

Public Health Assessment

Initial/Public Comment Release

CTS/MILLS GAP ROAD SITE

ASHEVILLE, BUNCOMBE COUNTY, NORTH CAROLINA

EPA FACILITY ID: NCSFN0406988

**Prepared by
North Carolina Department of Health and Human Services**

JANUARY 12, 2010

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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 Health Assessment and Consultation
Atlanta, Georgia 30333

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Acronyms

AF	Attenuation factor
AT	Averaging time
ATSDR	Agency for Toxic Substances and Disease Registry
CDC	Center for Disease Control and Prevention
CF	Conversion factor
cm	Centimeter
CREG	ATSDR Cancer Risk Evaluation Guide
CR	Contact rate
CV	Comparison Value
DAF	Dermal absorption efficiency
DWM	N.C. DENR Davison of Waste Management
DWQ	N.C. DENR Davison of Water Quality
ED	Exposure duration
EF	Exposure frequency
EMEG	ATSDR Environmental Media Evaluation Guide
EQRR	EQ Resource Recovery
IRi	Inhalation rate
IUR	Inhalation Unit Risk factor
Kg	Kilogram
L	Liter
LOAEL	Lowest Observed Adverse Effect Level
MCLG	EPA Maximum Contaminant Level Goal
MCL	EPUSA Maximum Contaminant Level
M	Meter
mg	milligram
µg/dL	micro-gram per deci-liter
µg/m ³	micro-gram per cubic meter
µg	microgram
ng	nano-gram
NA	Not applicable
N.C. DENR	North Carolina Department of the Environment and Natural Resources
N.C. DHHS	North Carolina Department of Health and Human Services
NIOSH	National Institute for Occupational Safety and Health
NOAEL	No Observed Adverse Effect Level
ppm	Parts per million
ppb	Parts per billion
RfC	Reference Concentration
RfD	Reference Dose
SAd	Dermal surface area available for absorption
SAg	Dermal surface area available for ingestion
SVOC	Semi-volatile organic compound
EPA	U.S. Environmental Protection Agency
VOC	Volatile organic compound

*** These acronyms may or may not be used in this report**

SUMMARY

INTRODUCTION The N.C. Division of Public Health (DPH) understands the community’s concerns about contact with chemicals from the CTS/Mills Gap Road (“CTS”) site. The N.C. DPH’s top priority is to make sure the community near the site has the best science information available to safeguard its health.

The DPH performed a comprehensive evaluation of available environmental analytical data associated with the CTS site. This public health assessment evaluates potential public health hazards related to exposures to contaminated groundwater, drinking water, soil, surface water, and outdoor and indoor air on and near the CTS/Mills Gap Road site near Asheville, NC (EPA site ID: NCSFN0406988).

CTS manufactured electronic components on the site from 1952 until 1986 and related operations are believed to be the source of the chemical contamination. Contaminated soils and groundwater were identified on the CTS property and in surface waters leaving the property in 1991. Groundwater contamination associated with the CTS site was identified in July 1999 on a nearby property east of CTS. Also in 1999, chemical contamination (trichloroethylene [TCE]) was found in drinking water wells near the site, at which time residences in the area were connected to municipal drinking water supplies.

CONCLUSIONS **The N.C. DPH reached five conclusions in the public health assessment:**

Conclusion 1 **The DPH concludes that chemicals identified in the past and current samples of private well waters, surface waters, sub-surface soils, crawl-space air, sub-surface soil gas and outdoor air are not expected to harm people’s health.**

Basis for decision The concentrations of chemicals detected in the private well waters, surface waters, sub-surface soils, crawl-space air, sub-surface soil gas and outdoor air were compared to health effect studies of people and animals coming into contact with the chemicals. The levels measured in these samples were lower than the levels expected to harm health or to cause an increase in cancer rates.

Next steps The DPH makes the following recommendations:

- Limit access to contaminated stream and spring (“seep”) surface waters near the east side of the CTS property.
- Continue monitoring of the potential for sub-surface volatile organic compounds to move into dwellings near the site and present an

inhalation hazard.

Conclusion 2 **The DPH cannot currently conclude whether groundwater with elevated concentrations of the metals chromium and lead could harm people’s health. There is not adequate information to determine whether groundwater with elevated lead and chromium has been, or is, a source for private drinking water wells.**

Basis for decision There is no indication that people have been in contact with concentrations of lead or a toxic form of chromium (hexavalent chromium) in their private drinking water wells. Many people in the area have in the past and currently get their drinking water from private wells. Studies of groundwater flow in the area of the CTS site indicate that groundwater located at different depths are inter-connected and have been used as regional drinking water sources.

Lead in groundwater was found at concentrations greater than the health guideline value referenced by the N.C. Department of Health and Human Services (DHHS) for private well water supplies. It has not been confirmed that the groundwater with the elevated lead has been used, or will be used, as a drinking water source.

Elevated levels of chromium have been identified in groundwater in the area of the CTS property. If the chromium is present as substantial concentrations of hexavalent chromium, and the waters have been, or maybe used as a drinking water source, adverse non-cancer and cancer health effects could result from long-term ingestion.

Next steps The DPH makes the following recommendations:

- Determine if the groundwater supply with the elevated lead or chromium was or is being used as a drinking water source for private wells.
- If the groundwater was used as a drinking water source, or may be used as a drinking water source in the future, gather current analytical data on lead, total chromium, and hexavalent chromium concentrations.
- Prevent the use of the groundwater supply as a drinking water source if lead or chromium is elevated to levels exceeding health or regulatory guidelines.
- Include lead and chromium analysis of private well water supplies monitored in the area of the CTS site.

Conclusion 3 **The DPH concludes that other groundwater contaminants, including the volatile organic compound (VOC) trichloroethylene**

(TCE) and vinyl chloride, are not expected to harm people's health.

Basis for decision There is no indication that people have been drinking water that contains VOC contaminants observed in the groundwater samples. The concentrations of TCE and other contaminants related to the CTS site and detected in groundwater beyond the property (off-site) were lower than the levels expected to harm people's health.

Vinyl chloride was found in groundwater on the CTS property, but not off-site. Long-term ingestion of vinyl chloride at the concentration observed in the on-site groundwater could result in both non-cancer harm to people's health and a moderate cancer risk. There is no potential for health effects if the vinyl chloride does not travel off-site and people are not exposed.

Next steps The DPH makes the following recommendations:

- Monitor the concentration of contaminants in the groundwater moving off the CTS property, particularly vinyl chloride.
 - Identify all users of private drinking water wells within the flow-path and at the leading edge of detected groundwater contamination. Periodically monitor their well water for volatile organic compounds (VOCs). Provide an alternative drinking water source if concentrations exceed regulatory or health-based guidelines.
-

Conclusion 4 **The DPH concludes that the residents using a private well identified in 1999 as contaminated with trichloroethylene (TCE), for possibly as long as 11 years, could have been harmed by drinking the water or breathing TCE escaping from the water to the household air.**

Persons using two spring private wells serving one home until approximately 1994, and serving two other homes until 1999, could have been harmed by drinking the water or breathing TCE escaping from the water to the household air.

Basis for decision TCE contamination was identified in three private wells serving three homes in July 1999 and the wells were disconnected. It is not known when the contamination first appeared in the well water, or what the range of TCE concentrations were over the time the well was being used. Some of the health issues reported by family members include those that have been associated with TCE contact. An increased cancer risk is indicated if the long-term occupants of the residence were in contact with TCE concentrations similar to those in the single well water sample collected in 1999.

Drinking water contaminated with TCE and breathing TCE volatilized from the drinking water supply over many years in large amounts may

cause adverse health effects. These effects include increased risk of kidney or liver cancer; dizziness, lung irritation, impaired heart function; and nerve, kidney or liver damage. Reproductive effects such as impaired fetal growth or decreased fertility may also result. There may be an increased risk of birth defects or leukemia to children of women exposed during pregnancy.

Next steps

The DPH makes the following recommendations:

- Persons who lived at these locations and were in contact with TCE contaminated well water should have their health periodically evaluated by a physician. They should make their physician aware that they have been in contact with TCE. The medical evaluation should include routine testing of liver and kidney function, with urinalysis.
-

Conclusion 5

The DPH N.C. Central Cancer Registry (CCR) determined that cancer rates for the population living in a 1-mile radius around the CTS property were not elevated.

Basis for decision

The CCR studied the number of cancers reported by health care providers in the area surrounding the CTS site to the expected number of cases in the same time period. The study focused on the types of cancers linked with TCE contact: liver cancer, renal cancer, and non-Hodgkin lymphoma. The results of the investigation indicate that the observed numbers of cases of these cancers fall within the expected range, and there is no evidence of a clustering of cancer cases in the study area.

The cancer evaluation is limited by the small population size of the study area and the availability of cancer records only since 1990. Because of the long latency period of most cancers the evaluation is also limited by the use of a person's address at the time of diagnosis rather than the ability to identify if and where the critical exposure that led to cancer development took place.

Next steps

The DPH makes the following recommendations:

- Continued monitoring of cancer rates in the area around the CTS site.
-

For more information

If you have concerns about your health, you should contact your health care provider. Please call the N.C. Division of Public Health at (919) 707-5900, or send an e-mail to nchace@ncmail.net and ask for information on the CTS/Mills Gap Road Site Public Health Assessment.

PURPOSE AND HEALTH ISSUES

The North Carolina Department of Health and Human Services (N.C. DHHS) Division of Public Health (DPH) Epidemiology Branch, which is a cooperative partner of the Agency for Toxic Substances and Disease Registry (ATSDR), was asked to conduct a public health assessment (PHA) on the CTS/Mills Gap Road (CTS) site by the North Carolina Department of the Environment and Natural Resources (N.C. DENR). The local community has expressed concern regarding concentrations of the volatile organic compound trichloroethylene (TCE) found in groundwater and private drinking water wells on and around the CTS site. Historical electroplating operations on the CTS property are believed to be the source of the contamination. The U.S. Environmental Protection Agency (EPA) and the N.C. DENR have on-going investigation and remediation efforts associated with the TCE contamination. The CTS PHA evaluates past and current environmental sampling data and the public health significance of human exposures to contaminants found in environmental media on the site and surrounding properties. Groundwater, private well water, sub-surface soils and soil vapors, outdoor air, and residential crawl-space air surveys from homes in the vicinity of the CTS site were evaluated. This document discusses the potential public health impacts related to chemicals found at the CTS site and provides recommendations for actions to prevent, reduce, and further identify the possibility of site-related exposures that could result in adverse health effects.

BACKGROUND

SITE DESCRIPTION AND HISTORY

The former CTS Site is located off Mills Gap Road, approximately one mile east of Skyland, near Asheville, in Buncombe County, North Carolina (Appendix A, Figure 1). The site consists of approximately nine acres of maintained grounds containing a large single-story building. The nine-acre fenced property represents the core industrial portion of the original 54 acre CTS holding. The remaining 46 acres were parceled and sold to developers for residential development. The area surrounding the Mills Gap Road facility is a mix of residential and industrial properties. The closest residence is approximately 70 feet from the fence line surrounding the 9-acre CTS site.

The former CTS site operated as an electroplating facility for approximately thirty-four years. Electroplating operations began on the site in 1952 by IRC, Inc. when the land was purchased and the building constructed. CTS, Inc. bought the site in 1959. CTS operated an electroplating facility on the site from 1959 until 1986. Both IRC and CTS employed the chlorinated organic compound trichloroethylene (also known as TCE) to clean or degrease metal objects in the electroplating process. Mills Gap Road Associates (MGRA) purchased the property in 1987 and is the current owner (OSC 2009).

A screening site inspection (SSI) was completed in February 1991 by the NUS Corporation, an EPA contractor. The objective of the SSI was to characterize site contaminants and determine if a release had or may occur, and to identify possible migration pathways and potentially exposed populations. Concentrations of metals and organics were identified in soil, sediments and

surface water samples collected on the CTS property at concentrations greater than typical background levels, and in some cases regulatory levels. The detected contaminants were consistent with those associated with electroplating operations. No site-related contamination was found in a ground water sample collected from the nearest private well, located 4,000 feet northwest of the site. The study recommended no further remedial action for the site (NUS 1991). [Subsequent environmental studies at the site indicated that the private well sample collected in 1991 was not in the direction of groundwater flow from the site.]

The site was identified during follow-up on a citizen complaint in July 1999 by the North Carolina Department of Environment and Natural Resources (N.C. DENR). A taste and odor complaint was registered for a potable supply spring southeast of the plant. High concentrations of chlorinated solvents were identified in two springs and one domestic well, located topographically down-gradient from the site.

In August 1999, the N.C. DENR referred the Site to the EPA's Emergency Response and Removal Branch (ERRB) for removal eligibility consideration. ERRB evaluations initiated in 1999 identified contamination of potable drinking water supplies with chlorinated organic compounds. High concentrations were found in two springs and one domestic well located down-gradient of the site. ERRB determined contamination of potable drinking water supplies with chlorinated organic compounds posed a threat to public health or welfare or the environment. Bottled water was provided to four households that had been using the contaminated drinking water sources, and they were ultimately connected to the Asheville-Buncombe municipal supply.

Samples collected in 2001 from beneath the former CTS plant revealed elevated concentrations of volatile organic compounds (VOCs, including TCE and benzene), semi-volatile organic compounds (SVOCs, including 2-methylnaphthalene and phenanthrene), and total petroleum hydrocarbons (TPH, as no. 2 fuel oil or diesel fuel). TCE was detected in all the samples and was typically the contaminant present at the highest concentration. Surface waters traveling off-site were also contaminated with VOCs and TPH. A soil vapor extraction (SVE) system was brought on-line in July 2007 for removal of VOCs from the subsurface (OSC 2009). The SVE system is still in operation.

Following mitigation of the immediate threat posed by the contaminated springs and water well, EPA entered into negotiations with the identified Potentially Responsible Parties and executed an Administrative Order on Consent (AOC) with CTS Corporation and Mills Gap Road Associates in January 2004. On-Site removal activities began in June 2004 (EPA, 2007).

Currently, the NC Division of Waste Management (DWM) is working in its role as a support agency to EPA as they work with the responsible parties to remove imminent threats to public health and the environment at the CTS site.

DEMOGRAPHICS

According to Census 2000 data, approximately 2,979 people live within one mile of the CTS site. Census figures show a predominantly White population (94% compared to 72% in the state

and 75% in the U.S.). Other ethnic groups include 2% African-Americans, 0.7% Hispanics, 3% Asians, and 0.5% American Indians (see Appendix C, Table 1).

The educational level of the population in this area is higher than the rest of the state with 92% of the population having earned a high school diploma or above, compared to 77% for the rest of the state and 80% for the total U.S. population. The percentage of individuals living below the poverty level in this area is also lower than the rest of the population, with a 3% compared to 12% in the rest of the state and in the rest of the U.S. There are 1,288 housing units occupied, with 74% occupied by the owner, and 26% occupied by renters.

SITE GEOLOGY AND HYDROGEOLOGY

The CTS site is underlain by saprolite materials, described as reddish brown silty or clayey soils near the surface and underlain by sandy silt and silty sand, developed by weathering of crystalline rock. The saprolite material ranges from approximately 28 to 81 feet thick beneath the site and in adjacent areas. Saprolite materials have the capacity to act as reservoirs, storing water that infiltrates the soil, including precipitation, surface water that runs onto the site, and water disposed on the site. The saprolite materials under the site consist of dry materials nearer the surface with underlying moist and wet materials of varying thickness underneath, all perched above garnet-mica bedrock. Bedrock beneath the saprolite materials are metasedimentary and metavolcanic rocks. Contaminants from the site migrate downward through the porous saprolite material to the impervious bedrock, where they tend to pool up, and also to move into fractures in the bedrock. Some of the contamination then migrates laterally in groundwater, both through bedrock fractures and along the top of the bedrock, until it discharges at springs (“seeps”), or into streams downhill from the site (TNA 2008). A 2009 study indicated a groundwater divide is present in the north central portion of the site, with the position of the divide changing in response to precipitation. In the southern portion of the site the groundwater flows to the north and east. Groundwater in the central portion of the site flows to the northwest and east/southeast. Springs are located east and west of the site (MACTEC 2009).

SITE VISIT

The N.C. DPH conducted a site visit of the CTS site in April 2009. The site included a chain-linked fenced area enclosing a large area that included a single large building and a small guard shack located at the entrance gate to the fenced area. The majority of the site is currently covered with over-grown grass, with small areas covered by asphalt. A group of 55-gallon drums was observed located near the guard shack. Multiple “no trespassing” signs were observed on the Mills Gap Road side of the fence, including a large “warning - no trespassing” sign that included the U.S. EPA and N.C. DENR logos. The area surrounding the site includes primarily single family residences and a few small business/industrial facilities. A fenced area was observed east of the CTS property that presumably encloses the springs adjacent to the site.

COMMUNITY HEALTH CONCERNS

The Buncombe County Health Department held several community meetings (the most recent on October 29, 2008 and April 21, 2009) to address community questions and concerns about the former CTS site, including groundwater and soil vapor contamination. Buncombe County, EPA,

ATSDR, N.C. DENR and N.C. DHHS representatives were available for questions during these meetings. The agenda of the public meetings included a site history, chronology of events, the federal and state response, and public health issues associated with the contamination at the site. Most of the local residents attending the public meeting were concerned about contamination in their drinking water wells. Some residents wanted to know if their wells were “safe” and if there was the potential for the contaminants to impact their drinking water supply. Citizens also were concerned with outdoor exposures to vapors, such as children playing outdoors or waiting at a bus stop. Concerns were also expressed regarding property values in association with contaminated well waters. Although health and environmental representatives would not address specific well water sampling results for individual residents during the public meetings, the appropriate representative was available to speak with residents one-on-one after the meetings. N.C. DPH prepared two documents in October 2007 to address community health concerns; *Frequently Asked Questions (FAQs), Mills Gap (former CTS Plant) Site, Asheville, NC* and *Trichloroethylene (TCE) Fact Sheet and FAQs*. A list of community concerns gathered during public meetings and the documents referenced above are included in Appendix G.

The N.C. DPH performed a comprehensive evaluation of past and current environmental analytical data associated with the CTS site. The intent was to evaluate the potential health risks associated with the contaminants identified in the data across all potential exposure scenarios and address the concerns voiced by the community. The DPH’s evaluation incorporated highly protective health effect assumptions of the potential for exposure and exposure concentrations. The objective is to protect public health and to provide the community with a public health assessment that evaluates the “worst-case” exposures and minimizes uncertainties related to identifying potential health effects. While the “contaminant of concern” for the CTS site was identified as TCE, DPH’s health evaluation included all chemicals detected in the drinking water, ground water, surface water, soil, and air samples. Concerns expressed by the community included those associated with soil, indoor and outdoor air, drinking water, and surface water contamination. The DPH addressed these concerns as is reflected in the discussions and recommendations provided in this report.

Community members were also concerned with the potential for increased cancer rates in the area around the former CTS facility. This concern was addressed by the N.C. DHHS Central Cancer Registry Center for Health Statistics in a report dated August 1, 2008 (see Appendix H). Cancer rates for Buncombe County and a 1-mile radius around the CTS site were found to be typical of the numbers and types of cancers expected in North Carolina.

DISCUSSION

The ATSDR Health Effects Evaluation Process

This section provides a summary of the ATSDR health effects evaluation process. A more detailed discussion is provided in Appendix D.

The ATSDR health effects evaluation process consists of two steps: a screening analysis, and at some sites, based on the results of the screening analysis and community health concerns, a more in-depth analysis to determine possible public health implications of site-specific exposure estimates.

The two step screening analysis process provides a consistent means to identify site contaminants that need to be evaluated more closely through the use of “comparison values” (CVs). The first step of the screening analysis is the “environmental guideline comparison” which involves comparing site contaminant concentrations to water, soil, air, or food chain comparison values derived by ATSDR from standard exposure default values. The highest concentration of a chemical found for each sample set in is compared to CVs to provide a “worst-case” exposure estimate. The average concentration for chemicals found in multiple samples is also compared to CVs to provide an “average” exposure estimate. The second step is the “health guideline comparison” and involves looking more closely at site-specific exposure conditions, estimating exposure doses, and comparing the dose estimate to dose-based health-effect comparison values.

ATSDR comparison values are set at levels that are highly health protective, well below levels known or anticipated to result in adverse health effects. When chemicals are found on a site at concentrations greater than the screening values (CVs) it does not mean that adverse health effects would be expected. CVs are set at levels well below concentrations of known health effects to serve as a highly health protective initial screen of human exposure to chemicals. Contaminant concentrations at or below the CV may reasonably be considered safe. Those chemicals that are greater than the CV undergo further evaluation.

After completing a screening analysis, site contaminants are divided into two categories. Those not exceeding CVs do not require further analysis. Contaminants exceeding CVs are selected for a more in-depth site-specific analysis to evaluate the likelihood of possible harmful health effects. Contaminant concentrations exceeding the appropriate CVs are further evaluated against ATSDR health guidelines (HGs). Health guidelines represent daily human exposure to a substance that is likely to be without appreciable risk of adverse health effects during the specified exposure duration. N.C. DPH also retained for further assessment contaminants that are known or suspected to be cancer-causing agents. To determine exposure dose, N.C. DPH uses standard assumptions about body weight, ingestion or inhalation rates, and duration of exposure. Important factors in determining the potential for adverse health effects include the concentration of the chemical, the duration of exposure, the route of exposure, and the health status of those exposed. Site contaminant concentrations and site-specific exposure conditions are used to make greatly health protective estimates of site-specific exposure doses for children and adults that are compared to ATSDR health guidelines. An exposure dose is an estimate of how much of a substance a person may come into contact with based on their actions and habits.

Increased numbers of cancers over the number that would be expected in a population are estimated for chemicals suspected or known to cause cancer. Estimates of increased numbers of cancers are calculated using the estimated site-specific exposure dose and a chemical’s cancer slope factor (CSF) provided in ATSDR health guideline documents. This calculation is based on the highly health protective assumption that there is no safe level of exposure to a chemical that causes cancer. However, the calculated risk is not exact and tends to overestimate the actual risk, if any, associated with conditions of the site-specific exposure 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 additional cancer risk for the exposed population. The cancer risk is expressed as the number of additional cancers over the number of cancers that occur in a population without these exposures. The N.C. Central Cancer Registry

states that one out of every two men and one out of every three women will develop a cancer of some type during his or her lifetime.

Exposure dose estimates are also compared to data collected in animal and human health effect studies for the chemical of concern on the site. The health effects data are generally taken from ATSDR or EPA references that summarize data from studies that have undergone extensive validation review. Comparisons are made for non-cancer and cancer health effects, where applicable. Comparisons are made on the basis of the exposure route (ingestion/eating, inhalation/breathing, or 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, when available. Alternatively, animal data and the lowest chemical dose or concentration where adverse health effects were observed is used for comparison. More detailed discussion of the process used to determine potential adverse health effects is provided in Appendix D.

There are limitations inherent to the public health assessment process. These include the limitations of the analytical data available for a site, the health effect study information, and the risk estimation process. To overcome some of these limitations, “worst-case” assumptions are used to evaluate site data and interpret the potential for adverse health effects. ATSDR screening values (CVs) and health guideline values (HGs) incorporate large margins of safety to be highly health protective and protect groups of the exposed population that may be particularly sensitive, such as children and the elderly. Exposure concentrations are calculated using the highest concentration of a chemical found in the water, soil or air on the site. Large margins of safety are again used when comparing exposure concentrations to the health effect study data. The assumptions, interpretations, and recommendations made throughout this public health assessment err in the direction of protecting public health.

Site-Specific Exposures

Groundwater was evaluated for ingestion exposures related to drinking water supplies using standard ATSDR exposure assumptions. Surface water samples were evaluated for incidental (unintended) ingestion by children during recreational swimming, using highly health protective exposure parameters (1 hour of swimming activity per week for 26 weeks a year for 10 years, and ingestion of 50 ml of surface water [1.7 oz.] per event). Soils were also evaluated for incidental ingestion by children and adults, as well as pica-behavior child ingestion rates. Soil ingestion can occur by the unintentional intake of soil on hands or food items and the mouthing of objects. Pica-behavior soil ingestion involves ingesting unusually high amounts of soil. ATSDR uses a conservative value for child pica ingestion rates, 5,000 mg/day (ATSDR 2005).

Residential crawl-space, sub-slab soil gas, outdoor (ambient) air, and sub-surface soil gas samples were evaluated for inhalation exposures. A 30-year exposure period was used as a highly health protective maximum exposure period to account for the lack of information on the time of subsurface contaminant transport on and off-site of the CTS property. A 30-year exposure period also represents the average maximum length of residence at a single location as determined for EPA risk assessment studies. Sub-slab and soil gas exposure estimates for volatile organic compounds (VOCs) were calculated by applying standard highly health protective “attenuation factors” to the analytical data. An attenuation factor represents the decrease in amount of vapor (gas) as it travels through the soil up into a building where it may be

inhaled. Attenuation factors were taken from EPA guidance (EPA OSWER VI 2002). Highly health protective factors were applied to the analytical data to provide a “worst-case” exposure estimate that represents the highest expected exposure concentration. A 0.1 attenuation factor was applied to sub-slab soil gas and sub-surface soil gas concentrations as indicated in the calculation below. The adjusted gas concentration was used for subsequent site-specific exposure estimates and health effects evaluations.

$$\text{Adjusted vapor concentration} = \\ (\text{Detected soil gas or sub-slab gas concentration}) \times 0.1$$

Trichloroethylene (TCE) is the primary contaminant of concern for the CTS Site. ATSDR’s current TCE comparison and health guideline levels, which include only non-cancer values, were used for this evaluation. In addition, more conservative (health protective) proposed EPA non-cancer and cancer health-effect evaluation values for TCE were used in this assessment. More information regarding recent toxicological reviews of TCE effects and the current ATSDR and EPA proposed comparison values are included in Appendix F.

Exposure Pathway Analysis

Chemical contaminants in the environment can harm people’s health, but only if people have contact with those contaminants at a high enough concentration (dose), for a long enough time (exposure period) to cause a health effect. The concentration of a chemical that causes an adverse health effect will vary with the way a person is exposed (by eating or drinking the chemical, by breathing the chemical, or by skin contact with the chemical). Other factors, such as a person’s age, gender or their health status, may also affect whether they are harmed by contact with a chemical at a given concentration. Knowing or estimating the frequency with which people have contact with hazardous substances is essential to assessing the public health importance of these contaminants. The exposure pathway is evaluated to determine if people can come into contact with site contaminants.

A completed exposure pathway is one that contains the following elements:

- a source of contamination, such as a hazardous waste site or contaminated industrial site,
- travel of the contaminant through an environmental medium such as air, water, or soil,
- a point where people come in contact with a contaminated medium, such as drinking water, soil in a garden, or in the air,
- an exposure route, such as drinking contaminated well water or eating contaminated soil on homegrown vegetables, or inhaling contaminated air, and
- a population that can come into contact with the contaminants (be exposed)

A completed pathways is one in which all five pathway components exist and exposure to a contaminant has occurred, is occurring, or will occur. If one of the five elements is not present, but could be at some point, the exposure is considered a potential pathway. An exposure pathway is eliminated from further assessment if one of the five parts is missing and will not occur in the future. The length of the exposure period, the concentration of the contaminants at the time of exposure, and the route of exposure (skin contact, ingestion, and inhalation) are all critical elements considered in defining a particular exposure event.

A. Completed Exposure Pathways

The population of concern for this study is residents living near the CTS property. A completed pathway for this site is past ingestion (drinking) and dermal (skin contact) of contaminated groundwater before their contaminated private wells were disconnected. Soils on the CTS property were contaminated with volatile organic compounds (VOCs) used during industrial activities on the site. Contaminants were carried downward to the groundwater flowing beneath the site, resulting in contaminated groundwater flowing off the site. Contaminated groundwater being supplied to a household or commercial facility may provide an exposure pathway through ingestion (by drinking the water), inhalation (breathing chemicals dissolved in water that can escape to the air, such as during a shower), and dermal contact (when taking a shower or bath). During investigations of the CTS site, private drinking water wells and springs used for drinking water sources were disconnected. Users of the contaminated private drinking water were provided access to municipal drinking water supplies when contamination was identified. This eliminated ingestion, inhalation and dermal pathways for exposure to contaminated groundwater for persons connected to municipal water supplies.

Contaminants of concern for the CTS site have been observed in surface waters in the area. The CTS site may be the source of these chemicals, likely by surface run-off over contaminated soils associated with the CTS facility and discharge of contaminated groundwater passing through the site and up to the surface. Persons coming into contact with these surface waters during recreational activities such as wading or swimming present an exposure pathway. Completed exposure pathways exist for persons that may have had or currently have contact with the contaminated water from the springs (“seeps”) east of the site. A fence was placed around the springs in December 2007, preventing access. The fence was taken down temporarily in several locations during construction of the soil vapor extraction (SVE) system, allowing temporary access to the springs. The fence was replaced after construction of the SVE was completed.

The small stream formed by the combined flow from the springs east of the site travels beyond the fence around the springs, providing a past, current, and future exposure point as long as the waters are contaminated. The stream is typically small (estimated at 2 inches deep and 1 foot wide, personal communication with N.C. DENR) and so provides limited exposure potential. In addition, the SVE system when operational will likely reduce exposure potential from the springs and streams as the concentration of TCE and other volatile chemicals is reduced.

Volatile contaminants may volatilize (out-gas) from soil and groundwater, migrate through sub-surface air spaces and enter buildings, collecting in a living space where they may be inhaled by occupants. Many variables influence the levels of volatile chemicals entering a home from a water supply, including the chemical’s physical and chemical properties, seasonal variations, and building construction. Factors to consider when evaluating indoor exposures to volatile chemicals in supplied waters is that some of these chemicals are also common components of materials routinely used or present in the home or commercial and industrial operations, such as cleaning chemicals, textiles, or building materials. Exposure to air from a crawl-space is assumed to be limited to occasional activities. ATSDR does not consider crawl-space activities to be a full-time exposure source. However, crawl-space air samples collected from near-by residences indicate VOCs have migrated to the soils and crawl-spaces under the sampled homes. Volatile gases in the soil under residences with basements or concrete slabs were also measured to provide an estimation of exposure potential in these homes.

Volatile chemicals in soil and groundwater may also volatilize to the outdoor air where people may breathe them. Groundwater may be discharged at the surface from springs, or into streams or rivers, providing an exposure point for breathing volatile chemicals moving from groundwater into the air. VOCs were found in air samples taken near the springs where persons in the immediate vicinity of the springs may be exposed. VOCs were also found in air samples collected during mobile monitoring events along roadways west of the CTS property. Persons may breathe VOCs while traveling in these areas. Table 2 illustrates the completed exposure pathways for the CTS site.

Table 2. Completed exposure pathways for the CTS site.

Source of Contamination	Contaminant Travel Pathway	Exposure Point	Route of Exposure	Exposed Population
Contaminated groundwater	Groundwater, Springs	Private well water	Ingestion, dermal (contact), inhalation	Persons in the past with contaminated well water
Contaminated surface water east of the site	Surface water	Springs and streams	Ingestion, dermal (contact)	Persons in the past and currently with access to the contaminated surface water
Crawl-space air containing volatile organics coming from contaminated soil or groundwater	Air	Crawl-space	Inhalation	Persons in the past and currently breathing air in a contaminated crawl-space
Outdoor air containing volatile organics coming from contaminated surface water and soil	Air	Outdoor air in vicinity of site	Inhalation	Persons in the past and currently breathing in areas of site volatile organic chemicals

Note: For a completed exposure pathway all 5 components must be present at a site.

B. Potential Exposure Pathways

A current and future potential exposure pathway exists should unidentified private wells in the groundwater flow path from the CTS site be identified and are found to contain contaminants identified as emanating from the CTS site. Continued efforts to identify private well users in the path of the TCE contaminated groundwater plume traveling through the CTS site, test their water, and disconnect their wells if contaminated would eliminate this potential exposure pathway. Control of the transport of the TCE groundwater plume and/or remediation of the TCE plume would eliminate this potential exposure pathway.

A potential exposure pathway is identified for possible future exposures to the stream formed by the combined flow of the springs east of the site and passing through the fenced area. Elevated contaminant concentrations have been identified in the springs and stream water, should they continue, may present an exposure hazard.

Sub-surface soil samples collected on and off-site of the CTS property were evaluated to provide a comprehensive, highly protective evaluation of potential health effects associated with all site-related media. Subsurface soils can present an exposure point to persons that have direct access to the contaminated sub-surface soils through activities such as digging or construction activities. A low potential for exposure was determined for contaminated sub-surface soils since they were located within the fenced CTS property. Levels of substances found in off-site sub-surface soils were found to be within typical North Carolina soil background levels, or were at concentrations below ATSDR's health screening levels. Table 3 lists potential exposure pathways identified for the CTS site.

Table 3. Potential exposure pathways for the CTS site.

Source of Contamination	Contaminant Travel Pathway	Exposure Point	Route of Exposure	Potentially Exposed Population
Contaminated groundwater	Groundwater	Private well water	Ingestion, dermal (contact), inhalation	Persons currently with, or in the future with, contaminated well water
Contaminated surface water from springs east of the site	Surface water	Springs	Ingestion, dermal (contact)	Persons in the future with access to the contaminated surface water
Contaminated sub-surface soil	Soil	Sub-surface soil	Ingestion	Persons in the past, present or future with access to contaminated sub-surface soils

Note: For a potential exposure pathway one or more components at the site are missing or uncertain to exist.

Site-Specific Exposure Conditions Considered for the CTS Site

The CTS facility was in operation from 1953 until 1985 under various operators. Soil, surface water and sediment contamination was identified on the CTS property in 1991. The well nearest the site was identified and tested for TCE contamination in the 1991 study. The tested well was located 4,000 feet northwest of the site. No contamination was detected in the well water sample. Later studies indicated that this well was generally up-gradient of the direction of groundwater flow from off the CTS property. Future studies indicated groundwater flows under the CTS property from west to east. Building of the first phase of the Southside Village subdivision began in 1998.

TCE was detected in two springs east of the CTS facility and one residential supply well approximately 2,000 feet to the east, providing in 1999 the first indication of contaminated groundwater. Four households using the springs and the well as drinking water sources were supplied with bottled water and were ultimately connected to a municipal water supply in 1999. In 2000, TCE was again found in springs to the east of the site and in one of nine wells, the same well that was found to have TCE contamination in 1999 and had been disconnected. No contamination was found in springs to the west in 2000. It was recorded that no potable waters in the area were contaminated in 2001. Five residential wells with the potential to be impacted

by the contaminated groundwater flow all showed no contamination in 2006. During the 2006 sampling, one resident chose not to have their water tested, and three wells were either not in service or were not used as a drinking water source. A soil vapor extraction system (SVE) was put into operation to remove TCE vapor from the subsurface in 2006. Higher concentrations of contaminants were seen in streams and springs both east and west of the site in late 2007 (TNA 2008, N.C. DENR Timeline). Sixty-six private wells within a 1-mile radius of the site (most to the north and east of the site) were sampled in 2007. Contamination was found in one well $\frac{3}{4}$ miles to the northeast. Eight active wells within $\frac{3}{4}$ mile north of the site were sampled in 2008 and the same well that was contaminated in 2007 again showed contamination. Residences on two streets were connected to the municipal water supply after the 2008 collections. Site documents note that the contamination observed in these wells may not be associated with the CTS site, since the area is not down-gradient of groundwater flow from the site.

On the basis of the above information a 10-year exposure period was used for possible groundwater and drinking water exposures. The time period coincides with the time-frame contamination was initially identified in a private well and the springs down-gradient and adjacent to the site. This is also when private wells in the area of the identified contaminated private well were disconnected and the properties were provided a municipal water supply. A more health protective 30-year exposure period was also used for drinking water evaluations. A 30-year exposure period was used for soil, ambient (outdoor) air, and indoor air contamination evaluations. This exposure period was based on the time of initiation of residential construction in the area and the likelihood that soil contamination was evident before groundwater contamination was detected. The 30-year time period also represents the typical length of residential occupation at a given location.

Environmental Sampling Data

The following information outlines field-sampling activities conducted by the N.C. DENR, EPA, and EPA contractors from September 2007 through August 2008. Discussions include only compounds found in each environmental medium at concentrations equal to or greater than the analytical method minimum reporting concentration. Figures taken from EPA and DENR reports are provided to identify locations of collected samples and do not necessarily provide results for all data that was evaluated in this Public Health Assessment.

Groundwater Samples

Although there is no indication that persons are being directly exposed to the contaminants identified below in the groundwater, there may be unidentified private wells in the area that access these waters. To provide a complete evaluation of the potential hazards associated with the CTS site, NCDPH chose to include an evaluation of the groundwater data in this assessment. This information may also serve to inform persons and agencies that are considering future activities on the site and in the area surrounding the site.

Groundwater samples were collected by the EPA in December 2007 and January 2008 from six temporary monitoring wells installed on-site and off-site to the east of the CTS property. One well was on the northwest side of the CTS property and the others were off-site, within approximately 1,200 feet east of the property. Analytical results indicated the metals total chromium and lead, the semi-volatile organics n-nitroso di-n-propylamine and pentachlorophenol, and the volatile organic compounds cis-1,2-dichloroethylene (cis-1,2-DCE),

trichloroethylene, and vinyl chloride were present at concentrations greater than ATSDR CV values. All were carried through health-effect evaluations. The volatile organic compound (VOC) benzene was also detected at a concentration less than CV values but was carried through a health-effects evaluation because it is identified as a human carcinogen. See Appendix A, Figure 2 for groundwater sample locations.

Trichloroethylene (TCE) was detected in three of six groundwater monitoring wells at concentrations ranging from 13 to 1,500 µg/L, all exceeding the EPA Federal Maximum Contaminant Level (MCL) of 5 µg/L. The EPA MCL value was used for screening site water levels since ATSDR has not published a CV for TCE. A MCL is the regulatory limit set by EPA that establishes the maximum permissible level of a contaminant in water that is deliverable to the user of a public water system. The highest TCE concentration (1,500 µg/L) was detected on the northwest side of the CTS property. TCE was not detected in the two off-site samples collected the furthest to the east (down-gradient). Lower concentrations of TCE were detected in the two off-site samples directly east of the CTS property (22 and 14 µg/L). The pentachlorophenol was detected at the sample location furthest to the east of the site. Vinyl chloride and cis-1,2-DCE are breakdown products of TCE, indicating some natural attenuation of the subsurface TCE plume. The other TCE detections were at the two sample locations closest to the east side of the property (22 and 14 µg/L) (TN&A 2008).

Lead was found in two of five monitoring wells at concentrations exceeding the 15 µg/L Federal Action Level (AL). The lead detections (71 and 35 µg/L) were from the two off-site sample locations furthest to the east of the site. The lead value quantified for a third groundwater sample was less than the AL (2.2 µg/L), but the result was not considered valid due to quality control issues (TN&A 2008). ATSDR's lead CV is the EPA action level of 15 µg/L. Under the Lead and Copper Rule (LCR) EPA requires the testing of public water systems and states that actions be taken to lower lead levels if more than 10% of the samples collected at residences have lead levels greater than 15 µg/L (ATSDR 2007d). The EPA lists 0 µg/L as the goal for lead in drinking water. The Centers for Disease Control and Prevention (CDC) considers children to have an elevated blood lead level at 10 micro-grams per deci-liter (µg/dL) or greater (ATSDR 2007d). However, CDC identifies that blood lead levels in children less than 10 µg/dL can result in decreased cognitive function, developmental delays, and behavior problems (CDC 2009).

Private Drinking Water Wells

DENR collected nine samples from drinking water wells in July 1999 following a citizen complaint. TCE was found in one well approximately 1,000 feet east of the CTS property at 270 µg/L. TCE and other VOCs were also detected in water from two springs that had been used as drinking water sources. One spring was serving two homes. The second spring had served a third home until approximately 1994, at which time that home was connected to the city water supply. TCE at 21,000 µg/L, 49 µg/L 1,1,1-trichloroethane (1,1,1-TCA) and 31 µg/L 1,1-dichloroethene (1,1-DCE) was detected in the spring sample serving the two homes at the time. TCE at 15,000 µg/L, 570 µg/L 1,1,1-TCA, and 370 µg/L cis-DCE was detected in the spring sample that was no longer in use (N.C. DENR 1999). The spring samples were collected at the springs, not at the tap in the homes. No samples were collected at the tap. For use in the homes the spring water was collected in an above ground container and piped from the collection vessel to the homes, likely reducing the concentration of VOCs to which persons may have been ultimately exposed.

The TCE concentrations are greater than the EPA Maximum Contaminant Level of 5 µg/L. A Federal Maximum Contaminant Level (MCL) is the regulatory limit set by EPA that establishes the maximum permissible level of a contaminant in water that is deliverable to the user of a public water system. The 1,1,1-TCA and cis-1,2-DCE in the spring used until 1994 both exceed the MCL values (200 and 70 µg/L, respectively). The MCL (70 µg/L) for the 1,1-DCE detected in the spring used until 1999 was also exceeded.

The N.C. DENR collected drinking water samples from 66 residential wells within a 1-mile radius of the CTS property in November and December 2007. Most of the locations were northeast, east and southeast of the CTS property. Samples were analyzed for volatile organic compounds (VOCs) including TCE. A total of six different VOCs were found in seven samples. Detected VOCs included TCE, cis-1,2-DCE, chloroform, bromodichloromethane, toluene and chloromethane. Only TCE and bromodichloromethane concentrations were greater than ATSDR CVs and were carried through health-effect evaluations. The TCE detection was 57 µg/L, detected at a residence ¾ mile northeast of the CTS property. Bromodichloromethane (BDCM) was detected in two samples, both exceeding the ATSDR cancer CV. BDCM is identified as a “probable” human carcinogen.

The N.C. DENR collected water samples in January 2008 from eight active private residential wells located in the immediate vicinity of the highest TCE concentration detected in the residential wells sampled in 2007. The locations are north of the CTS site. TCE and cis-1,2-DCE were detected at a single location at concentrations less than CVs (4.32 µg/L TCE and 1.35 µg/L cis-1,2-DCE) (N.C.DENR data). The TCE concentration was carried through a health-effect evaluation because EPA’s proposed revised health guideline information identifies it as a human carcinogen. The residences were connected to a municipal supply after the samples were collected. Because of their location relative to the CTS property, and what is known about the direction of groundwater flow under the CTS site, the contamination observed in these wells might not be related to the CTS property (personal communication N.C. DENR 2009). The source of the drinking water contamination in this area is currently under investigation by EPA and DENR. The location of the private well samples is identified in Appendix A, Figure 3.

Surface Water

Water from three springs on the near east side of the site (approximately 400 feet east of the CTS property) was sampled in July 1999. TCE, 1,1,1-trichloroethane (1,1,1-TCA), cis-1,2-DCE and 1,1-dichloroethene were detected. TCE (21,000 µg/L) and 1,1,1-TCA (570 µg/L) concentrations were greater than CVs and were carried through health effect evaluations.

Four stream and three spring surface water samples were collected within approximately 400 feet east and 800 feet west of the CTS property in September 2007. The spring samples were at the same location as the samples collected in 1999. TCE, cis-1,2-DCE and 1,1,1-TCA were detected, with the highest concentrations detected in samples collected to the east. The highest concentrations were 19,700 µg/L TCE, 1,190 µg/L cis-1,2-DCE, and 856 µg/L 1,1,1-TCA. The high TCE and 1,1,1-TCA detections were from the same spring and the high cis-1,2-DCE detection was from a stream. See Appendix A, Figure 4 for sample collection locations and analytical data.

An additional 14 surface water samples were collected in November and December 2007 within approximately ¾ mile to the west and east of the site (Appendix A, Figure 5). Sample locations included eight streams and six springs. TCE was found in all samples except for two springs ¾ mile to the southwest and one stream ¾ mile to the southeast. TCE concentrations were highest on the east side of the CTS property and decreased with distance away from the site to the east. The highest TCE concentration (18,000 µg/L) was detected at the location nearest the east side of the CTS property, and other samples collected in the same immediate area ranged from 998 to 11,600 µg/L). TCE concentrations were lower on the west side of the property in two spring samples next to the site. The VOC cis-1,2-DCE was found intermittently in decreasing concentrations moving away from the site to the east, all in stream samples. One stream near the east side was contaminated with 1,1,1-TCA. The chemicals naphthalene, vinyl chloride and bis-2-ethylhexyl phthalate (BEHP) were each detected in one sample location on the east and west sides nearest the site. See Appendix A, Figure 5 for sample collection locations and analytical data.

TCE, cis-1,2-DCE, 1,1,1-TCA, bis-2-ethylhexyl phthalate (BEHP), and vinyl chloride concentrations exceeded CVs in the surface water samples collected in September through December 2007. Each was carried through a health-effects evaluation.

Sub-Surface Soil Samples

In December 2007 and January 2008 EPA collected sub-surface soil samples at five locations on the CTS property and 10 locations to the west, north and east off-site of the property. Soils for analyses were collected from depths ranging from 2 to 30 feet below the surface. Typically, ATSDR does not evaluate sub-surface soils for potential health-effects due to the limited potential for human access and exposure. Sub-surface soil data was evaluated for this site to provide additional assurance that adverse health effects were not indicated in response to public concerns associated with this site. All soils were analyzed for VOCs, semi-volatile organic chemicals (SVOCs), cyanide and metals. Analytical results indicated that eight SVOCs (all polycyclic aromatic hydrocarbons [“PAHs”]), the metals arsenic, barium, chromium, lead, selenium, and silver, and cyanide and the VOC acetone were detected in the soils. See Appendix A, Figure 6 for sample locations and analytical results.

The metal arsenic was the only detected substance with a concentration exceeding an ATSDR CV. Arsenic was detected in six of the 15 samples, with all detections less than the non-cancer CV, and all exceeding the cancer-effect CV, and was thus carried through a health-effects evaluation. Detected arsenic concentrations ranged from 2.1 to 6.1 mg/kg, with all detections identified as estimated values.

Polynuclear aromatic hydrocarbons (PAHs) were detected in a single soil sample located on the northwest corner of the CTS property. Eight PAH compounds were detected at concentrations from 42 to 70 micrograms per kilogram (µg/kg or “parts per billion”), with all concentrations identified as “estimated” values due to quality control issues. ATSDR does not have CVs for the individual chemicals making up the group of chemicals referred to as “PAHs”, other than a CREG for benzo(a)pyrene (BaP). PAHs are a group of chemicals formed during the incomplete burning of gas, wood, coal and other organic materials. They can also be found in substances such as crude oil, coal, creosote, and asphalt. They are found throughout the environment in air,

water, and soil. No data was available for background concentrations of PAHs in area soils. Detected PAHs were carried through a health-effects evaluation.

Residential Crawl-Space Air Samples

EPA collected crawl-space air samples in December 2007 to evaluate the potential for volatile contaminants in the groundwater or soil to move from the subsurface into off-site residential living spaces where inhalation exposures might occur. A passive air sampling technique (“SUMMA” canisters) was used to collect 24-hour air samples on 12 properties with dirt crawl-space foundations. Residential properties within approximately 800 feet of the west, south and east sides of the CTS property were sampled. The air samples were analyzed for VOCs. TCE, carbon tetrachloride, chloroethane, chloroform, chloromethane, cis-1,2-DCE, methylene chloride, tetrachloroethylene (PCE), 1,1,1-TCA and trichlorofluoromethane were detected. See Appendix A, Figure 7 for sample locations and analytical results. Three of the 10 detected VOCs in the December 2007 24-hour passive crawl-space air samples were detected at concentrations greater than ATSDR cancer effect CVs for inhalation exposures (carbon tetrachloride, chloroform and methylene chloride) and were carried through health-effect evaluations. TCE was detected above the analytical method reporting limit in six of 12 samples (0.161 to 3.78 parts per billion by volume, “ppbv”) with the highest detection located off-site near the groundwater seeps (springs) to the southeast of the CTS property. All TCE detections were less than CVs, but TCE was carried through a health-effects evaluation using the EPA proposed health-effect values. The highest carbon tetrachloride and chloroform detections (0.0875 and 0.124 ppbv, respectively) were at the same sample location, adjacent to the southwest corner of the CTS property. The highest methylene chloride detection (2.45 ppbv) was from the sample location furthest to the west of the property.

Four additional crawl-space air samples were collected in residences southeast of the site in December 2007. These samples were analyzed for TCE and PCE on site using EPA’s Trace Atmospheric Gas Analyzer (“TAGA”). TCE was detected at one location at 0.23 ppbv (a concentration less than the CV) and was reported at two other locations as “estimated” concentrations less than the analytical method minimum reporting concentration (the lowest concentration of precise quantitation of the chemical). PCE was detected in a single sample at an estimated concentration less than the reporting limit. The TAGA crawl-space sample locations and analytical results are provided in Appendix A, Figure 8. The four TAGA crawl-space samples collected in December 2007 for on-site TCE and PCE analysis had lower concentrations than the passive air samples and no additional health effect evaluations were performed for these samples.

EPA collected five additional crawl-space air samples in August 2008 on the west and east sides of the CTS property. TCE was found in all five samples. The highest TCE concentration was 1.38 ppbv (less than the CV), found at the sample location nearest the east side of the property. The location and analytical results for the August 2008 samples are provided in Appendix A, Figure 9. TCE concentrations found in the five crawl-space samples collected in August 2008 were lower than those observed in December 2007 and no additional analysis of the August 2008 data was performed.

The highest crawl-space air concentrations were used to calculate estimated exposure doses for cancer health-effect evaluations.

Residential Sub-Slab Soil Vapor Samples

EPA conducted sub-slab soil vapor studies in December 2007 to evaluate the potential for inhalation exposure to volatile contaminants in groundwater or soil rising from the subsurface into off-site residential living spaces. Ten properties on a basement or concrete slab foundation were sampled using a sub-slab air sampling technique (“slam-bar”). Sampling ports were installed through the slab and collected samples were submitted for laboratory analysis for TCE and tetrachloroethylene (PCE). Residential properties near the west and east sides of the CTS property were sampled. TCE and PCE were each found in a single different location (see Appendix A, Figure 8). Neither TCE nor PCE were present at a concentration greater than inhalation CVs. Both TCE and PCE are identified as “probable” human carcinogens and were carried through cancer-effect evaluations to further address community concerns.

Other Soil Gas Samples

Eighteen soil gas samples were collected in December 2007 by EPA. Samples were collected at a depth of approximately four feet below the surface and the soil gas analyzed on site for TCE and PCE. The samples were collected along three lines running from approximately 200 to 1,300 feet east of the site, down-gradient of the groundwater flow direction from the site. Each of the three lines of samples ran in a path from the southwest to northeast. Four additional samples were collected adjacent to the north side of the property. TCE was found in three of four samples in the line of samples collected closest to the east side of the site and included the highest concentration (460 ppbv). PCE was the only detection in the next line of samples to the east (1.2 ppbv PCE). There were no detections in the line of samples furthest to the east, or the four locations adjacent to the north side of the property. Sample locations and analytical results are provided in Appendix A, Figure 8. Only the highest detected TCE concentration exceeded the CV, but since both TCE and PCE are identified as “probable” human carcinogens they were carried through cancer-effect evaluations.

Outdoor Air Samples

Outdoor air samples were collected in close-by areas east and west of the CTS property to determine if volatile site contaminants were escaping from contaminated soil or water and were present in the air where they could be inhaled. EPA collected ambient air (outdoor air) samples in December 2007 using a bus-mounted mobile TAGA system. Samples were collected along the same route on local roadways in the vicinity of the CTS site during two mobile monitoring events. Air samples were analyzed for TCE and PCE. The highest TCE concentration detected was 21 ppbv, detected at Surrey Run near the entrance to Hidden Valley, on December 10, 2007. TCE was also detected at 4 ppbv along the South Side Village Drive west of the site. The highest TCE concentration detected during the December 12, 2007 sampling was 0.49 ppbv, also observed at the entrance to Hidden Valley. No PCE was detected during either sampling event. The route and results of the two mobile air sampling events are provided in Appendix A, Figures 10 and 11. The 21 ppbv concentration does not exceed the current ATSDR inhalation CV for TCE but does exceed the EPA proposed inhalation reference concentration (RfC = 7.1 ppbv).

TAGA ambient air sampling was also performed in December 2007 along a slope adjacent to the east side of the CTS property and at four “seeps” (springs) located to the east in the direction of groundwater flow away from the site. These samples were analyzed for TCE and PCE. Ambient air concentrations at the seeps ranged from 3.2 to 70 ppbv TCE (see Appendix A, Figure 8). No PCE was detected.

Additional ambient (outdoor) air samples were collected at 11 locations in August 2008 adjacent to the site and down-gradient to the east. TCE was found in seven of the locations, with the highest concentration at 277 ppbv, located adjacent to the property on the east side, at the groundwater seeps. The remaining detections ranged from 0.078 to 1.6 ppbv TCE. Lower ambient TCE concentrations were observed in the same area in the December 2007 (3.2 to 70 ppbv). No PCE was detected at either time. All outdoor TCE concentrations, except the single 277 ppbv, are less than ATSDR inhalation CVs for exposure periods up to one year. All TCE detections are less than the ATSDR acute CV (2,000 ppbv for exposures up to 14 days). Sample locations and analytical results are noted in Appendix A, Figure 9. The 277 ppbv TCE concentration was used for health-effect evaluations since it exceeds the current ATSDR and EPA proposed inhalation CVs.

Public Health Implications

This section discusses the health effects that could plausibly result from exposures to contaminants at the CTS site. For a public health hazard to exist, people must contact contamination at levels high enough and for a long enough time to adversely affect their health. Evaluation of potential public health hazards are based on ATSDR assessment procedures. The conditions at the site revealed four completed exposure pathways (Table 2).

ATSDR prefers to use site-specific conditions whenever possible to evaluate whether people are being exposed to contaminants at levels of health concern. However, two important site-specific determinants are not known for this site: (1) when the contaminants from the site reached private drinking wells; and, (2) what levels of contamination residents might have been exposed to over time (the levels could have been higher or lower than those detailed in this study). Because of these unknowns, N.C. DPH must rely on reasonable assumptions rather than site-specific information in this instance.

Substances detected in the environmental samples discussed below are summarized in tables in Appendix E. Tables include the range of detections, environmental media comparison values used for the screening analysis, exposure dose estimates for each substance, and health-effect comparison values. Table 23 following summarizes the health effect information discussed in the following section into a single table. More detail is provided in the tables in Appendix E.

Groundwater Data

Groundwater data was evaluated for potential adverse health effects related to drinking contaminated waters (Appendix E, Tables 4 and 5). There is no information to indicate that people have been exposed to the substances and concentrations discussed below in the groundwater samples. Despite this, DPH completed a health evaluation of the groundwater data since private wells have been used in the past in the area.

Pentachlorophenol and n-nitroso di-n-propylamine are identified as probable human carcinogens and both were carried through cancer health-effect evaluations. An estimate of the number of cancers related to pentachlorophenol ingestion indicated less than one additional cancer in population of 100,000 persons exposed. Estimated site-specific exposure doses were 200,000 times less than the lowest health study value causing cancer in animals. Estimated increases in cancer cases due to the observed concentration of n-nitroso di-n-propylamine indicated two

additional cases in a population of 100,000, and an estimated exposure dose 40,000 times less than the lowest health study value causing cancer in animals. No health study data was available for human exposures. The estimated increased cancer risk for the benzene concentration was less than one per 100,000 (actual estimate was less than 1 in a million). As a result of these evaluations, no adverse health effects would be expected with long-term exposure to pentachlorophenol, n-nitroso di-n-propylamine, or benzene at the concentrations observed in these groundwater samples.

Lead was found in groundwater at concentrations exceeding the 15 µg/L AL, which is also the N.C. DPH health guideline level for private well water supplies. If the groundwater has been or may be used as a drinking water supply source the N.C. DPH recommends further testing to characterize the extent of the elevated lead levels. The N.C. DPH also recommends including lead testing in all subsequent analyses of groundwater private well drinking water sources in the area. Private wells with lead concentrations greater than 15 µg/L exceeds N.C. DPH's health guideline value for drinking water and alternative drinking water sources should be provided, or measures immediately undertaken to reduce the lead concentration to less than 15 µg/L.

Chromium data was reported as total chromium, and did not determine what proportion of that concentration, if any, was made-up of the more toxic hexavalent chromium, or the less toxic trivalent chromium. To provide the most health-protective evaluation, the groundwater detections of total chromium were evaluated against hexavalent chromium health values. Two of the four total chromium detections were greater than the lowest hexavalent chromium CV (none exceeded the trivalent chromium CVs). These two samples were collected the farthest to the east off-site of the CTS property. Estimated site-specific exposure doses for children and adults were calculated and health effects comparisons indicate potential adverse non-cancer and cancer health effects if hexavalent chromium concentrations make up a significant portion of the total chromium. If hexavalent chromium concentrations make-up less than approximately 9 µg/L of the total chromium concentration then no adverse health effects are indicated for the selected exposure parameters.

Although the groundwater data is not adequate to fully assess the nature of the observed chromium, at the acidic groundwater pH levels observed (pH 4.5 to 5.0, TNA 2008) the less toxic trivalent chromium species may predominate. Typical conditions existing in groundwater, would also contribute to a prevalence of trivalent versus hexavalent chromium, further reducing the potential for health effects. Hexavalent chromium in groundwater rarely occurs naturally. Therefore, unless there is a contamination source contributing to the elevated chromium levels, trivalent forms may be more likely. Additional investigation of the groundwater chromium is recommended. N.C. DPH recommends determining if the chromium is trivalent or hexavalent, whether the elevated concentrations are naturally occurring or due to a contamination source, and if due to contamination, the extent of the contamination. Providing alternative supplies of water is recommended if groundwater with chromium concentrations exceeding regulatory or health guidelines are being used for drinking.

ATSDR recommends assessing the combined effects of select metals that have a wide range of effects on common target organs. These metals include lead and chromium, which have differing sensitive effects. The critical sensitive effect for lead is identified as neurological effects, particularly in infants and children. The critical effect for hexavalent chromium is uncertain.

Potential combined adverse health effects are assessed by summing the estimated dose levels relative to health effect guideline values when the metals are detected at concentrations greater than one tenth their health-guideline values. Groundwater lead levels in this study did not exceed health-effect guideline values. Health-effect guideline values for groundwater chromium were exceeded if the detected levels are assumed to be predominantly the more toxic hexavalent chromium, rather than predominantly the less toxic trivalent chromium. There is only one study with information on the potential interaction of chromium and lead. As a result of this information, there is limited evidence for potential increased effects related to the combined exposures to lead and chromium in the groundwater in this study (ATSDR 2004).

Vinyl chloride (VC) was detected in the groundwater sample collected on the CTS property and the concentration (48 µg/L) exceeds both ATSDR non-cancer and cancer CVs, as well as the EPA MCL (2 µg/L). ATSDR identifies vinyl chloride as a “known” human carcinogen. Health-effects evaluation using site-specific estimated exposure doses for ingestion indicates there is potential for adverse non-cancer and cancer effects related to long-term ingestion. No VC was detected in the down-gradient samples collected off site, indicating there is no apparent exposure source. Without an exposure source there is no health hazard. Regardless, N.C. DPH recommends the VC concentration in the groundwater be closely monitored. Vinyl chloride is a break-down product of TCE and cis-1,2-DCE and may occur in other subsurface locations that have conditions conducive to the natural break-down of these contaminants.

TCE health-effect evaluations using site-specific estimated exposure doses based on the highest detected TCE concentration indicate the potential for adverse health effects. Exposure dose estimates were greater than the proposed EPA reference concentration (RfC), an estimate of a daily exposure that is likely to be without a risk of adverse effects to the general population and sensitive subgroups during a lifetime of exposure (ATSDR 2005).

Private Drinking Water Well Samples

Well water samples were evaluated for adverse health effects due to drinking (ingesting) the water. Calculations of estimated increased number of cancer cases for the 270 µg/L TCE indicated “low” to “moderate” numbers (2 to 40 per 100,000 population) for a 10-year exposure period using the range of proposed EPA cancer risk values. Calculations for TCE exposures related to the spring source drinking water were based on the available data which reflects concentrations found at the spring and would not likely represent what persons would have been exposed to at the tap. Concentrations of VOCs at the tap would likely have been reduced due to the storage of the water at the spring and piping to the homes. The estimated exposure dose for TCE was greater than current and proposed health guideline values, indicating the potential for non-cancer adverse health effects. Calculations of estimated increased number of cancer cases for the 21,000 µg/L TCE indicated “high” to “very high” numbers (200 to 3,000 per 100,000 population) for a 10-year exposure period using the range of proposed EPA cancer risk values. A shorter exposure period would result in a proportional reduced risk of increased cancers. Because the time frame of contamination of the drinking water can not be conclusively identified for the 270 µg/L detection, the potential for adverse health effects with a longer exposure period were evaluated. If a more health protective 30-year exposure period is used for the TCE detection identified in this well, the number of increased cancers ranges from “low” to a “high” increase in the number of cancers (estimated at 7 to 100 increased cancer cases per 100,000 population). The July 1999 data and health-effect values are listed in Appendix E, Table 6 and 7.

Uncertainty exists in the evaluation of the potential health effects associated with the TCE concentrations in these private well locations. A single analysis was done on the well waters prior to the wells being disconnected and the homes supplied with a municipal water supply. Prior TCE concentrations in the well water could have been higher or lower. Additionally, based on information provided by persons living at these locations, they used the well for approximately 10 to 12 years, but when TCE may have first appeared in the water, and at what concentration, is not known. Family members living at the location with the 270 µg/L TCE detection have identified health effects that may be associated with TCE exposure, but these same health effects may also be associated with other causes. While exposure to TCE is likely based on the single well sample, DPH cannot currently conclude that the health issues the family members have identified are a result of their TCE exposure. Cancer risk estimates greater than 10 additional cases per population of 100,000 indicate an unacceptable level of cancer risk. In addition to the ingestion risks, there may have been additional risks due to inhalation (breathing) of TCE that escaped from the water to the air during activities such as showering or bathing. No indoor air data exists to quantify the potential risk related to TCE inhalation exposure at this residence. The potential for harmful health effects may be increased if the persons using the contaminated well water were exposed to both drinking and breathing high levels of TCE. It is not known if the 21,000 and 15,000 µg/L detections at the springs are representative of actual exposures from the drinking water available within the homes. The spring water was collected in external concrete structures and pumped to the homes. There may have been some reduction of TCE concentrations resulting from out-gassing where it was exposed to headspace. The DPH concluded that the single TCE concentration for these wells may have been adequate to cause harmful health effects if the household occupants were exposed for as long as 10 years. Because of the lack of knowledge of the length of time the well was contaminated, and at what concentrations over the contamination period, a great deal of uncertainty exists in identifying potential health risks.

TCE and bromodichloromethane concentrations found in the 66 private well samples collected by N.C. DENR in November and December 2007 were evaluated for potential health-effects. No adverse non-cancer health effects were indicated.

Calculations of estimated increases of cancer cases indicated “low” numbers of increased cancers (1 additional cancer in a population of 100,000). No adverse health effects related to TCE ingestion exposures are indicated at these concentrations for the selected exposure parameters. The data and health-effect values for the 66 private well samples are listed in Appendix E, Tables 8 and 9.

Bromodichloromethane (BDCM) cancer-effect calculations indicate the estimated site-specific exposure dose using the maximum detected concentration is 790,000 times lower than the lowest cancer-effect level identified in animal studies. No apparent increased numbers of cancer cases were indicated (less than 1 per 100,000 population). No adverse health effects are indicated related to BDCM exposures at these concentrations.

Although lower than CVs the TCE concentration detected in the January 2008 private well samples collected by N.C. DENR was carried through a cancer-effect evaluation. Cancer-effect evaluation of the TCE concentration estimates “low” numbers of increased cancers (2 additional cases of cancer per 100,000 population). The estimated exposure dose for TCE was 140,000

times lower than the lowest animal cancer health-effect level. No adverse health effects are indicated for the TCE and cis-1,2-DCE exposures in this well. The N.C. DPH recommends continued efforts to identify private wells that are used as drinking water sources in areas of observed contamination or in the flow-path of known contaminated groundwater. Periodic monitoring of identified private wells for VOC contamination and connection to alternative drinking water supplies is recommended if contamination is found that exceeds regulatory or health-based guidelines.

Some of the contaminants in the well water samples are identified as “volatile” and could volatilize (“out-gas” or move from being dissolved in the water into air) from waters during activities such as showering, bathing, car washing or watering the lawn. The magnitude of these exposures varies depending on the frequency of showering and bathing, time spent indoors, air exchange rates in the bathroom and house, and other factors. ATSDR states that non-ingestion exposures may yield a contaminant dose that is comparable to the ingestion dose (ATSDR 2005a). Concentrations of volatile compounds in the drinking water samples discussed in this section (TCE and cis-1,2-DCE) are not likely at concentrations high enough to cause adverse health effects due to inhalation exposures. Bathroom air concentrations during showering were calculated using the maximum concentration of each VOC in the well water. All values were less than inhalation screening values.

Table 23. Summary of the health effects evaluation information for chemical concentrations for all sample types exceeding comparison values at the CTS site. (Table continued on next page.)

Contaminant	Exposure Pathway	Detected at Concentration Above Screening Values?	Site Exposures Above Health Guideline Screening Values?	Site Exposures Above Health Study Values?	Are Health Risks Indicated?	Are Cancer Risks Indicated?
Private Well Water, collected Jan. 2008						
Trichloroethylene (TCE)	Drinking	No	No			No
Private Well Water, collected Nov. to Dec. 2007						
Trichloroethylene (TCE)	Drinking	Yes	Yes	No	No	No
Bromodichloromethane	Drinking	Yes	No			No
Private Well Water, collected Jul. 1999						
Trichloroethylene (TCE), Groundwater well	Drinking	Yes	Yes	No	No	Yes
Trichloroethylene (TCE), Spring wells	Drinking	Yes	Yes	Yes	Yes	Yes
1,1,1-Trichloroethane (TCA), Spring wells	Drinking	Yes	No			
cis-1,2-Dichloroethane (c-1,2-DCE), Spring wells	Drinking	Yes	No			
1,1-Dichloroethene (1,1-DCE), Spring wells	Drinking	Yes	No			
Groundwater, collected Dec. 2007 to Jan. 2008 (not confirmed as a drinking water source)						
Trichloroethylene (TCE)	Drinking	Yes	Yes	No	No	No
cis-1,2-Dichloroethane (c-1,2-DCE)	Drinking	Yes	No			
Lead	Drinking	Yes	No	Yes	Possible - If a drinking water source	
Pentachlorophenol	Drinking	Yes	No		No	
n-Nitroso di-n-propylamine	Drinking	Yes	No		No	
Chromium	Drinking	No for Total Chromium, Yes for Hexavalent Chromium	No for Total Chromium, Yes for Hexavalent Chromium	No for Total Chromium, Unknown for Hexavalent Chromium	No for Total Chromium, Unknown for Hexavalent Chromium	
Vinyl Chloride	Drinking	Yes	Yes	Yes	No – Not detected off site	No – Not detected off site

Table 23, continued. Summary of the health effects evaluation information for chemical concentrations for all sample types exceeding comparison values at the CTS site.

Contaminant	Exposure Pathway	Detected at Concentration Above Screening Values?	Site Exposures Above Health Guideline Screening Values?	Site Exposures Above Health Study Values?	Are Health Risks Indicated?	Are Cancer Risks Indicated?
Surface Water, collected Sept., Nov. and Dec. 2007						
Trichloroethylene (TCE)	Drinking/ Swimming ¹	Yes	Yes	No	No	No
cis-1,2-Dichloroethane (c-1,2-DCE)	Drinking/ Swimming ¹	Yes	No			
1,1,1-Trichloroethane (TCA)	Drinking/ Swimming ¹	Yes	No			
Bis(2-ethyl hexyl)phthalate	Drinking/ Swimming ¹	Yes	No			No
Vinyl Chloride	Drinking/ Swimming ¹	Yes	No			No
Surface Water (Springs), collected Jul. 1999						
Trichloroethylene (TCE)	Drinking/ Swimming ¹	Yes	Yes	No	No	No
1,1,1-Trichloroethane (TCA)	Drinking/ Swimming ¹	Yes	No			
Sub-surface Soil, collected Dec. 2007 to Jan. 2008						
Arsenic	Eating	Yes	Yes	Yes	No	No, Buried Soils & at Background Levels
Polynuclear Aromatic Hydrocarbons (PAHs)	Eating	Yes	No	No	No	No
Crawl-space Air, collected Dec. 2007						
Carbon Tetrachloride	Breathing	Yes		No	No	No
Chloroform	Breathing	Yes				No
Methylene Chloride	Breathing	Yes		No	No	No
Trichloroethylene (TCE)	Breathing	No		No	No	No
Sub-slab Soil Gas, collected Dec. 2007						
Trichloroethylene (TCE)	Breathing	Yes		No	No	No
Soil Gas, collected Dec. 2007						
Trichloroethylene (TCE)	Breathing	Yes		No	No	No
Ambient Air, collected Aug. 2008						
Trichloroethylene (TCE)	Breathing	Yes		No	No	No

¹ Evaluated as accidental drinking of water by children while swimming

Surface Water Samples

Spring samples collected in 1999 were evaluated for potential health effects associated with intermittent incidental ingestion of water as might be anticipated for children while swimming or playing in the springs (Appendix E, Tables 10 and 11). Long-term exposures such as those associated with a residential drinking water source were not included in surface water evaluations. The swimming incidental ingestion exposures were calculated as one hour per week of swimming, for six months a year, for 10 years. The estimated exposure dose for the highest 1,1,1-TCA concentration was less than the ATSDR non-cancer health guideline. No adverse health effects associated with incidental ingestion is indicated.

Surface water samples collected in September, November and December 2007 were treated as a single sample set for health-effect evaluations associated with incidental ingestion of water by children while swimming (Appendix E, Tables 12 and 13). Estimated site-specific exposure doses calculated with maximum detected concentrations for cis-1,2-DCE, 1,1,1-TCA, naphthalene, bis(2-ethylhexyl)phthalate (BEHP) and vinyl chloride indicate no expected adverse health effects. ATSDR identifies BEHP as a “probable” human carcinogen. Cancer health-effect calculations estimate less than one excess cancer per one million persons at the estimated BEHP exposure dose, indicating cancer-effects would not be anticipated.

No dermal effects were evaluated since no ATSDR or EPA dermal CVs were available for any of the chemicals detected in surface waters. While the lack of dermal CVs does not allow evaluation, the ability to come into contact with the surface waters, and the typical intermittent nature of contact with the surface waters, would reduce the potential for adverse effects. For most exposure situations, ATSDR generally considers dermal exposure to be a minor contributor to the overall exposure dose as compared to those from ingestion and inhalation (ATSDR 2005a).

The incidental ingestion exposure estimate for children at the maximum TCE concentration (19,700 µg/L) for all samples exceeds the EPA proposed health guideline value (0.0003 mg/kg/d RfC). The estimated exposure dose calculated for the geometric mean concentration (386 µg/L) is less than the EPA RfC. No ATSDR dermal or inhalation comparison values are available for TCE. Although the evaluation does not indicate adverse health-effects would be expected for incidental ingestion by children while swimming, caution is recommended for incidental ingestion or direct contact exposures for sensitive populations to waters with TCE concentrations at these concentrations. The springs sampled to the east of the CTS site were isolated by a fence which was constructed in December 2007. Warning signs were also placed on the fence. During construction of the soil vapor extraction (SVE) system sections of the fence were temporarily removed. The fence, when intact, serves to limit, if not eliminate access to the springs which are located on private property.

Sub-Surface Soil Samples

Typically, ATSDR does not evaluate sub-surface soils for potential health-effects due to the limited potential for human access and exposure. Sub-surface soil data was evaluated for this site to provide additional assurance that adverse health effects were not indicated in response to public concerns associated with this site.

Cancer-effect evaluations for arsenic incidental soil ingestion estimate no increase in the number of cancer cases for adults (less than one additional cancer per 100,000 population). Human cancer-effect health study data estimates child exposure doses for the highest arsenic concentration was 1,100 to 2,300 times lower than the lowest study dose level for exposure periods of 16 and 12 years respectively. Child pica-behavior dose estimates were 46 times lower than the lowest study dose resulting in a cancer-effect over a 12-year exposure (Appendix E, Table 17). Three of the five arsenic detections, including the highest detection, were located on the CTS property. The other two detections were at the closest sample locations to the west and southeast of the property. The soils with arsenic detections were all collected at least 10 feet below the surface. Limited exposure potential would be expected for sub-surface soils located on the property, such as digging to the depth of the sample collection. No site-specific background metal data for comparison was indicated for this study. As a result, other data resources were sought. In their 2008 revision of average natural background concentrations of metals in North Carolina soils, the NC Department of Agriculture listed a value of 4.5 mg/kg arsenic (NCDA 2008). Detections less than twice the average background concentration are typically considered in the normal range in risk assessment. As a result of the comparison to typical background concentrations of arsenic in North Carolina soils, the limited exposure potential to the detected arsenic in sub-surface soils, and the potential for adverse cancer effects only for pica behavior, no adverse health effects are indicated for the arsenic levels observed in soils on and around the CTS property.

Polynuclear aromatic hydrocarbons (PAHs) were detected in a single soil sample located on the northwest corner of the CTS property (Appendix E, Tables 15 and 17). ATSDR does not provide CVs for individual PAHs other than a CREG for benzo(a)pyrene (BaP). BaP is the most studied of the individual chemicals of the PAH group, and has shown to be the most toxic. Seven of the eight detected PAHs, including BaP, are identified as “probable” human carcinogens by ATSDR. To evaluate potential adverse health effects associated with incidental ingestion of soil PAH concentrations, the other eight PAH chemicals were converted to an equivalent BaP concentration and summed to provide a “BaP-equivalent” concentration for all detected PAHs. An estimated incidental soil ingestion BaP-equivalent exposure dose was calculated for pica-behavior children, and children and adults using typical soil exposure rates. Estimated numbers of increased cancers were less than one per 100,000 population. Based on the limited exposure potential related to the location of the single PAH sub-surface soil detection on the CTS property, and the low exposure dose estimates relative to known health-effect study data, no adverse health effects are indicated for PAHs.

Appendix A, Tables 14 through 16 lists the detected chemicals in the sub-surface soils and those that exceeded comparison values.

Residential Crawl-Space Air Samples

The highest crawl-space air concentrations were used to calculate estimated exposure doses for cancer health-effect evaluations (Appendix E, Table 18). A 30-year period was used to represent a conservative (highly health protective) exposure period estimate for the typical maximum length of time a person lives at a single residence and to accommodate for a lack of information on the length of time soils have been contaminated with TCE and other VOCs. When evaluating crawl-space inhalation exposures ATSDR utilizes a 20 to 50% reduction of the measured VOC

concentration for calculation of the estimated exposure concentration. For this study, to provide a worst-case exposure estimate to crawl-space VOCs, the measured crawl-space concentration was used for exposure estimates. This would serve to overestimate exposure concentrations and potential health risks. There is no data to indicate that persons were exposed to the concentrations of chemicals detected in the crawl-space air samples. Actual exposure concentrations in the living areas of the tested residences would likely be less. Testing of the indoor air is the most appropriate means to identify if exposures are present.

ATSDR identifies carbon tetrachloride as a “probable” human carcinogen. Exposure dose estimates for the carbon tetrachloride indicate “no apparent increased cancers” (less than one additional cancer for a population of 100,000 exposed). Chloroform is identified as a “likely” human carcinogen by ATSDR. Chloroform exposure dose estimates indicate “no apparent increased cancers” (less than one additional cancer per 100,000 exposed persons). There is no chloroform ATSDR or EPA human or animal cancer-effect study data for comparison. Methylene chloride is identified as a “likely” human carcinogen by ATSDR. Methylene chloride exposure dose estimates indicate “no apparent increased cancers” (less than one increased cancer per 100,000 exposed persons). The TCE cancer-effect evaluation estimates “low” to “moderate” numbers of increased cancers (2 to 10 per 100,000 population) using current and proposed health guidelines. Based on these evaluations, no cancer or non-cancer adverse health-effects are indicated for 30-year inhalation exposures to these VOCs at the concentrations in the December 2007 crawl-space samples.

Due to the nature of soil sampling and vapor transport studies, the crawl-space sampling should be considered a "snapshot" of exposure to contamination at one point in time. Actual concentrations of contaminants may vary in homes based on seasonal changes, heating and ventilation system use, and other factors. Additional information on these factors and the possible impacts on the concentrations of contaminants present in the air are not provided from one round of sampling. Yet, the highly health protective assumptions made in the crawl-space evaluation reduce the uncertainty associated with the sampling data.

Residential Sub-Slab Soil Gas Samples

A 0.1 “attenuation factor” was applied to soil gas TCE and PCE concentrations to represent conservative estimates of indoor air concentrations available to occupants for inhalation (Appendix E, Table 19). Estimates of increased numbers of cancers due to TCE inhalation at the concentration detected in the single sample (0.80 ppbv, located west of the CTS property) ranged from less than one to two per 100,000 population for the current and proposed range of cancer risk factors. The inhalation exposure dose estimate was 1.2 million times lower than the lowest animal cancer-effect study value. No human values were available for comparison. The PCE evaluation estimates “low” numbers of increased cancers (three additional cancers per 100,000). No human values were available for comparison. No adverse health effects are indicated from breathing air with TCE or PCE at the concentrations detected in the December 2007 sub-slab soil gas samples.

Other Soil Gas Samples

A 0.1 attenuation factor was applied to soil gas concentrations to represent conservative estimates of indoor air concentrations available for inhalation (Appendix E, Table 20).

TCE: The adjusted maximum TCE soil gas concentration is 2,000 times lower than lowest no-effect human study value for a 4-hour exposure, and 4,300 times lower than the lowest-effect human study value for a 7-hour per day for 5 days exposure. The adjusted maximum TCE concentration was used to estimate cancer-effects for 30-year residential exposures. Estimates of increased numbers of cancer ranged from “moderate” to “high” (20 to 1,000 per population of 100,000). The two other TCE detections in this line of samples were much lower and cancer-effect evaluations of the mean concentration were calculated. The mean calculation estimates “low” to “high” increased numbers of cancers (4 to 210 per 100,000).

PCE: The attenuation factor adjusted PCE concentration was 1,700 times less than the lowest no-effect human study values for long-term exposures, and 83,000 times lower than the lowest human study for a 14-year intermittent exposure. There was “no apparent” risk of additional cancers (less than one additional cancer per 100,000 population).

The soil gas data evaluated in this sample set represents TCE and PCE concentrations in the sub-surface soil environment and not concentrations found in residential breathing zones. There is no indication that persons have been or are being exposed at the concentrations observed in the soil gas samples. The soil gas concentrations were adjusted with highly health protective attenuation factors to represent “worst-case” changes in TCE and PCE concentrations as they move through the soil to the area under a building, where they may ultimately gain access to indoor air. A less health protective attenuation factor referenced in guidance documents (0.01) results in adjusted concentrations 10 times less than those used for this evaluation, with an associated 10 times decrease in health-effect estimates. The highly health protective adjustment used in this study results in the maximum expected indoor concentrations, the highest expected exposure concentrations, and estimates of the maximum expected (“worst-case”) adverse health risks. Crawl-space samples collected in the vicinity of the sub-surface soil vapor samples do not indicate that TCE or PCE concentrations in the range estimated with the conservative attenuation factors have been found in residences. Soil gas concentrations are variable and decreased to below detection limits a short distance to the east of the CTS site. Health effect evaluations included a highly protective estimate of cancer effects for both TCE and PCE assuming long-term exposures at the adjusted soil gas concentrations. Because of the lack of exposure potential and the highly protective assumptions used, adverse health effects are not indicated for the TCE and PCE soil gas concentrations.

To be protective of the community’s health, N.C. DPH recommends TCE and other volatile gases in the sub-surface be closely monitored for potential exposures in indoor and outdoor living environments. Continued monitoring of soil gas and crawl-space concentrations, or indoor air environments, are recommended if there is evidence of the potential for soil gas concentrations to increase over those in this health assessment, or to be transported to areas where human exposures are likely to take place, such as residential dwellings.

Outdoor Air Samples

The highest detected TCE concentration collected along the roadway (21 ppbv) is 95 times less than the ATSDR CV for short-term exposure periods (less than 15 days) (Appendix E, Table 21). The 21 ppbv concentration is 4,500 times less than the no adverse health-effect study level for a 4-hour exposure, and 9,500 times less than the lowest adverse effect level for a second human

study using a 7-hour per day exposure for 5 days. No short-term effects are indicated for inhalation exposures at the TCE concentrations seen in the roadway monitoring, such as persons travelling along the roadway or waiting for a bus.

The highest TCE concentration detected in the other ambient air samples (not collected along the roadways) was 277 ppbv near the seeps (springs) to the east of the CTS property, observed in August 2008 (Appendix E, Table 22). Exposures were calculated to evaluate potential health effects associated with short-term intermittent recreational exposures near the seeps. The 277 ppbv detection is 340 times lower than the lowest no adverse health effect level from human studies with a 4-hour inhalation exposure, and 2,200 times lower than the non-cancer long-term (chronic) exposure in an animal study. The geometric mean concentration for the December 2007 samples (0.945 ppbv) is 100,000 times lower than the health-effect level. The lowest adverse effect level for a second human health study using a 7-hour per day for 5 days exposure period was 720 times higher than the highest outdoor air sample, and 760,000 times higher than the geometric mean TCE concentration. Based on the health effect evaluations, the variability in the detected TCE concentrations at the seeps, and the likely short-term exposure scenarios expected in the immediate vicinity of the seeps, no adverse health effects would be expected to persons intermittently exposed to the TCE concentrations measured in this area. The security fence that has been placed around the seeps will prevent access to the immediate vicinity of the springs, preventing persons from breathing any released volatile chemicals at their highest concentration.

Selected Site Contaminant Toxicological Information

The following information is provided for TCE, chromium and lead. Additional information is included in materials in Appendix F and H and in documents listed in the References.

Trichloroethylene (TCE)

Trichloroethylene is a colorless liquid which is used as a solvent for cleaning metal parts and as a solvent to make other chemicals. Trichloroethylene can be found in some household products, including, paint removers, adhesives, and spot removers.

It is not known if drinking water contaminated with trichloroethylene (TCE) causes non-cancer illness in humans. Childhood leukemia has been observed after maternal exposure to TCE-contaminated drinking water during the prenatal period. Breathing small amounts may cause headaches, lung irritation, dizziness, poor coordination, and difficulty concentrating. Breathing large amounts of TCE may cause impaired heart function, unconsciousness, and death. Breathing it for long periods may cause nerve, kidney, and liver damage. Evidence from animal and epidemiological studies also suggest that exposure to TCE might be associated with congenital heart defects and poor intrauterine growth. Studies in rats and mice show that TCE can effect fertility, but the relevance to humans is not clear (NRC 2006). Human epidemiological studies have been limited by difficulties in estimating exposure levels and by the presence of other solvents with similar toxic effects. In rats and mice, TCE begins affecting the liver, kidney, and developing fetus at doses as low as 1 mg/kg/day. These studies are limited, however, by inadequate characterization of exposure, inadequate quantification of results, or lack of endpoints suitable for deriving chronic endpoints. The current ASTDR cancer classifications listed for TCE are “under review” (EPA), “reasonably anticipated to be a carcinogen” (NTP), and “probably

carcinogenic to humans” (ATSDR 1997e, ATSDR 2003, EPA 2001b, NJDHSS 2003). In recent years evidence supporting TCE’s ability to cause cancer has been strengthened.

Chromium

Chromium is a naturally occurring element found in rocks, animals, plants, and soil. It can exist in several different forms, including trivalent and hexavalent chromium. Hexavalent chromium is more toxic than trivalent. Small amounts of trivalent chromium are considered to be a necessity for human health. Chromium can easily change from one form to another in water and soil, depending on the conditions present. Chromium is widely used in manufacturing and is found in products such as treated wood, tanned leather and stainless steel cookware.

The main health problems seen in animals following ingestion of hexavalent chromium compounds are irritation and ulcers in the stomach and small intestine, and anemia. Trivalent chromium compounds are much less toxic and do not appear to cause these problems. Sperm damage and damage to the male reproductive system have also been seen in laboratory animals exposed to hexavalent chromium. Skin contact with certain hexavalent chromium compounds can cause skin ulcers. Some people are extremely sensitive to hexavalent chromium or trivalent chromium. Allergic reactions consisting of severe redness and swelling of the skin have been noted.

The U.S. Department of Health and Human Services (U.S. DHHS), the International Agency for Research on Cancer (IARC), and the EPA have determined that hexavalent chromium compounds are “known” human carcinogens. In workers, inhalation of hexavalent chromium has been shown to cause lung cancer. Hexavalent chromium also causes lung cancer in animals. An increase in stomach tumors was observed in humans and animals exposed to hexavalent chromium in drinking water.

It is likely that health effects seen in children exposed to high amounts of chromium will be similar to the effects seen in adults. It is not known whether children would be more sensitive than adults to the effects of chromium. It is not known if exposure to chromium will result in birth defects or other developmental effects in people. Some developmental effects have been observed in animals exposed to hexavalent chromium. In animals, some studies show that exposure to high doses during pregnancy may cause miscarriage, low birth weight, and some changes in development of the skeleton and reproductive system. Birth defects in animals may be related, in part, to chromium toxicity in the mothers (ATSDR 2008a, ATSDR 2008b).

Lead

Lead is a naturally occurring toxic metal. It may be found in its pure form or in combination with other minerals. Lead has no nutritional value, but is very valuable in manufacturing. In industry, lead is used in the production of batteries, solder, paints, ammunition, sheet metal, and other metal alloys. Lead was found in house paint sold before 1978. Since 1978, paint sold for residential use can contain no more than 600 parts per million lead. Most lead is now used to manufacture car batteries. Other lead sources include bullets, fishing weights, curtain weights, some glazed ceramics, and plumbing solders made before 1986.

Lead is a well known developmental neurotoxin, and also affects the kidneys, blood formation, reproduction, humoral immunity, and the peripheral nervous system (ATSDR 2007d). Long-term lead exposure for working adults is associated with decreased performance in some tests that measure functions of the nervous system. Lead exposure may also cause weakness in fingers, wrists, or ankles. Lead may also cause anemia. In pregnant women, high levels of exposure to lead may cause miscarriage. According to the ATSDR there is no conclusive proof that lead causes cancer, however both the U.S. Department of Health and Human Services and EPA have determined that lead is a probable human carcinogen. Children are more sensitive to the effects of lead than adults, and studies show that even low lead levels that do not affect adults can be detrimental to a child's cognitive development.

Additional Contaminant and Health Information

Additional contaminant and health hazard information is provided in Appendix H for TCE, chromium and lead. The information is provided in the form of fact sheets prepared by ATSDR and N.C. DPH. These fact sheets provide information on the occurrence of these chemicals in the environment and adverse health effects that may occur with exposures exceeding health-effect levels through different routes of exposure. Additional information on these and the other chemicals identified in the environmental matrices associated with the CTS site is available on ATSDR's web site through the "Toxic Substances Portal" (<http://www.atsdr.cdc.gov/substances/index.asp>). Additional discussion of recent findings on the toxicity of TCE and the EPA proposed CVs and health guidelines is provided in Appendix F.

HEALTH OUTCOME DATA

In addition to studying exposure and chemical-specific toxicity data as part of the public health assessment process, N.C. DPH also considers health outcome data, such as mortality and morbidity data. The following criteria are evaluated when determining if a study of health outcome data is reasonable: (1) presence of a completed human exposure pathway, (2) high enough concentrations of contaminant to result in measureable adverse health effects, (3) sufficient numbers of exposed people in the pathway for effects to be measured, and (4) a health outcome database where disease rates for the population of concern can be identified.

N.C. DPH identified groundwater, private drinking water well, surface water and air completed exposures pathway for the CTS site. The limited number of potentially exposed persons, the length of the potential exposure periods, the concentrations of contaminants of potential exposure, and the potential long-term health effects associated with the site contaminants limit the study of health outcome data related to this site. Non-cancer health statistics are not available at the level necessary for evaluation. A cancer rate study was done for Buncombe County and for a 1-mile radius around the CTS property. The study compared the numbers and types of cancers in the study area to typical data observed in other areas of North Carolina. The cancer rate study did not identify elevated numbers of cancers over what is expected for the number of persons studied. The types of cancers observed in the study population reflected the types and numbers expected in the community. The cancer study report is included in Appendix G. The ability to associate chemicals from a specific site to resulting cancers in a population is complicated by a number of factors. It is estimated that one out of every two men and one out of every three women will develop a cancer of some type during his or her lifetime. As a result, it is

common to find what appear to be cancer cases clustering in neighborhoods over a period of years. This will occur in any neighborhood. As people age, their chance of getting cancer increases, and so as we look at a community, it is common to see increasing numbers of cancer cases as the people in the community age. Different types of chemicals cause different types of cancers (such as liver, lung, or colon). Cancer rate studies look for excess cancers related to exposures to specific chemicals over the 30% expected in a population. We are all exposed to hundreds of natural and man-made chemicals on a daily basis. Although not all chemicals can cause cancer, separating the health-effects of these chemicals from those in a particular cancer study is statistically difficult. An added complication is that cancers are typically developed long after the initial exposure to the causative chemical, in many cases years to decades afterward.

CHILD HEALTH CONSIDERATIONS

The ATSDR recognizes there are unique exposure risks concerning children that do not apply to adults. Children are at a greater risk than are adults to certain kinds of exposures to hazardous substances. Because they play outdoors and because they often carry food into contaminated areas, children are more likely to be exposed to contaminants in the environment. Children are shorter than an adult, which means they breathe dust, soil, and heavy vapors closer to the ground. They are also smaller, resulting in higher doses of chemical exposure per body weight. If toxic exposures occur during critical growth stages, the developing body systems of children can sustain permanent damage. Probably most important, however, is that children depend on adults for risk identification and risk management, housing, and access to medical care. Thus, adults should be aware of public health risks in their community, so they can guide their children accordingly. Other susceptible populations may have different or enhanced responses to toxic chemicals than will most persons exposed at the same concentration of a particular chemical in the environment. Reasons for these differences may include: genetic makeup, age, health, nutritional status, and exposure to other toxic substances (like cigarette smoke or alcohol). These factors may limit that persons' 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 scenarios, including incidental ingestion of surface waters during swimming, and exposure parameters, were considered in this assessment.

Children are particularly sensitive to lead as compared to adults. No safe blood lead level in children has been determined. Lead affects children in different ways depending on the level of exposure. High levels of lead exposure may increase the risk of children developing anemia, kidney damage, colic, muscle weakness, and brain damage. Lower levels of lead exposure may affect development and behavior. Even lower levels of lead exposure can affect a child's cognitive abilities and physical growth. Fetal exposure to lead is associated with premature birth and low birth weight. Fetal and early childhood exposure to lead has also been linked to decreased cognitive development and reduced intelligence in early childhood, and evidence suggests that these effects may persist into adulthood (see Appendix 2, for a child-specific public health statement). There is the potential that children were exposed to groundwater drinking sources containing lead at concentrations exceeding ATSDR comparison values. Calculated blood lead levels for children using the maximum and geometric mean concentration for the groundwater samples collected in 2007 and 2008 indicate estimated blood lead levels less than the Center for Disease Control and Prevention (CDC) health-effects action level of 10 µg/dL.

The number of children possibly exposed, if any, the length of the exposure, and actual exposure concentrations over time are unknown.

The TCE concentration in the groundwater monitoring well samples collected on the CTS property was high enough to potentially cause adverse health effects to children. TCE concentrations found off-site down-gradient were lower and adverse effects would not be expected. Vinyl chloride was also detected on the site in groundwater at concentrations that could potentially cause health effects to children. No vinyl chloride was detected off-site. Elevated total chromium was found in groundwater east of the site. If the concentration of chromium detected in the groundwater is made up of elevated hexavalent chromium concentrations, then children may be at risk of health effects. There is no indication that children have been or are being exposed to groundwater in the area of these sample locations. However, monitoring of the exposure potential and verification of a lack of exposure is recommended.

High concentrations of TCE were observed in surface waters and seeps near the east side of the CTS property. Although the health effect evaluation did not indicate the potential for adverse health effects, N.C. DPH recommends limiting access of children to these waters to protect them from inhalation, direct contact, and incidental ingestion exposures that might occur during swimming or wading.

COMMUNITY HEALTH CONCERNS EVALUATION

The community living around the CTS/Mills Gap site has expressed concerns regarding the potential for adverse health effects, including cancer, to persons drinking contaminated well water, using contaminated well water for bathing or other household uses, and breathing air containing volatile contaminants associated with the site.

Family members at the residences to the east of the CTS property where TCE was observed in 1999 in their private well waters have expressed concerns that their health issues may be related to TCE exposure. Persons using the groundwater well have identified health concerns including liver abnormalities, immune system deficiencies, possible kidney effects, and liver cancer. Persons using the spring water drinking water source have identified health issues. DPH can not confirm that these health effects are related to TCE exposure because of limited medical and occupational data, limited historical well water data, and the length of time since the exposure has ended.

The N.C. DPH was not able to conclude whether chromium and lead concentrations detected in groundwater collected down-gradient of the CTS property in 2007 present a public health hazard. There is no indication that people have been exposed to the elevated chromium or lead. Whether these particular waters have been used as a drinking water source is unknown. All other evaluations of potential exposure pathways and identified contaminants concentrations do not indicate the potential for adverse health effects, including exposures to children.

CONCLUSIONS

N.C. DPH has reviewed sampling and analytical data from a variety of environmental samples collected by the EPA and N.C. DENR on, and in the area near, the CTS/Mills Gap site. Contaminant concentrations in groundwater, surface water, sub-surface soil, sub-surface soil gas, crawl-space gases and outdoor air were all evaluated. The DPH reached five conclusions in this health assessment:

The DPH concluded that the residents using a private groundwater and spring wells identified in 1999 as contaminated with TCE could have been harmed by drinking their well water or breathing TCE that escaped from the well water to the air (volatilized) during activities such as showering or bathing. The length of time they used contaminated well water is not known. The concentrations of TCE that they may have been exposed to in the air or drinking water over the period of contamination are also not known, other than the single 1999 sample concentrations of TCE in the waters. The DPH cannot currently conclude whether the health effects identified by the families living at the residences east of the CTS site where TCE was detected in 1999 are a result of TCE exposure. A single well water sample was collected at each of the residences before the wells were closed. No samples were collected in the homes for the samples served by the spring source. The potential for adverse health effects are indicated on the basis of the single sample concentrations and assuming a long-term exposure period (10 years or more). During an interview with the DPH Public Health Physician a family member that had used the groundwater well reported health effects that may be linked to TCE exposure, however these same health effects may also be the result of other circumstances (smoking, occupational exposures, infectious diseases, and genetic predispositions). Because of the length of time that has passed since the exposures were stopped, the limited data available for the well water, and limited data on occupational and medical history, we do not have the ability to directly link the reported health effects to the well water exposures. These findings are relevant only for persons that were long-term users (more than 10 years) of the private well water at this location before the well was disconnected. Drinking or breathing TCE over many years in large amounts may cause adverse health effects. These effects include increased risk of kidney or liver cancer; dizziness, lung irritation, impaired heart function; and nerve, kidney or liver damage. Reproductive effects such as impaired fetal growth or decreased fertility may also result.

The DPH cannot currently conclude whether groundwater with the metal chromium has or may present a drinking water hazard. There are no indications that drinking water supplies contained elevated concentrations of chromium, but the available analytical data does not adequately identify the type of chromium in the groundwater to determine if a health hazard would exist if the groundwater was used as a drinking water supply.

The DPH cannot currently conclude whether groundwater with elevated concentrations of the metal lead has been or may present a drinking water hazard. While there are no indications that private drinking water supplies contain elevated concentrations of lead, more information is needed to determine if people may be using private drinking water supplies with elevated lead.

The DPH concludes that other groundwater contaminants, including trichloroethylene (TCE), are not expected to harm people's health. There is no indication that private drinking water wells,

other than the single well discussed above, contain concentrations of TCE that may present a health hazard.

The DPH concludes that levels of chemicals identified in the private well waters, surface waters, sub-surface soils, crawl-space air, sub-surface soil gas and outdoor air will not harm people's health.

The DPH N.C. Central Cancer Registry (CCR) determined that cancer rates for a 1-mile radius around the CTS property were not elevated. Cancer cluster investigations such as this are subject to a typical set of limitations as expressed in the CCR report provided in Appendix G. The cancer evaluation for this site is limited by the small population size of the study area and the availability of cancer records only since 1990. Because of the long latency period of most cancers the evaluation is also limited by the use of a person's address at the time of diagnosis rather than the ability to identify if and where the critical exposure that led to cancer development took place.

RECOMMENDATIONS

- Encourage persons that lived at the residences identified in 1999 as having elevated TCE in their private well waters and spring water drinking sources to undergo complete medical evaluations, making their health-care providers aware of the circumstances of their exposure to TCE.
- Identify if there are private wells currently being used as drinking water sources in the path of the contaminated groundwater flow emanating from the CTS property. Periodic VOC monitoring of these private wells, if they exist, is recommended. If contaminants are identified at concentrations exceeding regulatory or health-based drinking water guidelines, alternative drinking water sources should be provided.
- Determine if additional drinking water sources may be impacted in the area of the contaminated wells in the residences north of the CTS site. (On the basis of the described groundwater flow through and away from the CTS site the contamination observed in these wells may not be related to the CTS site.)
- Determine the hexavalent chromium component of the groundwater where elevated total chromium was reported if these waters are being, or may be used as a drinking water source.
- Determine the lead concentration of the groundwater where elevated lead was reported if these waters are being, or may be used as a drinking water source.
- Monitor lead levels in private well supplies in the areas where groundwater concentrations of lead exceeded the regulatory level.
- Monitor groundwater moving off the CTS property for vinyl chloride, a known human carcinogen that is a breakdown product of contaminants found associated with this site. If vinyl chloride is identified in drinking water sources exceeding regulatory or health-protective guideline values it is recommended that alternative drinking water supplies be provided.
- Monitor groundwater in the flow path from the CTS site that are being used or may be used as drinking water sources for TCE and other contaminants. Provide an alternative

drinking water source if contaminant concentrations exceed regulatory or health-guideline values.

- Prevent children from wading or swimming in surface waters and springs near the east side of the property where elevated concentrations of TCE were detected.
- Continued monitoring of out-gassing of VOCs from elevated concentrations in the sub-surface into dwellings where they may present an inhalation hazard.
- Control potential inhalation exposures in the area of the seeps (springs) adjacent to the east side of the CTS property, either by controlling discharges or controlling access.

PUBLIC HEALTH ACTION PLAN

The purpose of the Public Health Action Plan (PHAP) is to ensure that this health assessment provides a plan of action designed to mitigate or prevent potential adverse health effects.

A. Public Health Actions Completed

- Residences known to have contaminated groundwater as their private drinking water wells have been connected to alternative drinking water sources.
- Public meetings have been held to provide the community an opportunity to voice their concerns to EPA and N.C. DENR.
- EPA and N.C. DENR have provided periodic updates on site activities to the public, as well as local and state government officials.
- N.C. DPH distributed two Health Education documents in October 2007: *Frequently Asked Questions (FAQs), Mills Gap (former CTS Plant) Site, Asheville, NC* and *Trichloroethylene (TCE) Fact Sheet and FAQs*
- The public and local and state government officials have been made aware of N.C. DPH's intention to review site environmental data and produce this public health assessment.
- N.C. DPH presented a description of the Public Health Assessment process at a public meeting (Fall 2008) and prepared update statements for inclusion into the public record.

B. Public Health Actions Planned

- The draft copy of N.C. DPH's public health assessment "for review" will be made available to the public and government officials. Copies will be made available to the community. Locations may include the Buncombe County Health Department, other Buncombe County offices, or the local library. The document will be posted for public comment on N.C. DPH's Health Assessment and Consultation (HACE) Program website. The document will also be accessible through the ATSDR web site.
- Other government agencies (EPA, N.C. DENR, Buncombe County) and the public will have the opportunity to comment on the draft Public Health Assessment (PHA) for at minimum 30 days. Comments will be reviewed by N.C. DPH and addressed as appropriate in the "final" study document. The final PHA document will be made available to other government agencies and the public as indicated above.
- The results of the PHA will be presented by N.C. DPH in a public meeting to be held in Skyland, NC, or nearby. Time will be provided for questions after the presentation.
- N.C. DPH will make available to the public and the local health department fact sheets

and other education outreach materials for TCE and chromium, or other requested site contaminants. A study summary fact sheet will also be made available. Electronic copies will be made available to the local health department and the public, and will be posted on the HACE web site.

- N.C. DPH will provide review of additional analytical or health data generated on or around the site as requested by the community, local health departments, N.C. DENR or EPA.
- N.C. DPH will prepare a fact sheet for primary care providers of the adverse health effects associated with trichloroethylene exposure. The fact sheet will include web links to additional information.

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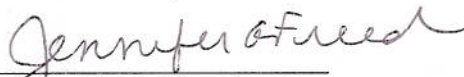
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CERTIFICATION

This Public Health Assessment (public comment draft) for the Mills Gap Road/CTS Site was prepared by the North Carolina Division of Public Health (N.C. DHHS) under a cooperative agreement with the Federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health assessment was initiated. Editorial review was completed by the cooperative agreement partner.



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



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REFERENCES

- (ATSDR 1989a). *Toxicological Profile for Bromodichloromethane*. 1989. ATSDR. <http://www.atsdr.cdc.gov/toxprofiles/tp129.html>
- (ATSDR 1989b). *Toxicological Profile for n-Nitroso di-n-propylamine*. 1989. ATSDR. <http://www.atsdr.cdc.gov/toxprofiles/tp142.html>
- (ATSDR 1995). *Toxicological Profile Polycyclic Aromatic Hydrocarbons (PAHs)*. 1995. ATSDR. <http://www.atsdr.cdc.gov/toxprofiles/tp69.html>
- (ATSDR 1996). *Toxicological Profile for 1,2-Dichloroethene*. 1996. ATSDR. <http://www.atsdr.cdc.gov/toxprofiles/tp87.html>
- (ATSDR 1997a). *Toxicological Profile for Chloroform*. 1997. ATSDR. <http://www.atsdr.cdc.gov/toxprofiles/tp6.html>
- (ATSDR 1997b). *ToxFAQs for Chloroform*. 1997. ATSDR. <http://www.atsdr.cdc.gov/tfacts6.html>
- (ATSDR 1997c). *ToxFAQs for Tetrachloroethylene (PERC)*. 1997. ATSDR. <http://www.atsdr.cdc.gov/toxprofiles/tp18.html>
- (ATSDR 1997d). *Toxicological Profile for Trichloroethylene (TCE)*. 1997. ATSDR. <http://www.atsdr.cdc.gov/toxprofiles/tp19.html>
- (ATSDR 1997e). *Public Health Statement for Trichloroethylene (TCE)*. 1997. ATSDR. <http://www.atsdr.cdc.gov/toxprofiles/phs19.html>
- (ATSDR 2000a). *Toxicological Profile for Methylene Chloride*. 2000. ATSDR. <http://www.atsdr.cdc.gov/toxprofiles/tp14.html>
- (ATSDR 2000b). *Toxicological Profile for Pentachlorophenol*. 2001. ATSDR. <http://www.atsdr.cdc.gov/toxprofiles/tp51.html>
- (ATSDR 2000c). *Toxicological Profile for Toluene*. 2000. ATSDR. <http://www.atsdr.cdc.gov/toxprofiles/tp56.html>
- (ATSDR 2003). *ToxFAQs for Trichloroethylene(TCE)*. 2003. ATSDR. <http://www.atsdr.cdc.gov/tfacts19.html>
- (ATSDR 2004). *Interaction Profile for: Arsenic, Cadmium, Chromium, and Lead*. U.S. DHHS, ATSDR. 2004. <http://www.atsdr.cdc.gov/interactionprofiles/ip04.html>
- (ATSDR 2005a). *Public Health Assessment Guidance Manual (Update)*. January 2005. <http://www.atsdr.cdc.gov/HAC/PHAManual/index.html>

(ATSDR 2005b). *Toxicological Profile, Carbon Tetrachloride*. 2005. ATSDR
<http://www.atsdr.cdc.gov/tfacts30.html>

(ATSDR 2006a). *Toxicological Profile for 1,1,1-Trichloroethane*. 2006. ATSDR.
<http://www.atsdr.cdc.gov/toxprofiles/tp70.html>

(ATSDR 2006b). *1,1,1-Trichloroethane ToxFAQs*. 2006. ATSDR.
<http://www.atsdr.cdc.gov/tfacts70.pdf>

(ATSDR 2006a). *Toxicological Profile Vinyl Chloride*. 2006. ATSDR.
<http://www.atsdr.cdc.gov/toxprofiles/tp20.html>

(ATSDR 2007a). *Minimal risk levels (MRLs) for hazardous substances*. Atlanta, GA: US Department of Health and Human Services. Available from URL:
<http://www.atsdr.cdc.gov/mrls.html>

(ATSDR 2007b). *ToxGuide for Arsenic*. 2007. ATSDR.
<http://www.atsdr.cdc.gov/toxprofiles/tp2.html>

(ATSDR 2007c). *ToxGuide for Lead*. 2007. ATSDR.
<http://www.atsdr.cdc.gov/toxguides/toxguide-13.pdf>

(ATSDR 2007d) *Toxicological Profile for Lead*. 2007. ATSDR.
<http://www.atsdr.cdc.gov/toxprofiles/tp13.pdf>

(ATSDR 2007e). *ToxFAQs for Lead*. 2007. ATSDR. <http://www.atsdr.cdc.gov/tfacts13.html>

(ATSDR 2008a) *Toxicological Profile for Chromium, Draft for Public Comment*. 2008. ATSDR.
<http://www.atsdr.cdc.gov/toxprofiles/tp7.html>

(ATSDR 2008b). *ToxFAQs for Chromium*. 2008. ATSDR. <http://www.atsdr.cdc.gov/tfacts7.html>

(ATSDR 2008c). *Public Health Statement for Chromium*. 2008. ATSDR.
<http://www.atsdr.cdc.gov/toxprofiles/phs7.html>

(ATSDR 2008a Air). *Air Comparison Values in $\mu\text{g}/\text{m}^3$* . Last Update Oct. 27, 2008. ATSDR DHAC.

(ATSDR 2008b Air). *Air Comparison Values in ppb (for VOC Compounds Only)*. Last Update Oct. 27, 2008. ATSDR DHAC.

(ATSDR 2008 DW). *Drinking Water Comparison Values*. Last Update Oct. 27, 2008. ATSDR DHAC.

(ATSDR 2008 HG). *Health Guideline Comparison Values*. Last Update Oct. 27, 2008. ATSDR DHAC.

(ATSDR 2008 Soil). *Soil Comparison Values*. Last Update Oct. 27, 2008. ATSDR DHAC.

(ATSDR TCA MMG). *Medical Management Guidelines for 1,1,1-Trichloroethane (CH₃CCl₃)*. (ATSDR). <http://www.atsdr.cdc.gov/MHMI/mmg70.pdf>

(CDC 2009). *Recommendations for Blood Lead Screening of Medicaid-Eligible Children Aged 1--5 Years: an Updated Approach to Targeting a Group at High Risk*. Centers for Disease Control and Prevention, MMWR. August 7, 2009 / 58(RR09);1-11. <http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5809a1.htm>

(EPA 2001a). *OSWER Draft guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)* Dec. 2001. EPA. <http://epa.gov/osw/hazard/correctiveaction/eis/vapor.htm>

(EPA 2001b). *Trichloroethylene Health Risk Assessment: Synthesis and Characterization. External Review Draft*. US Environmental Protection Agency, Office of Research and Development. EPA/600/P-01/002A. August 2001.

(EPA 2007). *Consumer Factsheet on: 1,1-DICHLOROETHENE*. <http://www.epa.gov/safewater/dwh/c-voc/11-dichl.html>

(EPA 2008). *On scene coordinator site: Mills gap groundwater contamination site*. http://www.epaosc.net/site_profile.asp?site_id=A4P5%20

(EPA 2008 GW). *2008 Well Locations and Results*. 2008. EPA.

(EPA MGR). *Superfund Site Information, Mills Gap Road Groundwater Contamination Site Information*. <http://cfpub.epa.gov/supercpad/cursites/csitinfo.cfm?id=0406988>

(Fetter 1988). *Applied Hydrogeology, Second Edition*. 1988. C.W. Fetter. Macmillan Publishing Co., NY, NY.

(IARC). International Agency for Research on Cancer. Available at <http://www.iarc.fr/>

(IRIS). Integrated Risk Information System (IRIS). EPA. <http://cfpub.epa.gov/ncea/iris/index.cfm>

(Johnson 2003). Johnson, P.D., S.J Goldberg, M.Z Mays, and B.V Dawson., 2003. *Threshold of trichloroethylene contamination in maternal drinking waters affecting fetal heart development in the rat*. Environ. Health Persp. 111:289-292.

(LMTS 2008). *Trip Report, W. A. 0-296, Mills Gap Road*. Lockheed Martin Technology Services. April 28, 2008.

(MACTEC 2009). *Mills Gap Road Site – Report of Phase I Remedial Investigation*. July 2009.

(NCDA 2008). *Heavy Metals in North Carolina Soil, revised September 2008*. N.C. Department of Agriculture and Consumer Services.

(N.C. DENR data). Data summary tables supplied by N.C. DENR.

(N.C. DENR CTS Timeline). *CTS Timeline A8*. N.C. DENR.

(N.C. DENR 1999). *Immediate Removal Action Request Mills Gap Road Groundwater Contamination*. N.C. DENR to U.S. EPA. August 16, 1999.

(NJDHSS 2003). *Case-control study of childhood cancers in Dover Township (Ocean Country), New Jersey*. New Jersey Department of Health and Senior Services. 2003. Trenton, New Jersey: New Jersey Department of Health and Senior Services.

(NRC 2006). *Assessing the Human Health Risk of Trichloroethylene: Key Scientific Issues*. National Research Council, National Academy of Sciences. National Academies Press. July 2006.

(NUS 1991). *Screening Site Inspection, Phase II, CTS of Asheville, Inc., Skyland, Buncombe County, North Carolina*. NUS Corporation. February 1991.

(NTP 2005). *Report on Carcinogens, 11th Edition*. National Toxicology Program, US Department of Health and Human Services. January 2005.

(OSC 2009). *Mills Gap Groundwater Contamination Site, Asheville, NC, EPA region IV*. USEAP On Scene Coordinator (OSC) web site. http://www.epaosc.net/polrep_profile.asp?site_id=A4P5

(TNA 2008). *Subsurface Soil and Groundwater Sampling Report, Mills Gap, Asheville, Buncombe County, North Carolina, TDD: TNA-05-001-0043, Revision 1*. Prepared for EPA. April 2008.