Health Consultation

PUBLIC COMMENT RELEASE

HIGHWAY 18 GROUND WATER

KERMIT, TEXAS
EPA ID: TXN000606716

Prepared by the
Texas Department of State Health Services

NOVEMBER 5, 2019

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

Health Consultation: A Note of Explanation

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Summary

Introduction

The Highway 18 Groundwater Plume site is located in Kermit, Winkler County, Texas. In August 2017, the United States Environmental Protection Agency (EPA) added the site to its National Priority List (NPL) because of groundwater contamination with tetrachloroethylene (PCE) and trichloroethylene (TCE). During routine monitoring of the Kermit public water system (PWS), TCE was first detected in 1994 and PCE was detected in 2000.

In 2013, 2014, and 2015, the Texas Commission on Environmental Quality (TCEQ) collected samples from 18 private residential water wells and 11 unblended public drinking water wells, in Kermit, Texas. TCEQ detected PCE and TCE in wells during the sampling events. In 2014 and 2015, TCEQ also sampled soil surrounding four commercial properties that are potential source locations. TCE, PCE and other contaminants were not detected in soil samples. The source area(s), full extent of the groundwater contamination, and the direction of the groundwater flow are still unknown at this time.

The Agency for Toxic Substances and Disease Registry (ATSDR) was established by Congress in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act, also known as the Superfund law. Since 1986, ATSDR has been required by law to conduct a public health evaluation at each site on the EPA NPL. The Texas Department of State Health Services (DSHS) has a cooperative agreement with ATSDR to perform public health evaluations for all listed NPL sites in the state of Texas. The ATSDR and DSHS's top priority at this site is to ensure that the community around the site has the best information possible to safeguard its health. In doing so, DSHS evaluates available data to determine if there are exposures to chemicals that could be harmful to health and makes health recommendations to reduce or eliminate any harmful exposures identified, as necessary.

DSHS evaluated available environmental data including limited water samples from 18 private residential wells from 2013 to 2015 and a more robust data set of routine compliance samples taken as part of the Safe Drinking Water Act requirements of the Kermit PWS from 1994 to 2018 to determine if past and present exposures to chemicals in drinking water may harm people's health. DSHS will review and evaluate additional data as it becomes available.

Conclusions	DSHS reached three conclusions in this health consultation:
Conclusion 1	People who used private residential well water tested from 2013 to 2015 were not exposed to TCE or PCE at levels expected to harm people's health. Data are not available to evaluate the risk for harmful exposures before 2013 or after 2015. In the future, people using private residential water wells downgradient of the plume(s) (i.e., located in the path of the plumes' movement) could be exposed to PCE or TCE through ingestion (drinking the water), inhalation (breathing TCE that has evaporated from water while showering, bathing, washing dishes, etc.), or dermal (skin contact) exposure if the plumes migrate.
Basis for Conclusion	Limited sampling of water from private wells was available for DSHS' evaluation with some private wells sampled only one time over the 2-year sampling period. During the 2013-2015 sampling events, TCEQ found PCE in the drinking water from two private residential water wells at levels that are not expected to cause harm from ingestion, inhalation, or dermal contact during showering, hand washing, and bathing. TCEQ did not detect TCE in any of the private residential wells sampled. Private residential well water samples were not collected prior to 2013. There is currently no ongoing well monitoring program, so DSHS cannot assess potential future exposures. Current knowledge indicates groundwater flows to the southwest, but the flow direction is still being assessed. Once the groundwater flow direction is determined, any wells located downgradient of the suspected plume location(s) (*i.e.*, in the direction the plume is moving) could be at risk for future TCE and PCE contamination.
Conclusion 2	Past and current ingestion, inhalation, or dermal exposure to PCE and TCE in water supplied by the Kermit PWS is not expected to harm people's health.
Basis for Conclusion	During routine sampling for regulated contaminants from 1994 to 2018, PCE and TCE were not found at levels expected to harm people's health. Kermit PWS blends water from multiple public water wells prior to distribution through two entry points, the Underwood Pumphouse (EP1) and the Walton Pumphouse (EP2). DSHS evaluated exposures to drinking water from Underwood Pumphouse (EP1) because levels of TCE from this entry point were above health comparison values. Using the ATSDR Shower and Household Water-Use Exposure (SHOWER) model (version 1.0.1), DSHS estimated total exposure doses for people drinking, breathing, and coming in contact with water containing the maximum TCE level detected in Underwood Pumphouse (EP1). By using the maximum TCE level detected from 1994 to 2018, DSHS was able to use a highly protective health assumption when determining health risks.

	DSHS determined that estimated exposure doses for all residents were below levels at which health effects occurred in scientific studies. Water supplied to residents supplied from the Walton Pumphouse (EP2) did not have concentrations of contaminants above health comparison values, therefore, harmful effects are unlikely, and exposures were not evaluated further.
Conclusion 3	Because TCE and PCE were detected in the groundwater and may be present in the shallow groundwater table, volatile contaminants could potentially migrate through soil in the form of vapor and enter the indoor air of homes and workplaces. This process is called vapor intrusion and could lead to inhalation of contaminants in indoor air. DSHS does not have enough information to determine if past, present, or future inhalation of TCE or PCE resulting from vapor intrusion could harm people's health.
Basis for Conclusion	DSHS could not assess this exposure pathway because the source area(s) and the extent of the contamination are not known at this time. Also, subsurface soil, soil gas, and shallow water environmental samples have not been collected.
Recommendations	DSHS recommends that: • EPA continue their investigation of the extent and source(s) of groundwater contamination in the shallow aquifer (Cenozoic Pecos Alluvium) and the Santa Rosa aquifer. • EPA develop and implement an ongoing monitoring plan for private residential wells that are currently contaminated or at risk for future contamination based on direction of groundwater flow. Once the groundwater flow direction is determined, any drinking water wells located downgradient of the suspected plume location(s) (*i.e.*, in the direction the plume is moving) could be at risk for future TCE and PCE contamination and should be monitored regularly. • EPA evaluate the vapor intrusion pathway at and around the site with attention given to homes and other occupied buildings overlying the groundwater plume once it is characterized.

Next Steps

- DSHS will provide this document for a public comment period to community members, city officials, the TCEQ, the EPA and other interested parties. After the public comment period, DSHS will consider public comments and revise the health consultation as necessary. A final version will be released to community members, city officials, the TCEQ, the EPA and other interested parties.
- DSHS will provide community education regarding human health concerns in Kermit, TX during community events.
- DSHS will continue to work with ATSDR, EPA, and TCEQ to evaluate additional data as they become available.

Background

The Texas Department of State Health Services (DSHS) evaluated the public health significance of groundwater contamination with trichloroethylene (TCE) and tetrachloroethylene (PCE) in Kermit, Winkler County, Texas. This site is known as the Highway 18 Groundwater Plume Superfund site. The United States Environmental Protection Agency (EPA) added the site to the National Priorities List (NPL) on August 3, 2017 [1]. DSHS evaluated available environmental data including water samples from 18 private residential wells from 2013 to 2015 and routine compliance samples of the Kermit PWS from 1994 to 2018 to determine if past and present exposure to chemicals in drinking water may harm people's health. DSHS will review and evaluate additional data as it becomes available.

PCE and TCE have a variety of industrial uses. PCE is mostly used as a cleaning agent at dry cleaners, degreasing operations, and in auto products, and is used during the process of making other chemicals [2]. TCE can be used in the process of making textiles and when removing grease from fabricated metal parts [3]. TCE and PCE are both hazardous to human health at certain levels. Under certain environmental conditions, PCE and TCE can break down into other volatile organic compounds (VOCs) such as vinyl chloride [3].

Site Description and History

The Highway 18 Groundwater Plume site is located in Kermit, Winkler County, Texas at the intersection of Highway 18 and Jeffee Drive. Groundwater in the Santa Rosa aquifer at the site is contaminated with TCE and PCE. The Kermit PWS first detected TCE in its system in 1994 and PCE in 2000 as part of routine compliance sampling for federally regulated contaminants. However, TCE and PCE levels at the distribution points have consistently been below EPA's maximum contaminant level (MCL)[1] of 5 µg/L [4].

During three sampling events conducted from 2013 to 2015, the Texas Commission on Environmental Quality (TCEQ) tested private residential and public drinking water wells within a 4-mile radius of the site's presumed center [5]. Based on data collected during these sampling events, the groundwater plume is assumed to be located at the intersection of Highway 18 and Jeffee Drive [6]. The extent of the groundwater contamination beyond approximately 0.25-mile northwest of the site center is unknown due to the lack of groundwater wells to sample in that area (see Appendix B). Also, the source area(s) of contamination and the direction of the groundwater flow are not known at this time.

The Santa Rosa Sandstone, the Santa Rosa aquifer, and the Cenozoic Pecos Alluvium aquifer are the primary sources of water for the Kermit PWS and private drinking water wells [6]. Surrounding the site, the Santa Rosa aquifer is approximately at 250 ft below ground surface (bgs) to 500 ft bgs and consists of sandstone and clay. The Cenozoic Pecos Alluvium surrounding the site is located at 2-6 ft bgs to approximately 250 ft bgs and consists of sand and gravel [6].

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[1] MCLs are enforceable regulations that limit the highest levels of a contaminant that are allowed in drinking water by the EPA.

In some areas, the Chinle Formations Equivalent, which consists of shale and gray sandstone, lies between the Cenozoic Pecos Alluvium and the Santa Rosa aquifer while in other areas it is speculated that the two aquifers are interconnected. TCE and PCE are suspected to have been released onto the ground and then to have migrated through the Cenozoic Pecos Alluvium to the Santa Rosa aquifer.

Approximately 5,708 people live in Kermit; 51% are female and the majority (59%) are Hispanic/Latino [7]. The city of Kermit has mixed residential and commercial usage. The area surrounding the city is mostly used for industrial purposes [6]. The Kermit PWS serves an estimated 5,714 individuals and has 2,465 residential connections [8].

The Kermit PWS owns 12 public drinking water wells, 9 of which are currently used. These wells draw from the Santa Rosa aquifer. Water from the wells is diverted to two separate entry points (EP) for distribution: the Underwood Pump House (henceforth known as EP1) and the Walton Pump House (henceforth known as EP2). The water is mixed (blended) and stored in underground tanks at each entry point before it is distributed. Water from four Kermit PWS wells is mixed and distributed through EP1, and water from the remaining five active Kermit PWS wells is mixed and distributed through EP2. Each entry point provides water to approximately half of the population served [6].

Available Data

Groundwater

DSHS evaluated data from two sources in this health consultation: (1) TCEQ data collected from 2013 to 2015 from 18 private residential wells and 11 Kermit PWS wells; and (2) Kermit PWS routine compliance sampling from 1994-2018, collected from EP1 and EP2.

From 2013 to 2015, TCEQ conducted three sampling events and collected groundwater samples from 18 private residential wells and 11 Kermit PWS wells. Some of these wells were sampled multiple times. All samples were analyzed for VOCs.

People are not exposed directly to water from the 11 individual Kermit PWS wells at the wellheads because the water is mixed and stored in underground tanks at each entry point before it is distributed, as described above. Therefore, DSHS evaluated data collected by the Kermit PWS at EP1 and EP2 from 1994-2018 as part of routine sampling for regulated contaminants. These samples represent the chemical concentrations people are exposed to when using the Kermit PWS water.

TCE was detected in three Kermit PWS wells and during Kermit PWS' Safe Drinking Water Act routine compliance sampling at EP1 and EP2. TCE was not detected in any private residential wells. PCE was detected in six Kermit PWS wells and two private residential wells, including one belonging to the Kermit Independent School District (ISD). PCE was also detected during Kermit PWS' routine sampling for regulated contaminants. Toluene was detected in one Kermit PWS well. It was not detected in private residential wells nor during Kermit PWS' routine compliance sampling for regulated contaminants (see Appendix C, Table C1).

Soil

TCEQ also conducted soil sampling in 2014 and 2015. Samples were taken from multiple commercial properties that were suspected sources of contamination. In total, 19 soil samples were collected and analyzed for VOCs. None of these samples contained detectable levels of VOCs, so the data were not evaluated further [6].

Data quality

Data reviewed in this report were collected by TCEQ or the Kermit PWS using standard procedures. Data collected by TCEQ were reviewed by EPA for quality assurance/quality control. Thus, DSHS assumed adequate quality assurance/quality control procedures were followed with regards to data collection, chain of custody, laboratory procedures, and data reporting.

Exposure Evaluation

Chemical contamination in the environment can only harm a person's health if there is contact with (exposure to) the chemical and if the amount of the chemical the person comes into contact with is high enough to cause harm. Whether people can come into contact with a chemical depends on several factors, including: 1) the source of contamination (where the chemical comes from); 2) how the chemical is transported through environmental media (e.g., movement through the air); 3) a point of exposure (e.g., outdoor air); 4) a route of human exposure (e.g., breathing in the outdoor air); and, 5) an exposed population (e.g., people living and working in the area with contaminated air) [9]. Contact with a chemical will only happen if there is a completed exposure pathway. All five of these factors must be present in order for an exposure pathway to be completed [9]. DSHS evaluated multiple pathways in this health consultation (see Table 1).

Table 1. Exposure Pathways Evaluated at the Highway 18 Groundwater Superfund Site

Source	Point of Exposure	Environmental Media	Route of Human Exposure	Exposed Population	Pathway Classification
Unknown	Kermit PWS drinking water	Groundwater	Ingestion Inhalation Dermal contact	Residents (all ages)	Past (completed) Present (completed) Future (potential)
Unknown	Private residential wells	Groundwater	Ingestion Inhalation Dermal contact	Residents (all ages)	Past (completed) Present (potential) Future (potential)
Unknown	Homes and other occupied buildings above the groundwater plume	Indoor air (vapor intrusion)	Inhalation	Residents (all ages) and other building occupants	Past (potential) Present (potential) Future (potential)
Unknown	At the potential source area(s)	Soil	Ingestion Dermal contact	Residents (all ages), visitors, workers	Past (potential) Present (potential) Future (potential)
Unknown	At the sampled commercial properties	Soil	Ingestion Dermal contact	Visitors and workers	Past (eliminated) Present (eliminated) Future (eliminated)

Public Health Implications

DSHS used a two-step process to determine if exposure to detected chemicals might harm people's health. First, DSHS conducted a screening analysis to determine if site-related exposures might harm people's health. During the screening analysis, DSHS evaluated private residential well data and Kermit PWS routine sampling data by comparing the maximum concentration of each chemical to environmental screening comparison values published by the ATSDR. Comparison values (CVs) are the chemical-and media-specific (i.e., air, water, soil) concentrations of a contaminant that are not likely to harm people's health (see Appendix C, Table C1). It is important to note that if a chemical concentration exceeds a CV, it does not necessarily mean there is a health concern. It means the chemical-and site-specific exposure scenario warrants the calculation of chemical-and site-specific doses. These doses are then compared to health-based guidelines. For contaminants over the CV, DSHS estimated the total dose from all exposure pathways for children and adults. To evaluate non-cancer health effects, DSHS compared the estimated total dose to ATSDR's appropriate health-based guideline. For chemicals capable of causing cancer, DSHS calculated the cancer risk from the estimated total dose (See Appendix E, Table E1). Cancer risk estimates represent a theoretical excess cancer risk which is expressed as a proportion of the exposed population that may be affected by the chemical during a lifetime of exposure.

For doses that exceeded the health-based guidelines, DSHS conducted a more detailed public health evaluation by comparing estimated doses to toxicological studies to assess potential public health impacts. More information regarding the evaluated health impacts can be found in the Health Effects Evaluation section of the document.

Past, present, and future exposure: ingestion of Drinking Water and Inhalation After Showering and other household water use

To determine which contaminants detected in drinking water were selected for further evaluation, DSHS compared the maximum concentrations of toluene, TCE, and PCE found in groundwater samples to ATSDR's CVs for drinking water (see Appendix C, Table C1).

TCE and PCE are volatile and can easily move from water into air during normal household water usage, such as showering and cleaning [10]. Therefore, DSHS also assessed inhalation of TCE and PCE in indoor air. DSHS used the ATSDR Shower and Household Water-use Exposure (SHOWER) Model (Version 1.0.1) to estimate average daily TCE and PCE concentrations in indoor air. These average daily concentrations were compared to ATSDR's comparison values for air (see Appendix C, Table C2). For information regarding the SHOWER Model calculations and assumptions, see Appendix D.

Private Residential Wells

DSHS evaluated past (since 2013 until 2015) exposure to water from 18 private residential wells that were sampled. TCE was not detected in any of the private residential wells (see Appendix C, Table C1). PCE was detected in two of 18 private residential wells sampled and screened against ATSDR's CVs.

Ingestion - PCE concentrations did not exceed ATSDR's CV for drinking water

Inhalation - DSHS used the maximum PCE water concentration, which was collected from the Kermit ISD Well #1, to estimate the average daily indoor air concentration resulting from household water use. The modeled air concentration did not exceed the ATSDR air CV (see Appendix C, Table C2).

PCE concentrations found in private residential well water are not likely to harm people's health.

DSHS did not have sufficient data to evaluate future exposures nor exposures occurring prior to 2013. Groundwater is currently thought to flow to the southwest, but it is still being assessed. Once the groundwater flow direction is determined, any groundwater wells located downgradient of the suspected plume location(s) (i.e., in the direction the plume is moving) could be at risk for future TCE and PCE contamination and should be monitored regularly.

Kermit Public Water System

DSHS reviewed data collected from the 11 Kermit PWS wells (see Appendix C, Table C1). However, since people do not come into contact with water directly from these wells, the data do not represent chemical concentrations that people are exposed to and were not further evaluated. DSHS evaluated past (1994-2018) and present exposure to drinking water supplied by Kermit PWS using data collected from EP1 and EP2 during routine sampling for regulated contaminants. This water is mixed from the individual Kermit PWS wells and represents the chemical concentrations people are exposed to when using the Kermit PWS water (see Appendix C, Table C1).

Ingestion – The maximum PCE concentrations detected during routine sampling did not exceed the CV. The maximum TCE concentration exceeded the CV at EP1, but not at EP2.

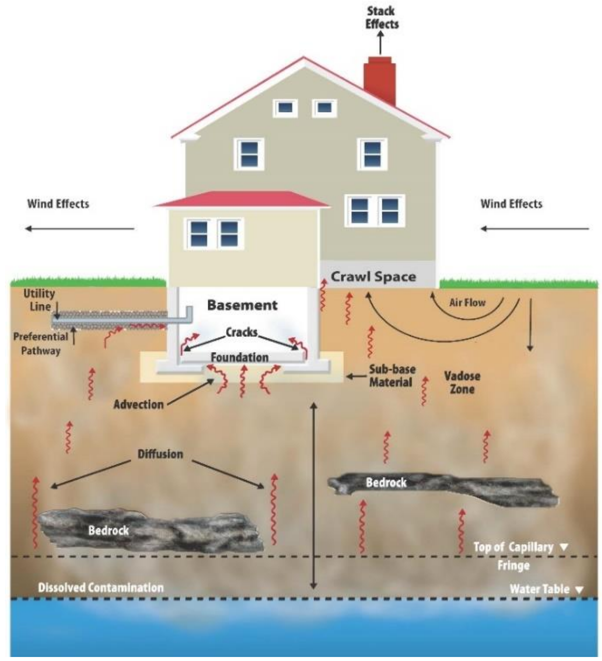
Inhalation – DSHS used the maximum PCE and TCE concentrations detected during routine sampling for regulated contaminants at EP1 and EP2 to estimate average daily indoor air concentrations resulting from household water use. The estimated PCE concentrations did not exceed the PCE air CV; however, the estimated TCE indoor air concentration exceeded the TCE air CV (see Appendix C, Table C2).

Since the maximum TCE concentrations exceeded the CVs for both ingestion and inhalation for residents supplied by EP1, DSHS proceeded to evaluate the public health impacts of exposure to the chemical in Kermit PWS water.

Vapor Intrusion

Because TCE and PCE were detected in the groundwater and may be present in the shallow groundwater table, volatile contaminants could potentially migrate through soil in the form of vapor and enter the indoor air of homes and workplaces [11]. This process is called vapor intrusion and could lead to inhalation of contaminants in indoor air (see Figure 1). However, DSHS could not assess this exposure pathway because source area(s) and the extent of the contamination are not known at this time. The characterization of the extent and source area(s) of the contamination are needed to understand if overlying or nearby buildings and homes are at risk of vapor intrusion. Also, subsurface soil, soil gas, or shallow water samples have not been collected.

FIGURE 1: VAPOR INTRUSION DIAGRAM



Source: ATSDR Evaluating Vapor Intrusion Pathways [11]

Incidental Ingestion and Dermal Contact with Soil

DSHS evaluated 19 soil samples that were taken in 2014 and 2015 from multiple commercial properties that were suspected sources of contamination. None of these samples contained detectable levels of VOCs, so the data were not evaluated further [6]. DSHS will evaluate the soil pathway if the source(s) is determined and additional samples are available. Until then, DSHS cannot eliminate the soil pathway.

Health Effects Evaluation

DSHS calculated ingestion exposure doses for TCE using age-specific ingestion rates and body weights, assuming residents supplied by EP1 were exposed to the maximum contaminant concentration measured during routine sampling (1.4 µg/L). DSHS did not calculate doses for residents supplied by EP2 because contaminants did not exceed their corresponding CVs. DSHS used the ATSDR SHOWER Model to calculate age-specific inhalation and dermal exposure doses. Ingestion, inhalation, and dermal doses were added together to determine age-specific total exposure doses (see Appendix D, Table D9). This total exposure dose is an estimate of how much TCE people are exposed to from all routes of exposure combined. Doses vary between age groups because of differences in factors such as intake and ventilation rates per kilogram body weight [9]. To be protective of public health, DSHS used conservative assumptions to calculate doses, assuming higher-than-average exposures (See Appendix D, Table D8).

Non-Cancer Health Effects

To evaluate non-cancer health effects, DSHS compared estimated total exposure doses to health-based guidelines. The health-based guideline used for TCE was ATSDR'S chronic minimal risk level (MRL) of 5×10^{-4} mg/kg/day [2]. MRLs are based on laboratory or human studies that document no observed or lowest observed adverse effects levels (NOAELs or LOAELs). If an estimated exposure dose is below the MRL, adverse non-cancer health effects are not expected to occur [9]. It is important to note that if an estimated dose is higher than the MRL, it does not necessarily mean it will harm people's health; it means that an in-depth evaluation is needed to determine if non-cancer health effects are likely.

Estimated total TCE doses for children ranged from 1.5×10^{-4} mg/kg/day to 6.6×10^{-4} mg/kg/day, with children between the ages of 1 and 2 years old having the highest dose (see Appendix D, Table D9). The estimated doses for adults, and pregnant women were 1.5×10^{-4} mg/kg/day, and 2×10^{-4} mg/kg/day, respectively. The estimated total dose for children between the ages of 1 and 2 years old exceeded the MRL (5×10^{-4} mg/kg/day). Therefore, DSHS conducted an in-depth evaluation of non-cancer health effects of exposure to TCE.

Scientific data indicate the immune system, kidney, and liver may be affected by TCE exposure, and also suggest developmental effects such as fetal heart malformations and immune system effects are the most sensitive targets of TCE toxicity [3]. These health effects have been observed in oral and inhalation studies.

The MRL is based on three critical studies in which adverse effects on the immune system and fetal heart malformations were noted in mice and rats exposed to TCE in drinking water:

- In one study, pregnant female rats that were exposed to TCE were shown to give birth to newborns with a higher rates of developmental heart defects [11]. Scientists used the results of this study to develop a 99^{th} percentile human equivalent dose (HED_{99}) for TCE of 0.0051 mg/kg/day. An HED_{99} is the dose expected to produce similar health effects in humans. This HED_{99} is the value used by ATSDR to evaluate the potential for developmental heart defects in babies as a result of pregnant women being exposed to TCE during the three-week window of critical fetal heart development in the first trimester of pregnancy [12]. The estimated total dose for pregnant women exposed to TCE is 25 times lower than the observed HED_{99} (0.0051 mg/kg/day).
- A HED_{99} health effect level of 0.048 mg/kg/day was derived from a study that showed immune system effects and decreased thymus weight in female adult mice exposed to TCE in drinking water for 31 weeks [13]. This value is used by ATSDR to evaluate potential non-cancer immune system health effects for all age groups [6]. The estimated total dose for children between the ages of 1 and 2 years old exposed to TCE is 73 times lower than the observed HED_{99} (0.048 mg/kg/day).

- A LOAEL of 0.37 mg/kg/day was derived from a study of mice exposed to TCE in drinking water during gestation and following birth [14]. This value is used by ATSDR to evaluate potential noncancerous developmental immunotoxicity health effects for all age groups [6]. The estimated total dose for children between the ages of 1 and 2 years old exposed to TCE is 560 times lower than the observed LOAEL (0.37 mg/kg/day) used to evaluate immunotoxicity effects in mice.

The total estimated TCE dose for children between the ages of 1 and 2 years old, considered to be the most highly exposed age group, was well below the health effect levels for immunological effects. Therefore, past and current exposures are not expected to harm the health of adults or children of all ages.

Cancer Health Effects

TCE is classified as a human carcinogen. DSHS estimated TCE cancer risks from ingestion, dermal, and inhalation exposure. Since the exact duration of exposure to residents is unknown, DSHS used a conservative approach in the calculating the adult and child cancer risks by assuming 21 years of exposure for children and 33 years of exposure for adults, which is based on an above-average residential occupancy duration for the U.S. population [15]. TCE is a mutagen. A mutagen is a physical or chemical agent that changes genetic material. Changes in genetic material can cause cancer. If exposure to TCE occurs in early life, there is an increased risk for developing kidney cancer. To better determine the risk to children, DSHS used age-dependent adjustment factors (ADAFs) for children. A detailed discussion of cancer risk calculations is found in Appendix E.

Cancer risk estimates are not actual cases of cancer in a given community. Instead, they are a tool used by DSHS to determine whether there are exposures that put people at an increased risk for cancer and warrant a public health recommendation to protect health

DSHS estimates the excess cancer risk for children to be five cancers in a population of one million. For adults, DSHS estimates the excess cancer risk to be three in a population of one million (see Appendix E, Table E1). DSHS interprets this to be a low increased lifetime risk of developing cancer among both children and adult; therefore, no public health recommendations are needed to protect health.

Children’s Health Considerations

In communities faced with air, water, or soil contamination, children could be at greater risk than adults from certain kinds of exposure to hazardous substances. A child’s lower body weight and higher intake rate result in a greater dose of hazardous substance per unit of body weight. Sufficient exposure levels during critical growth stages can result in permanent damage to the developing body systems of children. Studies suggest fetuses and young children may be especially sensitive to the harmful effects of TCE [3]. Children are dependent on adults for access to housing and medical care, and for risk identification and exposure prevention. Consequently, adults need as much information as possible to make informed decisions regarding their children's health. DSHS took this into account, and specifically evaluated exposures among young children and pregnant women.

Limitations

The source, timeframe, and lateral and vertical extent of contamination is unknown at this time and cannot be determined based on currently-available data. Some of the drinking water wells were not sampled during each of the three sampling periods, so DSHS could not assess the changes over time.

The groundwater flow direction is still being assessed, which limits DSHS' ability to evaluate future exposures.

DSHS does not know how long people were exposed to TCE or PCE in the Kermit PWS drinking water. Sampling data prior to 1994 was not available. While TCE was first detected in 1994, contamination could have occurred earlier.

One potential exposure pathway (vapor intrusion) could not be assessed because the source area(s) and the extent of the contamination are not known at this time. Also, subsurface soil, soil gas, or shallow water samples have not been collected.

Conclusions

Based on the currently-available data, DSHS reached three conclusions:

Conclusion 1: People who used private residential well water tested from 2013 to 2015 are not currently exposed to TCE or PCE at levels expected to harm people's health. Data are not available to evaluate the risk for harmful exposures before 2013 or after 2015. In the future, people using private residential wells downgradient of the plume(s) (i.e., located in the path of the plumes' movement) could be exposed to PCE or TCE through ingestion (drinking the water), inhalation (breathing TCE that has evaporated from water while showering, bathing, washing dishes, etc.), or dermal (skin contact) exposure if the plumes migrate.

<u>Basis for Conclusion</u>: Limited sampling of water from private wells was available for DSHS' evaluation with some private wells sampled only one time over the 2-year sampling period. During the 2013-2015 sampling events, TCEQ found PCE in the drinking water from two private residential water wells at levels that are not expected to cause harm from ingestion, inhalation, or dermal contact during showering, hand washing, and bathing. TCEQ did not detect TCE in any of the private residential wells sampled. Private residential well water samples were not collected prior to 2013. There is currently no ongoing well monitoring program, so the DSHS cannot assess potential future exposures. Current knowledge indicates groundwater flows to the southwest, but the flow direction is still being assessed. Once the groundwater flow direction is determined, any wells located downgradient of the suspected plume location(s) (i.e., in the direction the plume is moving) could be at risk for future TCE and PCE contamination.

Conclusion 2: Past and current ingestion, inhalation, or dermal exposure to PCE and TCE in water supplied by the Kermit PWS is not expected to harm people's health.

Basis for Conclusion: During past routine sampling for regulated contaminants from 1994 to 2018, PCE and TCE were not found at levels expected to harm people's health. Kermit PWS blends water from multiple public water wells prior to distribution through two entry points, the Underwood Pumphouse (EP1) and the Walton Pumphouse (EP2). DSHS evaluated exposures to drinking water from Underwood Pumphouse (EP1) because levels of TCE from this entry point were above health comparison values. Using the ATSDR Shower and Household Water-Use Exposure (SHOWER) model (version 1.0.1), DSHS estimated total exposure doses for people drinking, breathing, and coming in contact with water containing the maximum TCE level detected in the Underwood Pumphouse (EP1). By using the maximum TCE level detected from 1994 to 2018, DSHS was able to a highly protective health assumption approach when determining health risks. DSHS determined that estimated exposure doses for all residents were below levels at which health effects occurred in scientific studies. Water supplied to residents from the Walton Pumphouse (EP2) did not have contact with concentrations above health comparison values, therefore, harmful effects are unlikely, and exposures were not evaluated further.

Conclusion 3: Because TCE and PCE were detected in the groundwater and may be present in the shallow groundwater table, volatile contaminants could potentially migrate through soil in the form of vapor and enter the indoor air of homes and workplaces. This process is called vapor intrusion and could lead to inhalation of contaminants in indoor air. DSHS does not have enough information to determine if past, present, or future inhalation of TCE or PCE resulting from vapor intrusion could harm people's health.

Basis for conclusion: DSHS could not assess this exposure pathway because the source area(s) and the extent of the contamination are not known at this time. Also, subsurface soil, soil gas or shallow water environmental samples have not been collected.

Recommendations

DSHS recommends that:

1. EPA continue their investigation of the extent and source(s) of groundwater contamination in the shallow aquifer (Cenozoic Pecos Alluvium) and the Santa Rosa aquifer.

2. EPA develop and implement an ongoing monitoring plan for private residential wells that are currently contaminated or at risk for future contamination based on direction of groundwater flow. Once the groundwater flow direction is determined, any drinking water wells located downgradient of the suspected plume location(s) (i.e., in the direction the plume is moving) could be at risk for future TCE and PCE contamination and should be monitored regularly.

3. EPA evaluate the vapor intrusion pathway at and around the site.

Actions Planned

- DSHS will provide the final version of this document after the public comment period to community members, city officials, the TCEQ, the EPA and other interested parties.
- DSHS will provide community education regarding human health concerns in Kermit, TX during community events.
- DSHS will continue to work with EPA and TCEQ to evaluate additional data as they become available. The results will be summarized in additional Health Consultations or a Public Health Assessment, as needed.

Preparers of Report

Texas Department of State Health Services (DSHS) prepared this Health Consultation for the Highway 18 Groundwater site, located in Kermit, TX. This publication was made possible by Grant Number TS17-1701.NU61 under a cooperative agreement with the federal ATSDR. DSHS 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 DSHS.

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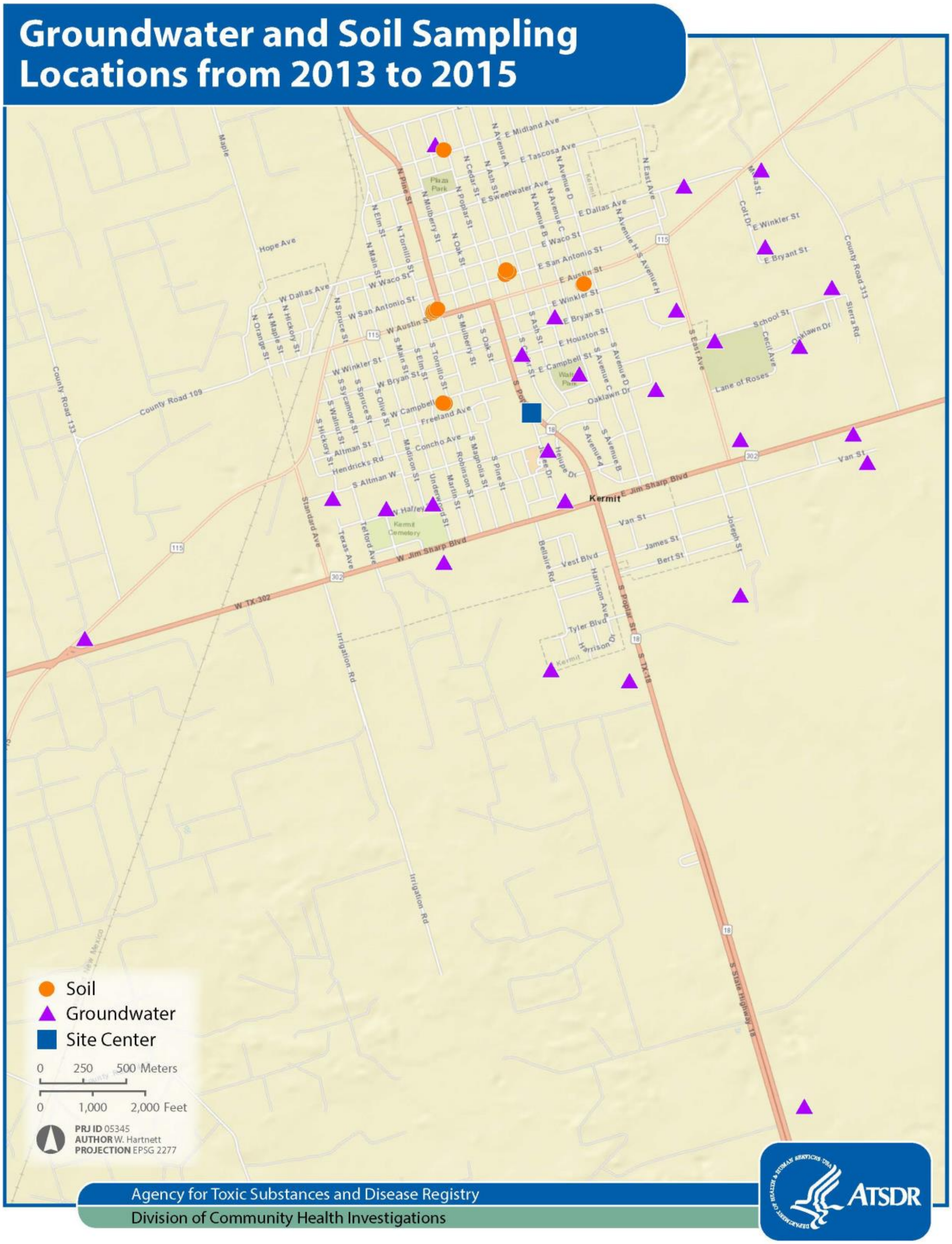
Appendix A: Acronyms and Abbreviations

µg/L	Micrograms per liter
mg/kg/day	Milligrams kilogram per day
$\mu g/m^3$	Micrograms per cubic meter
ADAF	Age Dependent Adjustment Factors
ADHEC	Average Daily Human Exposure Concentration
ATSDR	Agency for Toxic Substances and Disease Registry
CREG	Cancer Risk Evaluation Guide
CSF	Cancer Slope Factors
DSHS	Texas Department of State Health Services
EP	Entry Points
EPA	Environmental Protection Agency
HED_{99}	99^{th} Percentile Human Equivalent Dose
ISD	Independent School District
MCL	Maximum Contaminant Level
MRL	Minimum Risk Level
ND	Not Detected
NPL	National Priority List
PCE	Tetrachloroethylene
PWS	Public Water System
RMEG	Reference Dose Media Evaluation Guide
SHOWER	Technical Documentation for Shower and Household Water-use Exposure model
TCE	Trichloroethylene
TCEQ	Texas Commission on Environmental Quality
TWA	Time-Weighted Average
VOCs	Volatile Organic Compounds

Appendix B: Sampling Locations



Appendix C: Comparison Value Screening

DSHS evaluated available environmental data by comparing the maximum concentration of each chemical to environmental screening comparison values published by the Agency for Toxic Disease Registry (ATSDR). Comparison values are the chemical-and media-specific (i.e., air, water, soil) concentrations of a contaminant that are not likely to harm exposed people's health. Comparison values are derived from toxicological and epidemiological literature on chemical-specific routes of exposure and health effects. Chemicals found at concentrations greater than their respective comparison values are selected for further public health evaluation.

Table C1. PCE, TCE, and toluene concentrations in Kermit, Texas private residential wells (2013-2015), Kermit Public Water System wellheads (2013-2015), and routine samples from Kermit PWS EP1, EP2 (1994-2018) compared to ATSDR drinking water comparison values

Contaminant	Water Source	Number of Samples	Concentration Range (µg/L)	Comparison Value (µg/L)	Number of Samples with Contaminant Detections	Number of Samples Exceeding Comparison Value
Trichloroethylene (TCE)	Kermit PWS (EP1)	29	0.5 - 1.4	0.43 (CREG)	24	24
	Kermit PWS (EP2)	27	ND - ND		0	0
	Kermit PWS wellheads*	19	ND - 1.46		5	**5**
	Private residential wells	26	ND - ND		0	0
Tetracholorethylene (PCE)	Kermit PWS (EP1)	28	ND - ND	12 (CREG)	0	0
	Kermit PWS (EP2)	26	ND - 2.9		11	0
	Kermit PWS wellheads*	19	ND - 45.7		10	2
	Private residential wells	26	ND - 1.50		4	0
Toluene	Kermit PWS (EP1)	14	ND - ND	560 (RMEG)	0	0
	Kermit PWS (EP2)	14	ND - ND		0	0
	Kermit PWS wellheads*	7	ND - 0.6		1	0
	Private residential wells	20	ND - ND		0	0

*Unblended water sample collected from wellhead; this does not represent an actual exposure concentration for residents as drinking water is blended prior to distribution to residents.

ND = Not Detected; CREG = Cancer Risk Evaluation Guide; RMEG = Reference Dose Media Evaluation Guide

Data source: Hazard Ranking System Documentation Record and TCEQ Drinking Water Watch [4, 7]

Table C2. Estimated TCE and PCE indoor air daily human exposure concentrations from the SHOWER Model

Contaminant	Water Source	Maximum Water Concentration (µg/L)	Estimated Indoor Air Concentration based on the ATSDR Shower Model (µg/m³)	Comparison Value (CREG) (µg/m³)
TCE	Kermit PWS (EP1)	1.40	0.48*	0.21
TCE	Private residential wells	ND	0.17	0.21
PCE	Kermit PWS (EP2)	2.90	0.69	3.80
PCE	Private residential wells	1.50	0.36	3.80

*Estimated air concentration exceeded ATSDR air comparison value.
ND = Not Detected. For the non-detection of TCE in Private Residential Wells, the detection limit was used which was 0.5 µg/L.
CREG = Cancer Risk Evaluation Guide
Results are based on the four-person household model default exposure scenario.

Appendix D: Exposure Dose Equation Analysis

Estimated exposure doses are calculated to determine the amount of a chemical that could get into the body. These estimated exposure doses are calculated using the chemical concentration and default exposure parameters from ATSDR's Public Health Assessment Guidance Manual[1], EPA's Exposure Factors Handbook[2], ATSDR's Exposure Dose Guidance for Water Ingestion[3], and the Shower and Household Water-use Exposure (SHOWER) Model (V1.0.1)[4] when site-specific information is unknown.

Ingestion Dose

The contaminant concentration for the water ingestion exposure dose is based on maximum concentration of TCE in the Kermit PWS, which was 1.4 µg/L. Age-specific ingestion rates and body weights in Table D8 were used with the below formula to calculate age-specific estimated exposure doses for drinking water.

Water Ingestion Exposure Dose Equation[5]

$$D = \frac{C\ x\ IR\ x\ EF}{BW}$$

D = exposure dose (mg/kg-day)
C = contaminant concentration (mg/L)
EF= exposure factor (unitless)* default of 1, assuming person daily exposure.
IR = ingestion rate of water (L/day)
BW = body weight (kg)

Exposure Factor Equation

$$EF = F\ x \frac{ED}{AT}$$

F = frequency of exposure (days/year)
ED = exposure duration (years)
AT = averaging time (days--ED x 365 days/year for non-carcinogens; 78 years x 365 days/year for carcinogens)

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[1] Agency for Toxic Substances and Disease Registry, *Public Health Assessment Guidance Manual (2005 Update)*, U.S. Department of Health and Human Services. Public Health Service, 2005: Atlanta, Georgia.

[2] U.S. Environmental Protection Agency. Exposure Factors Handbook. Available at: http://www.epa.gov/ncea/efh/report.html. Last accessed July 30, 2018.

[3] 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.

[4] Agency for Toxic Substances and Disease Registry (ATSDR), *Exposure Dose Guidance for the Shower and Household Water-use Exposure (SHOWER) Model v1.0* U.S. Department of Health and Human Services. Public Health Service. 2018: Atlanta, Georgia.

[5] 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.

Usage of SHOWER Model for Calculation of Dermal and Inhalation Doses

DSHS used the ATSDR SHOWER model to calculate estimated indoor air concentrations. If a contaminant surpassed either the indoor air comparison values or the drinking water comparison values, DSHS went on to calculate doses for inhalation and dermal exposure using the SHOWER model. Results for PCE are not shown because neither the estimated indoor air nor maximum water concentrations exceeded their respective comparison values. The SHOWER model outputs dermal and inhalation doses for each exposure group based on the maximum water concentration of TCE of 1.4 µg/L. The doses modeled are based on many assumptions in the SHOWER model.

DSHS used a conservative approach to calculate the inhalation and dermal doses by selecting the highest exposed person in the modeled scenario. This scenario included a person showering after four consecutive morning showers in a four-person household with no ventilation fan and assumed that the person is home all day. Each household member takes an eight-minute shower with a five-minute stay in the bathroom. Children at age of birth to less than 1 year of age were not evaluated for shower scenarios because they do not shower. According to EPA's Exposure Factor Handbook, 9% of children 1 to less than 2 years of age and 14% of children 2 to less than 6 years of age take showers[6].

Dermal Dose

Dermal absorption of TCE and PCE through the skin during showering, and hand contact with faucet water is also an exposure pathway that can contribute to the total dose of exposure for a person[7]. The below dermal equations were used to calculate the total dermal absorbed dose from showering, and handwashing exposure based on the maximum concentration of TCE of 1.4 µg/L. Depending upon the activity, the model used various approaches for calculating the water concentration used to estimate dermal uptake. The SHOWER model assumed the person would have a total of five-bathroom sink uses events per day and fifteen main house sink uses per day (e.g., kitchen, utility sinks) and one shower or bath.

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[6] U.S. Environmental Protection Agency. Exposure Factors Handbook. Available at: http://www.epa.gov/ncea/efh/report.html. Last accessed July 30, 2018.

[7] Agency for Toxic Substances and Disease Registry (ATSDR). 2018. Technical Document for the Shower and Household Water-use Exposure (SHOWER) Model v1.0. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, May 23

Dermal Dose Equation[8]

Part 1: $DA\ event = FA\ \times\ Kp\ \times\ C'w \times \frac{tevent}{1+\ B} + 2\ \times\ \tau event\ \times (\frac{1+3B+3B2}{(1+B)2})$

$$where, B\ =\ Kp\ \times \frac{\sqrt{MW}}{2.6}$$

DA_{event} = absorbed dose per event (mg/cm^2-event)
FA = fraction absorbed water (dimensionless)
C'W = average chemical concentration in shower, or faucet water(mg/cm^3)
τevent = lag time per event (hr/event)
tevent = site-specific event duration (hr/event)
t* = chemical-specific time to reach steady state (hr)
Kp = dermal permeability coefficient of compound in water (cm/hr)
B = dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis (dimensionless)
MW = molecular weight of contaminant

Part 2: $\boldsymbol{DAD}\ = \frac{DA\ event\ x\ SA\ x\ EV\ x\ EF}{BW}$

DAD = dermal absorbed dose (mg/kg/day)
DA event = absorbed dose per event (mg/cm^2/event)
SA = exposed body surface area (cm^2)
EV = event frequency (events/day)
EF = exposure factor (unitless)
BW = body weight (kg)

The SHOWER model will then calculate the total DAD by adding the individual DADs from showering, and hand contact with water throughout the day. The total absorbed dermal dose is shown in Table D9.

Part 3: $\boldsymbol{DAD_{total}} = DAD_{Shower} + DAD_{hand\ contact}$

Inhalation Dose

TCE and PCE are volatile organic compounds that can escape or volatize from contaminated water in indoor air when used for household purposes such as showering, bathing, or using the toilet and dishwasher. Inhalation of TCE and PCE while taking a shower can contribute significantly to the total dose for an exposed person.

[8] Agency for Toxic Substances and Disease Registry (ATSDR). 2018. *Technical Document for the Shower and Household Water-use Exposure (SHOWER) Model v1.0*. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, May 23

TCE concentrations in the main house rise and fall depending upon movement of contaminated air from the shower and bathroom as well as from other water sources being turned on and off throughout the day. The SHOWER model calculates the concentration in the indoor air for multiple sections of the house including the main house, the shower stall, and the bathroom. The shower stall has one direct source (i.e., shower water), while the bathroom has three direct sources (i.e., the toilet, the sink faucet, and the bathtub). The main house has three direct sources (i.e., the kitchen faucet, the clothes washer, and the dishwasher). The SHOWER model also accounts for TCE entering a different section either directly from the sources within the compartment or indirectly from another compartment. Thus, based on when and how long a source is used during the day (e.g., shower, bathtub, faucet, washers), the model predicts the concentration in the shower, the bathroom, and the main house for each second of the day (i.e., 86,400 seconds)[9].

The SHOWER model then calculates the average daily human exposure concentration (ADHEC) for the person. This ADHEC is a time-weighted average (TWA). The ADHEC is calculated by using the sum of all the contaminant air concentrations in the compartment where the person is located at each second of the day and divides it by the total number of seconds in a day (86,400 seconds). For the most highly exposed person in this scenario, Table D1 shows the exposure time and concentration that people experience from being in the shower and being in the bathroom immediately after the shower, separately from being in the house the rest of the day. In general, the chemical air concentrations in the shower and bathroom increase when persons take a shower or a bath and slowly decline afterwards. The exposure concentration from a shower and bathroom stay are much higher than the exposure concentrations from being in the main house shown in Table D1 but the exposure time is much lower. The percent exposure for each compartment is represented in Table D2.

[9] Agency for Toxic Substances and Disease Registry (ATSDR). 2018. *Technical Document for the Shower and Household Water-use Exposure (SHOWER) Model v1.0.* Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, May 23.

Table D1. Average human exposure concentration of TCE in the indoor air by locations modeled in SHOWER Model

Location	Exposure Time (minutes)	Average Human Exposure Concentration of 1st Person in household	Average Human Exposure Concentration of 2nd Person in household	Average Human Exposure Concentration of 3rd Person in household	Average Human Exposure Concentration of 4th Person in household
Shower and Bathroom Stay*	13	8.5	20	28	35
Main House**	1,427	0.069	0.099	0.13	0.16
Away from House	0	0	0	0	0
Average Daily Exposure	1,440	0.14	0.28	0.38	0.48***

* Exposure based on shower time and bathroom time immediately after shower
** Includes other bathroom visits throughout the day
*** Indicates the highest calculated ADHEC that was used for inhalation dose calculations in this Health Consultation.

Table D2. Percent exposure by locations modeled in SHOWER Model

Location	Exposure Time (minutes)	Percent Exposure (%) 1st Person in Household	Percent Exposure (%) 2nd Person in Household	Percent Exposure (%) 3rd Person in Household	Percent Exposure (%) 4th Person in Household
Shower and Bathroom Stay*	13	53	65	66	67
Main House**	1,427	47	35	34	33
Away from House	0	0	0	0	0
Average Daily Exposure	1,440	100	100	100	100

* Exposure based on shower time and bathroom time immediately after shower
** Includes other bathroom visits throughout the day

The ADHEC for the 4th person in a four-person household, which was 0.48 mg/m^3 (Table D1), age-specific breathing rates and body weights were used to calculate the inhalation dose (see calculation below). After doses were calculated, they were summed together. The inhalation dose is shown on Table D9.

Inhalation Dose Equation

$$Dose = \frac{C\ x\ BR\ x\ EF}{BW}$$

C = contaminant concentration in the air (mg/m^3)
BR = breathing rate (L/min)
EF = exposure factor (unitless)
BW = body weight (kg)

Table D3. Parameters used in calculations for inhalation and dermal doses from exposures to TCE through drinking, showering, washing hands and usage of indoor household appliances

Room	Appliance	Parameter	Value
Shower	Shower	Flow rate	7.6 L/min
Bathroom	Bathroom sink	Flow rate	3.2 L/min
Bathroom	Bathroom sink	Average duration per use	0.5 min
Bathroom	Bathroom sink	Uses per person per day	5 uses/person/day
Bathroom	Bathtub	Bathtub volume	76.5 L
Bathroom	Bathtub	Flow rate	22.7 L/min
Bathroom	Toilet	Volume per flush	10.8 L/flush
Bathroom	Toilet	Flushes per person per day	5 flushes/person/day
Main house	Clothes washer	Volume per cycle	117 L/load
Main house	Clothes washer	Average cycle duration	44 min
Main house	Dishwasher	Volume per cycle	23.1 L/load
Main house	Dishwasher	Average cycle duration	73 min
Main house	Kitchen sink	Flow rate	3.2 L/min
Main house	Kitchen sink	Average duration per use	0.5 min
Main house	Kitchen sink	Uses per person per day	15 uses/person/day
Main house	Other main house faucets	Average volume use per person per day	10.2 L/person/day

Table D4 provides the information used in the SHOWER model to determine exposure from the shower. The table includes the number of persons in the household, the shower or bath start time and duration, and the bathroom stay duration immediately after the shower or bath for each person. The ADHEC shown in Table D1 is calculated for the person with the highest exposure (indicated by an asterisk)[10].

[10]Agency for Toxic Substances and Disease Registry (ATSDR). 2018. *Shower and Household Water-use Exposure (SHOWER) Model v1.0, User's Guide.* Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, May 23.

Table D4. Timing and duration of showers and bathroom stays based on household size

1-Person Household size	2-Person Household size	3-Person Household size	4-Person Household size	Shower Start time	Shower Duration (min)	Bathroom stay after shower (min)
			1	6:18 a.m.	8	5
		1	2	6:32 a.m.	8	5
	1	2	3	6:46 a.m.	8	5
1*	2*	3*	4*	7:00 a.m.	8	5

Table D5. Routine times appliance used in the SHOWER Model

Clothes washer	Dishwasher
7:00 p.m.	9:00 p.m.

Table D6 shows an average human activity pattern throughout the day for the person with the highest exposure. This person starts out in the main house and then moves to other areas (the bathroom, the shower, away from home) at pre-determined times during the day[11].

Table D6. Human activity pattern throughout the day for the most highly exposed person scenario used in the SHOWER Model

Start Time	Location
12:00 a.m.	Main House
7:00 a.m.	Shower
7:08 a.m.	Bathroom
7:13 a.m.	Main House
10:00 a.m.	Bathroom
10:05 a.m.	Main House
2:30 p.m.	Bathroom
2:35 p.m.	Main House
6:30 p.m.	Bathroom
6:35 p.m.	Main House
10:00 p.m.	Bathroom
10:15 p.m.	Main House

[11] Agency for Toxic Substances and Disease Registry (ATSDR). 2018. *Technical Document for the Shower and Household Water-use Exposure (SHOWER) Model v1.0*. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, May 23.

Table D7 shows information on the size of each compartment in the house, the flow rate of the bathroom fan, and the air-exchange rate between different compartments. For scenarios in which the bathroom fan is turned off, the fan has a flowrate of 0 L/min.

- The shower stall is based on a standard small shower (3 x 3 x 8 ft);
- The bathroom is based on a standard, small bathroom (5 x 8 x 8 ft); and
- The house is based on a median size house (1,500 ft^2) with 8 ft ceilings.[12]

Table D7. Room volumes, air exchange rates, and fan flow rates used in the SHOWER Model

Parameter	Value
Shower volume	2,040 L
Bathroom volume (excluding shower)	7,020 L
Remainder of house volume	330,500 L
Flow rate of bathroom exhaust fan	0 L/min
Shower/bathroom air-exchange rate	6,100 L/hr
Bathroom/main house air-exchange rate	14,000 L/hr
House/outdoor air-exchange rate	153,200 L/hr

[12] Agency for Toxic Substances and Disease Registry (ATSDR). 2018. *Shower and Household Water-use Exposure (SHOWER) Model v1.0, User's Guide.* Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, May 23.

Table D8. Exposure assumptions used to calculate ingestion, dermal, and inhalation doses for TCE exposure through usage of water through drinking, showering, washing hands and other indoor appliance usage.

Exposure Group	Body Weight (kg)	Daily Breathing Rate (L/min)	Shower and Bathroom Breathing Rate (L/min)	Total Skin Surface Area (cm^2)	Hand Surface Area (cm^2)	Intake Rate of Drinking Water (L/day)
Birth to < 1 year	7.8	NC	NC	NC	NC	1.113
1 to < 2 years	11.4	5.56	12.00	5,300	300	0.893
2 to < 6 years	17.4	6.81	11.25	7,225	348	0.977
6 to < 11 years	31.8	8.33	11.00	10,800	510	1.404
11 to < 16 years	56.8	10.56	13.00	15,900	720	1.976
16 to < 21 years	71.6	11.32	12.00	18,400	830	2.444
Adult	80.0	10.53	12.35	19,810	980	3.092
Pregnant women	73.0	15.50	15.50	18,610	980	2.589

NC = Not Calculated

Doses are in mg/kg/day

Data Source: Agency for Toxic Substances and Disease Registry Agency for Toxic Substances and Disease Registry. *Exposure Dose Guidance for the Shower and Household Water-use Exposure (SHOWER) Model v1.0*. [4,10]

Table D9. Total TCE dose via ingestion, dermal, and inhalation exposures with maximum TCE concentration in water from Kermit Public Water System

Exposure Group	Inhalation Dose (4-Person Household) (mg/kg/day)	Ingestion Dose (mg/kg/day)	Dermal Dose (4-Person Household) (mg/kg/day)	Total Dose (mg/kg/day)	Total Dose Exceeds ATSDR Chronic Minimal Risk Level (0.0005 mg/kg/day)
Birth to < 1 year	NC	0.0002	NC	0.0002	No
1 to < 2 years	0.00054	0.00011	5.3E-06	0.000655	**Yes**
2 to < 6 years	0.00036	0.00008	4.5E-06	0.000444	No
6 to < 11 years	0.00021	0.00006	3.7E-06	0.000276	No
11 to < 16 years	0.00014	0.00005	3.0E-06	0.000192	No
16 to < 21 years	0.00011	0.00005	2.8E-06	0.000161	No
Adult	0.000098	0.00005	2.7E-06	0.000155	No
Pregnant Women	0.00015	0.00005	2.8E-06	0.000203	No

NC = Not Calculated

* Exceedance of ATSDR Chronic Minimal Risk Levels does not necessarily indicate harmful effects are likely to occur.

Appendix E: Cancer Risk Evaluation

Studies in animals and humans have shown that TCE is associated with cancer at three different target sites (non-Hodgkin lymphoma, liver, and kidney cancer), regardless of route of exposure[1,2]. EPA developed cancer slope factors (CSFs) for each target site. CSFs are quantitative indications of the carcinogenicity of a substance. CSFs estimate the increase in cancer risk per mg/kg/day of exposure to a carcinogenic substance.

DSHS estimated the adult and child cancer risks (from non-Hodgkin lymphoma, liver, and kidney cancer) for ingestion, dermal, and inhalation exposure to TCE. First, age- and route- specific risks were estimated (see Table E1). DSHS multiplied the combined dermal, ingestion, and inhalation dose by the oral CSF. DSHS assumed 33 years of exposure for adults and 21 years for children, and averaged exposures over a lifetime of 78 years[3]. Age-Dependent Adjustment Factors (ADAFs) were applied in kidney cancer risk calculations for childhood age groups to account for TCE's mutagenic mode of action and early-life susceptibility to kidney effects from TCE exposure.

TCE Total Exposure Dose Cancer Risk Equations:

$$\textit{Non-Hodgkin Lymphoma (NHL) and Liver Partial Cancer Risk} = D \times (\textit{NHL CSF} + \textit{Liver CSF}) \times \frac{ED}{LY}$$

$$\textit{Kidney ADAF-Adjusted Partial Cancer Risk} = D \times \textit{Kidney CSF} \times \textit{ADAF} \times \frac{ED}{LY}$$

NHL and Liver Partial Cancer Risk + Kidney ADAF-Adjusted Partial Cancer Risk = Total Cancer Risk

D = age-specific combined dermal, ingestion and inhalation dose (mg/kg/day; see Appendix D, Table D9)
ADAF = age-dependent adjustment factor (see Appendix E, Table E1)
CFS = cancer slope factor (mg/kg/day) (see Appendix E, Table E1)
ED = age-specific exposure during in years (see Appendix E, Table E1)
LY = lifetime in years (DSHS assumed 78 years)

[1] Agency for Toxic Substances and Disease Registry (ATSDR), *Toxicological Profile for Trichloroethylene*, U.S. Department of Health and Human Services. Public Health Service., Editor. 2014: Atlanta, Georgia
[2] United States Environmental Protection Agency (US EPA). *Toxicological Review of Trichloroethylene*. U.S. Environmental Protection Agency, Washington, DC, 2011.
[3]United States Environmental Protection Agency (US EPA), *Exposure Factors Handbook: 2011 Edition (Final)*. 2011. U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/ncea/efh/report.html. Last accessed July 30, 2018.

Table E1. Excess cancer risk among residents exposed to maximum TCE concentrations in Kermit PWS water via ingestion, inhalation, and dermal exposure

Age group	Total Dose from Ingestion, Inhalation, Dermal Exposure (mg/kg/day)	Age Group Exposure Duration (years)	Age Group Exposure Duration Averaged over a Lifetime of 78 years (unitless)	Kidney Unadjusted Lifetime Slope Factor (mg/kg/day)$^{-1}$	Kidney Cancer Default ADAF (mutagenic)	Kidney ADAF-Adjusted Partial Risk (unitless)	Kidney + NHL + Liver Unadjusted Lifetime Slope Factor (mg/kg/day)$^{-1}$	NHL+ Liver Lifetime Slope Factor (mg/kg/day)$^{-1}$	NHL and Liver Partial Risk (unitless)	Total Cancer Risk (unitless)
Birth to <1	0.000200	1	0.0128	9.3E-03	10	2.4E-7	4.6E-02	3.7E-02	9.4E-08	3.3E-07
1 to <2	0.000655	1	0.0128	9.3E-03	10	7.8E-07	4.6E-02	3.7E-02	3.1E-07	1.1E-06
2 to <6	0.000444	4	0.0513	9.3E-03	3	6.3E-07	4.6E-02	3.7E-02	8.3E-07	1.1E-06
6 to <11	0.000276	5	0.0641	9.3E-03	3	4.9E-07	4.6E-02	3.7E-02	6.5E-07	8.0E-07
11 to <16	0.000192	5	0.0641	9.3E-03	3	3.4E-07	4.6E-02	3.7E-02	4.5E-07	4.7E-07
16 to <21	0.000161	5	0.0641	9.3E-03	1	9.6E-08	4.6E-02	3.7E-02	3.8E-07	3.0E-06
Total years of childhood exposure:		21						**Cancer Risk (Children exposed from Birth to 21 years):**		5.3E-06
Adults	0.000155	33	0.4231	9.3E-03	1	6.1E-07	4.6E-02	3.7E-02	2.4E-06	3.0E-06
								Cancer Risk (Adults exposed for 33 years):		3.0E-06

mg/kg/day = milligrams per kilogram per day
ADAF = Age Dependent Adjustment Factor
NHL = Non-Hodgkin's Lymphoma