Health Consultation

GRANTS CHLORINATED SOLVENTS PLUME SITE
GRANTS, CIBOLA COUNTY, NEW MEXICO

EPA FACILITY ID: NM0007271768

APRIL 10, 2007

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
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Health Consultation: A Note of Explanation

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

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

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HEALTH CONSULTATION

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Prepared By:

Agency for Toxic Substances and Disease Registry
Atlanta, Georgia

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Purpose

The Agency for Toxic Substances and Disease Registry (ATSDR) in Atlanta, Georgia, is part of the U.S. Department of Health and Human Services. Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 (Superfund), ATSDR conducts public health activities at sites which the US Environmental Protection Agency (USEPA) places on the National Priorities List (NPL). This health consultation for the Grants Chlorinated Solvents Plume (GCSP) site was prepared in accordance with this statutory requirement.

ATSDR reviewed available documents, conducted a site visit in 2005, and met with USEPA to gather site-related information, issues, and concerns. This health consultation presents our findings and conclusions, identifies site-related public health issues, and recommends follow-up actions to mitigate exposures. It also describes the methods and data used to evaluate exposures.

Background

Site Description

The GCSP site is in a mixed commercial/residential area of the City of Grants, Cibola County, New Mexico. The site area is defined by a zone of groundwater contaminated by chlorinated solvents that include tetrachloroethene (PCE), trichloroethene (TCE), *cis*-1,2-dichloroethene (*cis*-1,2-DCE), *trans*-1,2-dichloroethene (*trans*-1,2-DCE), 1,1-dichloroethene (1,1-DCE), and vinyl chloride (VC).

The site area is approximately 12.25 acres with the following approximate street and property boundaries: Second Street to the west; Adams Avenue and Jefferson Avenue to the north; Anderman Street, Washington Avenue, and Mesa View Elementary School property to the east; and Stephens Avenue and the Rio San Jose to the south. The GCSP site contains former, current, and potential users of chlorinated solvents.

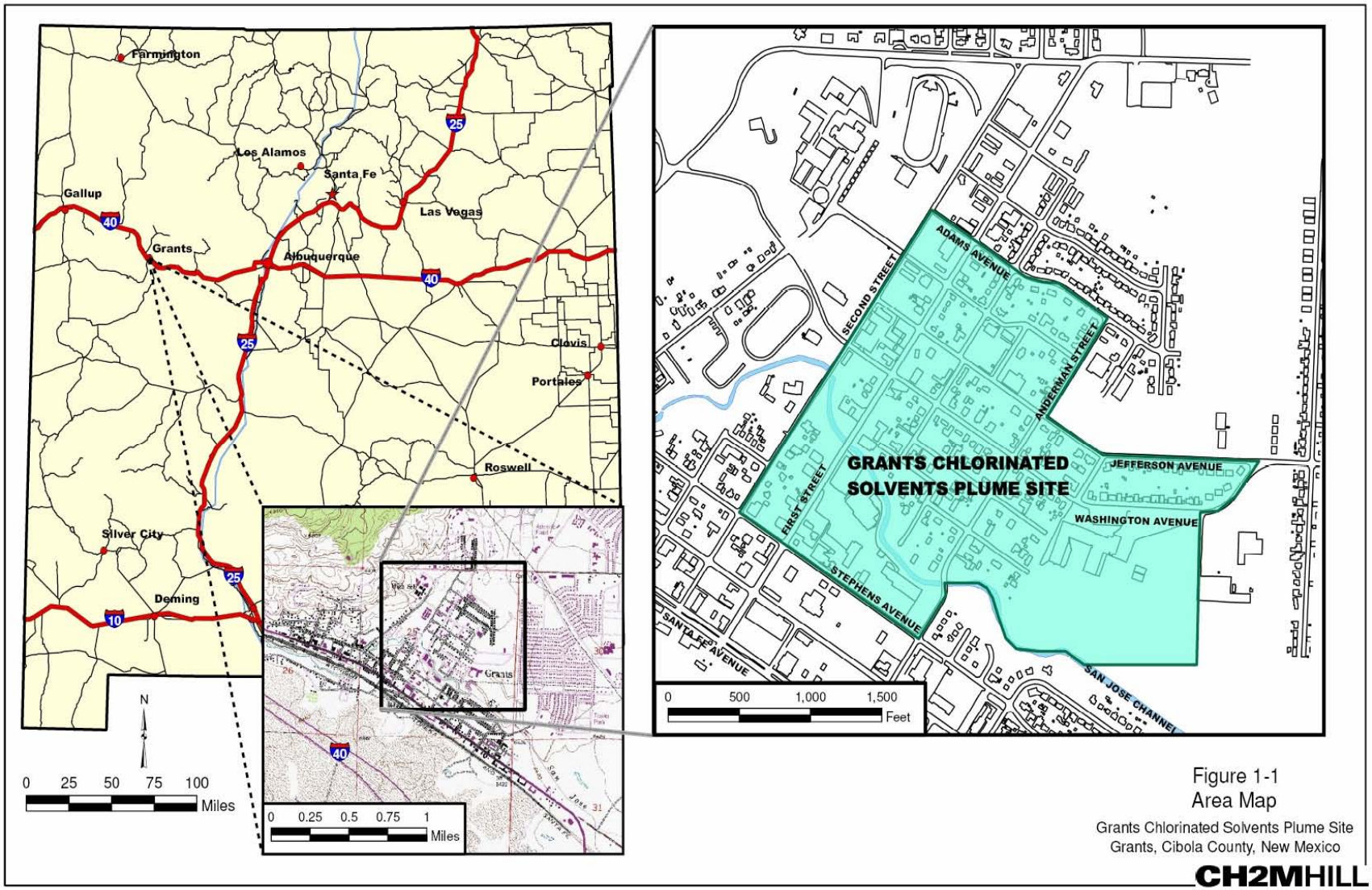
The City of Grants has about 8,800 people. The city is served by a municipal water supply from two wells located between 1-2 miles west of the site. The wells draw water from the San Andres/Glorieta Aquifer with the shallowest screen interval at about 149 feet below ground level. These wells have not been impacted by site groundwater contaminants (NMED 2004).

There are no private drinking water wells in the area of the groundwater contamination. The potential for new drinking water wells in the area is reduced by a local prohibition against use of private wells for drinking water within the city limits by the City of Grants (USEPA 2005). Three private wells were located in the site area during the course of the groundwater investigations. None of these wells are reported as currently in use for any purpose (NMED 2001).

Site History

Chlorinated solvents in groundwater were discovered in 1993 by the New Mexico Environment Department (NMED) during an investigation of service lines for unleaded gasoline tanks at a

Figure 1. Map showing GCSP Site, Grants, Cibola County, New Mexico (Figure taken from EPA Remedial Investigation Report)



local service station. NMED confirmed the presence of chlorinated solvents in shallow groundwater (NMED 2004). In addition dissolved-phase gasoline constituents, including methyl tert-butyl ether (MTBE), benzene, toluene, ethylbenzene, and xylenes (BTEX), were detected in groundwater, probably from some service stations in the area. The NMED Ground Water Quality Bureau – Superfund Oversight Section (NMED-SOS) subsequently conducted a two-year Site Inspection (SI) investigation.

Multiple sources of contaminants are suspected, including former and current dry cleaning operations along First Street (USEPA 2005a). In March 2004, the GCSP site was proposed to the NPL as a result of NMED investigations and additional information from EPA. The NPL status of the site became final in September 2004.

In cooperation with NMED, EPA initiated a remedial investigation (RI) in October 2003.

Additional subsurface soil, soil vapor, and groundwater samples were collected. Indoor and outdoor air samples were obtained to further characterize the nature and extent of contamination identified in previous investigations. The RI also provided details on the stratigraphy and hydrogeology, which were previously unavailable.

After the first series of indoor air sampling in October 2003, EPA requested ATSDR to determine whether exposure to indoor air contamination from site-related solvents posed a health hazard to occupants of the homes. ATSDR (2004a) concluded that concentrations of TCE and PCE detected during one round of indoor air sampling were below levels that would be expected to pose a public health hazard for noncancer health effects. However, because contamination concentrations vary over time, ATSDR concluded that one round of sampling was not sufficient to determine if residents were safe from long term exposure. ATSDR also concluded that it would be prudent public health policy to implement remedial actions in homes where VOC concentrations exceeded EPA Action Levels. ATSDR recommended additional air monitoring to better assess long-term exposure to VOCs in indoor air.

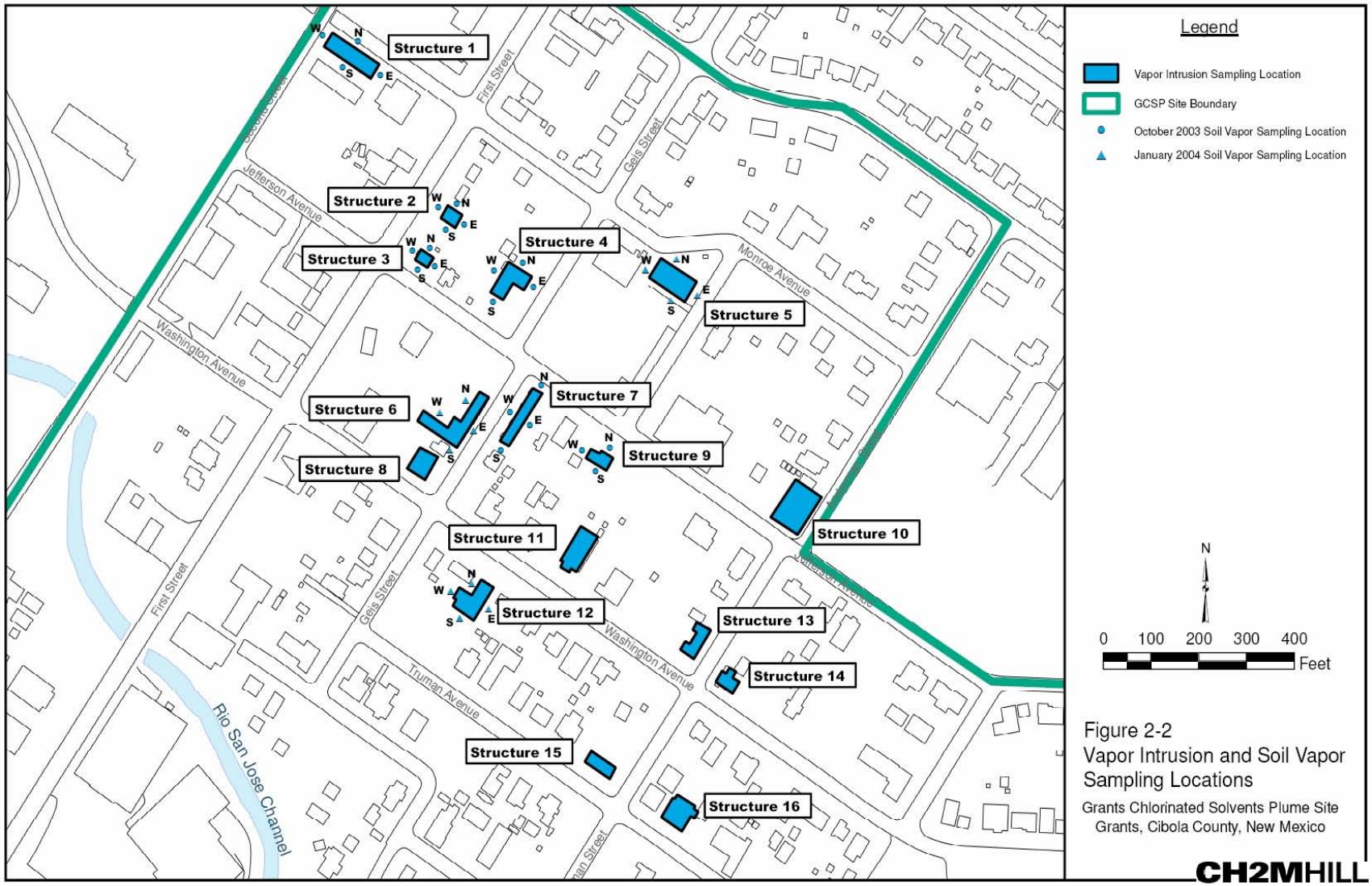
EPA contractors conducted additional sampling in 2004 (January and June) and in January 2005 (EPA RI Report). Sixteen structures, mostly residences, have been sampled during the four rounds of indoor air sampling. Outdoor air and offsite background samples were also collected.

Site Visit

ATSDR staff visited the Grants Chlorinated Plume site and the surrounding areas during the week of August 23, 2005. The site tour included the source of contamination (Holiday Cleaners, 715 First Street) and nearby areas along First Street, Second Street and Geis Streets. Cross streets were Monroe Avenue, Jefferson Avenue, and Washington Avenue (see Figure 2).

Mixed commercial and residential apartment buildings were located on the northwest side of First Street. A residential housing apartment was located directly behind Holiday Cleaners. Residential housing and mixed commercial buildings were located on the opposite side of First Street. Four unoccupied or abandoned residential and commercial buildings were located directly across from Holiday Cleaners along First Street starting at the intersection of Monroe Avenue and First Street. Mobile home units and residential housing were located behind the abandoned residential and commercial buildings located along Geis Street. At the time of the site visit, the residential structures appeared to be occupied.

Figure 2. Air sampling locations (Figure taken from EPA Remedial Investigation Report)



The ATSDR Team evaluated groundwater monitoring wells in relation to existing buildings to determine whether they were located on top of the groundwater plume. In addition, ATSDR evaluated structures above the plume to determine if they contained basements or crawlspaces that could trap vapors rising from the contaminated groundwater and soil. This visual inspection was non-intrusive and was done visually from public streets.

During the site visit, the ATSDR Team noted that the City utility trench located in front of the Holiday Cleaners paralleling First Street did not appear to have monitoring or sampling wells installed. A surface inspection did not indicate or reveal any past disturbance on the road surface to indicate past sampling events had occurred. In addition, no visible signs of existing monitoring wells were located in or adjacent to the utility trench.

The ATSDR Team also noted the presence of the private wells reported by NMED and EPA. An ATSDR team member spoke with one long-term resident about the wells and learned that the wells may have been originally intended for lawn irrigation. However, EPA interviews of well owners indicated that the wells are not currently in use.

Discussion

Introduction to Public Health Assessment Methodology

The presence of chemical contaminants in the environment does not always result in exposure to or contact with the chemicals. Because chemicals have the potential to cause adverse health effects only when people actually come into contact with them, exposure (the contact that people have with the contaminants) drives the PHA process.

People can be exposed to contaminants by breathing, eating, drinking, or coming into direct skin contact with a substance containing the contaminant. This section reviews available information to determine whether people in the community have been, currently are, or could in the future be exposed to contaminants associated with this site.

To determine whether people are exposed to site-related contaminants, investigators evaluate the environmental and human components leading to human exposure. This analysis consists of evaluating the five elements of an exposure pathway:

1. source of contamination,
2. transport through an environmental medium,
3. point of exposure,
4. route through which the contaminant can enter the body, and
5. a receptor population.

Exposure pathways can be complete, potential, or eliminated. For a person to be exposed to a contaminant, the exposure pathway must be complete. An **exposure pathway** is considered complete when all five elements in the pathway are present and exposure has occurred, is occurring, or will occur in the future. A **potential pathway** is missing at least one of the five elements, but could be complete in the future. An **eliminated pathway** is missing one or more elements and will never be completed.

Exposure to contaminants does not always result in adverse health effects. The factors that influence whether exposure to a contaminant or contaminants could or would result in adverse health effects include

- the toxicological properties of the contaminant,
- how much of the contaminant the individual is exposed to,
- how often and/or how long the exposure occurs,
- the manner in which the contaminant enters or contacts the body (breathing, eating, drinking, or skin/eye contact), and
- the number of contaminants to which an individual is exposed (combinations of contaminants).

Once exposure occurs, characteristics such as age, sex, nutritional status, genetics, lifestyle, and health status of the exposed person influence how that person absorbs, distributes, metabolizes, and excretes the contaminant.

The first step in assessing the potential public health significance of the exposure is to compare contaminant concentrations to health assessment comparison values for both noncarcinogenic and carcinogenic end points. Health assessment comparison values are media-specific contaminant concentrations used to screen contaminants for further evaluation. Exceeding a comparison value does not necessarily mean that a contaminant represents a public health threat, but does suggest that exposure to the contaminant warrants further consideration.

Noncancer comparison values are also known as *environmental media evaluation guides* (EMEGs) or *reference dose media evaluation guides* (RMEGs). They are based on ATSDR's minimal risk levels (MRLs) and EPA's reference doses (RfDs), respectively. MRLs and RfDs are estimates of daily human exposure to a contaminant that is unlikely to cause adverse noncancer health effects over a lifetime. Cancer risk comparison values are also known as *carcinogenic risk evaluation guides* (CREGs). They are based on EPA's chemical-specific cancer slope factors and an estimated excess lifetime cancer risk of 1-in-a million persons exposed for a lifetime. Conservative, standard exposure assumptions are used to calculate appropriate health assessment comparison values.

Evaluation of Environmental Contaminants and Exposure Pathways

Our review of environmental information reported by NMED and EPA indicated that people living and working in the site area could come in contact with site-related contaminants in three ways. These are 1) breathing indoor air with VOC vapors which have migrated inside from groundwater, 2) drinking contaminated groundwater, and 3) having direct contact with contaminated water. Direct skin contact with contaminated water could occur from using shallow groundwater wells to irrigate lawns and gardens, when basements are flooded by the rising groundwater, or during work on buried utilities where the utility trench intersects the contaminated water table.

Of these three exposure pathways, only exposure to contaminated indoor air is considered to be a completed pathway at present. Based on city ordinances, well surveys and our site visit, no one is currently known to be drinking site contaminated groundwater. There is a possibility of future exposures if groundwater contamination persists. Direct contact with contaminated groundwater

through irrigation wells and flooded basements is also a slight possibility with limited potential for exposure. While contact with contaminants by utility workers during maintenance and repair work on buried water, sewer, and telephone lines is possible, no environmental sampling has been performed to determine if contaminants are entering any of the utility trench areas.

Domestic Well Water – Potential Exposure Pathway

No one within the site area is known to be drinking water from a private well. Ingestion of contaminated well water is considered a potential future exposure pathway because of the known persistence of chlorinated solvents in groundwater. PCE and TCE are denser than water and tend to sink in groundwater until reaching a bottom boundary barrier, such as a dense clay layer or bedrock.

Some of the chlorinated solvents will continue to volatilize and move upward, through the top of the water table and overlying soils. The dissolution and volatilization of chlorinated solvents is a slow process that can last decades as the dissolved portion spreads with the flow of the groundwater. If left unremediated, in time the contaminated groundwater could spread beyond the boundaries of the current site area. The contaminants might also move downward into the drinking water aquifer below the current zone of contamination. Future municipal water supplies could be affected if a significant amount of contaminants reach the drinking aquifer. There is also a possibility of a domestic drinking water well being installed into a contaminated groundwater zone in violation of the local ordinance.

If residents irrigate their lawns with shallow groundwater in the future, they may be exposed to contaminants from direct skin contact and accidental ingestion. Results (Table A2 in Appendix A**)** from sampling of shallow wells in 2004 indicated only 1 well contaminated by VOCs. None of the shallow wells in the site area are currently used for any purpose.

To evaluate potential for future exposure, ATSDR evaluated the analytical results from sampling of monitoring wells installed by EPA and NMED. The groundwater contaminants of concern are displayed in Appendix A, Table 1.

Indoor Air – Completed Exposure Pathway

There are about 400 to 500 occupied structures within the GCSP site. Only about 10 percent of these structures (ATSDR estimates less than 50 structures) overlie contaminated groundwater. Indoor air samples were collected in homes and buildings that might have been affected by contaminants off-gassing from shallow groundwater. Samples were taken in a total 16 structures during four separate sampling events (USEPA 2005a).

The chlorinated solvents and petroleum products contaminating the shallow groundwater tend to volatilize and move vertically; moving as gases from the water table, through the few feet of soil (5-8 ft) then into basements, crawlspaces, and eventually into living spaces. As the contaminants move upward, the concentrations are greatly reduced (attenuated) by various natural processes such as dilution and dispersion. These attenuation mechanisms can reduce the concentrations of contaminants by an order of magnitude (divide by 10) to two orders of magnitude (divide by 100) or more. Such is the case with VOCs in groundwater and soil gas at GCPS.

The widespread distribution of PCE and TCE, as well as other VOC compounds, in structures above the plume of contaminated groundwater does not mean all or even the majority of the chemicals were from the groundwater. There are many other sources for both chemicals that are

commonly found in U.S. homes and outdoor air such as dry cleaning solvents. For example at 3 structures where outdoor air was measured, the outdoor air contaminant concentrations were very close to the levels of indoor air contaminants (i.e., at structure I, outdoor PCE was 7.2 $\mu g/m^3$ and indoor PCE was 8.1 $\mu g/m^3$); indicating that the indoor contaminants may have originated from the ambient air rather than soil vapor from the groundwater plume. The average outdoor air concentrations outside of the GCSP site area (samples taken at local fire station) was 0.043 $\mu g/m^3$ for TCE and 0.118 $\mu g/m^3$ for PCE.

The highest indoor air concentration of PCE (179 $\mu g/m^3$) was from the living room of a home with a basement overlying groundwater with PCE concentrations of 5,800 µg/L and PCE soil gas concentrations of 5,289 $\mu g/m^3$. In moving from soil gas to indoor air, PCE gas concentrations were attenuated to 179 $\mu g/m^3$. Other contaminants were also attenuated in a similar fashion. The same residence also had the highest indoor air concentration of TCE (103 $\mu g/m^3$) which was reduced from a nearby soil gas measurement of 23,038 $\mu g/m^3$. Maximum indoor air contaminant levels and corresponding nearby maximum soil gas concentrations are shown in Table 1.

The building with the highest reported levels of petroleum chemicals (benzene, ethylbenzene, toluene and xylenes) did not have corresponding high levels of the same chemicals in soil gas. Levels of most petroleum chemicals were an order of magnitude lower in soil gas as compared to indoor air. This indicates that the likely source was not groundwater or soil gas. During one of the air sampling events, the EPA sampling team observed a fuel spill at an adjacent service station (USEPA 2005a). While it unknown for certain, it is probable that this fuel spill was the primary source of benzene measured in air at that time. The substantial reduction in indoor concentrations from one sampling event to the next of petroleum contaminants (for example ethyl benzene changed from 214 $\mu g/m^3$ to 3.7 $\mu g/m^3$) supports the first measurements being influenced by the observed fuel spill. Regardless of the source, ATSDR has evaluated exposures to contaminants in indoor air measured at concentrations greater than health assessment comparison values.

Table 1. Maximum chemical levels in indoor air and corresponding soil gas concentrations (µg/m^3).

Chemical	*Maximum Indoor Air Concentration*	*Corresponding Soil Gas Concentration*
Benzene	15	20.7
cis-1,2-DCE	30	19,427
Ethylbenzene	214	26
MTBE	25	No samples
PCE	179	5,289
TCE	103	23,038
Toluene	282	85
Vinyl chloride	0.015	5.7 (estimated)
meta/para (m/p) xylene	606	70.3
ortho (o)-xylene	244	18
Total xylenes	850	88.3

Initial (Screening) Data Evaluation

Table 2 presents the chemicals detected in indoor air concentrations and the corresponding health comparison values used to evaluate exposure. Health comparison values (CVs) are concentrations at which no adverse health effects are reasonably expected. They can be derived based on cancer and/or noncancer health effects. A complete discussion of the health CVs used in this evaluation is presented in Appendix B.

The results of the initial data screening indicate that maximum levels of *cis*-1,2-DCE, ethyl benzene, MTBE, toluene, and vinyl chloride in indoor air were below health CVs. Therefore, exposure to these chemicals is considered minimal and no further evaluation has been conducted by ATSDR.

Based on the results of the initial screening, ATSDR has determined that exposures to benzene, and xylenes from indoor air require additional evaluation. Although concentrations of PCE and TCE were not found to exceed health comparison values, these chemicals are further evaluated in this health consultation to provide consistency and comparison with EPA's Human Risk Assessment for the same site.

Table 2. Maximum chemical levels in indoor air and health comparison values (µg/m^3)

Contaminant	*Maximum Indoor Air Concentration*	*Health Comparison Values**	*EPA Region 6 Screening values*	*Further ATSDR Evaluation Necessary?*
Benzene	15	30 (EMEG-acute) 20 (EMEG-intermediate) 10 (EMEG-chronic) 0.1 (CREG)	0.25	Yes
cis-1,2-DCE	30	*7, 9300 NIOSH **	37	No
Ethylbenzene	214	4,000 (EMEG-intermediate)	1,100	No
MTBE	25	2,000 (EMEG-chronic)		No
PCE	179	300 (EMEG-chronic)	0.33	Yes
Toluene	282	300 (EMEG-chronic)	5,200	No
TCE	103	500 (EMEG-intermediate)	0.017	Yes
Vinyl chloride	0.015	80 (EMEG-intermediate) 0.1 (CREG)	0.16	No
Total xylene	850	3,000 (EMEG-intermediate) 200 (EMEG-chronic)	100	Yes

* Information on environmental media guidelines (EMEGs), EPA Region 6 screening values, and cancer risk evaluation guidelines (CREGs) is provided in Appendix B. Table B1 provides some additional information on the chemicals listed. No health comparison value available for cis-1,2-DCE except NIOSH worker exposure level of 200 ppm, equivalent to 793 mg/m3.

Public Health Implications

Indoor Air

For chemical concentrations found to exceed health CVs, ATSDR performed calculations referred to as exposure doses and cancer risk estimates. These calculations estimate the amount of the chemicals of concern that individuals may be exposed to and the likelihood of cancer and noncancer health impacts. They are based on the types of site-specific activities that individuals may be involved with that result in contact with chemicals in the surface water.

Contaminants from groundwater or subsurface soil may have migrated into the indoor air of overlying structures. ATSDR has evaluated exposures to individuals who may live, work, or attend daycare in these buildings. Both adults and children have been considered as part of this health consultation. It was assumed that adults and children were exposed for 30 years and 6 years, respectively. Per ATSDR estimates, adults inhale approximately 20 cubic meters per day (cm^3/day) of air while children inhale about 10 cm^3/day. Conservatively, ATSDR also assumed that adults and children were in these buildings for 24 hours per day for 350 days per year. A complete discussion of the exposure assumptions and equations are presented in Appendix B of this health consultation.

ATSDR calculated exposure doses for inhalation of chemicals in indoor air to determine the potential for noncancer health effects. The calculated exposure doses were compared with health-based guidelines (e.g., ATSDR Minimal Risk Levels or EPA Reference Doses), when available. These guidelines are described in more detail in the Appendix B of this health consultation. Calculated exposure doses below these guidelines indicate that health effects are not expected. When calculated exposure doses for a particular chemical exceed the health-based guidelines, it is necessary to evaluate this chemical further and does not necessary indicate that health effects will occur. Instead, a closer look at the toxicological data available for the chemical is needed to fully evaluate the likelihood of health effects.

The scientific literature indicates some of the chemicals detected in indoor air at this site may be associated with cancerous effects. Therefore, ATSDR evaluated the cancer risk associated with these exposures. It should be noted that an increased cancer risk is not a specific estimate of expected cancers. Rather, it is an estimate of the increase in the probability that a person may develop cancer sometime during his or her lifetime following exposure to a particular chemical. The recommendations of many scientists, including ATSDR and EPA, has been that an increased lifetime cancer risk of one in one million (1×10^{-6}) or less is generally considered an insignificant increase in cancer risk. Cancer risk less than 1 in 10,000 (or 1×10^{-4}) is not typically considered a health concern. Cancer risk greater than 1 in 10,000 may pose a significant concern regarding cancerous effects.

The cancer risk estimates and calculated exposure doses for each of the chemicals are presented in Tables A3 and A4, respectively, in the appendix of this health consultation.

PCE

ATSDR's evaluation of PCE in indoor air indicates that calculated doses associated with site exposure were below the selected health-based guideline (or the adjusted chronic inhalation Minimal Risk Level) of 0.085 mg/kg/day with the exception of Structure L. The exposure dose calculated for children residing in structure L is 0.11 mg/kg/day which slightly exceeds the

health-based guideline. Therefore, further evaluation of Structure L was necessary. To avoid confusion, all structures are referenced alphabetically in the same manner as performed in the EPA Human Risk Assessment. Further review of the toxicological data indicates that harmful effects from PCE exposure were observed at doses several orders of higher than those associated with exposures in Structure L. Therefore, ATSDR concludes that PCE exposure associated with each of the individual structures sampled will not likely result in noncancer health impacts.

ATSDR's evaluation also indicates that exposure to PCE in indoor air associated with this site poses an insignificant to low increased cancer risk at most buildings sampled, with the exception of Structure L. Numerically, the calculated cancer risk for majority of the buildings sampled ranged from 5 extra cases per 10 million people exposed (or 5×10^{-7}) to 8 extra cancer cases per 100,000 people exposed (or 8×10^{-5}). The cancer risk calculated for Structure L, estimated to be 6 extra cancer cases per 10,000 people exposed (or 6×10^{-4}), indicates a moderate increased cancer risk.

PCE is a common commercial chemical used in the dry cleaning industry which has prompted a number of human studies on workers in this industry. These studies suggest a possible association between long-term PCE exposure and an increased risk of cancer. The cancer types most consistently showing an increase are esophageal cancer, bladder cancer, cervical cancer, and non-Hodgkin's lymphoma. PCE in air has also been shown to cause cancer in rats and mice following near lifetime exposure.

TCE

ATSDR's evaluation of TCE in indoor air indicates that calculated doses associated with site exposure were below the selected health-based guideline (or the adjusted chronic inhalation Minimal Risk Level) of 0.14 mg/kg/day at all structures sampled. Therefore, ATSDR concludes that TCE exposure associated with each of the individual structures sampled will not likely result in noncancer health impacts.

ATSDR's evaluation also indicates that exposure to TCE in indoor air associated with this site poses an insignificant to low increased cancer risk at 11 of 16 structures sampled. Numerically, the calculated cancer risk for these structures ranged from 3 extra cancer cases per 1 million people exposed (or 3×10^{-6}) to 3 extra cases per 100,000 people exposed (or 3×10^{-5}). A moderate increased cancer risk from TCE exposure was calculated for structures D, G, and H. High increased cancer risk (approximately 2 to 7 extra cancer cases per 1,000 people exposed (or 2×10^{-3} to 7×10^{-3}) was calculated for structures M and L, respectively.

In the 11th Report on Carcinogens, NTP (2005) determined that TCE is reasonably anticipated to be a human carcinogen based on limited evidence from human studies and sufficient evidence from animal studies suggesting that TCE acts through mechanisms that would likely cause cancer in humans. The IARC has determined that TCE is probably carcinogenic to humans. It should be noted that a range of cancer slope factors are available for assessing TCE exposure. ATSDR selected the most conservative cancer slope factor of 0.40 for its evaluation, for health-protectiveness.

Benzene

ATSDR's evaluation of benzene in indoor air indicates that calculated doses associated with exposures to individuals residing in 12 of 16 structures sampled were below the selected health-

based guideline (or the adjusted chronic inhalation Minimal Risk Level) of 0.0028 mg/kg/day. Calculated exposure doses for children at Structure F (0.0040 mg/kg/day) and Structure J (0.0030 mg/kg/day) slightly exceeded the health guideline. Further review of the available scientific literature indicates that exposure to benzene results in noncancer health effects at doses several orders of magnitude higher than the doses associated with Structures F and J. Therefore, benzene exposure is not likely to result in noncancer health effects at any of the structures sampled.

ATSDR's cancer evaluation indicates that exposure to benzene in indoor air associated with this site poses an insignificant to low increased cancer risk. Numerically, the calculated cancer risk for majority of the buildings sampled ranged from 4 extra cases per 1 million people exposed (or 4×10^{-6}) to 3 extra cancer cases per 100,000 people exposed (or 3×10^{-5}).

Xylenes

Xylene exposure doses calculated for each of the structures, with the exception of Structure F, were below the selected health-based guideline (or the adjusted chronic Minimal Risk Level) of 0.057 mg/kg/day. Calculated doses for Structure F were 0.20 mg/kg/day for adults and 0.48 mg/kg/day for children. The toxicological data indicates that adverse noncancer health effects occur at doses several orders of magnitude greater than those calculated for indoor air in Structure F. Therefore, exposure to xylenes is not likely to result in noncancer health effects for all of the structures sampled.

Xylenes have not been classified as cancer-causing. Therefore, cancer risks were not calculated for exposure to xylenes at the structures sampled.

Chemical Mixtures

In assessing the health risks to people exposed to multiple chemicals, USEPA and ATSDR frequently use a method of estimating risks known as the hazard index to consider noncancer health effects. The hazard index is the sum of the individual hazard quotients of the chemicals contributing to exposure. A hazard quotient is the estimated exposure dose of a chemical divided by appropriate health guideline, such as ATSDR's Minimal Risk Level (MRL) or EPA's reference dose (RfD). An MRL or RfD is the exposure dose below which no adverse effects are expected. According to EPA guidelines, if the hazard index is calculated to be less than 1, then no adverse health effects are expected from the combined exposure to the mixture of chemicals. It is especially important to note that a hazard index exceeding 1 does not necessarily mean that adverse effects will occur. If the hazard index is greater than 1, then further evaluation is needed to determine if adverse health effects might be possible.

To assess exposures to several cancer-causing contaminants, the theoretical lifetime cancer risk numbers that are calculated for exposure to each individual chemical are added together. As previously stated, an increased cancer risk is not a specific estimate of expected cancers. Rather, it is an estimate of the increase in the probability that a person may develop cancer sometime during his or her lifetime following exposure to a cancer-causing chemical. The recommendations of many scientists, including ATSDR and EPA, has been that an increased lifetime cancer risk of one in one million (1×10^{-6}) or less is generally considered an insignificant increase in cancer risk. Cancer risk less than 1 in 10,000 (or 1×10^{-4}) is not typically

considered a health concern. Cancer risk greater than 1 in 10,000 may pose a significant concern regarding cancerous effects.

Tables A3 and A4 in Appendix A provide additional summary information on the hazard indices and total cancer risks calculated with exposures at this site. A brief summary of the noncancer health effects and cancer risk follows.

Noncancer Health Effects: The hazard indices for Structures F, G, J, and L exceed one. Further evaluation of cumulative exposures to chemical concentrations detected in these structures indicates that noncancer health effects are not likely. As indicated in the previous sections, adult and child exposure to concentrations of PCE, TCE, benzene, and xylenes measured in the 16 structures sampled are not likely to result in adverse noncancer health impacts.

Cancer Risk: Cumulative cancer risk estimates for each of the structures indicate that an unacceptable increased cancer risk exists for the following structures: D, G, H, L and M. Cumulative cancer risks for these structures posed a moderate to high cancer risk, in particular due to the presence of TCE in indoor air. A low cancer risk was calculated for cumulative exposures associated with the other 11 structures sampled.

Direct Contact with Contaminated Groundwater

In the future, a few residents might use shallow wells to irrigate lawns. The private well located near the high concentrations along First Street was sampled in 2004 with results (9.7 ug/l for PCE and 19 ug/l for TCE) well below ATSDR acute health concern levels (200 ppb for PCE and 2000 ppb for TCE) applicable to infrequent direct contact or ingestion. The remaining private wells are currently considered too far from the known main plume area to be impacted. Therefore, there is no current public health hazard from the use of the private wells for lawn irrigation. If the concentrations of groundwater contaminants are not reduced by natural attenuation or remedial measures, however, concentrations could increase in the future.

Utility workers might also be exposed to VOCs while maintaining or repairing water, sewer, or other utility lines buried in the utility trenches adjacent to suspected sources of VOCs, such as Holiday cleaners. Because the utility trenches have not been sampled, it is unknown if contaminants are present in the trenches. Information is insufficient to evaluate the public health implication for utility workers potentially exposed to contaminants in utility trenches.

Child Health Considerations

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

Based on site-specific information, including indoor air data and toxicological data on the contaminants of concern, ATSDR has determined that children are not at risk for noncancer health-related problems. However, exposure to cancer-causing chemicals (such PCE, TCE, and

benzene) during childhood may contribute to the overall lifetime risk that an individual has of developing cancer over a lifetime from exposure to carcinogens.

Conclusions

On the basis of the available environmental data, ATSDR concludes the following:

1. Exposure to chemicals in indoor air in Structures D, G, H, L and M poses a public health hazard. Moderate to high theoretical increased cancer risk was calculated for these structures, primarily due to the assumption of persistent (assumed greater than 30 years) presence of TCE in indoor air. Remediation, as proposed by EPA, will reduce these risks. Noncancer health effects are not associated with exposures at these structures.
2. Exposure to chemicals in indoor air in Structures A, B, C, E, F, I, J, K, 8, and 10 and Daycare pose no apparent public health hazard to adults and children. Noncancer adverse health effects are not expected and low excess cancer risk was calculated for these structures.
3. Because no one is known to use shallow groundwater within the chlorinated plume area as a drinking water source at present, this pathway is considered to pose no current public health hazard. Information is not available to evaluate past exposures and they are considered indeterminate health hazards. Information is also insufficient to determine if the primary drinking water aquifer is endangered by downward movement of groundwater contaminants. Assessing future exposures is contingent on remedial actions that are completed and actual future groundwater uses.
4. The potential use of groundwater for irrigation of gardens and yards is considered to pose no apparent public health hazard. The low frequency and duration of exposures are not likely to result in adverse health effects.
5. Potential exposure of utility workers to contaminants in utility trenches adjacent to source areas is considered an indeterminate public health hazard because no sample results from the utility trenches are available.

Recommendations

1. As prudent public health action, we recommend remedial measures to prevent infiltration of contaminated groundwater into basements of residences and other buildings overlying contaminated shallow groundwater and remedial measures to prevent an increase in VOC infiltration into indoor air.
2. We recommend that EPA apply appropriate remedial measures to prevent future contamination of drinking water wells.
3. We recommend that utility trenches adjacent to source areas be sampled to determine if contaminants have seeped into the trenches in sufficient concentrations to pose a health hazard to utility workers.

Public Health Action Plan

The Region 6 office of the Environmental Protection Agency has issued a record of decision (ROD) for the Grants Chlorinated Solvents Plume site that includes vapor mitigation for 14 homes, as well as, groundwater remediation for the site. In addition, the ROD states that EPA

will work with NMED to issue a health advisory not to consume ground water from the existing wells within the plume area.

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Appendix A. Summary Tables

Table A-1. Monitoring well results for 2004 and 2005 displaying maximum concentrations

Station Name	*Sample Date*	*Chemical*	*Results*	*Units*
W-2	3/20/2005	*cis*-1,2-Dichloroethene	2700	µg/L
W-7	2/11/2004	Cyclohexane	860	µg/L
W-1	2/10/2004	Methyl tert-butyl ether (MTBE)	350	µg/L
W-6	3/22/2005	Tetrachloroethene (PCE)	40000	µg/L
W-2	3/20/2005	Trichloroethene (TCE)	6100	µg/L
W-11	3/21/2005	Vinyl Chloride	16	µg/L
W-1	2/08/2004	Methylcyclohexane	860	µg/L
W-11	3/21/2005	1,1-Dichloroethene	8.5	µg/L

Source: EPA Remedial Investigation Report, 2006; Table 5–6

Table A-2. Results of irrigation well sampling

Sample Date	*Chemical*	*Results*	*Units*
2/11/2004	Bromoform	1.5	µg/L
2/11/2004	*cis*-1,2-Dichloroethene	5.3	µg/L
2/11/2004	Tetrachloroethene (PCE)	9.7	µg/L
2/11/2004	Trichloroethene (TCE	19	µg/L

Source: EPA Remedial Investigation Report, 2006; Table 5-6

Table A-3. Calculated theoretical cancer risk for contaminants in indoor air

*Location**	*PCE Cancer Risk*	*TCE Cancer Risk*	*Benzene Cancer Risk*	*Total Cancer Risk*	*Overall Cancer Risk Conclusion*
A	1.6E-06	4.8E-06	4.42E-06	1.1E-05	Low increased risk
B	1.2E-06	8.3E-06	8.83E-06	1.8E-05	Low increased risk
C	1.7E-06	4.5E-06	6.97E-06	1.3E-05	Low increased risk
D	3.8E-06	1.0E-04	9.30E-06	1.2E-04	Moderate increased risk
E	Below CV	2.0E-05	6.97E-06	2.7E-05	Low increased risk
F	3.8E-05	1.4E-05	2.93E-05	8.1E-05	Low increased risk
G	2.6E-05	3.5E-04	1.91E-05	4.0E-04	Moderate increased risk
H	9.0E-06	1.0E-04	9.76E-06	1.2E-04	Moderate increased risk
I	2.8E-05	1.7E-05	8.37E-06	5.3E-05	Low increased risk
J	3.0E-06	2.5E-05	2.19E-05	5.0E-05	Low increased risk
K	7.5E-05	4.7E-06	5.58E-06	8.6E-05	Low increased risk
L	6.2E-04	7.1E-03	9.76E-06	7.7E-03	High increased risk
M	5.8E-05	1.6E-03	7.90E-06	1.7E-03	High increased risk
Daycare	1.4E-06	9.0E-06	5.58E-06	1.6E-05	Low increased risk
8	5.5E-07	2.5E-06	1.12E-05	1.4E-05	Low increased risk
10	Below CV	2.2E-05	1.77E-05	4.0E-05	Low increased risk

*For comparison and privacy purposes the location labels follow the method used by EPA in the Human Risk Assessment for Grants Chlorinated Solvents Plume Site.

This assessment utilizes the high end TCE cancer slope factor of 4.0E-01.

Exposures occurring during childhood and adulthood have been considered, for conservatism.

Cancer risk was not calculated for locations where contaminants were detected below health-based comparison values.

Xylenes were detected above screening levels at this site, but have not been found to result in cancerous effects. Therefore, cancer risk estimates for xylenes were not calculated.

Table A-4. Calculated noncancer hazard indices for residential exposure to PCE & TCE in indoor air

Location		*PCE Hazard*	*TCE Hazard*	*Benzene Hazard*	*Xylenes Hazard*	*Total Hazard Index for Chemicals Detected Above CVs*	*Noncancer Hazard Conclusion*
A	adult	0.0015	0.00014	0.09	0.06	0.1	No further evaluation is necessary.
	child	0.003	0.0003	0.2	0.13	0.3	No further evaluation is necessary.
B	adult	0.0011	0.0002	0.2	0.02	0.2	No further evaluation is necessary.
	child	0.003	0.0005	0.4	0.05	0.5	No further evaluation is necessary.
C	adult	0.002	0.00013	0.15	0.05	0.2	No further evaluation is necessary.
	child	0.004	0.0003	0.3	0.12	0.5	No further evaluation is necessary.
D	adult	0.004	0.003	0.2	0.009	0.2	No further evaluation is necessary.
	child	0.008	0.007	0.5	0.02	0.5	No further evaluation is necessary.
E	adult	Below CV	0.0006	0.15	0.02	0.2	No further evaluation is necessary.
	child	Below CV	0.0013	0.3	0.05	0.4	No further evaluation is necessary.
F	adult	0.04	0.0004	0.6	3.6	4.3	Additional noncancer evaluation is necessary.
	child	0.08	0.0009	1.4	8.4	9.9	Additional noncancer evaluation is necessary.
G	adult	0.02	0.010	0.4	0.06	0.5	No further evaluation is necessary.
	child	0.06	0.02	0.9	0.14	1.2	Additional noncancer evaluation is necessary.
H	adult	0.008	0.003	0.2	0.03	0.2	No further evaluation is necessary.
	child	0.02	0.007	0.5	0.06	0.6	No further evaluation is necessary.
I	adult	0.03	0.0005	0.2	0.09	0.3	No further evaluation is necessary.
	child	0.06	0.0011	0.4	0.2	0.7	No further evaluation is necessary.
J	adult	0.003	0.0007	0.5	0.06	0.5	No further evaluation is necessary.
	child	0.007	0.002	1.0	0.14	1.2	Additional noncancer evaluation is necessary.

Table A-4 Continued

Location		*PCE Hazard*	*TCE Hazard*	*Benzene Hazard*	*Xylenes Hazard*	*Total Hazard Index for Chemicals Detected Above CVs*	*Noncancer Hazard Conclusion*
K	adult	0.07	0.00013	0.12	0.04	0.2	No further evaluation is necessary.
	child	0.2	0.0003	0.3	0.1	0.5	No further evaluation is necessary.
L	adult	0.6	0.2	0.2	0.05	1.0	No further evaluation is necessary.
	child	1.3	0.5	0.5	0.11	2.4	Additional noncancer evaluation is necessary.
M	adult	0.05	0.05	0.2	0.02	0.3	No further evaluation is necessary.
	child	0.013	0.11	0.4	0.05	0.7	No further evaluation is necessary.
Daycare/	adult	0.0014	0.0003	0.12	0.03	0.2	No further evaluation is necessary.
	child	0.003	0.0006	0.3	0.08	0.4	No further evaluation is necessary.
8	adult	0.0005	0.00007	0.2	0.02	0.3	No further evaluation is necessary.
	child	0.0012	0.0002	0.5	0.05	0.6	No further evaluation is necessary.
10	adult	Below CV	0.0006	0.4	0.03	0.4	No further evaluation is necessary.
	child	Below CV	0.0015	0.9	0.06	0.9	No further evaluation is necessary.

Further evaluation and dicussuion is presented in the text for structures having a hazard index greater than one.

Noncancer hazard was not calculated for locations where PCE, TCE, and benzene were detected below health-based comparison values.

*For comparison and privacy purposes the location labels follow the method used by EPA in the Human Risk Assessment for Grants Chlorinated Solvents Plume Site.

Appendix B. ATSDR's Evaluation Process

Exposure Pathways

An exposure pathway is a route by which people can have contact with chemicals originating from a contamination source. An exposure pathway consists of the following five elements: 1) a source of contamination, 2) a media such as air or soil through which the contaminant is transported, 3) a point of exposure where people can contact the contaminant, 4) a route of exposure by which the contaminant enters or contacts the body, and 5) a receptor population. Exposure pathways are complete if all five elements are present and connected. If one of these elements is missing, the pathway is considered incomplete, and human exposure is not possible.

ATSDR evaluated the potential for human exposure to VOCs from Grants Chlorinated Plume site in a 4-step process. We first examined the pathways by which people could come in contact with contaminants. Then we screened the contaminants found in the exposure pathway to determine if levels were sufficient to warrant further health evaluation. For contaminants present at levels above screening values, we then reviewed likely exposure scenarios that could exist. In the final step, we determined whether a reasonable combination of chemical concentration and duration (amount of time a person might be exposed) was sufficient to cause illness or other adverse health problems.

Comparison Values and the Screening Process

To evaluate the available data, ATSDR used comparison values (CVs) to determine which chemicals to examine more closely. CVs are the chemical concentrations found in a specific media (for example: air, soil, or water) and are used to select chemicals for further evaluation. CVs incorporate assumptions of daily exposure to the chemical and a standard amount of air, soil, or water that someone may take into their body each day. CVs are generated to be conservative and non-site specific. These values are used only to screen out chemicals that do not need further evaluation; CVs are not intended as environmental clean-up levels or to indicate that health effects occur at concentrations that exceed these values.

CVs can be based on either carcinogenic (cancer-causing) or noncarcinogenic effects. Cancer-based comparison values are calculated from the U.S. Environmental Protection Agency's (EPA) oral cancer slope factor (CSF) or inhalation risk unit. CVs based on cancerous effects account for a lifetime exposure (70 years) with a theoretical excess lifetime cancer risk of 1 extra case per 1 million exposed people. Noncancer values are calculated from ATSDR's Minimal Risk Levels (MRLs), EPA's Reference Doses (RfDs), or EPA's Reference Concentrations (RfCs). When a cancer and noncancer CV exists for the same chemical, the lower of these values is used in the comparison for conservatism. The chemical and media-specific CVs utilized during the preparation of this health consultation are listed below:

- An **Environmental Media Evaluation Guide (EMEG)** is an estimated comparison concentration for which exposure is unlikely to cause adverse health effects, as determined by ATSDR from its toxicological profiles for a specific chemical.
- A **Cancer Risk Evaluation Guide (CREG)** is a comparison concentration that is based on an excess cancer rate of one in a million persons and is calculated using EPA's cancer slope factor (CSF).

The **USEPA Region 6 Human Health Medium-Specific Screening Levels** address common human health exposure pathways. They do not consider all potential human health exposure pathways nor address ecological concerns. The values are not regulatory, but are derived using equations from EPA guidance and commonly used defaults. These screening values are used in this document to provide some consistency in approach between the EPA Human Risk Assessment for GCSP site and the ATSDR Health Assessment process. EPA Region 6's Internet version of Risk-Based Human Health Screening Values can be found at the internet address http://www.epa.gov/earth1r6/6pd/rcra_c/pd-n/screen.htm.

Evaluation of Public Health Implications

The next step in the evaluation process is to take those contaminants that are above their respective CVs and further identify which chemicals and exposure situations are likely to be a health hazard. Therefore, calculations are performed to estimate the possibility of cancer and noncancer health problems. The calculations consider the activities of people living in the community. In this public health assessment, ATSDR has estimated exposure to chemicals in indoor air by adult and children residing in structures sampled as part of EPA's investigation. The same equations have been used for the noncancer and cancer calculations with the indicated modifications. The equations and the assumptions are based on the EPA Risk Assessment Guidance for Superfund, Part A,[1] EPA Risk Assessment Guidance for Superfund Part E,[2] and the EPA Exposure Factors Handbook,[3] unless otherwise specified. The assumptions and details on the noncancer and cancer evaluations of exposure are presented in the following equation and text.

The equation for estimating the dose of chemicals inhaled in indoor air by residents is as follows:

$$Dose\,(mg/kg/day) = \frac{C \times IR \times EF \times ED \times CF}{BW \times AT}$$

where

C = chemical concentration; micrograms per cubic meter (ug/m^3)

IR = inhalation rate; 20 and 10 cubic meters per day (m^3/day), respectively, for adults and children

EF = exposure frequency; 350 days/year assumes year-round exposure with 2 weeks away from the home per year

ED = exposure duration; 30 years for adults and 6 years for children

CF = conversion factor; 0.001 milligrams per microgram

BW = body weight; 70 kilograms for adults and 15 kilograms for children

[1] U.S. Environmental Protection Agency. Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual. Part A. December 1989.

[2] U.S. Environmental Protection Agency. Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual. Part E, Supplemental Guidance for Dermal Exposure. July 2004.

[3] U.S. Environmental Protection Agency. Exposure Factors Handbook. August 1997.

AT = averaging time; 10,950 days for noncancer (adults); 2,190 days for noncancer (children) and 25,550 days for cancer evaluation

Noncancer Health Effects

The doses calculated for exposure to each individual chemical are then compared to established health guidelines, such as ATSDR's Minimal Risk Levels (MRLs) or EPA's Reference Doses (RfDs), in order to assess whether adverse noncancer health impacts from exposure are expected. These health guidelines, described in more detail in the following text, are chemical-specific values that are based on the available scientific literature and are considered protective of human health.

Minimal Risk Levels (MRLs)

ATSDR has developed MRLs for contaminants commonly found at hazardous waste sites. The MRL is an estimate of daily exposure to a contaminant below which noncancer, adverse health effects are unlikely to occur. MRLs are developed for different routes of exposure, such as inhalation and ingestion, and for lengths of exposure, such as acute (less than 14 days), intermediate (15-364 days), and chronic (365 days or greater). At this time, ATSDR has not developed MRLs for dermal exposure. A complete list of the available MRLs can be found at http://www.atsdr.cdc.gov/mrls.html.

References Doses (RfDs)

An estimate of the daily, lifetime exposure of human populations to a possible hazard that is not likely to cause noncancerous health effects. RfDs consider exposures to sensitive sub-populations, such as the elderly, children, and the developing fetus. EPA's RfDs have been developed using information from the available scientific literature and have been calculated for oral and inhalation exposures. A complete list of the available RfDs can be found at http://www.epa.gov/iris.

Non-carcinogenic effects, unlike carcinogenic effects, are believed to have a threshold, that is, a dose below which adverse health effects will not occur. As a result, the current practice for deriving health guidelines is to identify, usually from animal toxicology experiments, a No Observed Adverse Effect Level (or NOAEL), which indicates that no effects are observed at a particular exposure level. This is the experimental exposure level in animals (and sometimes humans) at which no adverse toxic effect is observed. The NOAEL is then modified with an uncertainty (or safety) factor, which reflects the degree of uncertainty that exists when experimental animal data are extrapolated to the general human population. The magnitude of the uncertainty factor considers various factors such as sensitive subpopulations (for example; children, pregnant women, and the elderly), extrapolation from animals to humans, and the completeness of available data. Thus, exposure doses at or below the established health guideline are not expected to result in adverse noncancer health effects.

When site-specific exposure doses exceed health guidelines, it does not necessarily indicate that health effects will occur. Rather, it indicates that a more thorough look at the known toxicological values for this chemical and the site-related exposures are needed. The known toxicological values are doses derived from human and animal studies that are presented in the ATSDR Toxicological Profiles and EPA's Integrated Risk Information System (IRIS). A direct comparison of site-specific exposure doses to study-derived exposures and doses found to cause

adverse health effects is the basis for deciding whether health effects are likely to occur. This in-depth evaluation is performed by comparing calculated exposure doses with known toxicological values, such as the no-observed adverse-effect-level (NOAEL) and the lowest-observed-adverse-effect-level (LOAEL) from studies used to derive the MRL or RfD for a chemical.

It is important to consider that the methodology used to develop these health guidelines does not provide any information on the presence, absence, or level of cancer risk. Therefore, a separate cancer evaluation is necessary for potentially cancer-causing chemicals detected in samples at this site. A more detailed discussion of the evaluation of cancer risks is presented in the following section.

Cancer Risks

Exposure to a cancer-causing compound, even at low concentrations, is assumed to be associated with some increased risk for evaluation purposes. The estimated excess risk of developing cancer from exposure to chemicals associated with the site was calculated by multiplying the site-specific adult exposure doses, with a slight modification, by EPA's chemical-specific Cancer Slope Factors (CSFs or cancer potency estimates), which are available at http://www.epa.gov/iris.

An increased excess lifetime cancer risk is not a specific estimate of expected cancers. Rather, it is an estimate of the increase in the probability that a person may develop cancer sometime during his or her lifetime following exposure to a particular chemical. Therefore, the cancer risk calculation incorporates the equations and parameters (including the exposure duration and frequency) used to calculate the dose estimates, but the estimated value is divided by 25,550 days (or the averaging time), which is equal to a lifetime of exposure (70 years) for 365 days/year.

There are varying suggestions among the scientific community regarding an acceptable excess lifetime cancer risk, due to the uncertainties regarding the mechanism of cancer. The recommendations of many scientists and EPA have been in the risk range of 1 in 1 million to 1 in 10,000 (as referred to as 1×10^{-6} to 1×10^{-4}) excess cancer cases. An increased lifetime cancer risk of one in one million or less is generally considered an insignificant increase in cancer risk. Cancer risk less than 1 in 10,000 (or 1×10^{-4}) is not typically considered a health concern. An important consideration when determining cancer risk estimates is that the risk calculations incorporate several very conservative assumptions that are expected to overestimate actual exposure scenarios. For example, the method used to calculate EPA's CSFs assumes that high-dose animal data can be used to estimate the risk for low dose exposures in humans. As previously stated, the method also assumes that there is no safe level for exposure. Lastly, the method computes the 95% upper bound for the risk, rather than the average risk, suggesting that the cancer risk is actually lower, perhaps by several orders of magnitude.

Because of the uncertainties involved with estimating carcinogenic risk, ATSDR also employs a qualitative approach in evaluating all relevant data. The numerical risk estimate must be considered in the context of the variables and assumptions involved in their derivation and in the broader context of biomedical opinion, host factors, and actual exposure conditions. The actual parameters of environmental exposures have been given careful and thorough consideration in evaluating the assumptions and variables relating to both toxicity and exposure. A complete review of the toxicological data regarding the doses associated with the production of cancer and

the site-specific doses is an important element in determining the likelihood of exposed individuals being at a greater risk for cancer.

Table B-1. Additional information on chemicals discussed in the text.

Contaminant	*Conversion from ppb to µg/m³*	*Noncancer Descriptor* *	*Cancer Classification* †
Benzene	1 ppb = 3.19 µg/m³	Neurological impairment Hematological effects	Known human carcinogen-leukemia
Cis-1,2-dichloroethene (*cis*-1,2-DCE)	1 ppb = 3.97 µg/m³	Nerve, liver, kidney impairment	Not classified
Ethyl benzene	1 ppb = 4.34 µg/m³	Neurological impairment	Not classified
Methyl-*tert*-butyl ether (MTBE)	1 ppb = 3.61 µg/m³	Neurological impairment	Not classified
Perchloroethylene (PCE) Tetrachloroethylene	1 ppb = 6.73 µg/m³	Neurological impairment	Reasonably anticipated to be a human carcinogen
Toluene	1 ppb = 3.77 µg/m³	Neurological impairment	Not classified
Trichloroethylene (TCE)	1 ppb = 5.37 µg/m³	Neurological impairment	Reasonably anticipated to be a human carcinogen
Vinyl chloride	1 ppb = 2.56 µg/m³	Liver, nerve and immune impairment	Known human carcinogen
Total xylene	1 ppb = 4.41 µg/m³	Neurological impairment	Not classified

* From the ATSDR Toxicological Profiles published for each chemical.

† From the National Toxicology Program (NTP), the International Agency for Research on Cancer (IARC), and USEPA.