg/L)
Kensington Estates [1] (100)	1	4/1997	5.9
	2	4/1997	2.8
	Point of entry	3/24/1999	10.55
		6/15/1999	11.55
		10/11/1999	10.21
		Number detects > ingestion CV[2]	5/5
		Maximum detection, µg/L	11.55
		Average detection, µg/L	8.82

Table continued on the next page.

Table 2. continued.

Community Water System (Population)	Well No.	Date	TCE (µg/L)
Wesley Acres (168)	1	3/3/2000	0.5
		2/20/2008	3.0
		5/19/2008	3.0
		8/18/2008	3.3
		8/27/2009	ND
		7/27/2010	3.4
		7/20/2011	3.2
		3/28/2012	3.9
		8/7/2012	2.7
		11/13/2012	2.5
		7/16/2013	2.4
		5/16/2014	2.5
	2	3/5/2002	0.8
		2/20/2008	2.6
		5/19/2008	3.0
		8/18/2008	3.0
		8/27/2009	ND
		10/19/2009	2.1
		2/18/2010	2.7
		5/18/2010	ND
		7/27/2010	1.9
		10/19/2010	ND
		2/14/2011	ND
		4/25/2011	ND
		3/28/2012	ND
		4/24/2012	ND
		11/13/2012	ND
		4/16/2013	ND
		5/16/2014	ND
	Number detects > ingestion CV[2]		18/18
	Maximum detection, µg/L		3.9
	Average detection, µg/L		1.73

Table continued on the next page.

Table 2. continued.

Community Water System (Population)	Well No.	Date	TCE (µg/L)
Cedar Grove (404)	1	5/21/2002	ND
		4/21/2005	ND
		4/14/2008	ND
		8/19/2008	2.1
		11/11/2008	2.5
		8/3/2009	3.9
		4/27/2009	2.6
		2/9/2009	3.1
		10/15/2009	4.2
		1/18/2010	2.1
		7/27/2010	2.2
		10/26/2010	2.2
		5/12/2010	2.7
		2/17/2011	4.0
		4/25/2011	3.6
		8/16/2011	2.0
	2	5/21/2002	ND
		4/21/2005	ND
		4/14/2008	1.8
		8/19/2008	ND
		11/11/2008	ND
		8/3/2009	4.0
		4/27/2009	2.9
		2/9/2009	3.0
		10/15/2009	ND
		1/18/2010	ND
		2/17/2011	ND
		Number detects > ingestion CV[2]	17/17
		Maximum detection, µg/L	4.2
		Average detection, µg/L	1.97

[1] Kensington Estates wells were closed in 1999
[2] Ingestion Comparison Value (CV) = 0.43 µg/L (Cancer Risk Evaluation Guide)
µg/L = micrograms per liter (parts-per-billion, ppb)
ATSDR = Agency for Toxic Substances and Disease Registry
ND = not detected
TCE = trichloroethylene

Table 3. Summary of health-effect data for residential well denoted as HH-070 in Figure 1. Doses are for ingestion and inhalation of the maximum TCE concentration at this well location. Non-cancer risks are evaluated further if the total dose exceeds the minimal risk level (0.0005 mg/kg/day). Cancer risks are expressed as additional number of cancers in the specified population size.

Age Group	EPC	Ingestion Dose Estimate (mg/kg/day)		Shower Dose Estimate (mg/kg/day)		Total Dose Estimate (mg/kg/day)		Non-Cancer Risk Dose > MRL		Cancer Risk (birth to 21 years)		Cancer Risk (33 adult years)	
	µg/L	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE
Birth to < 1 year	170	0.024	0.011	NA	NA	0.024	0.011	YES	YES	2 in 1,000	2 in 10,000		
1 to < 2 years	170	0.013	0.005	0.301	0.013	0.314	0.017	YES	YES				
2 to < 6 years	170	0.010	0.004	0.185	0.008	0.194	0.012	YES	YES				
6 to < 11 years	170	0.008	0.003	0.068	0.008	0.075	0.011	YES	YES				
11 to < 16 years	170	0.006	0.002	0.063	0.006	0.069	0.008	YES	YES				
16 to < 21 years	170	0.006	0.002	0.025	0.004	0.030	0.006	YES	YES				
21 + years	170	0.007	0.003	0.029	0.004	0.035	0.006	YES	YES			7 in 10,000	1 in 10,000

EPC = Exposure point concentration
µg/L = micrograms per liter
mg/kg/day = milligrams per kilogram per day
MRL = Minimal Risk Level
RME = Reasonable maximum exposure
CTE = Central tendency estimate
NA = Not applicable

Table 4. Summary of health-effect data for residential well denoted as HH-107 in Figure 1. Doses are for ingestion and inhalation of the maximum TCE concentration at this well location. Non-cancer risks are evaluated further if the total dose exceeds the minimal risk level (0.0005 mg/kg/day). Cancer risks are expressed as additional number of cancers in the specified population size.

Age Group	EPC	Ingestion Dose Estimate (mg/kg/day)		Shower Dose Estimate (mg/kg/day)		Total Dose Estimate (mg/kg/day)		Non-Cancer Risk Dose > MRL		Cancer Risk (birth to 21 years)		Cancer Risk (33 adult years)	
	μg/L	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE
Birth to < 1 year	220	0.031	0.014	NA	NA	0.031	0.014	YES	YES	2 in 1,000	2 in 10,000		
1 to < 2 years	220	0.017	0.006	0.389	0.017	0.406	0.023	YES	YES				
2 to < 6 years	220	0.012	0.005	0.239	0.010	0.251	0.015	YES	YES				
6 to < 11 years	220	0.010	0.004	0.088	0.011	0.097	0.014	YES	YES				
11 to < 16 years	220	0.008	0.003	0.082	0.007	0.089	0.010	YES	YES				
16 to < 21 years	220	0.008	0.002	0.032	0.005	0.039	0.008	YES	YES				
21 + years	220	0.009	0.003	0.037	0.005	0.046	0.008	YES	YES			9 in 10,000	2 in 10,000

EPC = Exposure point concentration
μg/L = micrograms per liter
mg/kg/day = milligrams per kilogram per day
MRL = Minimal Risk Level
RME = Reasonable maximum exposure
CTE = Central tendency estimate
NA = Not applicable

Table 5. Summary of health-effect data for residential well denoted as HH-066 in Figure 1. Doses are for ingestion and inhalation of the maximum TCE concentration at this well location. Non-cancer risks are evaluated further if the total dose exceeds the minimal risk level (0.0005 mg/kg/day). Cancer risks are expressed as additional number of cancers in the specified population size.

Age Group	EPC	Ingestion Dose Estimate (mg/kg/day)		Shower Dose Estimate (mg/kg/day)		Total Dose Estimate (mg/kg/day)		Non-Cancer Risk Dose > MRL		Cancer Risk (birth to 21 years)		Cancer Risk (33 adult years)	
	µg/L	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE
Birth to < 1 year	1.1	1.60E-04	7.10E-05	NA	NA	1.60E-04	7.10E-05	NO	NO	1 in 100,000	1 in 1,000,000		
1 to < 2 years	1.1	8.60E-05	3.00E-05	1.95E-03	8.34E-05	2.03E-03	1.13E-04	YES	NO				
2 to < 6 years	1.1	6.20E-05	2.40E-05	1.19E-03	5.12E-05	1.26E-03	7.52E-05	YES	NO				
6 to < 11 years	1.1	4.90E-05	1.80E-05	4.38E-04	5.48E-05	4.87E-04	7.28E-05	NO	NO				
11 to < 16 years	1.1	3.80E-05	1.20E-05	4.08E-04	3.63E-05	4.46E-04	4.83E-05	NO	NO				
16 to < 21 years	1.1	3.80E-05	1.20E-05	1.59E-04	2.65E-05	1.97E-04	3.85E-05	NO	NO				
21 + years	1.1	4.30E-05	1.70E-05	1.86E-04	2.46E-05	2.29E-04	4.16E-05	NO	NO			5 in 1,000,000	<1 in 1,000,000

EPC = Exposure point concentration
µg/L = micrograms per liter
mg/kg/day = milligrams per kilogram per day
MRL = Minimal Risk Level
RME = Reasonable maximum exposure
CTE = Central tendency estimate
NA = Not applicable

Table 6. Summary of health-effect data for residential well denoted as HH-111 in Figure 1. Doses are for ingestion and inhalation of the maximum TCE concentration at this well location. Non-cancer risks are evaluated further if the total dose exceeds the minimal risk level (0.0005 mg/kg/day). Cancer risks are expressed as additional number of cancers in the specified population size.

Age Group	EPC	Ingestion Dose Estimate (mg/kg/day)		Shower Dose Estimate (mg/kg/day)		Total Dose Estimate (mg/kg/day)		Non-Cancer Risk Dose > MRL		Cancer Risk (birth to 21 years)		Cancer Risk (33 adult years)	
	µg/L	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE
Birth to < 1 year	1.5	2.10E-04	9.70E-05	NA	NA	2.10E-04	9.70E-05	NO	NO	2 in 100,000	2 in 1,000,000		
1 to < 2 years	1.5	1.20E-04	4.10E-05	2.65E-03	1.14E-04	2.77E-03	1.55E-04	YES	NO				
2 to < 6 years	1.5	8.40E-05	3.20E-05	1.63E-03	6.98E-05	1.71E-03	1.02E-04	YES	NO				
6 to < 11 years	1.5	6.60E-05	2.40E-05	5.98E-04	7.47E-05	6.64E-04	9.87E-05	YES	NO				
11 to < 16 years	1.5	5.20E-05	1.70E-05	5.56E-04	4.94E-05	6.08E-04	6.64E-05	YES	NO				
16 to < 21 years	1.5	5.10E-05	1.60E-05	2.17E-04	3.62E-05	2.68E-04	5.22E-05	NO	NO				
21 + years	1.5	5.80E-05	2.30E-05	2.54E-04	3.35E-05	3.12E-04	5.65E-05	NO	NO			6 in 1,000,000	1 in 1,000,000

EPC = Exposure point concentration
µg/L = micrograms per liter
mg/kg/day = milligrams per kilogram per day
MRL = Minimal Risk Level
RME = Reasonable maximum exposure
CTE = Central tendency estimate
NA = Not applicable

Table 7. Summary of health-effect data for residential well denoted as HH-069 in Figure 1. Doses are for ingestion and inhalation of the maximum TCE concentration at this well location. Non-cancer risks are evaluated further if the total dose exceeds the minimal risk level (0.0005 mg/kg/day). Cancer risks are expressed as additional number of cancers in the specified population size.

Age Group	EPC	Ingestion Dose Estimate (mg/kg/day)		Shower Dose Estimate (mg/kg/day)		Total Dose Estimate (mg/kg/day)		Non-Cancer Risk Dose > MRL		Cancer Risk (birth to 21 years)		Cancer Risk (33 adult years)	
	μg/L	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE
Birth to < 1 year	5	7.10E-04	3.20E-04	NA	NA	7.10E-04	3.20E-04	YES	NO	6 in 100,000	5 in 1,000,000		
1 to < 2 years	5	3.90E-04	1.40E-04	8.84E-03	3.79E-04	9.23E-03	5.19E-04	YES	YES				
2 to < 6 years	5	2.80E-04	1.10E-04	5.43E-03	2.33E-04	5.71E-03	3.43E-04	YES	NO				
6 to < 11 years	5	2.20E-04	8.00E-05	1.99E-03	2.49E-04	2.21E-03	3.29E-04	YES	NO				
11 to < 16 years	5	1.70E-04	5.60E-05	1.85E-03	1.65E-04	2.02E-03	2.21E-04	YES	NO				
16 to < 21 years	5	1.70E-04	5.40E-05	7.24E-04	1.21E-04	8.94E-04	1.75E-04	YES	NO				
21 + years	5	1.90E-04	7.70E-05	8.46E-04	1.12E-04	1.04E-03	1.89E-04	YES	NO			2 in 100,000	4 in 1,000,000

EPC = Exposure point concentration
μg/L = micrograms per liter
mg/kg/day = milligrams per kilogram per day
MRL = Minimal Risk Level
RME = Reasonable maximum exposure
CTE = Central tendency estimate
NA = Not applicable

Table 8. Summary of health-effect data for residential well denoted as HH-110 in Figure 1. Doses are for ingestion and inhalation of the maximum TCE concentration at this well location. Non-cancer risks are evaluated further if the total dose exceeds the minimal risk level (0.0005 mg/kg/day). Cancer risks are expressed as additional number of cancers in the specified population size.

Age Group	**EPC**	**Ingestion Dose Estimate (mg/kg/day)**		**Shower Dose Estimate (mg/kg/day)**		**Total Dose Estimate (mg/kg/day)**		**Non-Cancer Risk Dose > MRL**		**Cancer Risk (birth to 21 years)**		**Cancer Risk (33 adult years)**	
	µg/L	**RME**	**CTE**	**RME**	**CTE**	**RME**	**CTE**	**RME**	**CTE**	**RME**	**CTE**	**RME**	**CTE**
Birth to < 1 year	0.56	8.00E-05	3.60E-05	NA	NA	8.00E-05	3.60E-05	NO	NO	6 in 1,000,000	<1 in 1,000,000		
1 to < 2 years	0.56	4.40E-05	1.50E-05	9.90E-04	4.24E-05	1.03E-03	5.74E-05	YES	NO				
2 to < 6 years	0.56	3.10E-05	1.20E-05	6.08E-04	2.61E-05	6.39E-04	3.81E-05	YES	NO				
6 to < 11 years	0.56	2.50E-05	9.00E-06	2.23E-04	2.79E-05	2.48E-04	3.69E-05	NO	NO				
11 to < 16 years	0.56	1.90E-05	6.30E-06	2.08E-04	1.85E-05	2.27E-04	2.48E-05	NO	NO				
16 to < 21 years	0.56	1.90E-05	6.00E-06	8.11E-05	1.35E-05	1.00E-04	1.95E-05	NO	NO				
21 + years	0.56	2.20E-05	8.60E-06	9.48E-05	1.25E-05	1.17E-04	2.11E-05	NO	NO			2 in 1,000,000	<1 in 1,000,000

EPC = Exposure point concentration
µg/L = micrograms per liter
mg/kg/day = milligrams per kilogram per day
MRL = Minimal Risk Level
RME = Reasonable maximum exposure
CTE = Central tendency estimate
NA = Not applicable

Table 9. Summary of health-effect evaluation data for the Kensington Estates community water system. Doses are for the maximum TCE concentration for the water system. Includes DEQ Public Water Supply Section monitoring program data through August 12, 2014. Non-cancer risks are evaluated further if the total dose exceeds the minimal risk level (0.0005 mg/kg/day). Cancer risks are expressed as additional number of cancers in the specified population size.

Age Group	EPC	Ingestion Dose Estimate (mg/kg/day)		Shower Dose Estimate (mg/kg/day)		Total Dose Estimate (mg/kg/day)		Non-Cancer Risk Dose > MRL		Cancer Risk (birth to 2.5 years)		Cancer Risk (2.5 adult years)	
	µg/L	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE
Birth to < 1 year	11.55	0.0016	0.0008	NA	NA	0.0016	0.0008	YES	YES	5 in 100,000	4 in 1,000,000		
1 to < 2 years	11.55	0.0009	0.0003	0.0204	0.0009	0.0213	0.0012	YES	YES				
2 to < 6 years	11.55	0.0007	0.0003	0.0125	0.0005	0.0132	0.0008	YES	YES				
6 to < 11 years	11.55	0.0005	0.0002	0.0046	0.0006	0.0051	0.0008	YES	YES				
11 to < 16 years	11.55	0.0004	0.0001	0.0043	0.0004	0.0047	0.0005	YES	YES				
16 to < 21 years	11.55	0.0004	0.0001	0.0017	0.0003	0.0021	0.0004	YES	NO				
21 + years	11.55	0.0005	0.0002	0.0020	0.0003	0.0024	0.0004	YES	NO			4 in 1,000,000	<1 in 1,000,000

EPC = Exposure point concentration
µg/L = micrograms per liter
mg/kg/day = milligrams per kilogram per day
MRL = Minimal Risk Level
RME = Reasonable maximum exposure
CTE = Central tendency estimate
NA = Not applicable

Table 10. Summary of health-effect evaluation data for the Wesley Acres community water system. Doses are for the maximum TCE concentration for the water system. Includes DEQ Public Water Supply Section monitoring program data through August 12, 2014. Non-cancer risks are evaluated further if the total dose exceeds the minimal risk level (0.0005 mg/kg/day). Cancer risks are expressed as additional number of cancers in the specified population size.

Age Group	**EPC**	**Ingestion Dose Estimate (mg/kg/day)**		**Shower Dose Estimate (mg/kg/day)**		**Total Dose Estimate (mg/kg/day)**		**Non-Cancer Risk Dose > MRL**		**Cancer Risk (birth to 14 years)**		**Cancer Risk (14 adult years)**	
	µg/L	**RME**	**CTE**	**RME**	**CTE**	**RME**	**CTE**	**RME**	**CTE**	**RME**	**CTE**	**RME**	**CTE**
Birth to < 1 year	3.9	5.60E-04	2.50E-04	NA	NA	5.60E-04	2.50E-04	YES	NO	4 in 100,000	4 in 1,000,000		
1 to < 2 years	3.9	3.10E-04	1.10E-04	6.90E-03	2.96E-04	7.21E-03	4.06E-04	YES	NO				
2 to < 6 years	3.9	2.20E-04	8.40E-05	4.24E-03	1.82E-04	4.46E-03	2.66E-04	YES	NO				
6 to < 11 years	3.9	1.70E-04	6.30E-05	1.55E-03	1.94E-04	1.72E-03	2.57E-04	YES	NO				
11 to < 16 years	3.9	1.40E-04	4.40E-05	1.45E-03	1.29E-04	1.59E-03	1.73E-04	YES	NO				
16 to < 21 years	3.9	1.30E-04	4.20E-05	5.65E-04	9.41E-05	6.95E-04	1.36E-04	YES	NO				
21 + years	3.9	1.50E-04	6.00E-05	6.60E-04	8.70E-05	8.10E-04	1.47E-04	YES	NO			7 in 1,000,000	1 in 1,000,000

EPC = Exposure point concentration
µg/L = micrograms per liter
mg/kg/day = milligrams per kilogram per day
MRL = Minimal Risk Level
RME = Reasonable maximum exposure
CTE = Central tendency estimate
NA = Not applicable

Table 11. Summary of health-effect evaluation data for the Cedar Grove community water system. Doses are for the maximum TCE concentration for the water system. Includes DEQ Public Water Supply Section monitoring program data through August 12, 2014. Non-cancer risks are evaluated further if the total dose exceeds the minimal risk level (0.0005 mg/kg/day). Cancer risks are expressed as additional number of cancers in the specified population size.

Age Group	EPC	Ingestion Dose Estimate (mg/kg/day)		Shower Dose Estimate (mg/kg/day)		Total Dose Estimate (mg/kg/day)		Non-Cancer Risk Dose > MRL		Cancer Risk (birth to 6 years)		Cancer Risk (6 adult years)	
	µg/L	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE	RME	CTE
Birth to < 1 year	4.2	6.00E-04	2.70E-04	NA	NA	6.00E-04	2.70E-04	YES	NO	3 in 100,000	2 in 1,000,000		
1 to < 2 years	4.2	3.30E-04	1.10E-04	7.43E-03	3.18E-04	7.76E-03	4.28E-04	YES	NO				
2 to < 6 years	4.2	2.40E-04	9.10E-05	4.56E-03	1.96E-04	4.80E-03	2.87E-04	YES	NO				
6 to < 11 years	4.2	1.90E-04	6.70E-05	1.67E-03	2.09E-04	1.86E-03	2.76E-04	YES	NO				
11 to < 16 years	4.2	1.50E-04	4.70E-05	1.56E-03	1.38E-04	1.71E-03	1.85E-04	YES	NO				
16 to < 21 years	4.2	1.40E-04	4.50E-05	6.08E-04	1.01E-04	7.48E-04	1.46E-04	YES	NO				
21 + years	4.2	1.60E-04	6.40E-05	7.11E-04	9.37E-05	8.71E-04	1.58E-04	YES	NO			3 in 1,000,000	<1 in 1,000,000

EPC = Exposure point concentration
µg/L = micrograms per liter
mg/kg/day = milligrams per kilogram per day
MRL = Minimal Risk Level
RME = Reasonable maximum exposure
CTE = Central tendency estimate
NA = Not applicable

Table 12. Summary of health-effect data for the employees of the Gastonia Industrial Truck facility. Doses calculated for a 7-year exposure at the concentration of TCE detected when the well was closed for use as a drinking water source in 1989 (288 µg/L). Adult workers were assumed to drink 2 liters per day, 5 days per week, 50 weeks per year. Non-cancer risks are evaluated further if the total dose exceeds the minimal risk level (0.0005 mg/kg/day). Cancer risks are expressed as additional number of cancers in the specified population size.

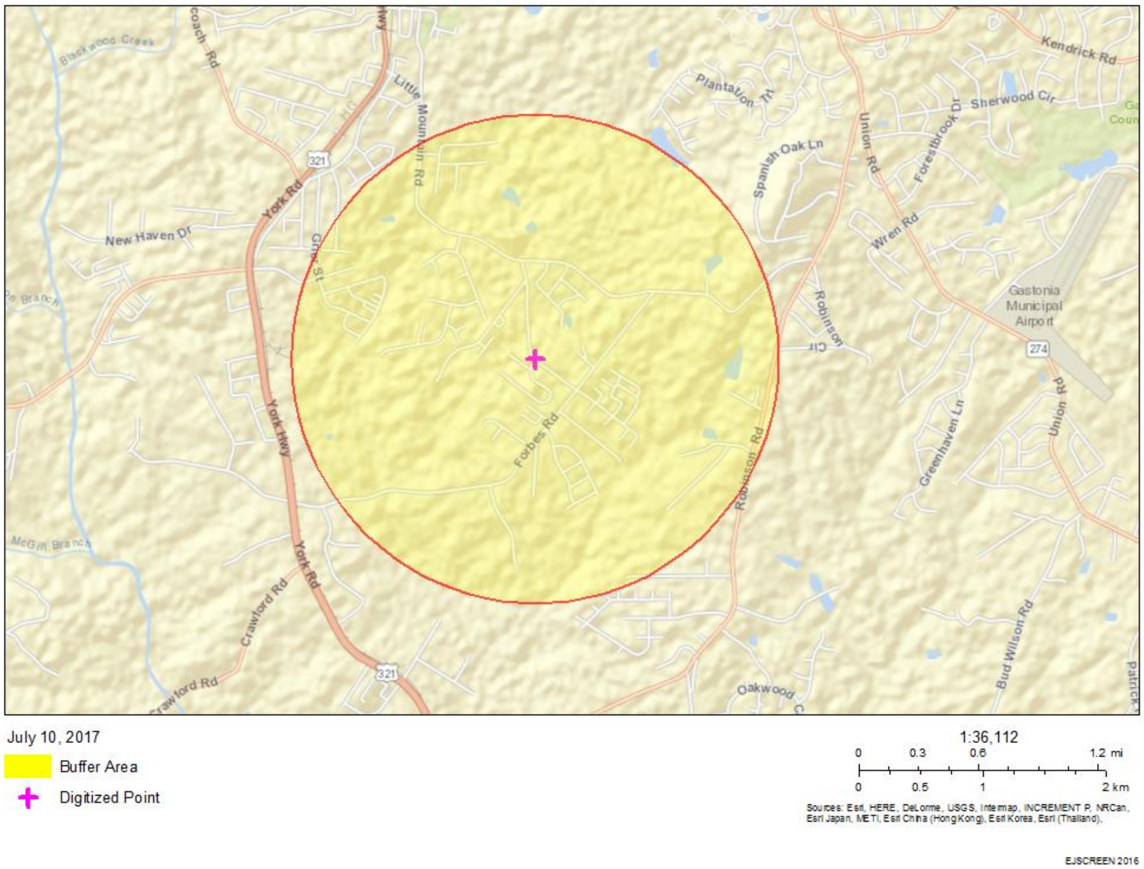
Well Identification	**EPC µg/L**	**Dose Estimate (mg/kg/day)**	**Non-cancer risk Dose > MRL**	**Cancer Risk (7 adult years)**
GIT Production Well	288	0.0049	YES	2 in 100,000

EPC = Exposure point concentration
µg/L = micrograms per liter
mg/kg/day = milligrams per kilogram per day
MRL = Minimal Risk Level

Appendix A: Community Demographics

	Community near Hemphill National Priority List Site*	Gaston County, North Carolina	North Carolina	United States
Total population	2,476	208,379	9,535,483	308,745,538
Percent Minority	16%	25%	25%	18.3%
Ethnicity				
White	85%	77%	68.5 %	72.4 %
African-American	12%	15%	21.5 %	12.6 %
Hispanics	2%	6%	8.4 %	16.3 %
Asians	0%	1%	2.2 %	4.8 %
American Indians	1%	0%	1.3 %	0.9 %
Poverty Level	NA	17.4%	17.4 %	15.5 %
Population with less than a High school diploma	12%	18%	14.2 %	13.3 %
Less than 9th grade	5%	7%	15.3 %	14.4 %
Number of housing units	1,023	89,356	4,417,210	133,351,840
Occupied housing units	986	79,209	3,775,581	116,926,305
Renter occupied housing unit	17%	33%	1,316,509	42,214,214
Percentage of population under 5 years of age	7%	6%	6.2 %	6.3 %
Percent of population age under 18	25%	23%	22.7%	22.8%
Percentage of population over 65 years of age	14%	14%	14.2 %	14.1 %

Based on Census 2010 figures and U.S. Census Bureau, 2011-2015 American Community Survey 5-Year Estimates.
*1-mile radius (see map on next page)
NA = Not available



One-mile radius from 5009 Hemphill Road. Map created by EJ Screen Tool July 2017. EJ Screen Tool was used to determine the community demographics for the community near the Hemphill Road TCE site.

Appendix B

Trichloroethylene (TCE) Factsheets

Trichloroethylene (TCE)

2013

Exposure to Trichloroethylene (TCE) has the potential to harm your health. The health effects of contact with any hazardous substance depend on how much, for how long and the way you are exposed. The effects also depend on personal factors such as your overall health, family history and lifestyle.

What is TCE?	Trichloroethylene (TCE) is a nonflammable, colorless liquid with a somewhat sweet odor and a sweet, burning taste.
Where is TCE found?	It is used mainly as a solvent to remove grease from metal parts, but it is also an ingredient in glue, paint removers, typewriter correction fluids, stain removers and gun cleaners. It has been used to clean electronic components.
How could I be exposed to TCE?	• Breathing, drinking or through skin contact. • Contact with contaminated soil. • Drinking from a contaminated well or water source. • If your water source is contaminted with TCE, activities such as showering, doing dishes or running a dish washer or a washing machine can cause TCE in the water to evaporate and contaminate your indoor air. • It can get into indoor air through the use of products that contain TCE in the home or by vapor intrusion. Vapor intrusion occurs when TCE in the groundwater or soil evaporates and gets into a building where people can breath it.
What guidelines have been set to protect human health?	The U.S. Environmental Protection Agency (EPA) has established screening values for TCE in the air, soil, and water. The maximum contaminant level for TCE in public drinking water systems is 0.005 milligrams per liter (0.005 mg/L) or 5 parts of TCE per billion parts water (5 ppb).
How can TCE affect my health?	Exposure in workplace settings showed that breathing small amounts for short periods may cause headaches, lung irritation, dizziness, poor coordination, and difficulty concentrating. Drinking or breathing small amounts of TCE for long periods may cause damage to the kidneys, heart, reproductive system, or immune system, and impaired fetal development in pregnant women.

Drinking or breathing larger amounts of TCE for long periods may cause damage to the nervous system, liver, or changes in mood or sleep patterns. Skin contact with TCE for short periods may cause skin rashes.

TCE is classified as a human carcinogen by the EPA. Studies have shown a strong association of TCE with kidney cancer. Studies suggest that TCE may be associated with liver cancer and non-Hodgkin's lymphoma. It may also be associated with childhood leukemia, bladder, esophageal, prostate, cervical, and breast cancers, althought the evidence is weaker.

How can I limit my exposure to TCE?

- Remove household sources of TCE.
- If your private well water is contaminated use an alternative source of water or a whole-house carbon filter and keep up with the filter maintenance.
- If you are concerned about TCE vapor intrusion, contact an envirnomental professional to assist in the initial evaluation, design, and installation of a control system.

When should I see a doctor?

See a physician if you or your children have symptoms that you think are caused by TCE exposure. You should tell the physician about the symptoms and about when, how and for how long you think you and/or your children were exposed to TCE.

Well Testing

Contact your local health department to have your well water tested.

Additional information

NC Department of Health and Human Services, Division of Public Health, Health Assessment, Consultation and Education program at (919) 707-5900 for additional information.

References

U.S. Environmental Protection Agency. Toxicological Review of Trichloroethylene (CAS No. 79-01-6) in Support of Summary Information on the Integrated Risk Information System (IRIS). September 2011. Available at http://www.epa.gov/iris/supdocs/0199index.html

U.S. Environmental Protection Agency. Trichloroethylene. Technology Transfer Network, Air Toxics Web Site. Accessed on November 20, 2012 from http://www.epa.gov/ttn/atw/hlthef/tri-ethy.html#ref4

Agency for Toxic Substances and Disease Registry (ATSDR). ToxFAQs for Trichloroethylene (TCE). Accessed on November 13, 2012 from http://www.atsdr.cdc.gov/tfacts19.html

nc department of health and human services

NCPH North Carolina Public Health

State of North Carolina • Department of Health and Human Services
Division of Public Health
www.ncdhhs.gov www.publichealth.nc.gov
NC DHHS is an equal opportunity employer and provider 4/13

Trichloroethylene (TCE)

Information for Health Professionals

TCE is a nonflammable, colorless liquid with a somewhat sweet odor and a sweet, burning taste. It is mainly used to remove grease from metal parts, in adhesives, paint removers, typewriter correction fluids, and stain removers. It has also been used to clean electronic components.

TCE can enter the environment when it is manufactured, used or disposed. People can inhale TCE's vapors or get it on their skin or in their eyes during manufacturing or while using household products containing TCE. TCE that is improperly disposed can enter the soil where it can evaporate and get inside buildings or move from the soil to the groundwater where it may enter drinking water wells.

Routes of Exposure

TCE may cause adverse health effects following exposure via inhalation, ingestion, dermal or eye contact. When considering the human health effects of TCE, it is important to make a distinction between occupational exposures to relatively high levels by inhalation and dermal contact versus general environmental exposures to low levels in drinking water and ambient air.

Main Body Systems Targeted

TCE poses a potential human health hazard for non-cancer toxicity to the central nervous system, kidney, liver, immune system, male reproductive system, and the developing fetus. Studies on the effects of chronic TCE exposure to the respiratory tract and the female reproductive system are limited.[i] Studies have shown that simultaneous alcohol consumption and trichloroethylene inhalation increases the toxicity of trichloroethylene in humans.

Signs and Symptoms

No unique pattern of symptoms characterizes TCE-induced illness.

- Gastrointestinal symptoms such as nausea, vomiting, abdominal pain, and diarrhea.
- Possibly an increase in the incidence of miscarriages and fetal heart malformations.
- Skin contact with TCE for short periods may cause skin rashes.
- Inhaling small amounts for short periods may cause headaches, lung irritation, dizziness, poor coordination, and difficulty concentrating.
- Ingesting or inhaling small amounts for long period may cause damage to the kidneys, heart, and reproductive system.
- Ingesting or breathing larger amounts for long periods may cause damage to the central nervous system, liver, or changes in mood or sleep patterns.
- Some studies in animals have found adverse health effects to the immune system.

Cancer Risk:

The U.S. Environmental Protection Agency has characterized TCE as "carcinogenic in humans by all routes of exposure." TCE has been associated with kidney cancer, but there is less convincing evidence for non-Hodgkin's lymphoma, and more limited for liver and biliary tract cancer.

Medical Evaluation

If a person presents symptoms that could be associated with a TCE exposure, a complete evaluation of symptoms is recommended in addition to a complete environmental, occupational and residential history. Liver and kidney function test, complete blood count and urinalysis are recommended. Recent exposures can be detected in the breath, blood or urine. Breath testing must occur within an hour or two after exposure. Blood and urine tests can find TCE and metabolites up to a week after exposure. TCE in the blood and urine has a short half-life and analysis for TCE is not useful for exposures that happened more than 5-7 days earlier. The presence of trichloroacetic acid in the urine should be interpreted with caution because certain medications (chloral hydrate and disulfiram) and other chlorinated hydrocarbons are metabolized to trichloroacetic acid, which is excreted in the urine. If blood is found in the urine, then a thorough workup should be conducted to find an etiology to rule out kidney or bladder cancer.

Treatment

- No medical treatment can remove TCE from the body. TCE is excreted primarily in breath as TCE or in urine as metabolites after an exposure occurs.

Prevention of Adverse Health Effects

- In order to reduce the risk of adverse health effects patients should be counseled on lifestyle changes such as smoking cessation, maintaining appropriate body weight, exercise, limiting alcohol consumption, and using appropriate personal protective equipment when working with chemicals. Giving the Hepatitis A and B vaccination may be prudent because of TCE's main mode of action and target organs.

Contact:
HACE Program (919) 707-5900
E-mail: nchace@dhhs.nc.gov
Address: N.C. Division of Public Health
OEE
1912 Mail Service Center
Raleigh, NC 27699-1912

Additional Information

"Trichloroethylene Toxicity: How Should Patients Exposed to TCE Be Evaluated?" Agency for Toxic Substances and Disease Registry
http://www.atsdr.cdc.gov/csem/csem.asp?csem=15&po=11

Environmental Medicine Education for Health Professionals, Agency for Toxic Substances and Disease Registry
http://www.atsdr.cdc.gov/emes/health_professionals/index.html

State of North Carolina • Department of Health and Human Services • Division of Public Health
www.ncdhhs.gov www.ncpublichealth.com
NC DHHS is an equal opportunity employee and provider 7/2013

[i] U.S. Environmental Protection Agency. Toxicological review of trichloroethylene (CAS No. 79-01-6) In support of Summary Information on the Integrated Risk Information System (IRIS), September 2011.

Appendix C: Equations to Estimate Dose

Equations used to estimate exposure dose for exposure to contaminants associated with the Hemphill Road TCE NPL site are shown below. These equations can be found in the ATSDR Public Health Assessment Guidance Manual (ATSDR 2005). Population-specific values used (ingestion rate and body weight) are consistent with ATSDR guidance (ATSDR 2014a, ATSDR 2014b).

Ingestion of contaminants present in drinking water

Exposure doses for ingestion of contaminants present in drinking water are calculated using the measured concentrations of contaminants in milligrams per liter (mg/L). The following equation is used to estimate the exposure doses resulting from ingestion of contaminated drinking water:

$$ED_w = \frac{C \times IR \times EF}{BW}$$

Where:

ED_w = exposure dose water (mg/kg/day)

C = contaminant concentration (mg/L)

IR = intake rate of contaminated medium (liters/day)

EF = exposure factor (unitless) = 1 for drinking water consumed daily

BW = body weight (kilograms)

Note: For this assessment, the following values were used:

Age Range	*95th Percentile ingestion rate (mL/day)*	*Mean ingestion rate (mL/day)*	*Body Weight (kg)*	*Age-Dependent Adjustment Factors (ADAF)*
Birth to <1 year	1,113	504	7.8	10
1 to <2 year	893	308	11.4	10
2 to <6 year	977	376	17.4	3
6 to <11 year	1,404	511	31.8	3
11 to <16 year	1,976	637	56.8	3
16 to <21 year	2,444	770	71.6	1
≥21 year	3,092	1,227	80	1

Note: L/day = liters of water per day; kg = kilograms

Calculations of Contaminant Exposures While Showering

When showering in contaminated water a person may be exposed to the chemicals in the water by breathing a portion of the chemical that comes out of the water into the air (inhalation exposure), or by absorbing the chemical from the water through their skin (dermal exposure). ATSDR uses conservative assumptions to estimate "worst case" exposures to VOCs during showering with contaminated water. The maximum concentration of VOC in the bathroom air is estimated with the following equation (Andelman 1990).

$$C_a = (C_w \times f \times F_w \times t)/V_a$$

Where:

C_a = bathroom air concentration (mg/m^3)
C_w = tap water concentration (mg/L)
f = fractional volatilization rate (unitless)
F_w = shower water flow rate (L/min)
t = exposure time (min)
V_a = bathroom volume (m^3)

Conservative calculation parameters are assumed, including a fractional volatilization of 0.6 for chlorinated VOCs, a flow rate of 8 L/min, and a small bathroom volume of 10 m^3. The reasonable maximum exposure scenario assumes a shower time of 30-50 minutes (depending on age), with a 20-30-minute bathroom stay after the shower. This is likely an over-estimation of time spent showering and in the bathroom, and can result in an over-estimation of the dose received and therefore risk. Calculated bathroom air concentrations of VOCs can then be compared to ATSDR inhalation comparison values. Inhalation exposure dose estimates can be made using ATSDR's inhalation dose calculations.

Inhalation (breathing) of contaminants present in air

Inhalation is an important pathway for human exposure to contaminants that exist as atmospheric gases or are adsorbed to airborne particles or fibers. Exposure doses for breathing contaminants in air were calculated using the estimated air concentrations from the shower model in milligrams per cubic meter (mg/m^3). The following equation is used to estimate the exposure doses resulting from inhalation of TCE-contaminated air. Inhalation and oral doses for TCE can be combined and evaluated together as both routes have the same toxicity endpoints.

$$D = (C \times IR \times EF) / BW$$

Where:

D = exposure dose (mg/kg/day)
C = contaminant concentration (mg/m^3)
IR = intake rate (m^3/day)
EF = exposure factor (unitless)
BW = body weight (kg)

Appendix D: Cancer Health Effect Evaluations

Theoretical increased numbers of cancers are calculated for known or suspected cancer-causing contaminants using the estimated site-specific exposure dose and cancer slope factor (CSF) provided in ATSDR health guideline documents. N.C. DPH evaluates cancer health effects in terms of possible increased cancer risk over background levels. In North Carolina, approximately 30% of women and 50% of men (about 40% combined), will be diagnosed with cancer in their life-time from a variety of causes. This is referred to as the “background cancer risk”. The term “excess cancer risk” represents the risk on top of the background cancer risk. A “one-in-a-million” excess cancer risk (1/1,000,000 or 10^{-6} cancer risk) means that if 1,000,000 people are exposed to the cancer-causing substance at a certain level every day of their lifetime (considered 78 years), then one cancer above the background number of cancers could develop in those 1 million people. This is a predictive tool that assist with making public health decisions aimed at protecting health and does not predict actual cancer cases. In numerical terms, the background number of cancers expected in 1 million people over their life-time is 40% or 400,000. If they are all exposed to the cancer-causing substance daily throughout their life-time, then 400,001 people may get cancer, instead of the expected 400,000. <u>The expression of the estimated cancer risk is not a prediction that cancer will occur, it represents the upper bound estimate of the probability of additional cancers. The actual risk may be much lower, or even no risk.</u>

The estimated cancer risk calculation is:

Estimated Cancer Risk = Dose x CSF x (ED/AT)

Where:

Estimated Cancer Risk = Expression of the cancer risk (unitless)
Dose = Site-specific dose of carcinogen (mg/kg/day)
CSF = Cancer Slope Factor ($[\text{mg/kg/day}]^{-1}$), a measure of cancer potency
ED = exposure duration (years)
AT = averaging time, for cancer risk estimates this is 78 years

This calculation is based on the assumption that there is no safe level of exposure to a chemical that causes cancer. However, the calculated risk estimate is not exact and tends to overestimate the actual risk associated with exposures that may have occurred. This increased cancer risk estimate does not equal the increased number of cancer cases that will actually occur in the exposed population, but estimates an excess cancer risk expressed as the proportion of a population that may be affected by a carcinogen during a lifetime or other selected period of exposure.

TCE exposure has been linked to three specific cancers: kidney, liver, and non-Hodgkin’s lymphoma. The mode of action for TCE suggests that children may be more susceptible to the kidney cancer endpoint, so age-dependent adjustment factors (ADAF) are used. A separate slope factor is used for kidney cancer, and total estimated cancer risk is calculated by adding together the estimated kidney cancer risk with the estimated liver and non-Hodgkin’s lymphoma cancer risk.

For specific exposure situations N.C. DPH may use exposure periods of less than a life-time to provide a more realistic estimation of the risks that are known or predicted to have occurred for a particular area. If information on the specifics of the exposure situations at a particular site is not known, then N.C. DPH will always use health protective values to estimate the maximum level of risk that we believe to be realistic. For private well users, cancer risks were calculated for two scenarios: daily exposure starting at birth and lasting 21 years, and daily exposure starting as an adult and lasting 33 years (95^{th} percentile residential occupancy period) out of a lifetime of 78 years (ATSDR exposure dose guidance life expectancy). For the privately-owned community wells, daily exposure durations were shorter (Kensington Estates = 2.5 years, Wesley Acres = 14.25 years, Cedar Grove = 6.33 years).